GAME CHANGER?
PLANNING FOR JUST AND SUSTAINABLE URBAN REGIONS

SciencesPo AESOP

Edited by
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Cover
Camilla Ariani

Typesetting and formatting
Yuma Ando, Sebastien Wony

ISBN: 9789464981827
Published by AESOP
Paris, 2024

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Design climate-adaptive urban green regeneration: Nbs strategies for future-proof streetscapes

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Abstract

In the last two decades, global cities are addressing climate challenges, by transforming their infrastructural spaces through Climate-adaptive Nature-based regeneration, also aiming to cope with local ecological, social and economic asymmetries. Inside a prevailing technical and performance-based approaches, to date design research around Climate-adaptive Nature-based regeneration of urban infrastructure is limited, failing to impact on current transformations and to be implemented beyond larger cities. Taking advantage from a 'research by design' methodology, the research aims to leverage design potential for climate-adaptive green regeneration of infrastructural spaces and mainstream this approach in current practices. With this purpose, an operational Framework is defined, giving both conceptual and operational insight for Climate-adaptive Nature-based Streetscapes that will be tested inside a Southern Europe urban context in the future.

1.Introduction[1]

In the last two decades, cities are addressing simultaneously climate change and its challenges, by transforming their infrastructural spaces through Nature-based regeneration, also aiming to cope with local asymmetries. Within these diverse actions and programs put in place, abandoned, underused or in use infrastructural spaces are transformed into new urban commons and experimental prototypes where cities are testing planning/design strategies and actions to be replicated and upscaled, enhancing spatial quality, liveability and wellbeing for all. Built around a specific idea of society and life standards, infrastructural spaces often reflect the values of society, giving or taking space and time off from social encounters and interaction, regardless of the impact on society at the different scales. Furthermore, on the smaller scale of public and collective spaces, the direct influence between the spatial configuration of these spaces on human activities, pointed out already by sociologists (Debord, 1957), anthropologists (Jacobs, 1961), and architects (Gehl, 2011) still constitutes a means to express a need for the upcoming transitions. In fact, the physical, social, infrastructural, and cultural complexity of grey infrastructures, from local streets to interregional highways, contributes to proactively transforming abandoned, underused or mono-functional pathways into livable and shared public spaces. In this way, by also including Nature-based solutions, they contribute to the urge for climate-adaptability.
By integrating Nature-based solutions, pedestrian-friendly and multi-modal mobility features, accessible public spaces and program through innovative and regenerative design processes into existing mono-functional infrastructural spaces, these spaces are turned into vibrant and multi-purpose streetscapes, providing economic, social and ecological benefits. The green regeneration of infrastructural spaces had been proven to be crucial to support and enact sustainable scenarios and foster environmental consciousness inside the urban environment. In essence, the integration of ecological principles into the social urban fabric underscores the interconnectedness of environmental sustainability and societal well-being, with streetscapes serving as tangible manifestations of this symbiotic relationship. The street, in its various shapes and configurations, (re) claims its central role in the urban morphology (Gregotti, 1989) and acts as a spatial collector of unregulated social practices, and as an urban attractor of time, space and mixité of uses (Andaloro, 2022). New urban natures and aesthetics had emerged, especially from the hermeneutical circle between EU and US, impacting both on our perception of what a climate-adaptive green streetscape is and the way we design it. From the New York City Greenstreet's program (1996) - today part of the City's Green Infrastructure (NY Environmental Protection, 2022)- green regeneration urban initiatives have evolved and multiplied, embracing new challenges, i.e., climate change. Boston, one of the pioneering cities in adaptation to climate change, from its report Climate Ready (2016) has continued its efforts to adapt that resulted also in the elaboration of the Urban Forest Plan (City of Boston, 2022). Los Angeles program for Urban Streets Forest (UFEC, 2021) addresses heat and pluvial flooding extremes from an equity perspective, selecting and re-designing infrastructural spaces that cross low-income, disadvantaged communities where disinvestments are chronic. At the same time, many European countries have developed adaptation plans and projects for cities to prepare to adapt to the worsening of climate changes through Nature-based solutions and Green Infrastructures and, at the same time, contribute to the decarbonisation of the built environment, coherently with the UN directives (United Nation, 2015b). Among the first ones, Danish National Adaptation Plan (NAP), developed after 2008 climate extremes (2008), the Dutch Delta Programme (2010), which informs and leads the national regeneration plan for all the different delta areas, and the Swedish National Adaptation Strategy (NAS) (2019), which also includes concern over the (negative) impacts of extreme weather events on public health, the economy, and the environment. (Sida, 2011). Moreover, and following the Paris Agreement (2015a), several municipalities across the continent have elaborated a Municipal Pact for Climate Action, developing strategic actions at a smaller scale to cope and/or adapt to climate changes. In addition, new geographies

[1] This paper is the result of a shared reflection of the authors, which have together contributed to the drafting version of the paper, under the supervision of Prof. I.Macaione. However, for the sole purpose of competition evaluations: the paragraphs '1. Introduction', '4. Methodology', and '5. Comparing case studies' are attributed to A.Raffa and B.Andaloro; the paragraph '2. Literature review and research questions', and '5.1 Central Alameda District: Central Avenue & 42nd Place, Los Angeles, CA', and '7. Conclusions' are attributed to A.Raffa; the paragraphs '3. Theoretical backgrouns', '5.2 Vief kwartier, a new neighboorhood in the change', '6. Discussion' are attributed to B.Andaloro.

for climate-adaptive nature-based regeneration of streetscapes are emerging. Melbourne, thanks to its Urban Forest Strategy (2012) and its operational plans at the neighborhood scale, had started redesigning its streets and public spaces increasing canopy to adapt and mitigate climate change (City of Melbourne, 2012). The Green Riyadh project (2019) is one of the most ambitious urban forestation plans developed in an arid city, which foresees 6,400 kms of streets and roads shaded by trees and the longest urban green corridor worldwide (Royal Commission for Riyadh City, 2024). Bogota, thanks to its Climate Action Plan (2021), is leading adaptation in the Global South through the implementation of Nature-based Solutions in the urban fabric and simultaneously addressing green inequalities (Bogota Climate Action Plan, 20xx). Nature-based solutions, thanks to pioneering cities pilot projects, are mainstreamed in big cities' streetscape worldwide by providing replicable and up-scalable examples. But a deeper understanding of this ongoing phenomena is lacking from a design perspective, both on a theoretical and operational level.

2.Literature review and research questions

In the last two decades green regeneration of infrastructural spaces had arouse interest also inside the design disciplines, questioning how nature-based design of streetscape can contribute to shape more sustainable scenarios (Im 2019; Rehan 2019). Johansson (2024) discuss the importance of implementing sustainable streetscape at the local scale through the design of Nature-based Solutions. Green regeneration of urban infrastructures via NbS implementation provides many benefits, i.e., economic, social and ecological while also improving space quality and supporting cities in climate change adaptation. The ubiquitous and multi-scalar nature of infrastructural systems provide opportunities, through green regeneration, to balance green open space unequal distribution, working on the quality of spaces where people spent more time daily; but also leverage issue and challenges, as underline by Raffa (2023) concerning climate-resilient nature-based regeneration of streetscapes at the neighborhood scale. In order to explore the present state of the art concerning the entanglements between green regeneration, climate adaptation and Nature-based solutions in terms of spatial quality and from a design perspective, a literature review has been conducted through Scopus and Google Scholar database and also through open-source international organization report and city's authorities plans and planning reports. Compared to other disciplinary fields, the contribution to the topic of design disciplines is quite reduced; among scientific contribution co-authored by multi-disciplinary research team, design disciplines are among the least recurrent. These resulted also in the low spatial quality of spatial visualizations that accompanied experimental works, which are more focused on the implementation of Nature-based solutions and the evaluation of their performance than their spatial implications. The majority of the selected papers develop design guidelines through analytical-comparative approach (Steenberg et. al., 2008; Klaasen 2007) among case studies or through experimental design (Nijhuis & Bobbink, 2012) in specific cities and/or streets typology; or combining both methods. Cabanek et al. (2022) elaborate a Biophilic Design Framework for streets' green regeneration via Nature-based Solutions and apply it to four prototypical streets sections between EU, US and Australia. Klemm et al. (2017) elaborate design guidelines for urban green infrastructure for climate adaptation, working at the city, park and neighborhood street level through a mixed method analysis that integrates micrometeorology and landscape architecture procedures. Furchtlener et al. (2022), inside a landscape design led multi-disciplinary research, provide qualitative-quantitative guidelines for turning Wien streets sustainable and integrating them into the city's green infrastructure, coping with climate change and ecological challenges. Tamminga et al. (2020), arguing that convivial green streets could be source for climate adaptation, extract from ten European case studies Nature-based solutions and devices at the interface between the streets and building. These were implemented in specific street sections, generalized according to the adopted typological criteria and translated into simple visualization to support future community engagement activities. Another consistent group regards experimental design studies, process and outputs, that beside being specific, have a general value. Lotfata et al. (2023), by research through design methodology (Cortesao & Lenzholzer, 2022), developed a conceptual study to test the feasibility of nature-based solutions into different street sections inside an informal neighborhood in Cairo. Moscatelli et al. (2023) through design-driven research explore the interconnection between neighborhood streetscape green regeneration, energy transition and climate change through Nature-based solutions design in arid climate. Hagen et al. (2021), inside an interdisciplinary project and

