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Towards Resilient and Inclusive Cities: A Framework for Sustainable Street-Level Urban Design

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Abstract: This study addresses the need for sustainable urban design, focusing on enhancing street-level interactions in line with the Sustainable Development Goals (SDG 11). The research specifically examines the evolving role of urban furniture and infrastructure in creating inclusive, resilient cities that respond to current challenges, such as climate adaptation and citizen accessibility. Using a qualitative mixed-methods approach, this study combines keyword analysis and semi-structured interviews with urban design experts, and comparative case studies in the Basque Country. Key themes emerged, including sustainable water management, Nature-based Solutions, technological integration, and pedestrian prioritization. These findings underscore a shift from static, object-oriented urban components to adaptable, modular designs that balance functionality with environmental and social sustainability. This study concludes with a checklist for urban furniture design, offering practical guidelines that will inform the next research phase: prototyping innovative urban furniture solutions to support more sustainable and inclusive city environments.

Keywords: sustainable urban design; street-level interaction; urban furniture; nature-based solutions; climate adaptation; modular design; urban resilience; inclusive cities

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1. Introduction

Although transformative changes in cities occur holistically, and how urban design is approached depends on higher level phenomena such as climate change or political decision-making, how humans interact with the city often happens at the level of interaction with the street. Street-level interaction, defined as the complex, everyday interactions that occur between people and the physical components of an urban environment at a close, pedestrian scale [1], pertains to the realm of human proxemic experience, where people interact with objects and negotiate their personal space with the public space [2]. Crucially, proxemic interactions with the (urban) space entail not only architectural design but also aspects related to the socio-technological individual and collective sphere.

On the one hand, hyperconnectivity and technological advances have transformed urban planning, enabling 'smart cities' where sensor networks and data optimize resources and enhance residents' quality of life. Gehl and Svarre [3] observe that digital technologies in urban spaces improve public service efficiency while fostering social interaction and civic engagement. This synergy between technology and urban design helps create dynamic, responsive environments aligned with evolving urban needs that relate to the way we use the city and move within the urban realm. A significant evolution in urban mobility is the shift from car dependency toward sustainable modes, such as bicycles, electric scooters, and autonomous vehicles. As cities redesign infrastructure for these modes, they enhance accessibility and improve urban environments [4,5]. Innovative urban infrastructure, like electric vehicle charging stations that double as Wi-Fi hubs and environmental monitoring points, optimizes space while reducing ecological footprints [1]. Additionally, adaptive

lighting systems and air quality-monitoring benches contribute to safer, more livable cities [6]. A multimodal transportation approach that combines public transit with micro-mobility solutions such as bikes and e-scooters is increasingly essential. Urban design can influence residents' transportation choices. Access to a wide range of services and activities as well as the ease of getting around a city are key factors that influence citizens' choice of transportation [7]. Mobility as a Service (MaaS) tools streamline urban transit by allowing users to plan and pay for different modes in a single system, encouraging sustainable choices [8]. On the other hand, climate adaptation (i.e., the need to adapt the design and functioning of cities to the challenges posed by climate change [9]) presents an opportunity to reimagine urban spaces. By integrating adaptive and mitigative strategies, cities can become more resilient, sustainable, and inclusive, ready for current and future climate challenges [10]. The recent emergence of Nature-based Solutions (NBSs), i.e., urban design solutions that emphasize the use of natural processes in urban design for climate adaptation and resilience, is promising and has the potential to radically change interaction with the city even at the street level. NBSs integrate environmental, social, and economic factors, underscoring nature's transformative role in sustainability [11]. Examples of NBSs include parks, green walls, porous pavements, and biodiversity-friendly structures that restore natural cycles [12,13]. A core NBS principle is diversity—creating multifaceted, multidisciplinary, and site-adaptable solutions for urban sustainability. In dense cities with limited green space, re-naturalization (as part of a holistic understanding of NBS) presents unique challenges [14]. Solutions may involve native plants that require minimal maintenance or designing habitats for local wildlife [15]. By balancing natural and artificial elements, urban planners can create resilient spaces adaptable to seasonal and climate changes, enriching the user experience. An interesting example for including water cycle parameters in urban street-level design is Rotterdam's 'water plazas' [16], an adaptive urban design, functioning as recreational spaces in dry conditions and as water reservoirs during storms [17]. The changes in the approach to urban design are reflected in the framing of the Sustainable Development Goals of the United Nations. SDG11 'Sustainable Cities and Communities' aims at 'making cities and human settlements inclusive, safe, resilient and sustainable' by achieving ten specific targets. In our research, we explicitly refer to target 11.3—Inclusive and Sustainable Urbanization, Target 11.5—Reduced Adverse Effects of Natural Disasters, and Target 11.7—Access to Safe and Inclusive Green and Public Spaces. While Target 11.5 is not directly related to the design of street-level interactions in the city, the tragic flooding events in Valencia in Spain in November 2024 [18] show how the design of the city's space even at the level of street interaction will have to adapt more and more to unprecedented adverse events even in areas of the world (e.g., Europe) where such events used to be unlikely. In the context of the United Nations' 2030 Agenda for Sustainable Development [19], in general, resilience is embedded within the SDGs as a component of sustainability. While sustainability and resilience are interrelated—both aiming to ensure long-term well-being—they differ in focus. Sustainability is about maintaining balanced development across various dimensions for the future, whereas resilience emphasizes the capacity to adapt and transform in response to immediate and long-term challenges. In the practice-based research approach that we present in this article, while sustainability is a general goal, design represents the strategic asset to enhance the capability of cities to resiliently adapt to the current circumstances.

The study presented in this paper is explicitly framed within the above mentioned SDG11 targets 11.3, 11.5, and 11.7. It is part of a two-year research project funded by the University of the Basque Country and the Basque Government. Started in November 2022, the project is led by the School of Architecture and the School of Engineering of the Basque Country in collaboration with a major manufacturer of street furniture and road elements (Transformados Metálicos S.L.—Trameinsa). The objective of the project is to '*define novel strategies for the design of the urban street space and its* components (e.g., urban *furniture) for more sustainable and egalitarian cities*', where 'sustainable' refers to technical, economic, cultural, and social sustainability and 'egalitarian' highlights the need to grant

universal accessibility, inclusivity, and moving towards a more-than-human perspective in urban design. The research actions conducted in this research project are oriented towards delivering tangible design outcomes (e.g., prototypes of novel urban furniture solutions). The present article reports the results of a preliminary phase of this project where we aimed at establishing a research framework grounded in experimental data to serve as a guide for the design of novel solutions in the upcoming phase (currently under development). This project responds to the following research questions: do we need a specific set of tools for the design of urban furniture and public space in the current, largely unprecedented, social, technological and environmental situation? Is there a new or renewed framework of design, both global and local, to work with? Our initial hypothesis is that there is a need for a renewed framework for public spaces design and urban elements (furniture and else) that demand a revisited set of design tools and methods. We intend to confirm this conjectural hypothesis by gathering insights from experts, checking research tendencies and comparing/assessing the success of similar design endeavors over time.

To answer the research questions and validate our hypothesis, we took a methodological approach framed within the boundaries of practice-based research, which 'is an approach to scientific inquiry that takes advantage of the unique insights gained through design practice to provide a better understanding of complex and future-oriented issues in the design field' [20]. While the final goal of the research is to design and prototype novel solutions (primarily product-oriented) for the urban street space (e.g., urban furniture and urban components such as electrical and network connectivity), we also aim at defining a set of replicable design tools and methods to tackle the design of street-level interactions. To achieve our goals, we first conducted a comprehensive review of emerging themes in the design of street-level interactions in the city by means of qualitative research methods, which include keyword analysis, semi-structured interviews, and case study analysis. The results of this first phase of the project allowed us to frame the current debate on the future of urban furniture and to delineate a design checklist that will guide the second phase of our research (i.e., the design and prototyping of a set of novel urban furniture). This is the first block of an upcoming design framework for future urban furniture that can be adaptable and scalable to other contexts towards a more sustainable and egalitarian urban space.

2. Materials and Methods

In this study, we employ different qualitative methods to review the state-of-the-art emerging research themes and architectural and technological solutions for the design of sustainable street-level interactions in the urban context. The combination of various methods, such as a systematic review, a site inventory of real case studies, and semi-structured urban expert interviews, has proven to be a valid approach for analyzing urban environments [21]. The results will inform, in Phase 2 of our research project, the design of novel urban furniture solutions to be first piloted in the context of the Basque Country's urban space. These new solutions will nurture, in turn, the iterative definition of a novel design framework for the design of street-level interactions (also intended to be commercialized in the future) for more sustainable and egalitarian cities through an approach inspired by practice-based research which employs 'methods and processes from design practice as a legitimate method of inquiry' [22]. Practice-based research 'is conducted through practice (through direct actions, activities and practices that take place in practice/the field) as well as research that studies human practices. This form of engaged research takes place at different scales, for example, in living labs, urban laboratories and at a more local scale on individual projects with a community' [23].

The concept of 'thinking globally and acting locally' is key for an effective urban design that balances global awareness with local specificity [24]. By thinking globally, we align strategies with universal trends, challenges and environmental problems, such as sustainable resource management and carbon reduction [25]. Acting locally, we ensure that these strategies are grounded in the unique cultural, social, and environmental context

of a specific place. Conversely, the study of local actions can be replicated in a global set of applicable tools, filtered through the local specificities of a given topologically defined urban situation [26].

Figure 1 shows a diagram of the study (which constitutes Phase 1 of the research project). Three qualitative research methods were employed: keyword analysis, thematic analysis of the interviews, and a comparative case analysis within a defined timeframe and geographical context. Results from each of the three methods were correlated and validated against emerging categories. These categories were obtained from the interviews' analysis, reviewed, expanded, and refined through the findings of the keyword frequency analysis, and ultimately validated through a comparative evaluation of six case studies through the Pugh Chart method [27]. The outcome of this study was an operational checklist that consists of 12 key design parameters that should be considered for practical application in sustainable urban design. This validated checklist is the first brick of an upcoming design framework that will offer a comprehensive set of criteria for a successful approach to the design of the public space and its elements, including urban furniture, within the framework of the Sustainable Development Goals, specifically SDG 11.

