

Maria Markiewicz*

Implementation of climate change adaptation policy in the local spatial development plans in Warsaw: A case study

* Warsaw University of Technology: Politechnika Warszawska, Warsaw, Poland
e-mail: maria.markiewicz@pw.edu.pl

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Abstract

The purpose of this paper is to present how a city's strategy to strengthen its resilience to climate change threats, as formulated in the Urban Adaptation Plan (UAP), is implemented in Local Spatial Development Plans (LSDPs), using Warsaw as a case study. The results of this exploratory study conducted in Warsaw show that the potential of local spatial planning for climate change adaptation is well utilised, and that LSDPs effectively implement the city's strategy to strengthen its resilience to climate change threats, as formulated in the UAP for Warsaw. As the study is limited to the capital city, it would be interesting to examine how the situation looks in other major cities in Poland, using the current study's results as a reference point. Considering that the policy-making process, including adaptation to climate change, may encounter cognitive, social, organisational/institutional, technological and financial barriers or constraints in nature, future research could include other research methods, such as monitoring the implementation of LSDPs provisions in urban space and interviews with spatial planners, municipal authorities, city residents and investors.

1. INTRODUCTION

With climate change advancing [IPCC 2007], cities are facing the necessity to adapt their spatial policies to new environmental challenges [Rozencaig et al. 2012; Masson et al. 2014; Carter et al. 2015]. When effectively managed and combined with adaptation strategies, spatial planning plays a leading role in building cities' resilience to climate change and in creating a favourable microclimate. This is because land use and land development have a substantial impact on cities' vulnerability to climate change [Measham et al. 2011; Hurlimann, March 2012; Bulkeley 2013]. Consistency between strategic documents, particularly the Urban Adaptation Plan (UAP) and the municipality's spatial planning documents, such as Local Spatial Development Plans (LSDPs), enables effective counteraction of the negative impacts of climate change [Kassenberg et al. 2019].

Given the numerous publications on climate change in urban areas, adaptation policy, and its integration into spatial planning, this literature review focuses on the last decade of research on mainstreaming climate change adaptation into local/urban spatial planning in European cities.

This study directly relates to the earlier Polish-rooted studies by Andrzejewska [2021], Borys [2022], Matuszko et al. [2023], Nowak and Bera [2024], and Nowak et al. [2024]. Andrzejewska [2021] analysed a set of 42 LSDPs from two Polish voivodships (the Greater Poland and Lower Silesia

voivodships) in terms of solutions aimed at preventing the adverse effects of climate change, but without directly linking them to the adaptation strategies formulated in the UAPs for large cities in these areas (in Wrocław and Poznań). Borys [2022] examined a set of 15 UAPs for Polish cities, identifying thematic areas of climate change adaptation (for which cities have planned local public interventions aimed at reducing their vulnerability to anticipated adverse effects of climate change) as one of the spatial planning activities. Matuszko et al. [2023] discussed climate change in Kraków and the role of LSDPs in minimising the urban heat island (UHI) effect. Nowak et al. [2024], participating in an international project, analysed three UAPs (for Athens, Barcelona, and Warsaw) regarding the formulation and translation of UAP provisions into the spatial planning domains of Greece, Spain, and Poland, respectively. Nowak and Bera [2024] provided an overview of the international discussion on how spatial planning is linked to responding to climate challenges. To some degree, this study relates to the work of Łaska [2021], who analysed a set of 26 randomly selected LSDPs from Warsaw regarding the protection of green areas from investment pressure. However, these documents only include the plans prepared before the adoption of the UAP for Warsaw.

Among the abroad-rooted research on the possible contribution of spatial planning to the adaptation of urban areas to climate change are the studies of Uittenbroek et al. [2012], Davidse et al. [2015], Yiannakou and Salata