through a Living Lab approach, introduce processes and actions for the co-design of greener and climate-adaptive regeneration of streetscapes in a dense neighborhood in Wien. Through a collaborative process replicable design solutions were elaborated, and tactical urbanism action take place as a means for raise awareness among neighbors.

Parallelly to our main objective of the literature review other considerations arose that had informed the present research. (i) Geographical asymmetries. Beside specific urban contexts that are at the forefront in tackling contemporary challenges - which are recognizing the urban relevance of infrastructural spaces to reinforce urban green infrastructure and the city's adaptive capacity- US a Northern and Central Europe are leading in the design research and urban experiments for the regeneration of infrastructural spaces into vibrant and adaptive streetscapes through NbSs implementation. Design research and implementation is to date limited in Southern Europe and in Mediterranean urban areas. Studies that deal with these geographical, climatic and socio-cultural contexts are lacking, although its urban areas are already starting experiencing the strong effects of climate change extremes and stresses. (ii) Urban environments' size. Large urban areas are pioneering the implementation of climate-adaptive Nature-based regeneration, worldwide. Medium and small size cities and urban environments, due to structural gaps, seem to be aside from this global tendency of regenerating infrastructural spaces into climate-adaptive nature-based streetscapes, not taking advantage from its potentials. Both these asymmetries are evident inside Italy, between North and South part of the country and among major and medium/small urban areas.

From the literature review, a three-folded problem appears. First, the possibilities derived from infrastructural spaces' nature-based regeneration is quite underestimated in current design strategies and actions which address urban climate adaptation and green infrastructure. Beside the asymmetrical conditions between pioneering cities and medium and small urban settlements there is a spread lack of consciousness about infrastructural spaces' transformation and their ecological, social and economic opportunities. Secondly, the role of design research for infrastructural space climate-adaptive nature-based regeneration is poorly explored in the current practices, which are still functionalist and sectoral. The hypothesis this research support is that the transdisciplinary dimension of architecture and design-related disciplines could contribute to deal with the complexity the topic requires and provide effective solutions that could innovate current approaches and practices and, at the same time, improve space quality and urban spaces' livability. There is a lack of knowledge concerning design principles and procedures to operationalize regenerative potentials of infrastructural spaces's climate-adaptive nature-based regenerations.

Thirdly, concerning the design, although the research has limited impacts in innovating current practices, it can guide and influence the practice, in a learning loop of knowledge. Understanding proper design procedures and tools is essential to mainstream climate-adaptive nature-based regeneration of infrastructural spaces, especially inside those geographical contexts and urban environments where is mostly lacking. There is the need to bridge design research and real-life outputs, through experimental design study as a bridging point between design research and urban effective transformation. Design as a form of transformational knowledge employs also methods and tools that can contribute to raise awareness, understanding and make shared choices among stakeholders.

Inside this problematic framework, the following research questions emerged: (i) How to leverage, from a design perspective, green regeneration for infrastructural spaces, turning them into climate-adaptive nature-based streetscapes? (ii) Which design procedures and tools can be displayed to enact, at a neighborhood level, streetscapes' potential to support also middle and small cities adaptation while reinforcing their green infrastructure? (iii) How this could work inside a Mediterranean, and in particular, Southern Italian (urban) context?

3. Theoretical background

Aiming at exploring climate-adaptive and nature-based approaches for streetscapes through a design-oriented research, it is relevant to position the research with the key concepts it is built on. The large overlapping of meanings and (design) approaches related to concepts such as climate, nature-based solutions, streetscapes, and adaptation, often related to a particular appropriation by a specific knowledge field, can in fact easily cause misinterpretation of these phenomena, their potentialities and vulnerabilities.

While we know from the recent regulations that climate acts and programmes are required to the municipalities, in order to alleviate the central governmental burden and to ensure a targeted approach to local specificities (as for example the Mayor Act), it is useful to point out the meanings and the implications of 'adaptation', especially on the physical space.
The idea of 'adaptation' to climate change is strictly interconnected to the process of 'mitigation', which constitutes an alternative approach to the climate issues, especially for specific sectors of production and consumerism (Klein at al, 2007). Mitigation is, in fact, defined as "an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases" (IPCC, 2001, 990), developed in order to implement policies for the progressive reduction of greenhouse gas emissions, which should not exceed 2°, as agreed in the Paris Agreement (2015a). While mitigation acts mostly on the causes of climate change, adaptation influences and focuses on its effects, through the definition of preventive or reactive actions (Manigrasso, 2019). The IPPC defines adaptation as an "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPPC, 2001, 982). This difference helps understanding the impact of these phenomena, which are more a-spatial in the case of the mitigation acts, as they refer to broader systems, such as production, or energy consumptions. Furthermore, adaptation actions can be earlier applied and shaped to the territories, at their different scales, so as to answer specific (local) needs. Additionally, the definition includes that "various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation" (IPPC, 2001, 982). In this addition we can notice the predisposition to an uncertain and indefinite contest, as a new state of art in the near future. This clarification therefore plays a crucial role in understanding the role of the spatial design, which is confronted with an unpredictable and uncertain reality, in which the possibility of change (at different scales and relative to different elements), becomes a new invariant element of the contemporary. The core of adaptation to support different types of policies and (governmental, social, cultural, spatial) tools, has contributed to the large diffusion of the term among the different knowledge fields, which has resulted in several different interpretation. Despite this, we can recognise a common shift in the paradigm: instead of acting (or designing) against the climate, we need to acting (or designing) with the climate.
In this respect, despite a ten-year development, as from the 'Urban Adaptation in Europe' (2024), the most recent EEA report, it has been highlighted how adaptation must (still) span all sectors and governance levels, addressing current and future climate risks. Additionally, the report underscores the need for concrete targets to measure progress, as only a small fraction of indicators in local adaptation plans are presently linked to specific goals. However, in the broad context presented by the EEA report, it is pointed out the growing focus on the adoption of nature-based solutions (NbS), which feature prominently in 91% of local adaptation plans there considered.
The spread of the culture of Nature-based solutions among different knowledge and research fields has recently contributed to focus on greenery as a crucial element of the spatial project. Firstly defined in 2008 (World Bank), in the frame of a research on the management of natural systems by benefitting both nature and society, NbSs have also contributed to the definition of a different approach about Nature: not against it, but rather with it (European Commission, 2021b). Lately, the attention for Nature-based solutions has also risen from different field, engaging different aspects and leaving considerable space for ambiguities and uncertainties derived by the inter-disciplinarity of this issue (European commission et al., 2020). Some of the definitions include "actions ad- dress environmental, social and economic challenges simultaneously by maximizing the benefits provided by nature (…) inspired by, supported by, or copied from nature" as from the EU initial document (European Commission, 2015c); or "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits", as by International Union for Conservation of Nature (IUCN, 2020); finally as "concept of nature-based solutions embodies new ways to approach socio-ecological adaptation and resilience, with equal reliance upon social, environmental and economic domains" (European Commission, 2021a). The heterogenity of the fields here involved, as stated by IUCN (2020), contributes to claim a more structured way to identify NbS as, for example, through eight criteria, such as (a) address societal challenges, (b) landscape scale of intervention, (c) biodiversity gain, (d) economic viability, (e) governance capability, (f) equitably balance trade-offs, (g) adaptive management, and (h) mainstreamed within an appropriate jurisdictional context. The impact of these solutions on the built and natural environment is broad and