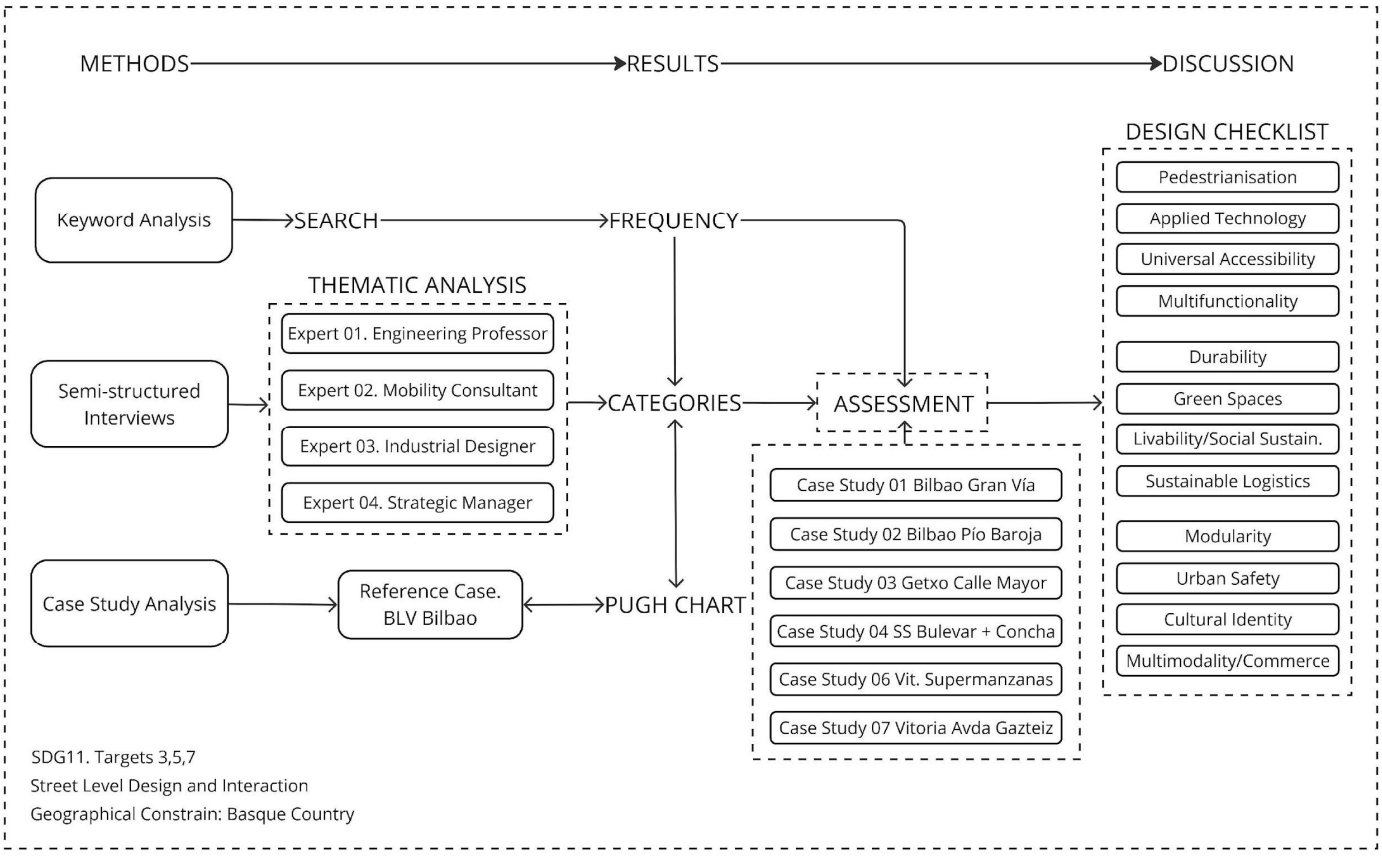

Figure 1. The diagram shows the methodological process of the study including the three qualitative methods employed, the emerging thematic categories, and the final design checklist with the 12 design parameters for successful implementation of the Sustainable Development Goal 11 within the context of the city.

2.1. Keyword Analysis

An initial review of current practices and theories is an essential prerequisite for informed decision-making in urban design practice [28]. Following a procedure established in Mosannenzadeh and Vettorato [29], a keyword analysis was used to extract relevant information from scientific literature on urban design and street-level interaction. The output of the keyword analysis was then cross-checked based on interviews with experts in different aspects such as policy makers, industry people, and academic professors (see

following section). The analysis was performed by progressively zooming in from a general vision of the urban space to the short-range, proxemic realm of urban furniture design. The keyword search target was organized into three broad thematic blocks that function as the general conceptual foundations on which we will ground the next phases of the research project, i.e., the design and prototyping of novel urban furniture and the definition of a replicable design framework for sustainable and egalitarian urban design at the street-level. These blocks are, from one side, typified topics of preliminary investigation for current urban furniture design (e.g., sustainability in design) coupled with, on the other hand, the specific key areas of our project (e.g., human interaction with objects). A third theme, which works as a connector of the previous two, is the role of technology and mobility in the city space. These three themes also directly relate to the three targets of the SDG11 goal which is the framework of reference of this research (see Introduction). Prior to the keyword analysis, we defined the three thematic areas of interest as follows:

1. Sustainability and design in future cities (based on SDG11. Target 11.5. *Reduce the Adverse Effects of Natural Disasters*): Global climate change is affecting human habits and the way we are used to inhabiting public space. Cities were designed for their local climate. Nowadays, they are facing difficulties adapting to these rapidly changing climatic conditions at the pace their citizens need. In principle, this change is moving towards a warmer planet and an increase in the level of the water of the oceans. This situation might have two crucial consequences: a need to protect cities and citizens from extreme heat and the urgency to solve potential migrations and global movements. The COVID-19 pandemic global problem probably helped consolidate an idea that was already permeating society: becoming more aware of the continuity of space and nature. Cities are not a framed finished entity, but a seamless special continuity with the 'wild, uncivilized' outside;
2. Planning strategy, technology, and mobility (SDG11. Target 11.7. *Provide Access to Safe and Inclusive Green and Public Spaces*): Ubiquitous technology is reshaping communications and relations. The coexistence between a real physical world and virtual meta-universes and their interwoven 'synapsis' are already part of daily life, blurring the limits between physical and virtual presence. Both the need to stop the consumption of petrol and advancements in information technologies and other sources of energy (e.g., electric) are opening up a new era in which mobility will probably be understood as a service and vehicles will explode in an array of different shapes and sizes; therefore, lanes and the occupation of the streets will change dramatically;
3. Citizen-city interaction (SDG11. Target 11.3. *Inclusive and Sustainable Urbanization*): The close-range urban space where we use the city is nothing but an open room where tensions and invisible forces interact. This human ecosystem is inhabited by humans, but also the visible/invisible components of the streets/squares, non-human sentient beings, and inanimate objects. This proxemic realm is where urban furniture and detailed street design become utterly relevant. Today, the city is an ecosystem where many actors interact. This block relates to everything that comprises the actual physical design of urban furniture or other elements and their interaction with the use, be it human or not.

The keyword analysis aimed to explore how these three themes, well-known at the public policy and governance level as well as the professional level, reflect in the academic and scientific debate. Given the practice-oriented approach of our research (whose main objective is the design of novel urban furniture for sustainable and egalitarian street-level interaction in the city), we consider the keyword analysis an appropriate approach (e.g., as compared to a literature review). We focused on extracting a limited number of keywords that we later compared with the results of the semi-structured interviews and the case studies analysis (see further below).

A search was conducted within the main academic publications research engines, specifically the Scopus database. The search targeted the title and/or abstract and/or

keywords, and was limited to entries with 40 or more citations. Books and congress papers were excluded. This was motivated by the fact that in Scopus, only some books contain keywords proposed by the author(s) and not all of them have an abstract. Additionally, in order to include sources with different indexing criteria (in this case research articles, books and book chapters, and conference proceedings) and avoid possible biases, it would have been necessary to search in fields common to all the sources. This would have required us to limit the search to the titles of the publications, since the title is the only common indexing field in the three sources mentioned. The research team made the decision to limit the sources to research articles and extend the search to keywords and abstracts. In this way, it was possible to include publications in which the terms of interest were not necessarily part of the title but could have been incorporated by the authors in the keywords or in the abstract. The search query we used was as follows: ('sustainab*') AND ('future street' OR 'street design' OR 'urban design' OR 'future cities' OR 'future city' OR 'sustainable street' OR 'neighborhood planning' OR 'street planning' OR 'city planning'). Results are presented in Section 3—Results.

2.2. Semi-Structured Interviews

Semi-structured interviews are a well-documented method for gathering qualitative data and expert insights [30]. In this study, we interviewed experts and stakeholders with significant experience in the design of public spaces. The selection of interviewees was made with a multidisciplinary perspective to ensure that all the design facets were covered with the initial candidates being discarded if minimum requirements such as experience (minimum 20 years of practice), direct relation to some of the selected cases (see Section 2.3), and complementary expertise among them were not met, a process recommended by Roulston [31] and Stokes [32] for ensuring rigorous qualitative research. This process of selection narrowed down the amount of available experts, while on the other hand, granted a reliable combined professional insight. Ultimately, we narrowed the selection to four participants. All the interviewees had at least 20 years of relevant experience, which is in line with established best practices for qualitative interviews [33]. Their work relates directly to both the geographic and disciplinary scope of the study. Additionally, the selected experts have overlapping areas of expertise, hence creating an imaginary interdisciplinary team capable of addressing all facets of street design. Each expert was also required to have experience leading interdisciplinary teams, thus ensuring they could provide not only individual insights but also collaborative perspectives on urban design [34]. The interviews were semi-structured to allow participants to reflect freely on a range of predetermined topics, while also enabling the interviewer to explore specific issues as they arose during the conversation [35]. This approach aligns with Kvale's [30] recommendation for flexible interview structures in qualitative research, particularly when capturing the complexity and subjective nature of design processes, technology, and urban planning [33]. To obtain comprehensive, comparable results across the different research methods employed in this study, the interviews were structured around the same three themes explored in the keywords analysis and in line with the SDG11 which is the reference framework of this research project, i.e., sustainability and design in future cities (SDG11, T11.5), planning strategy, technology and mobility (SDG11, Target 11.7), and citizen–city interaction (SDG11, Target 11.3).

Four interviews were conducted between April and May 2023, each lasting between 45 and 60 min. The four participants were as follows:

1. An academic (educator and researcher) in the field of engineering (Interviewee 01);
2. The lead consultant and managing partner at a transportation and urban mobility planning and modeling company in charge of some of the main mobility projects in metropolitan Bilbao (Interviewee 02);
3. A renowned furniture designer, architect, and president of the Basque Association of Designers (Interviewee 03);

4. A municipal councilor in charge of key projects for the urban development of the city of Bilbao (Interviewee 04).

Interviews were conducted in Spanish either online or in-person, and recorded and later transcribed for analysis. For the analysis of the interviews, we employed thematic analysis [36], which we will further discuss in Section 3—Results.

