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CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

E-ISSN 2450-8594

CEER 2022; 32 (4): 0123-0146
DOI: 10.2478/ceer-2022-0049
Original Research Article

URBAN NATURE AS AN ACTIVE MEANS OF ADAPTING PUBLIC SPACES TO CLIMATE CONDITIONS: CASE STUDIES FROM COPENHAGEN AND SELECTED POLISH CITIES

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Abstract

Progressive climate change brings many challenges to cities, which, in an effort to meet them, are looking for ways to create a built environment that is resilient and adapted to change. The subject of the paper is the urban nature, which, skillfully used and introduced into public space, becomes an active tool for adapting cities to future climate conditions. The aim of the paper is to identify key solutions to introduce urban nature into public spaces in the context of model strategic planning and urban design undertaken in cities. To this aim, development strategies, with a particular focus on urban nature, developed in Copenhagen over the past few years, were researched. Of those identified, the directions and actions that address public spaces and holistically link the needs of the built and natural environment with the needs of humans were selected. Research leads to a comparison of the model strategies and selected implementations used in Copenhagen, prioritizing the urban nature, with examples of strategic development policies and adaptation projects implemented in the public spaces of selected Polish cities. The result of the research is an assessment of the completeness of climate change adaptation measures undertaken in Poland, using the potential of urban nature in public spaces and recommendations for updating planning and strategic documents based on Copenhagen's model solutions.

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Keywords: climate adaptation, nature environment, urban resilience, strategic planning, adaptation activities

1. GENERAL RULES

Climate change intensifying as the years go by, is increasingly affecting the urban environment. According to the IPCC Fifth Assessment Report: Climate Change 2014 (AR5) [1], the cities can expect even more frequent and more extreme weather events in the coming years. One of the elements most vulnerable to transformation is public space [2]. The changes taking place under the influence of extreme weather conditions are reflected not only in the development of public spaces, but also affect the way they are used [3, 4]. Public space is most vulnerable to heat waves, intense precipitation, strong winds, and air pollution. The negative consequences of these changes are also conducive to the spread of diseases, which, combined with strong urbanization pressures, a steadily growing population, and epidemic threats, is the reason for searching new urban strategies and introducing or intensifying solutions that affect the microclimate, stabilize the thermal comfort of public spaces, and improve the quality of life in the city [5]. They are also based on strengthening the benefits of climate change, through appropriately selected adaptation activities that, consistent with the principles of sustainable development, can ensure balance and stability between the natural environment, the built environment, and the human beings functioning in them. Cities engaged in the process of preventing and adapting urban spaces to climate change and deepening resident awareness are looking for solutions to strengthen the resilience of public spaces that take into account economic, environmental, and social benefits [6,7,8]. The ambition of cities is to be ready to meet current and, future challenges and through strategic planning, adapt public spaces to climate change [9,10]. The search for ways to create attractive public spaces that are in harmony with urban nature and allow contact with each other is becoming a noticeable trend in the planning and design of contemporary urban areas [11,12,13].

Urban nature plays a key role in the adaptation of public spaces to climate change [14]. It has always been one of the city's most valuable resources. Depending on economic, political, communication and social factors, technical possibilities, as well as the characteristics of the land and the adopted spatial assumptions or aesthetic criteria, urban nature performed various functions: biological, didactic and educational, compositional and aesthetic, economic, leisure and recreational [15]. Today, skillfully used and introduced into public space, urban nature is becoming a tool for actively adaptation of cities to future climatic conditions and facilitating the achievement of better living conditions [16,17]. Taking into account modern challenges, as well as human needs, it

becomes necessary to introduce nature into the urban structure, to supplement its missing elements, and to protect the most valuable ones [18].

1.1. Urban nature

The urban nature links elements of the natural environment with the built environment. It is made up natural and transformed habitats with plants, animals, and fungi, inscribed in areas with different degrees of urbanization, scales, features, and surfaces [19]. Understood in this way, nature becomes an architectural element that co-creates architectural, urban, and landscape interiors. It fits into all categories of urban green areas, including: woodlands; parks and park-like facilities; areas used for agricultural purposes; allotments and home gardens; squares, greens and linear greenery of traffic routes; roadside trees and other individual trees, shrubs and small clumps of greenery; riparian vegetation of watercourses and reservoirs; wastelands, fallow land and other marginal communities [15]. Considering the cultural and social role of green areas, urban nature, which is part of them, surrounds or integrates with: green areas for passive recreation (walking and leisure parks, greens, squares, boulevards and promenades) and active recreation (sports parks, theme parks, forest parks, etc.); special purpose green areas (accessible - isolation trees, green areas of communication routes: streets, roads, railroads, etc., and limited accessibility - teaching gardens, parks and historic gardens, cemeteries allotment gardens, etc.); green areas accompanying residential developments, children's facilities (playgrounds, kindergartens, Jordan gardens), schools, higher education institutions (campuses), facilities (cultural-social, cultural, art, health, welfare, sports), office facilities, various types of infrastructure services (energy, communications, sewage, water supply or warehouses), shopping centers and complexes, factories and industrial facilities, etc.; agricultural and forestry areas (plant nurseries, production forests); tour and recreation areas (forests, suburban parks, scenic parks, reserves, Natura 2000 areas, etc.) [15]. One can consider urban nature from the point of view of its location in the spatial structure of the city or its interaction with urban functions. It shapes strictly urbanized areas (centers, downtowns) differently, where it is an element inscribed in urban spaces such as squares or streets. Otherwise, when it shapes places associated with recreational, cultural, and residential functions (parks, cemeteries). Still differently when it is part of urban areas where its disorderly character prevails (meadows, waterfront areas, ruderal areas). Urban nature in public spaces provides an appropriate microclimate, gives respite from high temperatures, protects against noise, affects air quality, provides shade, promotes air circulation, retains rainwater and provides habitats for various plant and animal species [20]. Urban nature is fundamental not only for the design of public spaces, but also for the quality of life, well-being, and health of people, allowing them to realize their