can also lead to a multi-functionality of NbS, or to their capacity to simultaneously address multiple societal challenges (Raymond et al., 2017; European Commission, 2021a; Sowińska-Świerkosz et al., 2021).
In addition to the multi-purpose aspect of involving NbS into a regeneration project, it is also crucial to consider the possible overlapping in the definition between NbSs and green (and blue) infrastructure (Albert, et al, 2019), as both terms refer to a not better specified infrastructure, which takes into account green elements as their main core. Nonetheless, as stated by IUCN (2020), the presence of blue-green elements as part of engineered solutions is a key criterion of Nature-based Solutions. The difference between Nature-based solutions and Green Infrastructure can lead to different interpretation. According to the definition provided by the European Commission (2013), which refers to Green (urban) Infrastructures as different kinds of natural and semi-natural assets that are strategically planned as a network of interlinked elements, they would enhance and synergize benefits provided by nature, in contrast to monofunctionally planned "grey" infrastructure (Hansen et al., 2014; Karsten, 2019). Finally, the Environmental and Energy Study Institute (EESI, 2019) attempts to define a difference among the terms by considering NbS as "solutions often result in environmental, economic, and social co-benefits" which "includes both green and natural infrastructure", and Green Infrastructures as "Projects that combine gray infrastructure with nature-based solutions to create hybrid systems that improve resilience to climate impacts, while also often resulting in environmental, economic, and social co-benefits".
The combination of Green Infrastructures and Nature-based solution contributes thus to exploring climate-adaptation in the physical space of collective (grey) infrastructures, investigating their (multi-purpose) potential in urban regeneration. In order to do so, the research focuses on the concept of streetscapes, meant as "the natural and built fabric of the street, defined as the design quality of the street and its visual effect" (Rehan, 2013), including horizontal and vertical surfaces which define its edges, as well as the facilities related. By considering the entire three-dimensionality of the streets, and by considering it not only as an infrastructural device, rather as a social, environmental, cultural, and also economic element of the built environment, it is possible to exploit its potential in boosting climate-adaptive nature-based design approaches for urban regeneration. The relationship between streets and public spaces and climate-adaptive approaches is also being explored in the last decade through the elaboration of (design) tool to help supporting a multi-disciplinary research or design approach. Among them, Raymond et al. (2017) shows that streets scale nature-based intervention addresses climate mitigation and adaptation to a much greater extent than building scale interventions. Moreover, Furchtlehner et al. (2022) questions how streets can be re-thought as green living spaces and provide recommendations for future-proof and sustainable streetscapes.
In conclusion, exploiting Nature-based solutions as learning devices for informing climate-adaptive and nature-based streetscapes, supports a design-based methodology able to deal with the urgent transitions of the physical space, thus also providing benefits on social, environmental and economic aspects.

4. Methodology

To deal with the uncertainty of the future, in the attempt to enrich design and research processes with new and unpredictive knowledge, requires defining a positioning between research and design. As for the field of Architecture (at its different scale, from building, to landscape, to urban studies), design constitutes both a means of exploration of theoretical questions, and of testing of practical matters. Moreover, while considering (re)new(ed) complex environmental challenges for the future, it is also important to support and focus on a reflexive approach with multiple feedback loops (Beck, 1994), as well as thriving for an answer which can no longer be certain (Rittel, 1973). Looking at the definition of research and design methodology through time, and looking at the categories defined by Frayling (1993), Hauberg (2011) and Schreurs (2005; Bruns, 2010), we have identified a three-phases methodology, divided into: (1) Research about (into) design, which examines models from which it derives its rules and procedures. This phase, as also intended by Findeli (2004) documents objects, phenomena and history of design, contributing to a scientific discipline studying design (Godin & Zahedi, 2014); (2) Research by or through design, a more explorative phase in which design (in its different forms and meanings) is shaped, in order to produce a new level of shared knowledge. For those who follows a RtD approach, this means to relate to material-based research, development works and

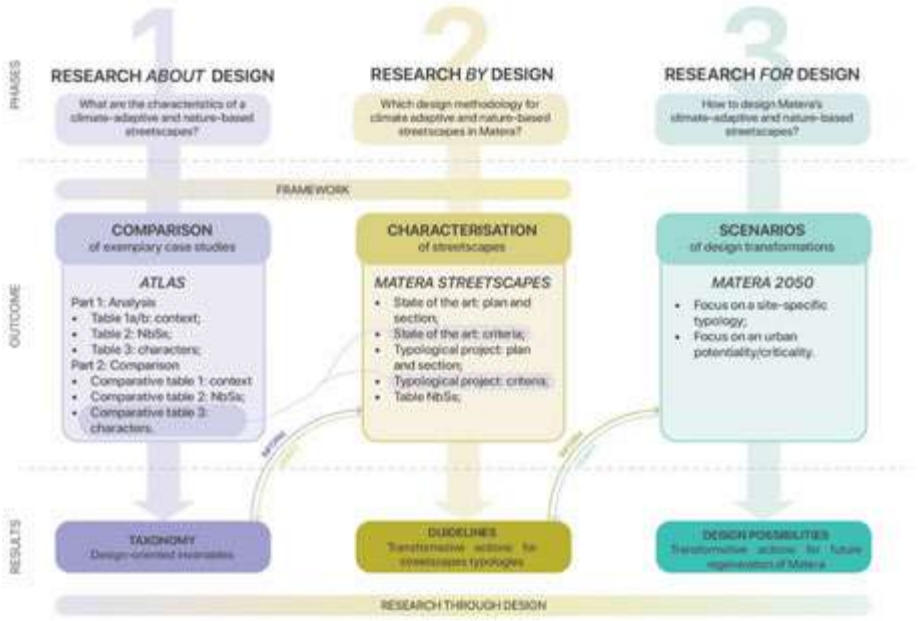
action research, through practical experiments in laboratories. These would result in reports (Hauberg, 2011), with the intended goal of societal change (Binder et al, 2006; Swann, 2002; Zimmerman et al., 2010). Also, RtD supports a (artifact) design process based on trial and error, to better tackle complex design problems (Toeters, et al., 2013). On the other side, in Research-by-design "concordance is sought between the methods of research and a form-giving, experimental design practice" (Hauberg, 2011): the approach produces knowledge through the design's tool and methods, in a direct relationship between analysing and proposing solutions. (3) Research for design, which explores a development phase, whose end product is an artefact, where the thinking is embodied in the artefact and the goal is not primarily communicable knowledge in the sense of verbal communication (Roggema, 2016)

Based on this structure, the research here discussed[2] is structured into these three phases, each one exploring a section of the research question, and informing and verifying the others in a continuous feedback loop. The first phase of 'Research about Design' aims at investigating the invariant characteristics of a climate-adaptive and nature-based streetscapes, aiming at desining a taxonomy of invariable design features.

The second phase of 'Research by Design' takes into account the lessons learned by the first phase, as to resonate on the possibility of defining a characterisation of streetscapes for the city of Matera, which will later be the application case of the research. In this phase, design and research will be highly interconnected to produce knowledge through the act of designing itself. As stated by De Jong (1992), this phase aims to generate desirable, perhaps unexpected, urban perspectives in place of probable, but less desirable, urban developments. By combination of the first and second phase, a Framework for Climate-adaptive Nature-based Regenerative Streetscapes is then defined, giving both conceptual and operational insight for designing for streescapes. Finally, the Guidelines will then inform and be verified by resulting from the final third phase of 'Research for Design', which will explore urban transformation scenarios for the future of Matera through a design-driven approach.

In the following paragraph, the paper will discuss in more details the first phase of the methodology, through ongoing insights of the research, focusing on its role in contributing to the definition of the design Framework.