[2017], Ramyar et al. [2021], Thoidou [2021], Asprogerakas and Tasopoulou [2021], Baack et al. [2024], Brandsma et al. [2024], Marino et al. [2025]. Davidse et al. [2015] analysed the implementation of two climate change adaptation strategies —avoidance and minimisation — in strategic and local spatial planning in Stockholm, Sweden. Uittenbroek et al. [2012] discussed how local adaptation strategies were integrated into spatial planning practices, with reference to two Dutch urban case studies concerning Schieveste in the Schiedam municipality and Wesflank in the Haarlemmermeer municipality. Baack et al. [2024], addressing the same question, provided a comparative case study of two other Dutch municipalities, i.e., Enschede and Zwolle. Ramyar et al. [2021], Asprogerakas and Tasopoulou [2021], and Thoidou [2021] have placed urban green infrastructure at the centre of urban planning to achieve urban resilience. While Asprogerakas and Tasopoulou [2021] explored how urban green spaces can provide a more holistic and integrated approach in the overall practice of urban adaptation planning, Thoidou [2021] examined this issue in Thessaloniki, Greece. Yiannakou and Salata [2017], focusing on Thessaloniki, demonstrated the potential of spatial planning to reduce the UHI effect. Marino et al. [2024] studied the implementation of nature-based solutions (NBS) for climate change adaptation in municipal planning, from the strategic to the regulatory level. They selected four Norwegian municipalities: Bodø, Innsjøfjord, Trondheim, and Stavanger. Brandsma et al. [2024] presented an international overview of the implementation of urban climate-responsive design strategies.

The purpose of this paper is to present how the city strategy aimed at strengthening its resilience to climate change threats, formulated in UAP [Kassenberg, Szymalski 2019], is implemented in LSDPs, using Warsaw as a case study. To the author's knowledge, no detailed research on the link between UAPs and LSDPs has been published. Although the paper describes the situation in Poland, it is believed to be a source of information for readers from different countries. It provides a basis for further discussion on this matter.

It is important to note that the UAP for Warsaw was prepared as part of a project launched by the Ministry of the Environment, which covered 44 cities in Poland with populations of over 100,000. The project aimed to “prepare city authorities and inhabitants to consciously and responsibly respond to possible climate change and its effects” [Borys 2022]. The requirement to prepare an UAP for a city with a population of 20,000 or more contained in Article 18a.1 of the Act on Environmental Protection Law (EPL) of 27 April 2001 [Act... 2001], amended by the Act of 27 November 2024 amending the EPL and certain other acts [Act... 2024]), came into force 14 days after the announcement of the amending act, i.e. on 11 December 2024. The entry into force of the provision concerning the adoption of the plan contained in Article 18b.1 of the amended EPL Act [2001] was postponed until 1 July 2025. The Act [2024] also introduced provisions for integrating climate change adaptation policy into the

spatial planning domain. They have also been in force since 11 December 2024. Article 71.2(2a) of the amended EPL Act [2001] requires municipalities that have an urban adaptation plan to take into account the conclusions and recommendations contained in this document when drawing up and updating municipal development strategies, supra-local development strategies, municipal master/general plans and local spatial development plans. At the same time, Article 1.2(3) of the amended Act on Spatial Planning and Management (SPLUM) of 27 March 2003 [Act... 2003] introduces a requirement to take climate change mitigation into account in spatial planning and development by extending the list of environmental protection requirements. According to Article 26.1(1) of the Act [2024], the referred regulations did not cover the above-mentioned spatial planning documents, in relation to which the consultation and agreement process was initiated before the adoption of UAPs.

The text following the introduction section is organised in three sections: section 2 includes materials and methodology, section 3 presents results and discussion, and section 4 concludes the paper.

2. MATERIALS AND METHODS

A set of LSDPs was examined using the qualitative method. The author was inspired by Mayring's [2014] content analysis method used in social research. It included reading the analysed documents, marking provisions that refer to analytical categories, writing research notes used in the re-test (second revision) of the LSDPs, repeating the steps in the re-test, and checking for consistency in the results. In Mayring's original method, analytical categories are usually determined using one of three ways: based on legislation, transferred from other similar studies or derived directly from the analysed text.

In this study, the analytical categories were named according to the areas of intervention (with some changes marked in square brackets) identified in the UAP for Warsaw [2019], which aimed to counter specific climate threats in the City (Table 1). The link between these categories and the LSDP provisions was established in two steps. First, within each of these categories, measures proposed in the UAP for Warsaw [Kassenberg, Szymalski 2019] that can be implemented through urban planning standards (in the LSDPs provisions) were used, which resulted in the determination of the first choice LSDPs provision classes aimed at counteracting the negative climate change in the city. In the next stage, they were supplemented by reviewing a selected set of LSDPs resolutions. This method allowed for the inclusion in the LSDPs classes of all requirements concerning the LSDP content specified in the Polish legislation (Article 15 of the Act of 27 March 2003 on Spatial Planning and Land Use Management (SPLUM) [Act... 2003] amended by the Act of 7 July 2023 amending the SPLUM Act and other acts [Act... 2023] [Act... 2023] and the Regulation [2003] replaced since 24 December 2021 by the Regulation [2021]).