needs, activities, contact with nature and other people [21]. By providing ecosystem services, it allows the city to adapt to climate change [22,23]. It helps ensure a resilient and diverse urbanized environment that can cope with current and future challenges, new diseases, the emergence of new species, etc. According to Aarhus University: „On the one hand, urban nature is nature, because it involves all the living beings and plants in the city (…) not just the overall green structure (…) but also a blackbird on a roof (…) dandelions pushing up among the cobble stones (…) at the same time, urban nature is urban, because it is the result of planning, landscaping, architectural designs, planting, refinement and control, and because it is surrounded by the city and thus borders the urban space around it." [24].

1.2. Purpose and Subject of Research

The subject of the paper is the adaptation of public spaces to climate change, considering urban nature as a key factor in the process of the spaces adaptation to contemporary needs. The aim of the paper is to identify key solutions that introduce natural elements into urban public spaces, in the context of model strategic planning and urban design. A model city that consciously plans and successfully implements activities that adapt urban space to climate change, increase biodiversity and create optimal conditions for active urban living is Copenhagen. The paper examines development strategies that take into account urban nature, developed in Copenhagen over the past years, and identifies examples of model adaptation solutions implementation. The paper also analyzes strategic activities planned and implemented in large Polish cities. Of those identified, directions and actions that concern public spaces and holistically link the needs of the built and natural environment with human needs were singled out. The research undertaken in the paper leads to a comparison of the model strategies applied in Copenhagen and selected implementations, prioritizing urban nature, with examples of strategic development policies and adaptation projects implemented in public spaces of selected Polish cities. The result of the research makes up an assessment of the completeness of climate change adaptation activities undertaken in Poland, utilizing the potential of urban nature in public spaces, and recommendations for updating the planning and strategic documents, based on Copenhagen's model solutions.

1.3. Description of the Method and Scope of Research

The research results presented in the paper were obtained from the analysis of spatial and strategic policy tools and documents, as well as adaptation activities planned and implemented in public spaces. A comparative quantitative analysis was performed to diagnose the role of urban nature as an active tool to adapt public spaces to climate change. The research was limited to strategies, plans, and

documents developed both in Copenhagen and 44 large Polish cities with *Urban Adaptation Plans* (UAPs) and was contained in the timeframe from 2011 to 2022. The selection of 44 Polish cities as a study group resulted from their participation in the project „Development of Urban Adaptation Plans for cities with more than 100,000 inhabitants in Poland" organized and co-financed by the Ministry of the Environment in 2017-2019 [25]; the complementarity of features characterizing the vulnerability of large cities to climate change; and the common methodology for developing UAPs documents for all cities. Copenhagen, on the other hand, has already distinguished itself from other European cities, since it enacted the first *Climate Adaptation Plan* (2011), with its comprehensive approach to the adaptation of urban areas to changing climate conditions and its model use in this process, of urban nature as an active tool for adapting public spaces to climate change [24]. The research used the method of logical argumentation based on a critical analysis of the current legal status of strategic planning and the implementation of climate change adaptation activities in urban public spaces. In particular, the analysis criteria included the coherence of the adaptation process and the direction and nature of planning and strategic activities, as well as ways to implement elements of urban nature at different scales and areas of the city, in individual public spaces, in the context of climate change adaptation activities. To achieve research objectives, such research techniques as literature review, planning and strategy documentation, description, interpretation, and analysis of data, and case studies were used.

2. RESEARCH RESULTS

2.1. Copenhagen's strategic model adaptation activities to promote the introduction of urban nature into public spaces

Copenhagen is a green and liveable city. It is also a city that stands out from other European cities in the way it approaches the adaptation of urban spaces to climate change. In its established urban policy, it aims to create a living, responsible, and resilient city [26]. Many of the activities carried out in public spaces have become known as pioneering or breakthroughs in adaptation to climate change. The city has been implementing adaptation activities using unique architectural and urban-landscape solutions to solve the climate problems of the urban environment for many years [27]. The determinant of the city's architectural policy, which is based on projects concerning blue-green climate change adaptation, health, active and social projects, are people. Urban nature plays an important role in adaptation activities. This is confirmed by the provisions of strategic documents such as: *Copenhagen Climate Adaptation Plan covering the perspective from 2012 to 2025*, *Copenhagen Community - Status of the Goals 2020*, *Copenhagen Solutions*