[2] The paper refers also to the researches conducted in the frames of (1) Urban Green Shape (2021-2023) "Axis IV-Education and Research for recovery – REACT-EU", Action IV.6 "Actions for research contracts on innovation and green topics", funded by PON R&I and FSE REACT EU, carried out by Alessandro Raffa, Scientific Resp.Prof. Ina Macaione (NatureCityLAB_DiCEM, Unibas) and (2) project Tech4You Technologies for climate change adaptation and quality of life improvement, 4.3.1 Azione 1, Fellow Researcher grant "Mitigation and Adaptation to Climate Change in Urban Areas: Green and Blue Infrastructures for the Resilient City", carried out by Bianca Andaloro, Scientific Resp. Prof. Ina Macaione (NatureCityLAB_DiCEM, Unibas).



4.1 Research about design, and the structure of the Framework

Within the first phase of 'Research about Design' we explore the complexity of the concepts which have defined the research question, investigating how practitioners, architecture firm and municipalities have tackled climate-adaptive nature-based design. Specifically, we explore how they have embedded NbSs into their projects though an Atlas of exemplary case studies, which showcases transformation processes. Although still in the making, the Atlas counts about sixty projects, designed and/or built in the last twenty years between Europe and United States[3] which contribute to the elaboration of the Framework for Climate-adaptive Nature-based Regenerative Streetscapes. The Framework, which explores both conceptual and operational approaches, aims to understand how to de-structure and de-compose nature-based, climate-adaptive projects, in order to extract and define applicable design principles and procedures. Its design-oriented nature contributes then to support a multi-scalar research process which could later be applied both for deductive and inductive approaches.
The Framework supports then a critical reflection on similar climate-adaptive and Nature-based regenerative projects: it is devised as a comprehensive design tool for architectural designers keen on exploring the spatial potentials offered by Nature-based Solutions (NbSs), and it aims to furnish multidisciplinary insights into the broad implications of these relatively recent solutions, evaluating the emergence of new typological and morphological categories in architectural composition. Therefore, the Framework integrates both qualitative and quantitative information and data to describe and analyse the projects chosen upon selection (Macaione, 2024). For the variety of information gathered and elaborated, the Framework can also relate to different stages of project development, involving realized, unrealized, and ongoing projects, thus providing nuanced but relevant interpretations. Moreover, it facilitates the examination of projects at different scales, from urban to building, encompassing public spaces and infrastructural elements.

[3] The projects considered by the research are mainly designed, developed and/or built from the years 2000, so as to show a declared interest towards the climatic issues. They all relate to the transformation of grey infrastructures at the different scales, analysing a multitude of typologies and the related transformation scenarios suggested by architecture and landscape recognized studios.

In addition to an initial section, related to the selection criteria of the projects involved, the Framework can be divided into two sections: Section1 is about the analyse of the selected case studies; section 2 is about the comparison of the analysed case studies.
Therefore, the first section ('Analyse') relates to the first level of understanding and de-composition of the cases and is divided into[4]:

- Part 1 delves into the contextual analysis of the projects, focusing on climatic, social, economic, and infrastructural aspects.
- Part 2 scrutinizes the specific climate-adaptive strategies and Nature-based solutions implemented in the projects, assessing their role in the design process and their impact on the site's social, environmental, and economic dimensions.
- Part 3 elucidates the intrinsic characteristics of each project, considering aspects such as time, space, and scale.

This initial phase of analysis leads then to the second section, 'Comparison', in which the projects are progressively put in relation with each others. In order to do so, a three-part comparison is developed:

- Part (a) compares contextual information about the projects, in order to point out initial insight about the relationship between geographical and climatic placement, as shown in Table 1 and 2;
- Part (b) shows the frequency and the details of the Nature-based solutions recognizable in the project involved. This would contribute to understand, in relation with the previous comparison, which solutions are …
- Part (c) aims to deeply explore the implication of the design invariants both in the process and in the projects, as to understand the common elements that fuel climate-adaptive and nature-based projects for streetscape.

5. Comparing case studies

The Catalogue of projects which feeds and inform the Framework includes projects related to different scales and in specific geographies, which explore the theme of urban regeneration through climate-adaptive and nature-based solutions. By collecting and analysing these exemplary case studies, we aims identifying design principles and procedures that facilitate the integration of climate resilience considerations into streetscapes' regenerative processes through Nature-based Solutions (NbSs). While the following paragraphs will contribute with more detailed information about two cases chosen from two different geographical areas, and the related analysis, the Tables 1 and 2 provide a first insight on the comparison of forty projects. Chosen between the US and Northern Europe, these projects highlight their potential in dealing with climate hazards, mainly with heath stress and flooding[5] in different types of grey infrastructures[6], regardless of the climatic types[7], or morphology[8].
The majority of these projects are also related to the development of research and development (R&D) processes conduced together with professionals, municipalities, community-based organisations, research centers and universities, which have often lead to the publication of operational documents, design-oriented guidelines and report, aiming to inform a wide public, including also planners and designers. The general approach of these documents is more technical and performance-oriented and, in the majority of cases, are less focused of streetscape spatial implications. Against this backdrop, two experiences, by using logics and tools proper of the 'designerly way of knowing' can contribute also to inform possible design modes of inquiry and procedures for enacting climate-adaptive and nature-based streetscapes. The case studies which will be deepen in the following paragraphs are framed inside these

[4] Regarding the two case studies discussed in this paper, the related tables of Section 1 'Analyse' can be found among the Annexes.
[5] As from the tables, six cases are related to only one climatic hazard, twenty cases to two climatic hazards, eleven to three climatic hazards, and three to four climatic hazards.
[6] As from the tables, fifteen cases refer to the Linear type, six cases refer to the Network type, four cases refer to the Radial type, and fourteen cases refer to the Grid type.
[7] As from the tables, two cases refer to the type A (tropical), three cases refer to the type B (arid), thirty-one cases refer to the type C (temperate), four cases refer to the type D (continental), according to the Koppen classification.
[8] As from the tables, six cases refer to the Costal type of city, twelve cases refer to the Delta type of city, fifteen cases refer to the River type of city, zero cases refer to the Mountain type of city, seven cases refer to the Flatland type of city.

experimental design guidelines, which had been developed in collaboration with two globally-relevant design firms.
The first experience regards Los Angeles streets' network has been developed by an interdisciplinary consortium, the Urban Forest Equity Collective (UFEC), which has landscape firm STOSS Landscape Urbanism among its consultants. The efforts of UFEC resulted into *LA Urban Forest Equity Street Guidebook* (UFEC, 2021) and other documents which address specific LA neighborhoods. Streets are envisioned as space of possibility to tackle climate change and the structural asymmetric distribution of green spaces which affects especially the most vulnerable neighborhood. Recognizing that each street, neighborhood, and community in Los Angeles embodies a unique set of social, economic, environmental, ecological, and infrastructural dynamics, the guidebook built up a multilevel and multi temporal model able to provide a straightforward and adaptable framework for prioritizing interventions and devising a street-space reforestation strategy which encompass both the neighborhood and the city scale. Central Alameda is then a pilot-project which tries to implement site-specific, climate-adaptive NbS and actions into underused, degraded streets spaces. Through a community design process, STOSS Landscape Urbanism, together with a multidisciplinary consortium, tries to operationalize the Urban Forest Equity strategy the city of Los Angeles has been developing.

The second one is *New Space For Living. Design guideline for public space (Felixx, 2021),* by the landscape firm FELIXX for the City of Groningen (the Netherlands), where the urban infrastructural system is decomposed through a typological approach. Nature-based solutions are implemented also with a spatial quality purpose according streets's context-specific conditions and constrains and visualized through sections. Climate-adaptive nature-based regenerative efforts is evaluated according to a set of parameters (mobility, safety, accessibility, health, social, economy, experience, ecology, climate adaptation and identity), before and after the foreseen implementation (visualised through scenario-based sections) also through a design approach based on phases. In the last part of the guidelines envisioned streets solutions are recombined and tested inside three Groningen's neighborhoods to tackle urban complexity with a site-specific approach. Within this context, Vief kwartier, is a development plan designed in collaboration between the Municipality of Groningen and renown architectural and landscape firms. As part of a broader urban project over the Europark area, the architects aim to transform a wide semi-abandoned parking lot area into a new, sustainable and climate-adaptive neighborhood, which implements a multiplicity of NbS into its streets and public spaces.