The set of ten LSDPs analysed in the study includes all the plans which preparation started after the adoption of the UAP for Warsaw (i.e., after 4 July 2019) approved in Warsaw up till 1 August 2025 (i.e., the date of the last revision of LSDPs published on the website of the Architecture and Spatial Planning Office of the City of Warsaw performed by the author). Table 2 presents the deadlines for LSDP preparation and their main characteristics, including the main terrain functions and terrain features that directly relate to the description of the specified categories, i.e.,

provisions aimed at counteracting the adverse effects of climate change threats in the city.

It is important to note that out of ten LSDPs included in Table 2, three plans were adopted after 11 December 2024 (applies to plans with nos. 2, 6 and 8). Still, only one plan (no. 2), in light of the legal regulations, required that the conclusions and recommendations from the UAP be taken into account in the process of its preparation, because only in this case was the consultation and agreement process initiated after the marked date.

Table 1. Analytical categories, provision classes and their description

Categories related to climate change		
Category	Labels	Description of the category/Provisions aiming to counteract the climate change threat in the city
Heat [island]	Cat.1	
	1. Ventilation of the city	1. Provisions ensuring the proper airing and ventilation of the city.
	2. Protection of green areas	2. Provisions protecting delimited green areas and increasing their portion in the total city area.
	3. Thermal comfort in microscale	3. Provisions improving thermal comfort in the microscale of the city.
Water [retention and flooding]	4. Restrictions for buildings (materials, colours)	4. Provisions introducing solutions that adapt buildings to climate change.
	Cat.2	
	1. Flood protection measures	1. Provisions ensuring the construction, maintenance, expansion, or reconstruction of existing flood protection measures.
	2. Restrictions on high flood risk areas	2. Provisions limiting the urbanisation pressure on floodplains.
Winds	3. Water retention systems in the city	3. Provisions ensuring the establishment of water retention systems in the city.
	4. Water retention solutions on a micro scale	4. Provisions ensuring the development of solutions that promote water infiltration or retention on a micro scale.
	5. Rainwater management	5. Provisions ensuring the application of systemic rainwater management.
	Cat.3	
	1. Protection zones around trees	1. Provisions introducing protected zones around old trees (natural monuments, trees of exceptional natural and landscape value).
	2. Cabling the power lines	2. A provision providing for the cabling of power lines underground.
Categories related to the sustainable built environment		
Infrastructure [resilience]	Cat.4	
	1. Usage of renewable energy sources	1. Provisions introducing solutions to increase the city's energy autonomy (heat and electricity), including increasing the renewable energy usage.
	2. Cabling the power lines	2. A provision providing for the cabling of power lines underground.
	3. Applying rainwater collection solutions	3. Provisions ensuring protection against overloading/damage to the rainwater collection system by introducing rainwater collection solutions.

Continued **Table 1.** Analytical categories, provision classes and their description

Categories related to climate change		
Category	Labels	Description of the category/Provisions aiming to counteract the climate change threat in the city
Categories related to the sustainable built environment		
Green spaces	Cat.5	
	1. Protection of larger green areas	1. Provisions ensuring the protection of larger green areas, including parks and allotment gardens, and increasing their size.
	2. Protection of smaller patches of greenery	2. Provisions ensuring protection of and introducing smaller patches of greenery, including roadside greenery and around buildings.
	3. Selection of species for planting	3. Provisions ensuring the usage of a specific type of species for new planting and more drought-resistant plants.
	4. Protection zones around trees	4. Provisions introducing protected zones around old trees.
	5. Degraded land transformation	5. Provisions promoting the transformation of degraded land into green spaces.
	6. Development of elements of BGI in microscale	6. Provisions promoting the application of a systematic approach to develop green roofs, walls, facades, rain gardens, ponds and other BGI elements.
	7. Protection of natural greenery	7. Provisions ensuring protection of natural greenery.
	8. Modelling of natural connection networks	8. Provisions ensuring protection and modelling of natural connection networks.
	9. Green spaces within the boundaries of the conservation area	9. Provisions ensuring protection of green spaces within the boundaries of the conservation area.