2.3. Case Study Analysis

The case studies analysis was conducted using the Pugh Chart method [27]. The Pugh method is a decision matrix often employed in design and engineering. By comparing multiple design options against a reference case, it offers a systematic framework that facilitates the evaluation of different design characteristics, thus helping make informed decisions on how to move forward. Once again, since the ultimate focus of our research is applied, i.e., to design and implement novel urban furniture for the sustainable and egalitarian city, we claim that the use of practice-oriented qualitative methods is the best-suited approach. Qualitative studies of the urban space at a street-level have also been conducted in other cities of the world with promising results, such as in London, UK [37] and several other European (Graz, Manchester, Frankfurt) and non-European (Guangzhou, Shenzhen, and Beijing) cities. For a comprehensive review of these case studies, the reader can refer to Wang [38]. In this study, we selected five of the main urban design projects developed in the larger cities of the Basque Country in the last two decades. As a reference case, we chose the redevelopment of the riverbanks of Bilbao in 2003 (Figure 2) by Juan Sádaba and Jose Luis Burgos [39], a multiple award-winning project designed and built by some of the co-authors of this study. This choice is justified by the thorough, first-hand knowledge of the project by its authors so that the Pugh matrix for comparison could be efficiently built (see Section 3 for details). Additionally, the reference case was built during the so-called 'Bilbao effect' years [40], a historical moment of great repurposing of much of the urban space of the city of Bilbao. As such, it well serves as a chronological benchmark to show how preoccupations and values have changed over the past crucial 20 years in the area under study.

In the early 2000s, the La Merced, Marzana, and Urazurrutia docks of Bilbao, located in the historical center of the city, underwent comprehensive rehabilitation aimed at modernizing the structures and pedestrianizing the area. The project, designed by Juan Sádaba and José Luis Burgos, sought to revitalize a degraded space and enhance its use as a daily riverside promenade along the Nervión river, the main river that crosses the city of Bilbao. The rehabilitation, fully funded by the Basque Government's Izartu program, aimed to create a vast pedestrian area along the riverbanks of the Nervión which, from the historical center, also reached other, newer areas of the river such as Abandoibarra and Barakaldo.

This project is characterized by a wooden cantilevered balcony resembling a pontoon, constructed in the narrowest section to ensure a pleasant walking experience (see Figure 2). This has become the most visually striking element of the project. Given the historical significance of the docks to the city, several literary texts referencing Bilbao were placed along its 450 m stretch, with each text representing each century of the city's existence. The rehabilitation of the La Merced, Marzana, and Urazurrutia docks has received significant recognition for its contribution to urban regeneration and heritage preservation. Notable awards include the Basque-Navarre Architecture Awards (Premios de Arquitectura Vasco-Navarro), the Spanish Urbanism Awards, where the project was awarded for its innovative approach to pedestrianization, public space creation and the promotion of Bilbao's cultural heritage, and the European Urban and Regional Planning Awards where the project received a special mention for its holistic approach to urban regeneration that blended sustainability, cultural heritage, and public space enhancement.

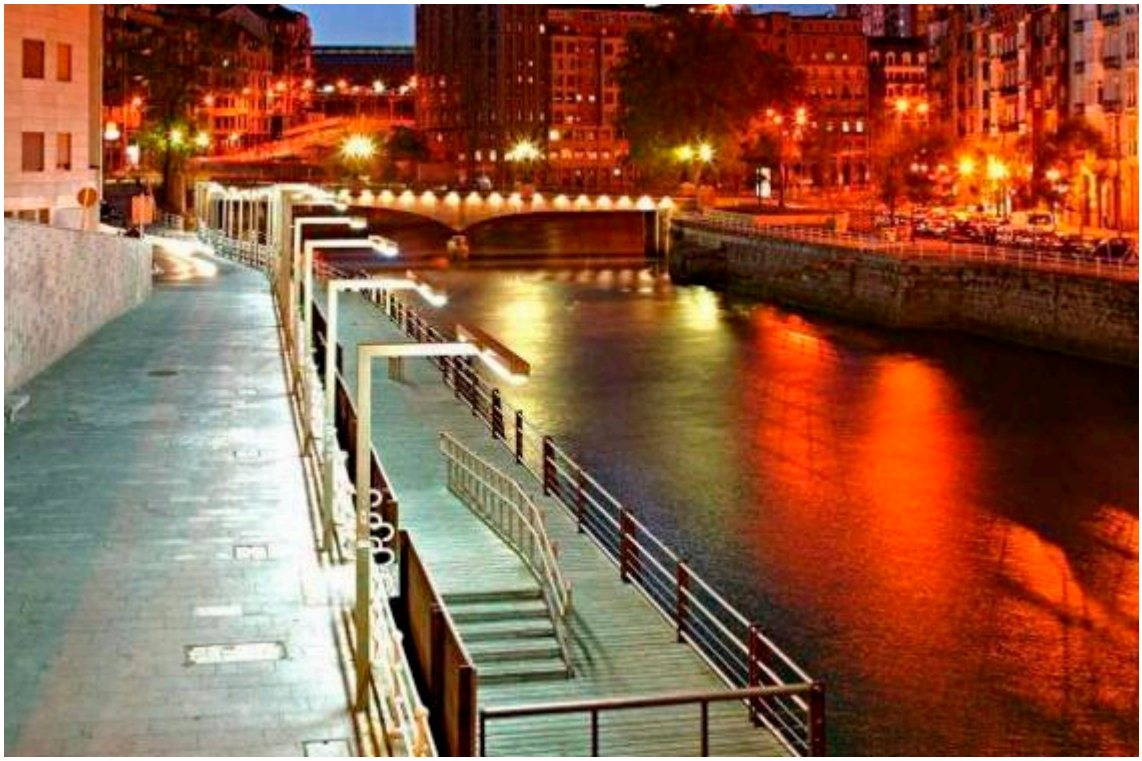

Figure 2. The Marzana riverbanks after the 2003 regeneration by the architects Juan Sádaba and José Luis Burgos.

Six case studies were selected for the Pugh Chart comparative analysis among the most significant urban renewal interventions at a street level in the three main cities of the Basque Country in the past two decades. Two additional cases, which the authors had thoroughly explored in previous research [41,42] were added: the Plaza Pío Baroja in Bilbao, and Calle Mayor in Getxo (the third most important city of the Bilbao province, Biscay). The six cases are briefly described below:

1. Gran Vía of Bilbao (Bilbao): The redevelopment of the Gran Vía (high street) in Bilbao, (started partial pedestrianization in the year 2000 and onward) (Figure 2) has been a key urban renewal project for the city. The initiative included widening pavements to enhance pedestrian mobility, installing modern urban furniture, and creating bike lanes. In addition, the public lighting system was upgraded, and accessibility solutions for people with reduced mobility were introduced;
2. Superblocks of Vitoria-Gasteiz: The so-called 'superblocks' are an innovative urban renewal project that reorganizes the city into large urban blocks to prioritize pedestrians and cyclists while restricting vehicular traffic in certain areas. This strategy, started in 2007, has transformed entire city sectors by reducing pollution and promoting more sustainable mobility;
3. Calle Gasteiz (Vitoria-Gasteiz): The redevelopment of Calle Gasteiz in 2012 (Figure 3) has been a major intervention in the capital of Álava, the third Basque province. The project aimed at improving both pedestrian mobility and urban sustainability: the street pavement was widened, and bike lanes were added, alongside the integration of sustainable urban drainage systems (SUDs) [43]. This project enhanced the green infrastructure of the street and made it more accessible for pedestrians and cyclists;
4. Playa de La Concha and Boulevard San Sebastián (San Sebastián): The reurbanization of the Boulevard of San Sebastián and the Paseo de La Concha started in the very late nineties and still going on with a very recent bike lane (2022) is one of the city's most iconic projects. This initiative combined the pedestrianization of the boulevard with the renovation of the La Concha promenade, creating a seamless connection between

the historical city center and the beach. Pavements were widened, rest areas were redesigned, and accessibility for people with reduced mobility was improved, with a focus on enhancing the pedestrian and tourist experience;

5. Plaza Pío Baroja (Bilbao): The redevelopment of Plaza Pío Baroja, with its last revamp in the year 2023 (Figure 4) has been a key project within the regeneration of Bilbao. Located next to the Nervión River, the plaza (square) has been redesigned to improve its connectivity with the riverfront, facilitating pedestrian access and creating a more open and multifunctional space. The square now features rest areas, with a large children's play area and improved connections with public transport;
6. Calle Mayor of Getxo: The Calle Mayor (high street) of Getxo has undergone a major redevelopment in 2023 focused on improving pedestrian mobility and accessibility. The project included the widening of pavements, the renewal of urban furniture, the installation of more efficient lighting systems, and improved connections with public transport. Additionally, parking lots were reorganized, and the area for private vehicles was reduced to encourage pedestrian and bike traffic.

Figure 3. Avda Gasteiz (Vitoria). Focused on transforming the avenue into a sustainable urban corridor, integrating green spaces, pedestrian-friendly pathways, and improved infrastructure to promote sustainable mobility and enhance urban biodiversity.

Figure 4. Redevelopment of Plaza Pio Baroja (Bilbao) with safe children's playground areas.

3. Results

We present the findings and analyses for each of the qualitative methods employed.

3.1. Keyword Analysis Results

The keyword analysis focused on scientific publications on three main areas of interest for our project, i.e., *sustainability and design in future cities, planning strategy for technology and mobility, and citizen–city interaction*. The goal of the keyword analysis was to help us map global tendencies within the research community as related to the topic under study (i.e., the sustainable and egalitarian city of the future) from design practice-based research (see Introduction). Consequently, the analysis was intended to be an initial 'trigger' for team reflection: it helped us draft the boundaries and acted as an initial delimitation of the area(s) of study which served as a canvas for the subsequent phases of the study.

A first round of was search based on the query ('sustainab*') AND ('future street' OR 'street design' OR 'urban design' OR 'future cities' OR 'future city' OR 'sustainable street' OR 'neighbourhood planning' OR 'street planning' OR 'city planning'), searched in papers' titles, abstracts, and keywords, yielding 531 results, further reduced to 501 after removing duplicates. We further selected the results by retaining only the entries that appeared in the 'keywords' section of the selected publications (and not in abstracts and/or titles). This led to a final selection of 428 entries. The results were then clustered around the three thematic areas of interest: citizen–city interaction, planning strategy for technology and mobility, and sustainability and design in future cities. These areas yielded a total of 226, 182 and 20 entries, respectively (see Figure 5), with citizen–city interaction being the most relevant group of publications, followed by planning strategy for technology and mobility. Interestingly, the thematic area of sustainability and design in future cities resulted in only 20 entries, thus falling far behind the discussion around street-level interaction within the city and mobility.