Project	City	Type of city					Climate type					Type of G.I.				Climate hazard				Design Firm
		C	D	R	M	F	A	B	C	D	E	L	N	R	G	H	F	D	W	
The Underline	Miami	●					●					●				●	●	●	●	JCFO
Lafitte Greenway	New Orleans	●							●			●				●	●	●	●	Design Works hop
Town Branch Commons	Lexington, Kentucky			●					●			●				●	●		●	SCAPE
RiNO Streetscape Design	Denver, Colorado			●					●						●	●	●			SASA KI
P Street Corridor	Lincoln, Nebraska			●						●		●				●	●			Design Works hop
Brickline Greenway	St. Louis, Missouri			●					●					●		●	●			STOSS
Englewood +AgroEco District	Chicago, Illinois		●							●		●				●	●			Gensler
Green Alleyways	Los Angeles			●				●							●	●	●	●		SALT
El Punto	Salem, Massachusets	●							●						●	●	●			SCAPE
Argyle Shared Street	Chicago, Illinois		●							●		●				●	●			Site Design Group

Pompano Beach Bvld Streetscape	Pompano Beach, Florida	●					●					●				●	●	●	●	EDSA
Central Alameda District	Los Angeles,			●				●				●				●	●	●		STOSS
Paramount Blvd Streetscape	Paramount City, California			●					●			●				●	●	●		Studio One Eleven
Gowanus Green	Brooklyn, New York			●					●						●	●	●			SCAPE
Culver Blvd Medians Park	Culver City, California					●			●			●				●	●	●		SWA
Milton Street Park	Los Angeles,			●				●				●				●	●	●		SWA
Hudson Square Streetscape	New York	●							●						●	●	●			MNLA
Binney/Galileo/Broadway Streetscape	Cambridge			●						●				●		●	●			Alta Planning +Design
West Florissant Avenue Great Street	St.Louis County, Missouri			●					●			●				●	●			SWT Deign
Niagara Medical Campus	Buffalo, New York					●			●			●				●	●			SCAPE

Table 1: Table 1 shows the comparison between the US case studies, as in Section 2 'Comparison', Part (a).

Project	City	Type of city					Climate type					Type of G.I.				Climate hazard				Design Firm
		C	D	R	M	F	A	B	C	D	E	L	N	R	G	H	F	D	W	
Centrumkwadraat	Enschede					●			●						●	●	●			De Urbanisten
Watersquare Benthemplein	Rotterdam		●						●				●			●	●	●		De Urbanisten
Hofbogenpark	Rotterdam		●						●			●				●		●		De Urbanisten
Zomerhofkwarter	Rotterdam		●						●				●			●	●			De Urbanisten
Tiel Watersquare	Rotterdam		●						●				●			●	●	●		De Urbanisten
Tidal Park Keilhave	Rotterdam		●						●						●	●	●			De Urbanisten
Karakter	Zoetermeer					●			●					●		●		●		De Urbanisten
Ringpark Het Schijn	Antwerp		●						●			●					●			De Urbanisten
Beatrixplein	Haarlem			●					●						●	●				De Urbanisten
Kettingplein	Gent					●			●				●				●			De Urbanisten
De Wapper	Rotterdam		●						●						●	●	●	●		De Urbanisten
Vief kwartier	Groningen					●			●						●		●	●		Felixx
Europaweg	Haarlem			●					●				●			●				Felixx
Barendrecht Vrouwenpolder	Barendrecht			●					●						●	●				Felixx
Cobercokwartier	Arnhem			●					●				●			●	●	●		DELVA
Groenklimatassen	Gent					●			●					●		●	●	●		DELVA
Buiksloterham	Amsterdam		●						●						●	●	●			DELVA

Holenkwartier Hoorn	Hoorn	•						•						•	•				DELVA
Ruimtelijk Raamwerk Buiksloterham	Amsterdam		•					•						•	•	•			DELVA
Schoonschip	Amsterdam		•					•						•	•	•			Space&Matter

Table 2: Table 1 shows the comparison between the North European case studies, as in Section 2 'Comparison', Part (a).

5.1 Central Alameda District: Central Avenue & 42nd Place, Los Angeles, CA

Over the past decades, the City of Los Angeles has undertaken a series of green urban regeneration initiatives that look at street spaces as opportunities to address the challenge of climate change, particularly urban heat, through an approach inspired by the concepts of equity and resilience. As part of the LA County 2045 Climate Action Plan (LA County, 2023), the City's Green New Deal. Sustainable City Plan (LA County, 2019) and the LA Countywide Sustainable Plan (LA County, 2019b) but also actions urged by local communities, the city has become a laboratory for green and climate adaptive urban regeneration of streetscapes. With the objectives of adapt to climate change, in particular heat stress, and simultaneously cope with the chronic asymmetries in green spaces distribution [9] which particularly affects the most vulnerable neighborhoods, the city has undertaken a process to explore design and planning opportunities coming from the interconnection between climate adaptation, equity and Nature-based regeneration and provide replicable and up-scalable solutions. With this objective was established the Urban Forest Equity Collective (UFEC), a consortium of designers and planners, forestry experts, researchers, Los Angeles City staff and community-based organization to create holistic, integrative and multifunctional strategies to support urban forest equity, adapt to climate change and improve space quality. Inside the LA Urban Forest Equity Street Guidebook (Shandas , 2022), streetscapes, and their multi-scalar ecological, social and economic entanglements with surrounding neighborhoods and communities, are envisioned as spaces of possibilities to pursue a more equitable, climate-adaptive and resilient urban environment through the implementation of NbS. This strategic document also tries to answer the question on how to operationalize urban forest and to assure an impactful and lasting implementation at a neighborhood scale. The UEFC worked on a framework that provided practical tools to prioritize and plan for the increased presence of green spaces and NbS in urban areas, and offer decision making support, community engagement strategies and visions for LA neighborhoods, demonstrating a powerful and achievable vision for a greener future. This framework adopts a three-tiers approach (Shandas, 2022): the green spaces and tree canopy implementation in the streetscape is described across three levels of intervention which have different intensity, i.e., low [10], medium, and high. Through these tiers, it becomes possible to assess the necessary investments, constraints, and opportunities to address historical inequalities in green spaces distribution. Recognizing that each street, neighborhood, and community in Los Angeles embodies a unique set of social, economic, environmental, ecological, and infrastructural dynamics, this multilevel model provides a straightforward and adaptable framework for devising a street-space reforestation strategy on a neighborhood and urban scale. In order to select pilot neighborhood and prioritize interventions a set of quantitative-qualitative parameters has been defined and organized in four steps which address both vulnerabilities and opportunities: (i) Step 1: Physical and economic needs (i.e. lack of tree canopy, high distribution of impervious surfaces, below average household income); (ii) Step 2: Environmental exposure (i.e. upper 50% for days projected over 90F, for PM2.5 and Diesel PM); (iii) Step 3: Socio-demographic conditions (i.e. poverty, level of education, population density, non-white and non-English speakers distribution, housing conditions, and areas previously redlined); (iv) Step 4: Feasibility and community readiness (i.e. partner activity, area utilization, presence of sites, community interest)

[9] Historical disparities in urban forest distribution that, in conjunction with present and future climate change patterns, can expose Los Angeles communities, in particular those that are already vulnerable, to increasing risks. Past race-based urban policies and planning, i.e. redlining, and structural disinvestments has resulted in urban forest unequal distribution across the city, affecting in particular low-income and black communities. Their impossibility to access to 'ecosystem services' provided by green spaces will exacerbate their vulnerabilities in the context of a changing climate, i.e. extreme urban heat, degraded air quality and heightened levels of flooding.
[10] In the case of level 1 (low complexity), community engagement and involvement of local associations in reforestation activities can be pursued.

(Shandas, 2022). After this investigation, Central Alameda (Gilliam et al., 2024) and Sylmar (Gibson et al., 2024) neighborhood had been selected and specific streetscapes pilot-projects had been identified in it. In the Central Alameda neighborhood, Central Avenue & 42nd Place and other streetscapes have been selected as test beds to apply the three-tier approach and implement NbS. STOSS Landscape Urbanism integrated community inputs throughout the design process (Gilliam et al., 2024). This collaborative approach involved multiple iterations of discussion, enabling the refinement of ideas and concepts. As a result, the design evolved through several rounds of feedback and led to the creation of diagrams and sections (Gilliam et al., 2024). This iterative process not only ensured that the final design resonated with the needs and aspirations of the community but also enriched the project with diverse perspectives, ultimately yielding a more comprehensive and inclusive outcome.