3. RESULTS AND DISCUSSION

The detailed results of the content analysis of the set of LSDPs for Warsaw (identified by the ordinal numbers in Table 2) with reference to the provisions counteracting threats related to climate change are shown in Table 3. They can be summarised as follows:

1. Within the category of "Heat [island]", four classes of measures aimed at counteracting this threat have been identified. To ensure adequate ventilation and airflow in the city, active protection (in the form of ventilation corridors) and/or passive protection (in the form of restrictions on the land use) are being introduced, with both types of provisions appearing in one plan (no. 6), the first type of provision in two plans (nos. 3 and 5), and the second type of provision in one plan (no. 7) out of the ten analysed LSDPs.

The plans include protecting both larger green areas (such as parks and allotments) and smaller ones (such as pocket parks and garden zones, green zones in residential and service areas, and buffer green areas in transportation areas), as well as groups or rows of trees and individual trees. Among the ten analysed LSDPs, none lacks green areas. Larger green areas are localised in eight plans (nos. 1-6, 8, 9). In plan no. 2, the park encompasses the entire plan area. In all LSDPs that delineate residential or

service areas (eight plans, nos. 1, 2-7, 9), these areas are accompanied by green areas. This also applies to areas marked on the plans as transportation areas (six plans, nos. 1, 3-5, 7-8). Public access to green areas is established in all the analysed LSDPs.

To support the improvement of thermal comfort in the city on a microscale, in addition to protecting designated green areas and increasing their share in the total area of the city, the LSDPs provide for the development of green elevations (green walls or vertical gardens) and green roofs, with green elevations and green roofs introduced in three plans (nos. 4, 7 and 8). In comparison, plan no. 5 refers to green walls, while the other two plans (nos. 9, 10) refer only to green roofs. Nine out of ten analysed LSDPs (except the plan no. 6) increase the share of biologically active areas (BAA) by reducing the area of paved surfaces (e.g., by removing impervious surfaces and introducing permeable surfaces). In the case of three plans (nos. 3-5), these provisions also apply to tram tracks.

Solutions to adapt buildings to climate change include reducing heat-absorbing surfaces in buildings and limiting their colours (the plans stipulate the use of only light and monochromatic colours). Whereas the use of specific colours is specified in nine plans (no buildings in the plan no. 2, which whole area covers a park), the specification of materials for the construction of roofs and/or walls of

Table 2. Local spatial development plans from the Warsaw area considered in the study [<https://architektura.um.warszawa.pl/informacje-o-planach>]

No.	LSDP resolution number Date of starting preparation of the plan Date of adoption of the plan District	Main terrain functions and terrain features related to the study
1.	LXXXVIII/2872/2023 14.10.2021 - 21.09.2023 Mokotów	Green areas (parks, allotment gardens, cemeteries), multi-family housing, services (various), residential greenery, trees recognised as natural monuments, roads of multiple categories, and an air exchange corridor.
2.	XXIII/887/2025 19.09.2024 - 10.07.2025 Bielany	Green areas (parks), groups of trees, and trees of exceptional natural and landscape value, as well as areas vulnerable to flooding in the event of a breach in the flood barrier.
3.	LXXXVIII/2873/2023 10.06.2021 - 21.09.2023 Mokotów/Ochota	Services (various), roads of different categories, green areas (parks), buffer green areas, rows of trees, trees of exceptional natural and landscape value, trees recognised as natural monuments, and the air exchange corridor boundary.
4.	IX/201/2024 10.06.2021 - 29.08.2024 Ochota	Services (various), multi-family housing, green areas (parks), residential greenery, buffer green areas, and roads of multiple categories.
5.	LXXXI/2661/2023 18.06.2020 - 25.05.2023 Ochota	Multi-family housing/services, green areas (parks), residential greenery, rows of trees, technical infrastructure, and access road.
6.	XXIII/885/2025 14.05.2020 - 10.07.2025 Śródmieście	Residential areas (various), services (different), green areas (gardens), rows of trees, surface waters, water intakes from Oligocene wells, border of the Natura 2000 Area OSO Middle Vistula River Valley, border of the Warsaw Landscape Protection Area, border of the area of particular flood risk, roads of multiple categories.
7.	XCVI/3221/2024 24.09.2020, 12.05.2022 - 14.03.2024 Targówek	Multi-family housing, services (various), green areas (parks), residential greenery, rows of trees, trees to be preserved, and roads of multiple categories.
8.	XXIII/880/2025 6.07.2023 - 10.07.2025 Ursus	Multi-family housing, single-family housing, services, green areas (parks), residential greenery, buffer green areas, rows of trees, trees recognised as natural monuments, trees of exceptional natural and landscape value, water reservoir, roads of multiple categories.
9.	X/307/2024 13.10.2022-19.09.2024 Ursynów	Multi-family housing, educational services, green areas (parks), residential greenery, rows of trees, trees of exceptional natural and landscape value, roads of multiple categories.
10.	LXXII/2380/2022 15.10.2020 - 17.11.2022 Włochy	Services (various), including sport and recreation, rows of trees, trees to be preserved, and roads of multiple categories.