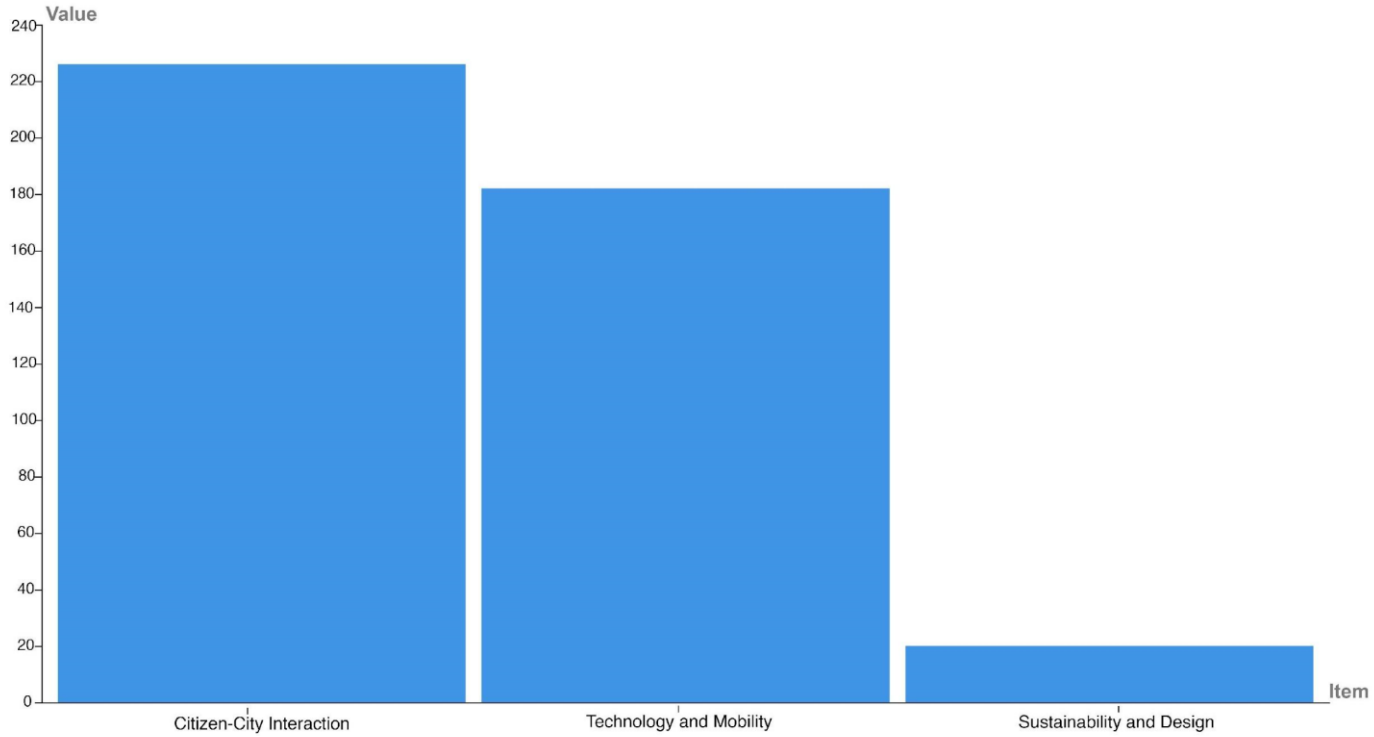

Figure 5. Distribution of three thematic areas based on the keyword analysis: citizen–city interaction is the most relevant area (with 226 entries), followed by technology and mobility (182 entries) and sustainability and design (20 entries).

Notably, while the search term 'sustainability' was included in the search within titles, abstracts, and keywords of the entries, in only 248 entries of the total retained 501 had the term 'sustainability' appeared among the paper's keywords.

The results from the keyword analysis, although not as comprehensive as a full literature review, provided valid insight into the current concerns within the academic community, and the thematic trends relevant to our analysis. Through a combined search strategy, where the term 'sustainability' (a key concept in SDG 11 and central to our project's objectives) was searched along with specific sub-terms that relate to the three main thematic lines of our research, we obtained a schematic overview of the most frequently cited topics. By organizing these terms according to their frequency in scientific literature and clustering them around macro-themes, we identified the indicators to consider in the definition of parameters for the design of novel urban interactions.

Besides clustering the keywords around the three main axes of our study (which, conversely, are inspired by the SDG11's themes), in Table 1, we show how the occurrence of specific keywords associated with the searched keywords led to the identification of emerging topics in the literature. Notably, there was a significant number of references to 'Water' in relation to sustainability and urban space design, making it by far the most frequent term. This was followed by keywords of a more technological and mobility-related nature, such as 'Traffic/Transport', 'Energy', and 'Pedestrianization'. In a third tier of recurrence, we found keywords like 'Air pollution', 'Greenery', and 'Climate change', again connected to more green or natural aspects. Interestingly, there was also a set of recurrent terms associated with sustainability and the natural environment that hinted at a solution-oriented approach: 'Urban ecosystem', 'Heat Island', and 'Stormwater'.

Table 1. Occurrence of keywords and clustering around emerging thematic areas.

Emerging Topics	Total	Most Popular Keywords	Number of Keywords
Ecology	134	Ecology	51
		(Urban) Ecosystem	68
		Biodiversity	15
Water	315	Water	315
Green Spaces or Green Elements	114	Green	93
		Vegetation	21
Contamination	255	(Air) Pollution	99
		Emissions	35
		Contamination	6
		Carbon	55
Climate	194	Climate change	95
		Storm/Stormwater	55
		Heat/Heat Island	44
Mobility	297	Urban transport/Traffic	132
		Mobility	17
		Car/Vehicle	17
		Walk/Pedestrian	131
Energy	138	Energy	138

3.2. Semi-Structured Interview Analysis

For the analysis of the semi-structured interviews thematic analysis, i.e., a qualitative text analysis method was used to code and identify emerging themes [44]. First, we performed an open coding of each interview to break down the text into parts and label each part with codes that reflect their meaning [45]. This first phase helped us to identify emerging themes grounded in the participants' experiences [46]. Codes and labels were then clustered to identify patterns, categories, and recurring themes which later informed the selection and analysis of the cases for the case studies comparative analysis (see below) based on the Pugh matrix. For this analysis, the data were coded using an inductive approach, identifying patterns, and emerging themes that aligned with the predefined categories, while also allowing for the emergence of new themes based on the participants' responses.

The coding process involved the following:

1. Exhaustive reading and segmentation: interviews were thoroughly read, and key points were labeled with descriptive codes;
2. Grouping codes into categories: the codes were grouped into categories reflecting emerging themes such as 'Pedestrianization', 'Accessibility', 'Applied technology';
3. Refining categories: the categories were adjusted for specificity and relevance as the coding progressed;
4. Extracting key concepts: key concepts were extracted using thematic reduction in order to identify the most representative areas of interest towards our final goal, i.e., the design of novel urban furniture and the definition of a framework for sustainable design of street-level interactions.

The open coding phase for each interview is reported below, as we believe it provides interesting insights on how the different backgrounds and experiences of the participants relate to the Sustainable Development Goals that served as guide for the interviews.

Expert 01. Engineering (Materials and Design) Professor and Researcher

- Use of software for sustainable design: The need to utilize software packages that take into account aspects such as eco-design, bionic design, life cycle analysis (LCA), sustainable manufacturing, and recycling is highlighted. Tools such as CATIA V5, Fusion 360, SolidWorks, Creo Parametric, EIME, SYNERA, and Granta Design are emphasized;
- Eco-design and bionic design: The interviewee stresses the importance of eco-design, which emulates nature's solutions to achieve more efficient and sustainable designs. Bionic and generative design enables the creation of optimized geometries based on natural patterns;
- Life cycle analysis (LCA): Life cycle analysis is key in assessing the environmental impact of products, considering carbon footprint, water usage, materials, and associated costs. Software like Granta Design facilitates these evaluations;
- Sustainable materials: Materials such as stainless steel, aluminum, and rot-resistant wood (wood treated with resins to enhance durability) are mentioned. The selection of materials must consider both durability and environmental impact, and tools like Granta Design enable the evaluation of various options;
- Additive manufacturing: This emerging technology, which uses the exact amount of material needed for component creation, is a prominent trend in sustainable manufacturing, as it minimizes material waste;
- Sustainable mobility and urban furniture: The design of urban furniture can contribute to sustainable mobility by offering additional services such as Wi-Fi, local information, and weather updates, thereby facilitating a more integrated urban experience. Additionally, bike stations and charging points for electric vehicles, positioned at multimodal nodes, enhance urban transport functionality;
- Modularity and durability: The use of modular designs is recommended, allowing damaged parts to be replaced without the need to replace the entire piece of furniture. This enhances sustainability and enables swift adaptation to new needs. Strategies such as using high-quality materials and anti-graffiti solutions to improve the durability of furniture are also highlighted;
- Challenges in sustainability: One of the greatest challenges mentioned is the selection of suitable materials and persuading buyers that more expensive materials may offer greater durability. Modularity is also seen as a solution that facilitates the maintenance, repair, and revision of urban furniture;
- Future trends: The interviewee envisions a future with increased urban mobility on foot, by bicycle, and by public transport, with greener cities and greater integration of technology, such as the sensorization of urban furniture. Although integrating sensors can be challenging due to the differing life cycles of products, it remains a promising trend.

Expert 02. Sustainable Mobility Consultant

- Location and flow in public spaces: It is essential that urban furniture does not obstruct the flow of people and integrates appropriately into the environment. Correct placement prevents urban furniture from becoming barriers to mobility;
- Universal usability: The design must be inclusive, taking into account gender, age, and the needs of all users. The functionality of urban furniture should take precedence over esthetics, with user interviews serving as a key tool for better understanding their needs;
- Road safety and visibility: Urban furniture must be placed in such a way that it does not impede visibility on streets, particularly in critical areas such as pedestrian crossings, to prevent accidents. Additionally, in spaces shared by pedestrians and vehicles, appropriate design can enhance safety;
- Contribution to sustainable mobility: Urban furniture can facilitate sustainable mobility if its location is strategically planned. It is crucial to avoid the disorderly prolifera-

tion of bicycle stations or charging points for electric vehicles without proper planning;

- Modularity and tactical urbanism: Modular design is useful for low-budget urban interventions, allowing for reversible changes before making definitive decisions. Modularity offers flexibility and adaptability for testing new solutions in public spaces;
- Challenges in facing change: One of the greatest challenges in projects is resistance to change. To address this issue, mathematical simulation tools are used to demonstrate the feasibility and benefits of proposed new measures;
- Sustainable materials: In the future, the materials used in urban furniture will increasingly be influenced by ecological and sustainability criteria.
- Adaptation to new pedestrian and shared spaces: The design of urban furniture must adapt to spaces where pedestrians and vehicles coexist, clearly delineating circulation areas to improve safety;
- Sensitization of urban furniture: Although the integration of sensors is a trend in the technological evolution of urban furniture, it poses challenges due to the differences in life cycles and functionality between the sensors and the urban furniture itself.