5.2 Vief kwartier, a new neighbourhood in the change

In the frame of a broad development project carried out in the last ten years by the Municipality of Groningen for the Europapark area (Gementee Groningen, 2024), the site 'Vief kwartier' is one of the nine plots destined to be redesigned and transformed. The area is relatively close to the city center of the capital of the Groningen region, and known for the FC Groningen's Euroborg football stadium. It is well connected to the national highway (N7, N37), and a few public transport stops can be found. Moreover, 'Vief kwartier' takes its name from the former Helpman Centrale gas power station and its five towering chimneys. Although it was demolished in 1998, the foundations of the gas power station are still in the area, willing to be involved in the future development plan. The project of the 'Vief kwartier', of which only the Masterplan has been released so far, presents the transformation of the whole area, now used as a parking lot. The project, promoted by the Dutch-based real estate companyABC Vastgoed and designed by a consortium comprising EFFEKT, vector-I, and Felixx landscape architects, embarks on the ambitious endeavor of developing a mixed-use, energy positive and climate-adaptive neighborhood. Moreover, it is based on the "New Space – Design Guideline Liveability of Public Space" developed in 2021 by the Dutch architectural firm Felixx and the Municipality of Groningen, for the transformation of public spaces, thus promoting five quality of life values, among which public space, sports and health, connection, and mobility, mixed-use and sustainability (Felixx et al., 2021). This research work, developed also in collaboration with the University of Amsterdam, points out several transformation scenarios for the different typologies of public spaces, and more specifically, of streets (Figure 4).
In order to build on the former foundations of the gas station (5.000-plus existing concrete piles and blockwork), the new 315 residential units will be entirely constructed using lightweight hybrid timber system, aiming for a energy positive design able to sequester carbon and integrate spatial devices able to harvest rainfalls and mitigate flooding. Four different plots are defined with different typologies and heights, creating a higher external edge and a progressive smaller terraced skyline toward the park. In the four block, the project envisions also courtyards for natural light and cross-ventilation (Table 4). The approved preliminary Masterplan introduces different nature-based solutions and nature-inclusive areas in the district, such as green avenues, and green shades (especially on the edge of the site), but also natural parks and playgrounds in the middle of the site, defining a core place for collective social activities for the surrounding communities. In addition, the project envisions smaller poket-parks where to engage in social activities.
The ongoing development of the Vief kwartier shows the Interest of the Municipality of Groningen to develop a system of spatial transformations which will take into strong consideration the natural components of the urban landscape, thus allowing green and blue infrastructure to settle. Furthermore, as foreseen in the "New Space – Design Guideline Liveability of Public Space", the transformation is envisioned to happen during different periods of time, allowing the neighborhood and the city to adapt to the changes.

6. Discussion

In the last part of the Analyse section[11] the two case studies are compared according to the main design principles: (i) Multi-scalarity, (ii) Multi-temporality, (iii) Multi-Functionality, (iv) Replicability and up-Scaling; (v) Multi-stakeholder collaboration [12]. These design principles had been previously deduced from the intersection between literature review's findings and from a wider comparison among the research's taxonomy of case studies . Both projects show how the integration of climate adaptation into urban green regeneration requires an holistic, integrative approach grounded on multi-disciplinary collaboration. Both projects address (i) Multi-scalarity (City, Neighborhood and Building) and, in particular, in Vief kwartier NbS are also embedded into the buildings. (ii) Multi-temporality is addressed differently in the two projects and in particular, in Central Alameda street project temporality shapes also an implementation logic. (iii) Multi-functionality is also strategic: in the US case study multi-functionality is explored on a street level while in the EU project through the integration between built and unbuilt space. (iv) Replicability and up-Scaling is addressed in both projects. Central Avenue & 42nd Place and its neighborhood is envisioned as a pilot project with an urban and metropolitan relevance. In the Dutch case, instead, Vief kwartier is a pilot project of a broader development project for the whole Europark area. (v) Multi-stakeholder collaboration is operationalized in both cases through a consortium that integrates public and private institutions, researchers, no-profit and community-based organizations and urban designers. Both projects show the synthetic dimension of the design process, through which bridging together different disciplines, objectives and aspirations, supporting adaptation and improving space quality, public health and resilience.
By combining the analyses of the design cases and of some recent design catalogues, and guidelines for the development of public, collective and open-air spaces in the urban fabric (World Bank, 2021; Felix et al., 2021), some design features are recurrent and support the contemporary search for flexibility in use, time and space. First, what seems the most relevant feature, is the necessity of a vision of transformation which guides the development of the project through all its phases, thus emphasizing the need for the project to focus on the quality of living space. Then, the aforementioned introduction of green matters among the architectural ones, for example, not only shows their recurrence, but claims for a deeper understanding of their role in spatial design. Furthermore, it is possible to notice that the developed process supporting the project has a strong component of multi-scalarity, providing solutions which work at the intersection of urban, neighbourhood and building scales. Finally, the regeneration of grey infrastructures into liveable, sustainable and climate-adaptive public streetscapes underlines the necessity and the possibilities envisioned by phase-based planning, ensuring the feasibility and economic viability of the project, allowing the ecosystems involved to integrate in a renewed balance.
As emerged by the analysis of case studies, the emphasis posed to the multi-functionality of NbS, in most cases, is today dominant and preventing form a space-based reflection that could improve spatial quality, together with economic, ecologic, and social benefits.

7. Conclusions

In a renewed approach on the relationship between Architecture, Nature and Climate Change, pioneering cities worldwide are experimenting on grey and mono-functional infrastructural spaces, turning them into climate-adaptative Nature-based streetscapes to date, this trend reveals also asymmetries in the geography and size of cities.
Through the climate-adaptive Nature-based regeneration of infrastructural systems, new ecologies and aesthetics are emerging, but their spatial implications are currently under-investigated. Despite the emerging role of infrastructural spaces green regeneration to tackle climate challenge the role of design, both as a mode of research and practice, is underestimated and poorly-explored in this specific field, both in literature and practice. In addition, a strong disconnection between design research and practice

[11] The corresponding Tables can be consulted as Annexes of this paper. Specifically, here we refer to Table 3..
[12] Multi-scalarity, or the capability to a project to integrate design approaches which intertwine different scales; Multi-temporality: or the capability of the project to adapt and change over time, in relation to different moments of days, season and years, or scenarios; Multi-functionality, or the capability of the project to support different activities and functions in the private, public and collective spaces; Replicability and up-scaling, or the capability of the project to be applied, scaled up or down in analogous (climatic) condition; Multi-stakeholder collaboration, or the peculiarity of the project to be developed by a multidisciplinary group of direct, indirect, public, and private actors which represent diverse needs (Macaione et al., 2024).

still exists. More research is needed to go beyond current sectoral, technical and performance-based approaches and to leverage the potential of urban and architectural design inside this emerging field. A design-based approach can help to address the streetscape's climate-adaptive nature-based regenerative design in a more complex, integrative, and holistic manner. In order to overcome present limitations, the research, through the elaboration of the Framework for Climate-adaptive Nature-based Regenerative Streetscapes, aims to leverage the spatial dimension for streetscape's transformation and pursues operative outcomes. Future advances inside the ongoing research will involve completing the Framework by identifying design procedures and operational guidelines. Operational principles and procedures previously deducted, will be tested inside a medium size city and its neighbourhoods in the Mediterranean region, according to the third phase of the research methodology,
Once completed, the Framework would support the realisation of a design-oriented guidebook, providing a design methodology capable of tackling urgent inter-disciplinary spatial issues through the many facets of design, providing operational tools for future-proof resilient streetscapes, also for cities that are to date not tacking advantage from this opportunity.