for Sustainable Cities, *Copenhagen City Planning Strategy*, *World City with Responsibility - Municipal Planning Strategy 2018*, *Architectural Policy Copenhagen 2017-2025* etc. [28] However, its key role is primarily highlighted in the document entitled *Urban Nature in Copenhagen. Strategy 2015-2025* (UNS), produced in 2015 [24]. In the Strategy's assumption, urban nature is to become an active tool for the city's adaptation to climate change and at the same time create optimal conditions for urban living. Its role is to participate in the continuous development and transformation of urban spaces. Both the most valuable protected areas and elements, as well as those that are not covered by any legal regulations, become an integral part of this transformation. Gradually, greenery fills all urban, architectural and landscape interiors, creating green roofs, green walls, green streets, green squares, green courtyards, and others. Urban nature, protected and nurtured, is being introduced into the urban structure, both systemically and spotty manner. As early as 2009, even before the introduction of the *Copenhagen Climate Adaptation Plan*, 2011, the Copenhagen City Council approved a decision concerning „A Green Copenhagen" ensuring that the appropriate proportion of green space per capita is maintained. The strategy that Copenhagen has currently adopted defines goals and development directions leading to the realization of the vision: „creating more urban nature in Copenhagen" and „improving the quality of urban nature in Copenhagen" [24]. This strategy complements the provisions of other city planning and strategy documents [28]. The UNS strategy identifies eight strategic goals for: **biodiversity** – enhance biodiversity with a high diversity of species and habitats, ensure natural continuity, its authenticity and functional and aesthetic requirements; **climate adaptation** – adaptation to climate change, which will contribute to strengthening the role of nature; **nature areas** – ensure the maintenance and development of natural areas; **parks** – development and maintenance of city parks; **cemeteries** – development and maintenance of urban cemeteries with an emphasis on respect for peace, quiet, and their recreational role; **urban development** – ensure adequate quality area of urban nature and introduce green urban areas in the city's development areas; **municipal land** – care for the quality of nature during the renewal processes of urban areas and buildings; **non-municipal land** – actively support green initiatives on non-municipal land by engaging in partnerships with private actors and landowners; **trees** – increase the number of trees in the city, diversify species and care for existing trees; **spatial qualities** – creation, development and conservation of nature with special attention to human scale and urban character of space; **water** – protect access to water and waterfront areas, ensure its cleanliness, and care for associated vegetation and varied wildlife [24]. The strategy also defines five „quality parameters" important for achieving high-quality urban nature: biodiversity, climate adaptation, functionality, spatial qualities, and care and

maintenance. These parameters are key to the practical implementation of the strategic goals set. The Copenhagen Urban Nature Strategy includes four main areas that collectively cover the entire city: 1. Urban nature in green municipal areas, 2. Urban nature in urban development areas, 3. Urban nature on municipal land, 4. Urban nature on non-municipal land [24]. These areas represent different types of land and property, each characterized by different problems and requiring different approaches to solving them. For each area, different types of initiative that the city would like to implement have been assigned, each of which falls into five categories: tools, catalogues, action plans and projects, organizational changes, and partnerships. The planned initiatives include: *Urban nature in green municipal areas* – action plans, policy for cemeteries, nature management and nature rehabilitation, initiatives for endangered species, mapping urban nature, user studies, strategic management of urban nature, partnerships in green municipal areas, communication and learning about urban nature; for *Urban nature in urban development areas* – Green planning tool, Catalogue of urban nature solutions, Acquiring land for new green areas, Economic benefits of green areas, Urban nature in urban planning, Partnerships in urban development areas; for *Urban nature on municipal land* – Green planning tool, Tree policy and guidelines for trees, Catalogue of urban nature solutions, Climate adaptation and urban nature, 100,000 trees, Green links, Urban nature fund for municipal land, Utilizing operational competences across administrative boundaries, Partnerships in municipal areas; for *Urban nature on non-municipal land* – Catalogue of urban nature solutions, Urban nature fund, Partnerships on non-municipal land, Making room for rainwater [24].

The effect of planned activities that take into account the active role of urban nature is increased urban resilience, increased biodiversity, introduction of multifunctional solutions, gain new experiences, increasing user awareness, strengthening conservation efforts, introducing new natural elements, setting specific standards for the quantity and quality of urban nature, defining urban nature requirements in urban construction projects, and developing a catalog of green water management solutions. Indicators of achievements related to the key role of urban nature in Copenhagen include the following:

- „95% of the users are satisfied with the quality of the parks, cemeteries and nature areas in the City of Copenhagen",
- „The City of Copenhagen annually launches two nature maintenance projects in green municipal areas",
- „Urban nature is incorporated into every phase of urban planning in the City of Copenhagen",
- „At least 90% of Copenhageners in urban development areas are within less than a 15-minute walk from a park, beach, nature area or harbour bath",

- „50% of Copenhageners are satisfied with the amount of vegetation in streets, alleys and city squares”,
- „20% of Copenhagen’s total area is covered by tree crowns”,
- „10% of Copenhageners find that they take active part in the effort to create more and better urban nature”,
- „The City of Copenhagen annually carries out 50 partnership projects with an emphasis on urban nature” [24].