Expert 03. Professional Urban Furniture Designer

- Market homogenization and design marketing: companies are increasingly focusing on brand differentiation and marketing, relegating design to a secondary role in fashionable furniture;
- Traditional and digital craftsmanship: Both traditional and digital craftsmanship are regarded as ways to achieve greater product differentiation, although they do not necessarily enhance functionality. In interior architecture, craftsmanship plays a more significant role;
- Sustainable materials: Recycled textiles from plastic bottles (PETs) and recycled polyethylene boards have been used and are industrially competitive. However, working with more complex waste requires a more artisanal approach, increasing costs and complicating scalability;
- Upcycling and sustainability: Upcycling, or the reuse of waste without extensive transformation, is a key approach in projects. However, the lack of efficient waste management by authorities poses a major challenge;
- Technology and design: Technology is an integral part of design, from advanced tools to traditional methods. Technologies such as 3D printing and laser cutting allow for greater diversity and flexibility in design, but they are not a definitive solution. Design should be driven by values and objectives, rather than technology itself;
- Durability and emotional value: durability depends on both the materials and the context. Industrial materials may be more durable, but artisanal products offer an emotional value that fosters attachment and reduces long-term consumption;
- Modularity: Modularity is essential for allowing flexible configurations in furniture, such as in living rooms, kitchens, and shelving. This facilitates adaptation to different spaces and needs;
- Interdisciplinary collaboration: Collaborating with professionals from various disciplines, such as architects and technologists, enriches the design process. This transdisciplinary interaction is fundamental for exploring new possibilities and generating innovative ideas.
- Well-being and quality of life: furniture design has a direct impact on people's well-being, and to have a positive influence, it must focus on human life and needs, rather than purely economic values;
- Esthetics as a persuasive tool: esthetics plays a crucial role, not only in visual appeal but also as a tool to persuade and convince people of new values, beyond ethical concerns.

- Ecological crisis as a central challenge: The primary challenge for furniture design today is addressing the ecological crisis. Each designer must find a way to contribute to solving this crisis;
- A paradigm shift in design: it is anticipated that future generations of designers, motivated by the ecological crisis and emerging values, will lead a change in consumption and production models.

Expert 04. Political Manager in Charge of Works, Urban Planning, and Strategic Projects in Bilbao

- Shift in urban priorities (pedestrian vs. car): There has been a significant evolution in public space design, with pedestrians now being prioritized over cars. This shift has been particularly evident over the past 30 years, where urban design was once dominated by cars, but there is now greater awareness of the importance of creating more livable and pedestrian-friendly spaces;
- Pandemic as a catalyst for change: the pandemic heightened public awareness of the importance of public spaces, driving the need for more livable and usable streets as areas for staying, not just for passing through;
- Challenges in reducing space for cars due to parking: The availability of parking spaces for residents is one of the primary obstacles to reducing the space allocated to cars. Traffic restriction interventions rely on finding solutions for residential parking, particularly in areas where public transport is insufficient to compensate for the reduction in car use;
- Aging population and accessibility: The aging population necessitates the design of more accessible public spaces, including benches, railings, and comfortable routes for older people. Accessibility becomes a key criterion in urban planning;
- Public spaces adapted for children: Although there are fewer children in cities, there is still a demand for public spaces to be suitable for their use, which has led to an increase in playgrounds and swings in various neighborhoods;
- Local commerce and pedestrianization: Pedestrianized and more pedestrian-friendly areas help support local businesses, especially in peripheral neighborhoods where local commerce has suffered due to the rise in online shopping;
- Sustainable and healthy spaces: There is a demand for more sustainable and healthy environments, with more nearby green spaces for residents, which in turn improves the quality of life;
- Changes in urban logistics due to e-commerce: e-commerce has strained the urban distribution model, increasing the demand for loading and unloading zones, which were originally designed for traditional commerce, not for last-mile delivery;
- Diversity of transport modes and public space coexistence: The proliferation of personal mobility vehicles (PMVs), such as bicycles and scooters, has created new tensions in public spaces. While they occupy little space, their speed and coexistence with pedestrians require new planning strategies;
- Customized public space modification: Public space design does not follow a one-size-fits-all model but must be adapted to the needs and expectations of each neighborhood. The presence of cars and commerce, or the demand for green spaces varies by context, and the design must be adjusted accordingly;
- Maintenance and durability of urban furniture: Although there is a wide range of urban furniture available, one of the most common issues is durability in public spaces. Often, the selected pieces are not sufficiently resistant to vandalism or weather conditions, and they are not designed for easy maintenance or part replacement;
- Creative use of urban furniture: Imagination and innovation play key roles in the choice of urban furniture. In some cases, elements not originally designed as furniture have been used effectively, such as garden lamps used as traffic signage;
- Logistical problems and sustainable urban distribution: There is a need to restructure urban goods distribution, using smaller, less polluting vehicles (electric tricycles or pedal-assisted vehicles) and urban logistics hubs to facilitate last-mile delivery;

- Importance of functional and safe design: Public space design must be both functional and safe, considering the perception of safety from different perspectives (gender, age, etc.). Furthermore, the design should allow for comfortable use of the space, not just be esthetically pleasing;
- Cultural identity elements in public space: Incorporating local cultural and historical elements into the design of public spaces adds value and reinforces the identity of the neighborhoods. Examples include the restoration of old cranes, and kilns, or the creation of murals that preserve the historical memory of the area.

Figure 6 shows the cumulative values for the labels obtained from open coding across the four interviews. 'Technology and Software' were mentioned five times by the four interviewees, together with 'Sustainable material' and 'Modularity and Durability'. 'Mobility and Urban functionality', 'Sustainability challenges', 'Functional design and Usability', and 'Accessibility for all age groups' were each mentioned four times, followed by 'New technologies', 'Road safety and Shared spaces', 'Urban logistics and e-commerce'. All the other labels were mentioned twice and include 'Resistance to change', 'Impact on well-being and quality of life', 'Market differentiation', 'Craftsmanship and Sustainability', 'Cultural identity in public spaces', 'Multifunctional public spaces', and 'Pandemic'.

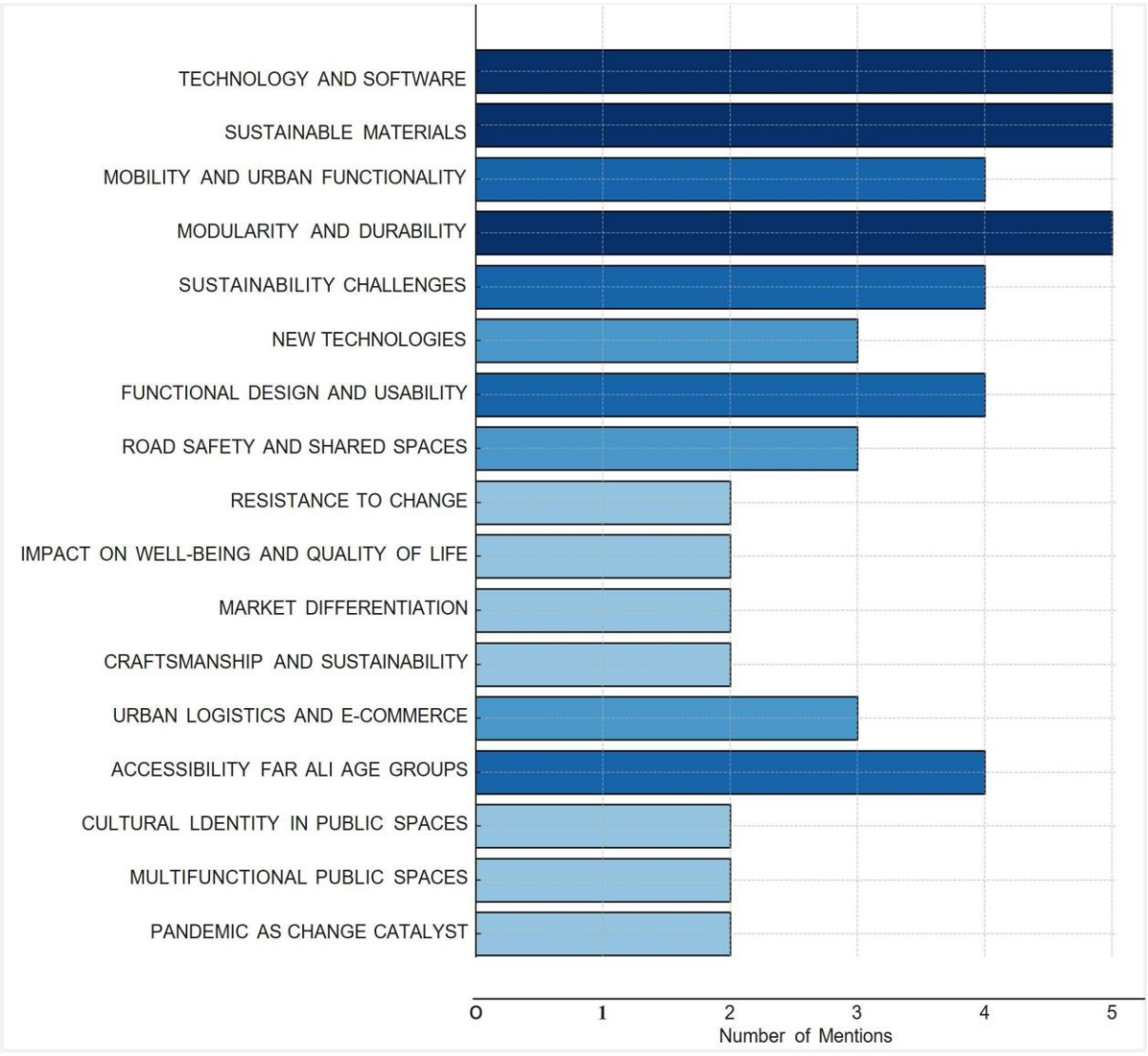

Figure 6. Cumulative values for the labels obtained from the open coding across the four interviews.

3.3. Emerging Themes: Toward a Checklist of Design Categories

Once the primary categories were established, emerging themes were identified across the four interviews. The objective is to pinpoint the most representative concepts for use in urban space design. A thematic reduction method was utilized [46], which entailed selecting the most frequent and meaningful words or expressions from the emerging categories in each interview to define higher level themes. Three themes were identified, each with related categories, as seen in Table 2. In order to gather as much insights as possible from this preliminary study, we opted to use consistent terminology across the themes used for the keyword analysis and the themes that emerged from the interviews analysis. These themes—and their related terminology—will form the main axis of the design framework we will define in a subsequent phase of research.

Table 2. Themes and categories as they emerged from the thematic analysis of the interviews with experts.

Theme 1—Mobility and Technology	Theme 2—Sustainability	Theme 3—Citizen–City Interaction
Pedestrian priority and reduction in space for cars	Durable and sustainable urban furniture	Modularity and flexibility in design
Technology in urban design	Sustainability and green spaces	Urban safety and coexistence
Accessibility for all age groups	Pandemic as a catalyst for urban change	Integration of cultural elements and local identity
Multifunctional public spaces	Sustainable urban logistics and distribution	Local commerce and pedestrian spaces

To keep consistency with the keyword analysis, i.e., framing the urban space by zooming from a more general to a narrower perspective and in line with the strategy employed by Mosannenzadeh and Vettorato [29], categories were clustered from the more general to the more specific. Below, we briefly describe each theme through the emerging categories that define it.

Theme 1—Mobility and Technology

1. Accessibility for all age groups: The aging population and the need to design accessible spaces are recurring themes. Cities must be prepared for older people and those with reduced mobility, with infrastructure such as ramps, lifts, railings, and comfortable routes. Additionally, there is an emphasis on designing safe play areas for children;
2. Technology in urban design: Technology plays an important role, from the sensorization of cities to the use of emerging technologies such as 3D printing and laser cutting. These tools allow for personalized urban design, but they must be used according to the project's objectives, rather than as an end in themselves;
3. Multifunctional public spaces. Urban spaces must be designed to serve multiple purposes: as places for transit, for staying, for local commerce, and for cultural or social events. Multifunctionality is key to ensuring that spaces can adapt to the different needs of the community and are sustainable in the long term under all aspects.