Aknowledgments
This work was supported by two ongoing research: (i) Urban Green Shape (2022-2025), funded by PON R&I and FSE-REACT-EU. PON "Research & Innovation" 2014-2020, Asse IV "Istruzione e ricerca per il recupero" – Azione IV.4 – "Dottorati e contratti di ricerca su tematiche dell'innovazione" e Azione IV.6 – "Contratti di ricerca su tematiche Green" and FSE-REACT-EU; Research Contract number 38-G-14879-1, CUP C49J2104334000, carried out by Alessandro Raffa, Scientific Res. Prof. Ina Macaione; the investigation has been also nurtured by the research carried by out by A. Raffa as Fulbright Visiting Scholar at University of Florida, College of Design, Construction and Planning and FIBER-Florida Institute for Built Environment Resilience (August-February 2024); (ii) Next Generation UE - PNRR Tech4You Project funds assigned to Basilicata University (PP4.3.1 - Green Shapes for the Urban Regeneration Processes, Environmental, Social, Cultural and Tourism Sustainability, Scientific referent: Professor Mariavaleria Mininni) - Technologies for climate change adaptation and quality of life improvement", field of intervention "1. New approaches and design paradigms to insertion and development of "green shapes" in the cities, to raise the architectural and urban quality, the environmental, social and cultural benefits", Code ECS00000009 – CUP C43C22000400006.

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Annexes

		Central Alameda District/ Central Avenue & 42nd Place	**Vief kwartier**
Design firm		STOSS, LA Urban Forest Equity Collective	Felixx, EFFEKT, vector-I
City		Los Angeles, US	Groningen, the Netherlands
Type of city		Flatland	Flatland
Year and status		2021-ongoing	2022-2023
Type of grey infrastructure		Linear/Grid	Urban grid
Extension of grey infrastructure		2.18 square miles	0,24 square miles
Shape of grey infrastructure		Linear/Grid	Grid
Climate type		BSh Semiarid Low Latitude	Cfb Temperate, no dry season, hot summer
Climate hazard	H	X	
	F	X	X
	D	X	X
	W		
Implementation phases		• LA Urban Forest Equity Collective was created; • Phase 1: • Los Angeles Urban Forest Equity (LAUFE) Streets Assessment Report (2021); • LAUFE Streets Guidebook (2021); • Phase 2: • LAUFE Design Guidebook (2024) • LAUFE Neighborhood Strategy (2024) • LAUFE Neighborhood Strategy Central Alameda (2024) • Urban Forest Equity Community Action Toolkit (2024)	• ABC Vastgoed (Dutch-based real estate company) acquired the site from the municipality of Groningen • ABC Vastgoed comprises a consortium of international designers: architects EFFEKT Architects, vector-i (local), Felixx landscape architects (landscape); • Approval of Felixx's "New Space - Design Guideline Liveability of Public Space, Groningen" (2021); • ABC Vastgoed and Municipality of Groningen sign a cooperation agreement for the development of Vief kwartier at the event Let's Gro(2023) • Feasibility studio approved

Table 3: Table 1A compares the U.S. and EU projects from a contextual point of view, giving a first insight on the typology of (grey) infrastructure which the project aims to transform, and the main climate issues of the related areas (elaborated by A.Raffa and B.Andaloro).

	Central Alameda District/ Central Avenue & 42nd Place	Vief kwarter
Vulnerabilities	Climate LA hardest-hit neighborhoods; Difficulties in managing flooding; Ecological Lack of tree canopy and green open spaces; Degraded green spaces; Lack of biodiversity and proliferation of invasive species; Low quality of natural resources, i.e. soil and water and noise pollution Infrastructure Mobility Car-centric mobility infrastructure; Lack of slow mobility; Lack of multimodality; Grey infrastructure Underutilized vehicular lane; Abundance of parking areas; Abundance of Impervious surfaces (more than 60%); Obsolescent water management gray infrastructure Utilities Overhead utilities limit sizes of existing trees Commons Lack of public space for social interactions; Lack of of public spaces, also green, for passive and active recreation; Lack of urban furnishing; Structural lack of investments on urban spaces, also as a result of 'redlining' Housing & Public Health Poverty; Low level of education; Cultural and linguistic divide; Cost burden renters and households; Household income lower than city average Lack of home internet and digital divide; Unhealthy habits of neighbors	Climate Difficulties in harvesting rainwater Difficulties in managing flooding Difficulties in saving energy Ecological The area destined for the new neighbourhood was a former industrial area In the proximity of the area there are small, disconnected green spaces; In the surrounding are there is the Helperpark; Lack of biodiversity ; The area is closed to a canal; The soil consists of a relatively poor quality of terrain with soft banks, grassland, shrubs and trees. Infrastructure Mobility Car-driven area; The area is in the proximity of a national highway (N7; N37); The area is served with train and bus stations; In the surroundings of the area there are a few disconnected bike lanes. Grey infrastructure The site is a parking lot; The area is paved with spontaneous grass and asphalt; The site is surrounded by a dense grid of driveways; Proximity of a medium-size connecting roadway; Commons The plot hosted the former plot of Helpman Centrale power station ('Vief piepen'), demolished n 1998; The site is currently used as parking spot for FC Groningen's Euroborg football stadium; The site contains the original power factory's foundations; The surrounding area has few services The surrounding area is manly residential; In the proximity is the FC Groningen Euroborg football stadium. Housing & Public Health Groningen's population is rapidly increasing; Groningen is suffering from a housing shortage;
Climate-related hazardous events	Flooding Climate change is heightening the likelihood of inland and coastal flooding through rising sea levels and increased occurrences of intense rainfall. Heat Rising average temperatures are leading to more frequent occurrences of dangerously hot days and heatwaves. Over the next three decades, Los Angeles is projected to endure 21 days with	Flooding 1) High emissions scenario: sea levels rises by up to 1.2 m by 2100, and possibly up to 2 m if the Antarctic ice sheet melts faster. 2) Lower emissions scenario: the rise could be between 26-73 cm by the end of the century. Temperature Increases Future projections suggest a further increase in temperature, ranging from 1.4 to 5°C higher by the end of

	temperatures exceeding 93ºF. Extreme heat stands as the primary climate hazard in the city, resulting in a considerable number of climate-related fatalities and hospitalizations. Additionally, the urban heat island effect is amplifying urban temperatures significantly. Extreme Weather Events The combined effects of climate change are amplifying the severity and frequency of extreme weather events, with drought, wildfires, and flooding emerging as particularly acute challenges. Projections suggest an intensification of these risks in the coming years	the century compared to the reference period (1995-2014). Extreme Weather Events The Netherlands is expected to experience more frequent and intense heatwaves, regardless of the emission scenario. By 2050, the number of tropical days (above 30°C) could increase significantly, with a possibility of temperatures reaching 40°C annually by the end of the century in a high emissions scenario. Additionally, the country is likely to face more extreme storms and an increased risk of drought, particularly in spring and summer.
Climate-related planning frameworks	LA Heat Action Plan (ongoing, expected 2024) LA County 2045 Climate Action Plan (2023); Green New Deal (2019); Complete Streets Design Guide for LA (2015) LA Countywide Sustainable Plan (2019); Stormwater Capture Master Plan (2015)	Europapark plan (2013; 2015; 2019, Gronigen Gementee); New Space - Design Guideline Liveability of Public Space, Groningen (Felixx, 2021);

Table 4: Table 1B analyses the two projects from a contextual, more specific point of view, pointing out the climatic, ecological, social, economic vulnerabilities from a spatial perspective, as well as climate related risks and the associated policy and planning framework (elaborated by A.Raffa and B.Andaloro).