The strategy developed for urban nature is an example of a holistic approach to the issue of the broadly understood natural environment, being in relationship with the built environment and humans. Its effectiveness is related to its subordination to general policies, strategies, and areas of activity, including urban development goals and the city's architectural policy, as well as to specific regulations enshrined in local land use plans. Many of the initiatives, activities, and projects enshrined in them have already been implemented, and many of them have gained the status of models and contributed to strengthening the resilience of public spaces, increasing their attractiveness, and giving them social value.

2.2. Selected examples of model adaptation activities in Copenhagen's public spaces: case studies

The adaptation activities implemented in Copenhagen's public spaces vary in location, the range of methods and tools used, the degree of impact on urban structures and the quality of life and ecological balance. However, in all examples, urban nature is an active tool for adaptation to climate change. The primacy is led by solutions that introduce nature into transformed public spaces, in conjunction with the use of innovative stormwater management systems - building urban flood control infrastructure. Adaptation of urban spaces revolves around the processes of revitalization, redevelopment of degraded or nonfunctional urban spaces such as: streets, squares, parks, neighborhood spaces. It also focuses on the creation of recreational areas and new landscaped green spaces adapted to mitigate the effects of rainstorms. Their premise is to take into account the peculiarities and character of the place and adapt solutions to the needs of residents.

- **Tåsinge Plads** (2013-2014) – adapting a 7.000 sqm urban square, located in a densely constructed urban area, to receive and retain rainfall of various intensities, while transforming it into a place for meetings, residents' activities, and leisure in a green environment. The square hybrid function was achieved through a whole system of rainwater retention and drainage (water tanks, rain troughs, purification filters, pumps) and the use of different species of vegetation introduced at different levels, in the form of plantings forming groves, grassy areas, or rain gardens. More than 1.000 sqm of the highly permeable biological surface was gained, used on a daily basis as a green recreational area for local residents, conducive to play, learning, and movement. The basis of the activities

was the active participation of the local community in the transformation process [29,30].

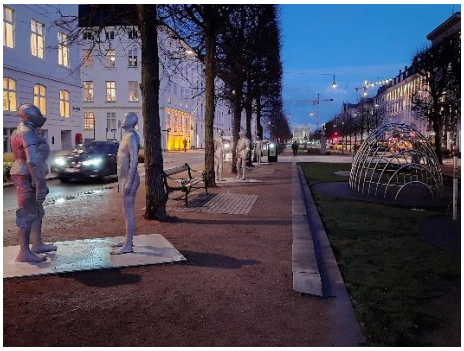
- **Sankt Kjelds Plads and Bryggervangen** (2017-2019) – adapting the 34.900 sqm public spaces, located within the Østerbro residential district, to climate change and, in particular, to threats from flash floods. Reconstruction of sewerage infrastructure related to the water management system (rainwater tanks, new storm sewers, elements of the water infrastructure), was linked to a change in the way public spaces are developed. One of the main factors in the transformation has been the narrowing of streets and intersections by reducing the amount of paved and impervious surfaces and replacing them with extensive plantings of trees and shrubs, vegetation strips, so-called „green streams", extensive rain gardens to absorb excess rainwater, as well as green courtyards to encourage neighborhood connections. It was important to create with them recreational places, landscaped with plants, encouraging residents to commune with nature, improving their well-being, benefiting the environment by means of: increasing biodiversity, reducing noise and air pollution and creating habitats for insects and other urban animals. After redevelopment, the area became the „green heart" of the district, fostering social interaction and activity, improving the health and quality of the life of residents, and reducing the effect of the urban heat island [31,32,33].
- **Sankt Anna Plads** (2012-2016) – the transformation of an urban avenue, covering an area of 24.500 sqm, embedded in the historic urban structure. The investment included: introduction of a sustainable rainwater management system, retaining water and directing its surface runoff toward the port, expansion of the recreational section in the form of a linear park with compositionally inscribed places of rest and activity for both residents and tourists, planting with trees, flowers, and grassy areas, adding variety with sculptures, increasing the importance of pedestrian and bicycle traffic, widening sidewalks at the expense of adjacent street lanes, removing off-street parking, and introducing underground parking, reducing the amount of paved and impermeable surfaces [34,35].
- **Scandiagate** (2017-2019) – adapting an unused public space of 4.800 sqm, located in a residential area in Sydhavnen, to the changing climate and transforming it into an attractive, natural space for interneighborhood gatherings. The space, thanks to a system of water reservoirs for collecting rainwater and appropriate landscaping with adapted vegetation and small architecture, has been adapted to different rainfall intensities. Urban nature has become the backdrop for many of the residents' daily activities: it accompanies mini playgrounds, recreation, and leisure areas, and cocreates areas of small crops and diverse gardens, including some where nature has been completely left to its own devices. The main objective of this project was to create a public space that connects the

old neighborhood with the new residential area under construction, developed in a way that ensures a high degree of biodiversity [36,37].