Theme 2—Sustainability

4. Durable and sustainable urban furniture: Urban furniture must be durable and able to withstand weather conditions, vandalism, and wear. Sustainability is an essential factor, with the use of recycled materials and techniques such as upcycling to reduce environmental impact;
5. Sustainability and green spaces: The creation of nearby green spaces and the reduction in the environmental impact of the urban environment are fundamental. Green areas not only improve residents' quality of life, but they also play an important role in the sustainability of urban design;

6. Pandemic as a catalyst for urban change: The pandemic has raised greater awareness of the importance of public spaces, leading to an acceleration of trends toward pedestrianization, sustainability, and the creation of more livable environments;
7. Sustainable urban logistics and distribution: The rise in e-commerce has increased the need for loading and unloading zones, requiring a redesign of urban logistics. The use of smaller, more sustainable vehicles for last-mile distribution is proposed, as well as the need for urban logistics centers.

Theme 3—Citizen–City Interaction

8. Modularity and flexibility in design: Modularity and flexibility are key concepts that allow urban spaces to adapt to different uses and changing needs. The importance of reversible interventions (tactical urbanism) and adaptable furniture to facilitate repair and maintenance is highlighted;
9. Urban safety and coexistence: Spaces must be safe, both in terms of physical safety and the perception of safety among different users (gender, age, etc.). Additionally, the coexistence of pedestrians, bicycles, personal mobility vehicles (PMVs), and other modes of transport must be properly managed to avoid tensions in public spaces;
10. Integration of cultural elements and local identity: the importance of integrating cultural and historical elements into the design of public spaces is emphasized, such as monuments, murals, or restored structures, to reinforce local identity and create a sense of belonging;
11. Local commerce and multimodal/pedestrian spaces: Pedestrian areas support local commerce, particularly in peripheral neighborhoods. A pedestrian-friendly urban environment is key to sustaining local businesses, which have been affected by the centralization of commerce and online sales.

3.4. Assessing the Alignment with the Targets of Sustainable Development Goal 11

Once we obtained higher level categories through thematic analysis, we assessed their alignment with the SDG11's targets, which are the grounding axes of our research. To quantify such alignment, we assigned values between 0 and 1 to each category, with a higher value indicating a stronger alignment with the target.

The values assigned to each category, within the range of 0 to 1, were determined through a collaborative and systematic process known as joint judgment, carried out by the research team consisting of four researchers. This approach aimed to ensure consistency, minimize individual biases, and accurately reflect the relevance of each category in relation to the specific SDG 11 targets. An outline of the steps for the joint judgment process follows:

1. Definition of criteria: Before assigning values, the team established clear criteria to evaluate each category, including:
    a. Direct impact: how directly does the category contribute to the SDG target?
    b. Cross-cutting relevance: how is the category connected to other dimensions of sustainable urban design?
    c. Frequency of mentions: how often was the category mentioned during the interviews?
2. Individual discussion and evaluation: Each researcher independently analyzed the data obtained from interviews, keyword analysis, and case studies. Based on their expertise and understanding of the data, they assigned preliminary values to the categories, following the defined criteria;
3. Joint sessions: during collaborative meetings, the preliminary values were shared and discussed. In these sessions, the following took place:
    a. Cases of significant discrepancies between individual scores were reviewed;
    b. Each researcher justified their assigned values based on the data and established criteria;
    c. Quantitative data (frequency of mentions) and qualitative interpretations were analyzed to refine the scores;

d. Ultimately, a consensus was reached on the final values, ensuring they represented a well-founded collective perspective;

4. Validation: The assigned values were cross-checked against the results of mention analysis and thematic alignment to ensure consistency across different data sources. This step validated the values as representative of the relative impact of each category on the SDG 11 targets

The results are presented below for each of the SDG11′s targets.

Target 11.3—Inclusive and Sustainable Urbanization

For this target, the focus was on categories that promote inclusion and adaptability in urban design, such as the following:

- Pedestrianization: high value (0.7) for its direct impact on reducing traffic and promoting inclusive spaces;
- Universal accessibility: high value (0.68) as it enhances social inclusion, particularly for older people and individuals with disabilities;
- Modularity and flexibility: high value (0.7) because it allows adjustments in urban design to suit different uses and needs;
- Multifunctionality: medium value (0.5), as it supports the adaptability of public spaces for various functions and user groups. Multifunctionality supports the adaptability of public spaces to accommodate various uses and needs, offering long-term benefits for urban resilience. As such, it can also support adaptation to emergency contexts (see Section 3.6). However, in such contexts, where speed and logistics are critical, its practical priority is lower compared to 'Sustainable Logistics'.

Target 11.5—Reduction in Adverse Effects of Natural Disasters

This target focuses on resilience and durability in design to withstand natural disasters, considering factors such as the following:

- Durability: high value (0.67) due to the importance of using durable materials in extreme environments.
- Applied Technology: High value (0.8), as technologies such as sensors can monitor the environment to prevent damage;
- Livability/social sustainability: medium value (0.57), considering the use of recycled materials and upcycling strategies to minimize environmental impact;
- Sustainable logistics: high value (0.98), sustainable logistics has a direct impact on the capacity of a city to react to emergency and natural disasters, for instance, by ensuring the rapid and efficient distribution of essential resources during emergencies or disasters, having a direct and tangible impact on this goal. Its high score indicates that, within the context of sustainable urban design, this category should be prioritized in practical recommendations (see Section 3.6);

Target 11.7—Access to Safe Green and Public Spaces

For this target, categories related to creating and ensuring safe access to green and recreational spaces received higher weighting:

- Green spaces: maximum value (0.84), as it directly supports the creation of green areas and improves access to safe spaces;
- Urban safety: high value (0.65) due to the importance of perceived safety in public spaces;
- Multimodal coexistence: moderate value (0.47); relevant in shared spaces where various modes of transport converge;
- Cultural identity: high value (0.66); the presence of cultural elements helps create an environment in which citizens feel safe and proud of their heritage, which justifies a moderate weighting of 0.66.

For each category and target, the above-described alignment values were correlated with the number of mentions of each category during the interviews (see Figure 6) using the following formula:

$$\text{Integrated weight} = (\text{Total Mentions} \times \text{Alignment Value})/\text{Maximum Alignment Value})$$

where 'Total Mentions' reflects the number of times a category was mentioned across the four interviews and 'Alignment Value' depends on the relevance of the category against the SDG11′s target, as described above. Figure 7 presents a heatmap of the results where the most relevant categories emerged from the interviews are correlated to the most relevant associated SDG11. While 'Pedestrianization (e.g., the transition towards a city for pedestrians rather than for cars) is most relevant for Target 11.7, the implementation of technological solutions in the city ('Applied Technology') is most relevant for Target 11.5 together with the definition of a sustainable model for logistics ('Sustainable Logistics'). Target 11.3, although with lower values, is most consistent with the design of green spaces.

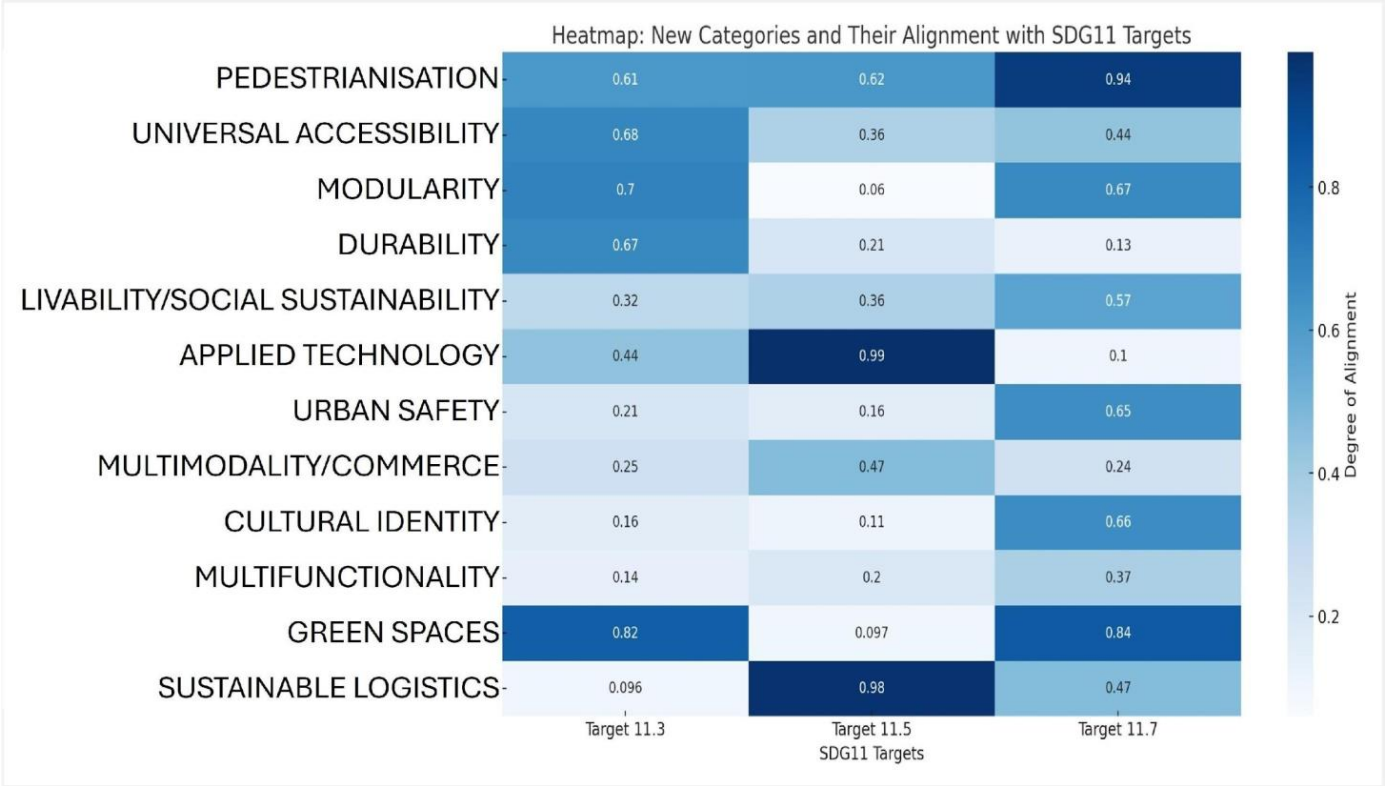

Figure 7. Heatmap of the correlation between SDG11's targets and the categories emerged from the interviews analysis.