Central Alameda District/ Central Avenue & 42nd Place				
Climate-adaptive spatial regeneration strategies	• Reinforce ecological connectivity; • Preserve existing vegetation and increase tree canopy; • Increase biodiversity, by introducing native species and make diverse habitat for other species; • Enhance quality for air and water; • Increase Multimodality and make space for safe, accessible and inclusive slow mobility (i.e. pedestrians and cyclist) across scale; • Stimulate local economies and investments in the surrounding areas; • Integrate bleu-green infrastructure for flood management with existing grey infrastructure;			
Nature-based Solutions			**Spatial actions**	**Spatial devices**
Typologies	**Benefits**	**Techniques**		
Open Green spaces	Climate: Reduce Heat Stress; Reduce Pluvial Flooding risk; Carbon Storage and sequestration; Ecological: Increase Biodiversity; Enhance soil and water quality; Social: Improve interaction; Improve physical, emotional and mental health; Provide opportunities for active recreation and tourism; provide educational opportunities;	Pocket Park	Distribute	Room
		Natural Playgrounds	Re-Connect	Room
Green Corridors	Climate: Reduce Heat Stress; Reduce Pluvial Flooding risk; Carbon Storage and sequestration; Ecological: Enhance ecological connectivity; increase Biodiversity; enhance soil, water and air quality; reduce noise pollution; Social: improve interaction; improve physical, emotional and mental health; provide opportunities for active recreation; Economic: Increase value; Create green jobs; Reduce healthcare costs; Reduce energy consumption;	Street Tree Canopy	Cover	Diaphragm
		Green Avenues	Connect	Threshold
		Urban Green Corridor	Connect	Pathway
Bioretention Areas	Climate: Reduce Pluvial Flooding risk; Carbon Storage and sequestration; Ecological: Enhance ecological connectivity; increase Biodiversity; enhance water quality; Social: improve interaction; improve physical, emotional and mental health; provide opportunities for active recreation; Economic: stimulate local economies and job creation;	Bioswale and Rain Garden	Gather	Threshold
		Permeable pavements	Clad	Surface

Table 5: Table 2 analyzes the Central Alameda District/Central Avenue &42nd Place project from a contextual point of view, giving a first insight on the typologyf (gray) infrastructure which the project aims to transform, and the main climate issues of the related areas (elaborated by A.Raffa).

Vief kwartier				
Climate-adaptive spatial regeneration strategies	• Promote five quality of life values: public space, sport and health, connection and mobility, mixed-use and sustainability; • Boost the importance of public open pedestrianised spaces to improve healthy lifestyles; • Increase availability of public spaces in different meteorological conditions for flood mitigation; • Renaturation of collective spaces; • Promote an innovative timber-hybrid mixed-use development; • Carbon-neutral and energy-positive scheme in existing and new construction; • Minimise carbon emissions; • (Rain)water management, through rainfall harvest;			
	Nature-based Solutions		**Spatial**	**Spatial**
Typologies	**Benefits obtained or expected**	**Technologies**	**actions**	**devices**
Building solutions	Climate: Delay in drainage of rainwater; Pluvial flood regulation; heath regulation; Ecological: Biodiversity increase (i.e.: sensory plants); Seasonal plants; Creation of new habitats for little animals; Noise reduction; Dust absorption; reduce air pollution. Social: Social engagement; social interaction; direct human contact with nature; Economic: Job opportunities for maintenance; (optional) savings for water consumption;	Extensive green roof Ground-based facade	Overlay Overlay	Surface Envelope
Open green spaces	Climate: Management of rainfall; Recycle of rainfall; Water storage; Heath stress reduction; air purifying; cooling effect; Ecological: Biodiversity increase and support; Seasonal plants/landscape; Creation of new habitats for little animals; Food production; removal of pollutants from air, water and soil; Social: Recreational use of garden; community engagement; social inclusion; human direct contact with nature; sensory skills improvement; physical activities encouraged Economic: Create training opportunities; Create Green jobs opportunities.	Climate-proof residential gardens Pocket parks Natural playgrounds	Connect Connect Connect	Filter Horizontal surface Room
Green corridors	Climate: Pluvial flood regulation; water pollution regulaton; heath stress reduction. Ecological: Encourage animal settlement; increase biodiversity in the area; Air quality improvement; carbon storage sequestration; UV ray reduction; Noise buffer. Social: Encourage social encounters and interaction; Shading; Enhancing street quality; Enhancing street identity. Economical: Create training opportunities; Create Green jobs opportunities.	Street tree canopy Green avenues	Connect Edge	Pathway Pathway

Table 6: Table 2 analyses the Vief kwartier project from a contextual point of view, giving a first insight on the typology of (grey) infrastructure which the project aims to transform, and the main climate issues of the related areas (elaborated by B. Andaloro).

	Central Alameda District/ Central Avenue & 42nd Place	Vief kwartier
Multi-scalarity	City • The project is part of a larger development project for equitable urban forest implementation both at a urban and neighborhoods scale; Neighborhood • The project regenerate streets spaces and has been developed at the neighborhood scale, engaging communities, local activities and residents; • Nature-based solutions are embedded into space, according to the local context characteristics; Buildings • the project do not work directly on surrounding buildings but it aims also to improve wellbeing for all, especially for the most vulnerable;	City • The project is part of a larger development project concerning the whole area of Europaparkhas both an infrastructural and proximity scale Neighbourhood • The project is developed at the neighbourhood scale, engaging communities, local activities and residents. • Open-air public spaces are designed as part of the neighbourhood and support community engagement. • Different nature-based and nature-inclusive solutions are embedded into the space, with different scales of deepening. Buildings • The area is divided into four blocks of buildings, the design of which has not been released yet (2024) • Nature-based and/or green solutions are embedded into buildings
Multi-temporality	• The development of the project is at a conceptual phase; • The project will be implemented through a three-tiers framework - according to the different intensity of forseen interventions - that has been defined by the Los Angeles Urban Forest Equity Streets Guidebook (2021);	• The development of the project is following administrative phases, and is now into the deepening of design phase • The project has a vibrant environment with retail, workplace, leisure and community facilities which create activity 18 hours a day, seven days a week in the neighbourhood • Proximity parks, poketparks and green areas are open during day and night
Multi-functionality	• Multi-functionality is promoted in the area, also introducing different type of mobility for pedestrian and bikers; • Nature-based solutions implementation will transform existing streetscape into a multi-functional and diverse space; • Streetscape are re-designed in order to multiplicate public space and activities, also in connection with existing facilities and amenities	• The neighbourhood aims to welcome a variety of uses for the open-air spaces; • Multi-functionality is promoted in the area, also introducing different type of mobility for pedestrian and bikers; • The neighbourhood will have mixed-uses in the buildings which will host residential unts (around 315), together with retail, workplace, leisure and community facilities • Green areas and corridors welcome interaction between species;
Replicability and up-scaling	• The project is one of the two pilot for the implementation of Los Angeles Urban Forest Equity Street Guidebook (2021) at a neighborhood scale and, once completed, to be tested and monitored • As a pilot project, it aims to be replicable and up-scalable, impacting on LA streetscape nature-based regeneration • Nature-based Devices and Solutions adopted address recurrent issues and can pe replicate in similar circumstances	• The project adopts “New Space - Design Guideline Liveability of Public Space, Groningen” (Felixx, 2021) for the (replicable) design of public open-air spaces; • Open-air spaces refer to specific typologies of nature-based devices which can be replicable in similar circumstances; • The built environment envisioned at this stage seems to be made of buildings with modular structure and nature-inclusive solutions integrated into them.
Multi-stakeholders collaboration	• The Urban Forest Equity Collective (UFEC) is a consortium of urban designers and greening experts, City of Los Angeles staff, community-based organizations, researchers, and consultants; • City of Los Angeles: LA Office for Forest Management; LA Bureau of Street Services & Sanitation and Environment; Department of Public works, Water and Power, Recreation & Parks; LA Center for Urban Natural resources Sustainability • University: LA Laskin Center for Innovation (UCLA); University of California Division of Agricolture and Natural Resources; University of Southern California Urban Tree Initiatives; • Organizations: Tree People, City Plants, North East Trees, South LA Tree Coalition; California Climate Action Corps; • Landscape architectural firm: STOSS Lanscape Urbanism • Consultancy for Climate Adaptation planning & analytics: CAPA Strategies	• Municipality of Groningen • The ABC team comprises a consortium of international designers that includes Copenhagen-based international practice, Groningen-based local architectural firm and Rotterdam-based Felixx landscape architects. The design team is supported by advisers and consultants, including integrated design for construction, for sustainability, Spark for mobility, Bouw 21 for realisation and Re:Invest for the co-working design. • Architectural firm(s): EFFEKT Architects, vector-I (local) • Landscape architectural firm(s): Felixx • Consultancy agency for construction: BREED ID • Consultancy agency for sustainability: Traject • Consultancy agency for mobility: Spark • Consultancy agency for building realisation: Bouw 21 • Consultancy agency for co-working design: Re:Invest

	• The project is grounded on community-informed design

Table 7: Table 3 explicates and compares the intrinsic design features of the two projects, specifically in relation to the notions of time, space, and scale (elaborated by A. Raffa and B. Andaloro).