- **Enghave Climate Park** (2014-2019) – adapting the 35.000 sqm historic park space to modern flood risks by creating, in keeping with the park's aesthetics, a coherent surface water management, equipped with an underground water reservoir, rain channels, movable perimeter walls, allowing multifunctional use of water and usability of the park at different rainfall intensities (playgrounds, sports fields). Water on a par with multispecies greenery is the leitmotif of the park, providing an educational and recreational element and a place for urban animal life. The development elements used, thanks to the combination of technical solutions with aesthetic and utilitarian ones, allow the surrounding users to interact socially on a daily basis in co-existence with nature, and also protect the adjacent buildings from the effects of flash floods. During rainfall, the park turns into a „water park" [38,39,40].
- **The district of Ørestad** (1997-to-now) – shaping a modern residential neighborhood resistant to climate change, emphasizing the quality of architectural and urban planning solutions, using urban nature to shape public spaces: green streets and green urban squares, linked hierarchically with semipublic spaces - courtyards, by means of: water assumptions, greenery elements, recreational areas (flower meadows, bee gardens, pocket parks, nature parks, urban farms, etc.). The essence of the concept is to build public and semi-public spaces in a way that is sustainable and adapted to climate change, increases and promotes biodiversity, and allows for inter-neighborhood connections [41,42].

Tåsinge Plads

Sankt Kjelds Plads



Sankt Anna Plads

Scandiagate

Enghave Climate Park

The district of Ørestad

Fig. 1. Selected examples of model adaptation activities in Copenhagen's public spaces, implemented urban nature, photos: A. Pancewicz

The examples cited, although representing different scales and different types of urban projects, expose the most important assumptions adopted by the Urban Nature Strategy for model adaptation activities in public spaces, including: a focus on the introduction of new technologies and broad infrastructural investments, spatial and architectural differentiation that allows human coexistence with urban nature, attention to the quality and attractiveness of urban spaces, and satisfaction of residents' social needs and activities. Case studies show that incorporating urban nature into projects that adapt public spaces to climate change not only allows sustainable management of rainwater and greenery, but is also an opportunity to create more resilient and livable cities.

2.3. Strategic planning of adaptation activities in Polish cities in the context of urban nature implementation

Polish cities have been looking for ways to increase the resilience of urban spaces to climate change for almost a decade [43]. This manifests itself in taking

legislative, organizational, planning, informational, or research activities. An important part of the adaptation projects undertaken is the development of urban strategies and investment plans that consider the risks arising from climate change. Consistent with the provisions of: *Strategy for Responsible Development to 2020 with an Outlook to 2030*, *The National Environmental Policy 2030*, *SPA 2020 - Strategic adaptation plan for sectors and areas vulnerable to climate change until 2020. With an Outlook to 2030*, *The National Urban Policy* and other planning and strategic documents at the regional and local levels [44] – *Urban Adaptation Plans* [45], became the first documents in Polish cities that were directly dedicated to strategic planning of activities to reduce or mitigate the effects of the most serious threats to cities from climate change, improve the safety of residents, shape urban nature and protect biodiversity. Their introduction into the legal system of cities at the rank of a strategic document was intended to integrate climate change adaptation issues into all relevant areas of management. Developed in conjunction with other municipal strategic and planning documents, it became the basis for city authorities decisions on implementing and coordinating adaptation activities, cooperating with other entities, and shaping the budget and seeking sources of investment financing. Among organizational, technical, informational and educational activities, an important role was assigned to adaptation activities related to the introduction, protection, and shaping of urban nature, based on systems and elements of blue-green infrastructure [46]. They included not only the strengthening of existing resources but also the construction and development of new elements inscribed in public spaces, introduced at different spatial scales and for different urban areas. The most common were activities related to the formation of landscaped green areas, reservoirs and watercourses, strengthening recreational and leisure functions and creating multifunctional green areas, renewal of public spaces taking into account the introduction of blue-green infrastructure elements, creation of green and shaded rest areas, neighborhood gatherings, playgrounds, increasing the area of biologically active areas, protecting permeable areas, natural floodplains, greening road systems, realizing the potential of urban ecosystem services, and introducing or updating urban planning documents [47]. Only in some cities has attention been paid to the need for cities to develop *Urban Green Space Development Strategies*, as a basis for conducting a sustainable and comprehensive policy on the formation and protection of urban nature, and as a strategic tool for planning, preparation, and implementation of specific solutions and investment projects.

Of the 44 Polish cities for which UAPs were developed in 2017-2019, only five of them: Gliwice, Poznań, Radom, Rybnik, Tychy, among their adaptation activities, have included the need to develop an *Urban Green Space Development Strategy*.

Under the assumptions of adaptation activities, *Strategies for the Development of Green Areas* in Polish Cities would form the basis for conducting a framework policy for shaping the urban natural environment and protecting its values. The Strategies would also define the principles of cooperation between local administration and residents and social organizations in the field of initiatives, activities, and undertakings concerning urban nature. Particular importance has been given to the formation and protection of publicly accessible green areas within urban boundaries, including all possible forms of organized and unorganized greenery, taking into account the elements of blue-green infrastructure possible in public spaces. These documents were to enable the planning, preparation, and implementation of solutions for the development of new and renewal of existing greenery elements/areas, their care and management, as well as facilitate the planning of future city budgets for spending on urban nature. The strategies' findings were to be a guideline for making provisions when drawing and updating local plans.