3.5. Case Study: The Pugh Chart

As a third step of the study, the categories emerged from the interviews were used to analyze, through the Pugh Chart method (see Section 2—Materials and Methods), six cases of urban interventions at the street level in the Basque Country. By adhering to the best practices in design evaluation [35] we want to 1. to validate the emerging themes and concepts from the keyword and interviews analysis as the basis to define a framework for sustainable and egalitarian urban design at the street-level and 2. to inform the definition of a consistent and replicable set of design tools for the urban furniture of the future.

First, we conducted a qualitative review of our reference case, i.e., the regeneration of the Bilbao riverbanks (see Section 2). As described earlier, the reference project dates to 2003, thus providing two decades of post-occupational data [47] that were used as a

substantial referential assessment to build the Pugh Chart. In Table 2, we can see how the 12 categories previously defined are used to build a matrix where values from −1 to +1 are assigned to describe how each case responds to each category in comparison with the reference case. Following the Pugh Chart method, when a case is considered to perform better than the reference case for a specific category (e.g., accessibility, durability, modularity, and so on, see Table 2) a value of +1 is assigned. When the performance is worse or lower, a value of −1 is assigned. When the value is considered equal or similar to that of the reference project, a value of 0 is assigned. The numerical data produced from the matrix will provide an analysis of the improvements, developments, or potential shortcomings of the case studies. More importantly, the Pugh Chart is a highly practical method that will allow the research team to define a design-oriented checklist where guidelines are provided on what design characteristics were effective and which ones require improvement. The assessment for each case, including the reference case, is performed by the design team, i.e., it is a subjective, yet collective (almost autoethnographic) assessment based on the team's knowledge. In product and industrial design, the Pugh Chart is a common method used to validate a new design as it compares to existing commercial products or to compare new products with an existing reference design in order to evaluate design options. Once the reference model is broken down into key parameters, the values are applied, graded, and collected for a reflective assessment by the team. Results from the case study comparisons are then used by the team to identify gaps or areas of improvement for future street-level interaction design, which will be central to the second phase of this project.

In an initial examination of the comparative Pugh Chart (see Table 3), what stands out are the categories rated at 0 and −1. Among the 12 categories, it is notable that, overall, the reference case (which, recall, dates back to 2003) still scores higher in terms of 'Modularity' and 'Cultural Identity', due to a project design that incorporates modular urban furniture and textual elements directly linking the site to its historical context and the broader city area. Although the selected cases generally reflect a thoughtful response to the urban context where they are implemented, especially in those cases that deal with the regeneration of existing areas, the emphasis is on 'Modularity' (which aims at integrating with the environment) and on 'Cultural identity' (which aims at integrating with the social environment) which, as mentioned in the Introduction play a crucial role in creating sustainable and egalitarian cities, does not seem to have advanced significantly in the past two decades. On the other hand, 'Livability/Social Sustainability', 'Multifunctionality', and 'Green Spaces' are ranked very similarly to the reference project, thus showing that there has been limited improvement in the attention to these aspects. However, as the keyword analysis and results from the interviews show, sustainability as a generic term is now an umbrella term that requires a comprehensive approach [48,49]. Such an approach ranges from a more efficient management of the city's logistics [50], preparation for a future pandemic, selection of durable or recyclable material, and climate resilience (e.g., climate shelters, heat mitigation strategies, water cycle awareness, see Coaffee [51]). Categories such as 'Applied Technology' and 'Sustainable Logistics', and 'Multimodality/Commerce', on the contrary, show great improvement since the implementation of the reference case, which makes sense in line with the natural development of mobility and technology in the last few years. Both concepts are interconnected. As for applied technology, as Graham and Marvin state [52], telecommunications are not merely supplementary to physical transport systems; rather, they fundamentally transform how people interact, work, and engage with their urban environments. In this sense, an improvement of this aspect will most likely impact other categories such as the 'Cultural Identity', 'Pedestrianization', or 'Multifunctionality' of the city space and the broader city-citizen interactions. Regarding the second parameter ('Sustainable Logistics'), the city has always been shaped by production and distribution flows. Today, however, the existence of global networks and the rise in e-commerce increased their impact on the design of the city. As the results from the interviews show (see point 4. In Section 4), this will require new protocols for space design that take into account an increased fluidity in the transit of goods around the city. Regarding the

parameters 'Pedestrianization' and 'Universal Accessibility', which are very much related, we do not observe a major shift in pedestrianization, as it is becoming a steady trend in the center of cities, while we can see that the latter, universal accessibility, improved in every project, showing a growing concern and implementation. The 'Durability' and 'Accessibility' components also improve in most of the comparative study cases, showing probably an increased attention to the quality of materials and the well-being of society through urban safety inclusion.

Table 3. Pugh Chart. Values are assigned as follows: 0 = the project is on par with the reference case study. +1: the project performs better than the reference case study for that category −1: the project performs worse than the reference case study for that category.

Factor	Gran Vía	Plaza Pío Baroja	Calle Mayor	La Concha y Boulevard	Calle Gasteiz	Supermanzanas
Pedestrianization	+1	−1	0	+1	0	+1
Applied Technology	+1	0	+1	+1	+1	+1
Universal Accessibility	+1	+1	+1	+1	+1	+1
Multifunctionality	−1	+1	0	0	0	+1
Durability	+1	0	+1	+1	+1	+1
Green Spaces	+1	−1	0	0	0	+1
Livability/ Social Sustainability	+1	0	0	0	0	+1
Sustainable Logistics	+1	0	+1	+1	+1	+1
Modularity	−1	0	0	−1	−1	0
Urban Safety	+1	0	+1	+1	+1	+1
Cultural Identity	−1	−1	−1	−1	−1	−1
Multimodality/ Commerce	+1	0	0	+1	+1	+1

It is interesting, on the other hand, to compare the vertical columns of the table, in addition to the individual components themselves. It can be observed that some cases yield significantly more successful evaluations than others; this is the case for the Superblocks and especially Gran Vía, whose ratings are consistently +1 except in the categories of modularity and multifunctionality. Interestingly, these are the cases with greater centrality within the urban fabric, providing insight into what has worked as a cohesive package of factors. Conversely, Plaza Pío Baroja shows poorer results compared to the others, which also seems to indicate that situations on the edge of the urban fabric, or possibly with less investment due to a lack of centrality, may be influencing the outcome.

Figure 8 shows how each case study performs against the reference case for each of the analyzed categories. Values are assigned from −1 to 1 according to the Pugh Chart (see Table 3).

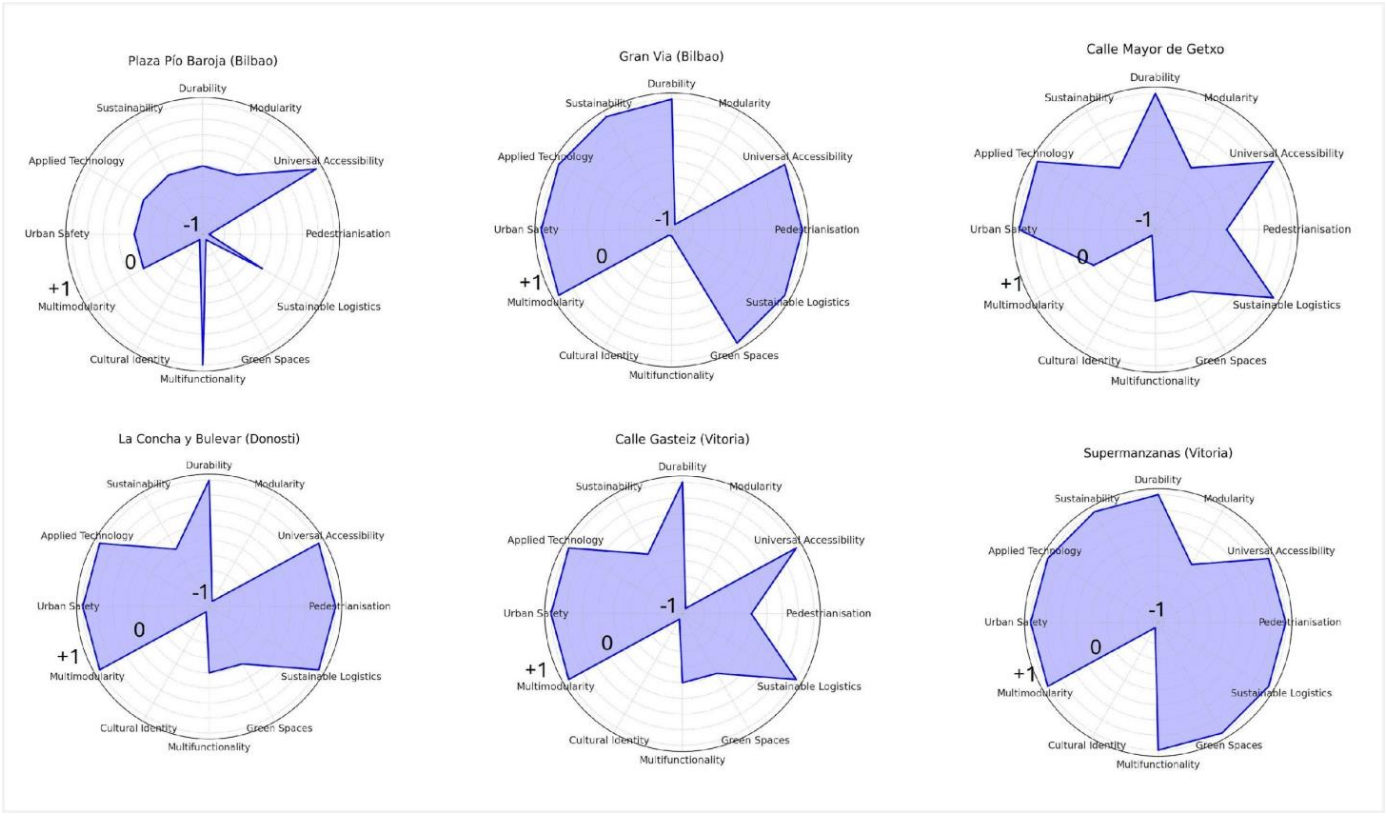

Figure 8. Histograms of the case studies and their performance performs against the reference case for each of the analyzed categories. Values are assigned from −1 (lowest performance) to 1 (higher performance). Zero represents a similar performance to the reference case.

3.6. Integrated Analysis: The Design Checklist

Building on the results of the three qualitative analysis a design checklist is defined that integrates the emerging categories towards the definition of the key blocks of a future design framework for sustainable and egalitarian urban furniture design. This checklist should be applied inside, taking into account a renovated balance between the natural and the artificial within a more dynamic urban ecosystem, as it emerges from the discussion of the results of this study.

The design checklist will serve as a tool for the next step of the research project, i.e., the design of novel urban furniture. Additionally, as it emerged from correlating the results from keyword analysis, interviews with experts, and case studies analysis, we believe it can be successfully adapted to other contexts of urban design and, thus, can serve as a replicable, scalable design tool. This checklist identifies twelve key parameters that have to be taken into account for the design of street-level interactions in the future sustainable and egalitarian city:

- Pedestrianization: clear efforts to reduce vehicular traffic and prioritize pedestrians, removing car traffic and implementing lighter mobility when possible;
- Applied technology (sensing, 3D printing): the implementation of intelligent management systems for monitoring space usage, traffic, or waste management presents a great opportunity for improvement and should also be integrated into the design by fostering a multidisciplinary approach technology, and should also serve as a tool to help people interact and participate with their cities;
- Universal accessibility: Universal accessibility is crucial and should be designed by including all perspectives (including temporary disabilities and other-than-human considerations) into the design process;

- Multifunctionality: The design of spaces to serve multiple functions, such as recreational areas, cultural events, and commercial activities, has been well considered, attracting, nowadays, multicultural vibrant activities. While this parameter aligns mainly with SDG 11.3 (see Section 3.4), from a design perspective it is worth considering its impact—however indirect—on the adaptability of the urban space in facing emergency situations (such as extreme climatic events). A multifunctional approach could facilitate, for instance, the transformation and adaptation of the public space to accommodate temporary shelters or supply distribution areas in emergency situations. The long-term planning of a multifunctional city could incorporate modular and multifunctional urban furniture to maximize space efficiency;
- Durability: In an increasingly uncertain climate, urban furniture should be designed to use durable materials, resistant to weather conditions and vandalism;
- Green spaces (eco-systemic, circular, post-anthropocentric): Green areas should be integrated into the design to improve air quality and provide resting areas for residents and visitors, while providing shelters in, for instance, heatwaves due to increased climate uncertainty. The water cycle and the concern for a more circular approach to the treatment of this aspect, including solving permeability of surfaces, should be taken into consideration as a key component to street-level public space design;
- Livability/social sustainability: even though a component that emanates from a proper combination of other elements in this checklist, it is key to consider the livability aspect of a given urban space as a key parameter to ensure quality of life in a city, making it essential as part of a design checklist, as this study suggested, partly as a derivate concern from the COVID-19 pandemic crisis;
- Sustainable logistics: Logistics in the urban area is a challenge, particularly due to the rise in e-commerce and last-mile delivery. Careful planning is needed to manage loading and unloading zones effectively. Practical recommendations should focus on designing and adapting urban infrastructure to support sustainable and efficient logistics by prioritizing designated loading and unloading zones, decentralized urban logistics hubs, and the use of sustainable vehicles for last-mile distribution. Additionally, as shown in Section 3.4, Sustainable Logistics can play a crucial role during an emergency crisis within the city space;
- Modularity: Urban furniture design that allows for quick configuration changes to adapt to different uses or events should be considered, also to maximize inclusive usage and economic and logistic sustainability;
- Urban Safety: Perceived safety is key to an egalitarian approach to urban design and should be addressed through, for instance, the use of good lighting and the creation of open spaces that enhance visibility, and the management of mobility and transportation (e.g., for bike lanes);
- Cultural identity: attention has to be paid to the preservation of historical elements and the inclusion of local art, reinforcing the place's identity and fostering a sense of belonging among citizens, while promoting the integration of new cultures and languages;
- Multimodality/Commerce: The coexistence of pedestrians, cyclists, and personal mobility vehicles (PMVs) should be considered through the creation of bike lanes and pedestrian routes, and the prevention and management of potential conflicts (e.g., at crossing points between different modes of transport) must be a key success parameter of urban interventions. Taking into consideration a good balance of commercial or facilitating commercial possibilities spaces in the design of street-level design is also key for an appropriate balance of design.

The checklist serves as a self-reflection tool to guide teamwork during the conceptualization and design phase and to track changes throughout the iterative prototyping process. In the next phase of the project, this checklist will be integrated into the design framework for innovative urban furniture, aiming to support the sustainable and egalitarian city of the future. This approach is in line with other practice-based research (i.e., research through de-

sign, see [53]) strategies where experimental research grounded in real-world cases—some designed by the authors of the research—is used to iteratively nurture the definition of a general design framework that can be replicable beyond the specificities of the cases used to define it thanks to its iterative approach grounded in real-world implementations [54].

The fundamental contribution of this research lies in the advancement of a better-identified and updated framework for the development of design projects aimed at improving the implementation of urban elements and the transformation of public space, based on a validated methodology that allows us to confirm and shape the hypothesis presented in the initial proposal. This checklist can be a useful tool not only for design teams like the one conducting this research, but also for policymakers and stakeholders tasked with making critical decisions and allocating resources for public space design. Having a verified and replicable checklist is extremely valuable for both the formulation of regulatory guidelines and the drafting of terms of reference for public tenders, a common tool for awarding such projects.

4. Discussion

The findings of this study suggest that society stands on the verge of a paradigm shift in how it envisions urban spaces, highlighting the need to transform the way these spaces are designed. The research presented in this article primarily arises from the project team's effort to substantiate, through corroborated data and verified information, the evolving design requirements for components within urban spaces that closely and interactively engage with people. Although existing studies address the concept of the city of the future, significant research offering sufficient data to establish a comprehensive checklist for structuring foundational principles of urban component design—particularly at the scale of furniture and human interaction—remains scarce. While following such a checklist does not inherently guarantee good design, it enables a validated minimum standard, synthesizes social, scientific, and technical considerations, and provides a more reliable estimation of the potential benefits and drawbacks of specific design choices.

Starting from the overarching concept of sustainability and its inevitable and essential presence within the Sustainable Development Goals (SDGs) and their targets and specifically to SDG11, it is of crucial importance to consider how to 'zoom in' and integrate the growing social, economic, and environmental concerns for sustainability into the design of elements that are close, tangible, and within reach, and whether this can be systematically approached. The data derived from this study's tripartite methodological framework provides valuable insights for constructing a viable checklist applicable to the near future.

While sustainability as a general term emerges across all our analysis, a full set of specific needs come to the surface through the interviews and the case study analysis that call for a new framework in the way we design (or re-design) our city space. In this sense, sustainability becomes a blurred term that needs to be broken down into specific components in order to be truly actionable and accountable. In our study, sustainability seems to be evolving in two main directions. On the one hand, the case study analysis seems to show a progression towards a more flexible concept of urban space, a vision in which closed, finished designs give way to more modular, adaptive, and multifunctional proposals. On the other hand, the predominance of human-made objects is mutating into an understanding of the city as an ecosystem where the natural and the artificial, the human and non-human components (other species, Nature-based Solutions, climate adaptation) must coexist.

In summarizing the results obtained through the overlapping and complementary filtering of the three categories related to SDG11 targets, we observe an overarching trend towards a paradigm shift or a change in the reference city model, at least within our field of study: the spaces where interactions occur between the city as a functional physical system and the citizens. One way to interpret this is to view the three categories as forming a new system with rebalanced dynamics. If we consider citizen–city interaction as our specific area of study, which is enabled and enhanced in its reactive and interactive possibilities by

technology in a post-fossil-fuel, car-free city, we can conceptualize the other two categories (technology–mobility and sustainability and design) as two fully complementary sides, with the need for balance evident in both the interview results and the keyword analysis.

Upon comparing and mapping these data across recent cases within our study area, we could argue that while technological progress and its implementation are advancing in line with the normative evolution of social trends, there is an emerging urgency to balance these 'hard' or directly quantifiable aspects of technology and mobility with 'soft' or seemingly indeterminate elements, such as those related to natural and post-human solutions. We could also posit that we are approaching the end of a somehow static objectual era in which the components of streets could be identified and named around car traffic and a clearly organized society into a more dynamic, inapprehensible and cohesive world in which objects (i.e., urban furniture) and city elements blur conceptually and transcend categories of things in a more interspecies, post-human organic entity; an interwoven ecosystem of interacting actors with similar agency. In this direction, and from a holistic approach, taking into consideration the key aspects and overarching concerns that clearly showed up in our research, themes like water, climate change, and Nature-based Solutions should be part of the very design of 'urban furniture' (a term that might also be revisited) as much as technology or materials themselves. When it comes to our specific realm of action, city–citizen interaction at the street-level and the design of novel urban furniture, while it has become common to think of global sustainability in the general approach to urban design and planning, there is still a need to instantiate this broad concept into specific design guidelines and tools to guide the design effort. As a work-in-progress result of this study, we propose a design checklist as the first tool of a broader design framework for street-level interactions and sustainable and egalitarian urban furniture design which we will develop as part of the second phase of the research.

5. Conclusions

In this study, a mixed-method qualitative approach was employed to investigate emerging themes and categories for the design of street-level interactions for a more sustainable and egalitarian city. Specifically, the research was framed within a two-year research project funded by the Basque Country Government in Northern Spain. The goal of the research is the design of novel urban furniture for the Basque Country's urban space along with the definition of a new framework which includes replicable and scalable design tools for future street-level interaction design. With this purpose in mind, we defined a preliminary study to map current emerging themes and identify the needs and gaps in urban design with a focus on the street-level. First, a keyword analysis was conducted, followed by semi-structured interviews with selected experts. Following this, a case study analysis was carried out by applying the practice-focused Pugh Chart method.

The results show how, while urban furniture design and the design of the street itself tended to be mainly objectual, today social and functional needs (e.g., related to transportation and mobility, and technology) emerge as crucial to the redesign of city–citizen interactions. Consequently, novel urban components must respond to broader needs where sustainability is an umbrella concept that has to be broken down into specific design components. In this study, we identified 12 basic components to define the first element of a future comprehensive design framework.

5.1. Limitations

The research conducted in this study—notably, experts' interviews and case study analysis—are explicitly limited in their geographical scope. In fact, while there is a global need to clarify approaches to urban design, our current research project, of which this paper reports on the exploratory phase, focuses on a homogeneous climatic and socio-political region, the Basque Country. This region is also where the professional activity of the coauthors is based and hence where first-hand knowledge of the stakeholders and the analyzed cases was collected over several years of activity as architects and designers.

Geographic specificity is often essential in urban research, as climatic, cultural, and socio-political factors can significantly impact design output [55]. Additionally, our research project (see Section 1) aligns with Gaver's claim [56] that generalizability in design research should, after all, focus on how expert knowledge can be shared with and impact specific communities through examples and reflection, rather than standardizing results. With these limitations in mind, in an upcoming phase of the project, we expect to validate the design checklist—as the basis of a broader design framework—by engaging a diverse group of potential users in order to assess its applicability and scalability to other geographical and cultural contexts. As for the upcoming design phase of novel urban furniture, the expected locations of the prototyping and implementation phase will happen in the urban space of the Basque Country (as per the goals of the research project); hence, in this case, the geographical limitation is reasonable.

5.2. Future Developments

In the upcoming phase of this research, we will apply the findings of this preliminary qualitative study to inform the design and prototype of next-generation urban furniture towards a more sustainable and egalitarian approach to street-level interactions. In particular, the design team will adopt the design checklist which includes the categories emerged from the study. A broader design framework will be defined that provides guidelines for designers to systematically take into account the three emerging themes, i.e., technology and mobility, citizen–city interactions, and sustainability, when approaching street-level interaction in the urban context.

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