Currently, of the 44 Polish cities with UAPs, only Bydgoszcz (2011) and Zielona Góra (2015) have an *Urban Green Space Development Strategy*, while seven cities have other types of local documents, programs, concepts, standards, or policies that set directions for the formation and development of urban greenery. These are: in Kraków – *Directions for development and management of green areas* (2019), in Łódź – *Standards for shaping greenery* (2018), in Płock – *Program for greening the city* (2017), in Toruń – *Concept for the development of green areas* (2018), in Tychy – *Green space management system for the city* (2019), in Walbrzych – *Green space standards of the city* (2019), and in Wroclaw – *Green and Environmental Policy* (2018).

Two of the cities with UAPs, Czeladź and Jaworzno, have proposed developing Master Plans for a coherent green space system. These Plans were intended to serve the development of a coherent greenery system within the city, based on an analysis of the potential of green areas, the requirements of urban space, and the needs of residents. The provisions of the Plans would be taken into account in the *Study of Conditions and Directions for Spatial Development* of the City and in *Local Plans*. Taking into account the investments in systemic adaptation, the overriding importance of urban nature, in only one case of the city of Częstochowa, an action was taken based on the introduction of systemic solutions aimed at increasing the number of tree and shrub plantings, the construction of parklets and small green resting places in neighborhoods, and the care of greenery in the city (*Green City Program*).

The role of urban greenery in the adaptation of public spaces to climate change is also included in the provisions of the UAP's adaptation activities for the development of a set of coherent planning/urban planning guidelines and principles for the design of urban public spaces that include climate change

adaptation issues. These guidelines and principles are concerned with the introduction, protection and management of natural resources in the city, the indication of directions for increasing urban biodiversity, access to greenery, and the replenishment of natural systems with biological, hydrological, and climatic functions. They are intended to be in line with urban planning standards, which are widely used as normative tools to protect the public interest. These guidelines are to apply to the entire city, taking into account the nature and specifics of its individual areas, with particular emphasis on the center and downtown, places where the urban heat island phenomenon occurs most strongly. The formulation of the guidelines, the specific provisions of which will be introduced into the city's planning documents, is expected to force the application of solutions in public spaces that would take into account urban nature in a way that would enable it to actively participate in climate change adaptation, as well as ensure the safety and greater comfort of residents. Eighteen of the forty-four cities with UAPs have planned to develop sets of such rules and guidelines. These include: Bytom, Chorzów, Czeladź, Gdańsk, Jaworzno, Katowice, Kielce, Legnica, Lublin, Mysłowice, Olsztyn, Płock, Radom, Ruda Śląska, Siemianowice Śląskie, Sopot, Sosnowiec, Szczecin.

Strategic adaptation activities for sustainable management of green areas, on principle, are intended to improve the quality of life in the city, enhance the aesthetic and social value of urban space, introduce spatial order, and harmonize the city with the natural, cultural, and landscape environment. Many of the activities planned and implemented in Polish cities in recent years are related to the revitalization of landscaped green areas and degraded areas into natural areas, the introduction/ development of new green areas/ recreational areas, and the protection of valuable natural areas/ floodplains [48]. In all these spatial scopes, 209 adaptation activities, enshrined in planning and strategic documents, were planned between 2014 and early 2022. During this period, 249 of them were implemented, with the highest number resulting not only from the implementation of adaptation activities enshrined in the documents, but also from the implementation of other urban projects and initiatives for which European or national funds were obtained. The overwhelming number of planned activities in the field of green space management (84) relate to the introduction or development of new green spaces and recreational and leisure areas. On the other hand, the largest number of projects (94) are being implemented in the field of revitalization of landscaped green areas [49].

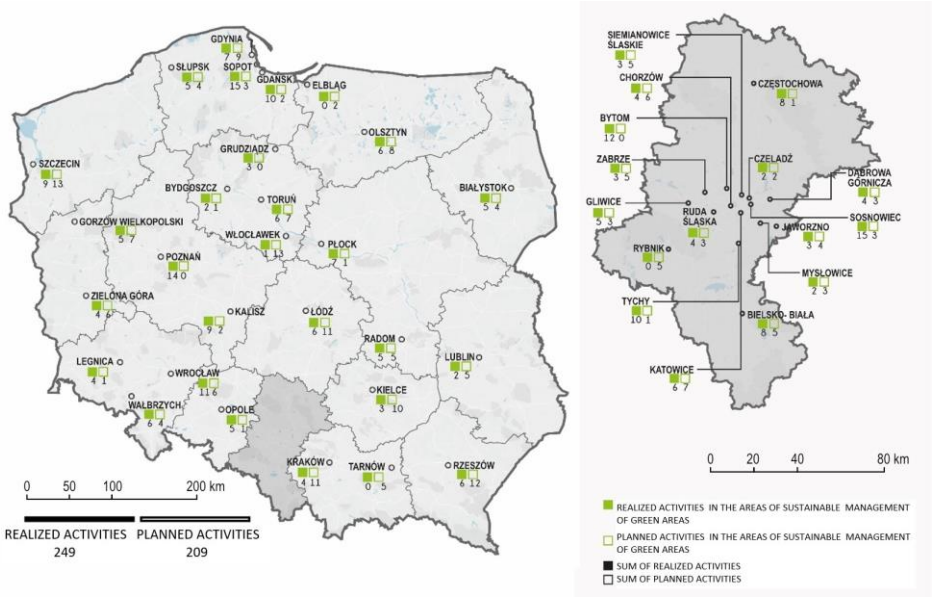


Fig. 2. The map of realized and planned adaptation activities undertaken in 44 Polish cities in the areas of sustainable management of green areas, author: W. Anczykowska based on [49]

Most of the actions taken in the forty-four Polish cities are small initiatives, microinterventions introducing blue-green infrastructure solutions, strengthening ecosystem services, implemented on the initiative of city authorities, civic budgets, or grassroots initiatives. Representative implementations, often reflecting residents' needs, included green streets, green squares, squares rain gardens, urban meadows, community gardens, green bus stops, green backyards, pocket parks, green roofs, green walls, vertical gardens, nature, and education paths. From 2014 to the beginning of 2022, 137 such activities were planned, while 281 were implemented [49]. The most popular activities that used urban nature to adapt public spaces to climate change were pocket parks. 38 such activities were planned and 55 were implemented, including activities involving the systemic introduction of urban pocket parks in individual cities. Other adaptation activities planned and implemented in public spaces of Polish cities take urban nature into account to varying degrees. These include spatial activities in the areas of sustainable water resources management, sustainable urban development, and transportation infrastructure. Among them, less importance is attached to systemic actions, while point actions, carried out on a microscale, which are a kind of so-called urban acupuncture, supporting the renewal of public spaces, complement the process of adaptation to climate change and translate

directly into an increase in their social and environmental attractiveness, dominate.

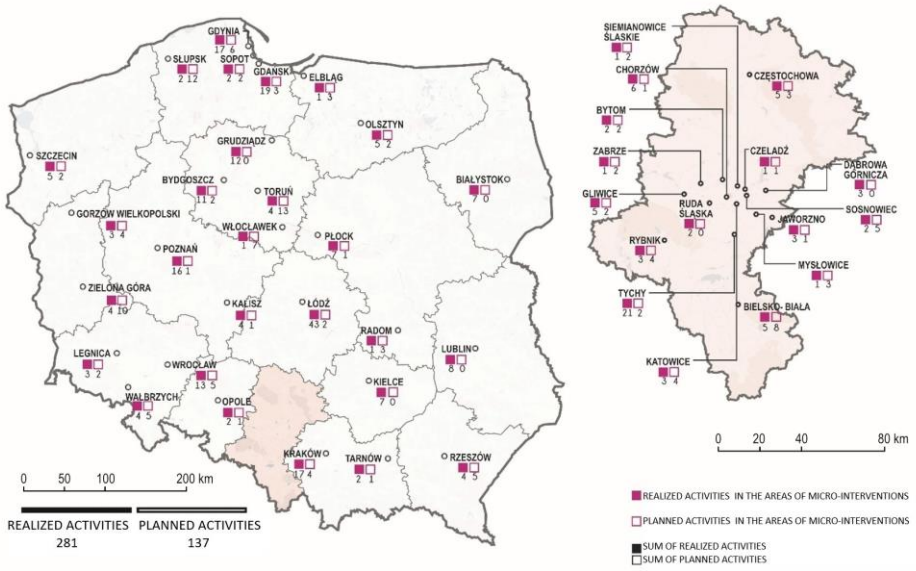


Fig. 3. The map of realized and planned adaptation activities undertaken in 44 Polish cities in the areas of microinterventions/ urban acupuncture, author: W. Anczykowska based on [49]

3. DISCUSSION OF RESULTS

The research showed that strategic planning that includes adaptation of public spaces to climate change and promoting solutions that prioritize urban nature is the basis for creating a built environment that is resilient and adapted to change. However, this depends on the adaptation of the city's development strategies and policies, the spatial policy pursued, and the way the city is managed, to the projected climate conditions. This is confirmed by research on Resilient Urban Planning [50], implementing urban resilience policies [51], and studies highlighting the key role of urban nature in creating adaptation strategies [17]. A comparison of Copenhagen's model approach of incorporating urban nature into activities that increase the resilience of public spaces, to adaptation policies implemented in Polish cities, provides an opportunity to identify directions and solutions that could contribute to the improvement and greater effectiveness of the activities carried out and ensure that Polish cities balance environmental and economic development, as well as urban resilience and quality of life. The research results presented in the paper indicate that the basis for the effectiveness of adaptation activities in public spaces is the inclusion and prioritization of urban

nature at every stage of the planning and implementation process. The keys are as follows:

- a holistic approach to implemented urban nature, in the context of the relationship: the built environment - the natural environment - the residents and their needs, taking into account different spatial scales and different urban areas, carrying out systemic activities and complementing them with spot actions, emphasis on multifunctionality of solutions, supporting community, diversity and activity in public space [52,53],
- consistency of the city's development documents and policies under development, including spatial planning, architectural policy, and urban design; provision of appropriate formal and informal instruments for the preparation, management, and coordination of the entire process of transformation of public spaces, ensuring implementation of the strategy and achievement of the set goals [54],
- detailed development of individual stages of implementation of urban nature in public spaces, taking into account the instruments of operational urban planning [55]; inclusion in the process of adapting the city to climate change of the following solutions: legal, organizational, and architectural-urban planning; involvement of public funds for financing individual investments; support for private investments [56],
- selection of innovative architectural and urban planning solutions, including infrastructure, based on the inventory of resources, analysis of conditions carried out at different spatial scales, and taking into account the guidelines from the provisions of planning and strategic documents; matching them to the character and specificity of the place, as well as visions and quality goals related to the development of the city, the natural system, and the needs of residents [57],
- inform landowners, users, and developers about the benefits of implementing urban nature in adaptive solutions for public spaces, resulting from the introduction of ecosystem services regarding increased security, increased property and land use value, resource savings, and improved quality of life in the city [58],
- socialization of planning and implementation processes, ensuring the selection of optimal solutions to meet the needs of residents; providing space for civic initiatives and social activities; cooperation, communication, conducting dialogue and integrated activities of various stakeholders; strengthening the responsibility for urban space and participation of residents, both at the stage of creating strategies and planning, as well as implementation of activities [59],
- exchange of experience between cities (conferences, workshops, meetings, joint projects, associations, and committees dealing with urban nature) allowing the dissemination of knowledge about instruments for effective planning and

implementation of adaptation activities in which urban nature plays a key role [60].

In view of the fact that planning activities stem from existing regulations and laws and that in Poland, among the adaptation activities enshrined in the Urban Adaptation Plans, there is a lack of strategic provisions geared towards raising the profile of urban nature and its role in adapting cities to climate change, systemic solutions are needed, forcing the introduction of solutions in which urban nature would be a key element of change. These should be based on:

- adaptation, both mandatory planning instruments dedicated to environmental issues and optional strategic urban development tools or environmental protection and climate change adaptation instruments, to the new climate guidelines, taking into account the scenarios of adaptation of public spaces to climate change and the possible consequences of implementing adaptation activities already planned; it is necessary to constantly update plans, programs, and strategies in terms of spatial development conditions and directions, city development strategies, revitalization programs, environmental protection programs, etc.;
- develop an *Urban Green Space Development Strategy*/ *Urban Nature Strategy* and include it as an adaptation activity in updated *Urban Adaptation Plans*, and take such a provision into account when developing new documents for other Polish cities. This is particularly important, given that cities also face other civilization challenges, such as pandemics, for example, which make the role of properly managed public space increasingly appreciated: open, accessible, enabling contact with nature and other people, and conducive to urban activity and recreation. The Strategy can be developed in the form of a single, coherent, and holistic document covering all issues related to urban nature or in the form of a set of key strategic documents on: biodiversity, climate change adaptation, protection of natural areas, designation of new green areas, introduction of solutions based on blue-green infrastructure, etc. The strategies should be complemented by urban planning guidelines and principles for shaping urban public spaces that take into account climate change adaptation issues, formulated for cities, and ultimately written into local development plans. The provisions of such city-wide strategies, together with the developed set of guidelines for public spaces that allow for the impact of climate change, regarding their location, accessibility, and development, as well as measurable indicators for greenery assessments, introduced into local plans, will allow the active participation of urban nature in the development of resilient and sustainable cities.

In the activities carried out in Polish cities, special attention should be paid not only to the development of legal regulations in the context of the

implementation of elements of urban nature in the process of activities that adapt public spaces to climate change, but also to the creation of more favorable conditions for spatial planning and urban and architectural design.

4. SUMMARY

Climate-adapted public spaces where the urban nature is introduced and properly transformed, can gain a strong, sustainable landscape identity. Climate-adapted urban nature can be pleasing and functional, can promote biodiversity and sustainability, and give residents a sense of contact with nature in close proximity to where they live. The basis of this approach is to know all the elements of the urban natural system and the relationships between them and to identify a model sequence of activities and actions that are crucial in the process of adapting public spaces to climate change. Non-standard spatial solutions, bold urban and architectural concepts, and innovative infrastructure projects that generate new opportunities in the formation of modern public spaces are important. Tools for adapting public spaces to climate change using urban nature, such as strategies, urban nature development plans, and urban green space plans, urban adaptation plans, although not legally binding, provide a framework for taking urban nature into account in the processes of urban planning, urban design, and city adaptation to climate change. They promote a common vision for urban greening, identify priority activities, ensure control over the quality of the solutions introduced, access to greenery, the diversity of its elements, the places where they are used; they can help achieve sustainable environmental improvements and benefit residents with additional ecosystem services, contributing to climate change mitigation. The process of adapting public spaces to climate change, in which urban nature is an active tool, is a time-consuming, multistage and costly task. However, its implementation can bring users of public spaces, as well as planners and designers, a lot of satisfaction and tangible natural, cultural, social and economic benefits.

The results of the research can help in the process of updating and improving general principles for the creation of urban and architectural solutions that favor the introduction and protection of urban nature in public spaces and the creation of sustainable and climate-resilient places [54].

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Editor received the manuscript: 01.10.2022