buildings is imposed by five plans of the entire set (nos. 1, 6-9).

2. In the case of the category "Water [retention and flooding]", the provisions concerning this issue have been divided into five classes. To eliminate damage caused by flooding resulting from high water levels in the Vistula River, one plan (no. 6) covering a narrow section of the Vistula Riverbed known as the "Warsaw corset" introduces provisions ensuring the construction, maintenance, extension, or reconstruction of existing flood protection measures in accordance with separate regulations.

Two plan drawings indicate areas of flood risk (concerning plans with nos. 2 and 6). To reduce urbanisation pressure on floodplains, both plans introduce restrictions on land use i.e., the first one (which whole area is covered by park) bans even the construction of temporary commercial facilities, and the second one (in which the flood-impacted area is designated for natural greenery, a park or a road) in the area occupied by the park allows only the construction of temporary park pavilions.

There are no large-scale investments related to water retention systems in the city; however, one plan includes

an element of water retention – the natural watercourse, i.e., the Vistula River – as well as the protection and creation of retention areas on a larger scale. This concerns the plan no. 6, where the green areas along the Vistula Riverbank are protected by separate regulations (as they are within the Natura 2000 OSO Dolina Środkowej Wisły (Middle Vistula Valley) area). The area of plan no. 7 is located within the range of an underground water reservoir, which is subject to separate regulations.

On a microscale, the LSDPs introduce solutions that increase the infiltration or retention capacity of the area, including the use of permeable surfaces (provisions in nine plans except the plan no. 6), the creation of rain gardens, small retention reservoirs, bioretention basins, absorption trenches, filtration ditches or other adapted solutions (provisions in all the analysed plans). Six plans (nos. 3, 5-9) out of the set of ten LSDPs prohibit drainage and other works that cause a permanent reduction in groundwater levels or limit the supply of aquifers, if they serve purposes other than nature conservation and rational water management.

Plans provisions ensuring the application of systemic management of rainwater/meltwater include: mandatory pre-treatment of rainwater and meltwater from contaminated paved surfaces, collected in sealed, open or closed sewage systems (seven plans, nos. 1, 3-5, 8-10), drainage of rainwater/meltwater from the plot or building site into the ground using surface drainage devices and, if this is not possible, collection in open or closed retention reservoirs and subsequent use for the property's own purposes (nine plans, nos. 1, 3-10) with the possibility of discharging excess water into the sewage system (eight plans, nos. 1, 3-8 and 10). Eight LSDPs (except the plans with nos. 6 and 7) require the implementation of permeable surfaces within paved roads, parking lots, and pedestrian routes in areas for which a minimum BBA share has been established. Nine plans (nos. 1, 3-5, 8-10) allow for the construction of rainwater/meltwater management systems and facilities that, in addition to their retention/infiltration functions, will serve social and recreational purposes. Summarising all these extensive provisions, they are included in six plans (nos. 1, 3-5, and 9-10). Plan no. 2 requires the use of solutions that involve plantings to aid infiltration.

3. For the "Wind" category, two provision classes were found to support resistance to this threat. The cabling of new power lines is introduced in all the analysed plans. This provision contributes to better use of the city's space and protects power lines from breaking in areas with strong winds.

All plan drawings indicate protective zones around trees that are natural monuments or have exceptional natural and landscape values. However, these provisions primarily aim to protect trees; they also enhance people's safety in their vicinity when a fence surrounds them.

4. Within the "Infrastructure [resilience]" category, three groups of provisions were found to support its resilience to climate change threats. All of the analysed LSDPs establish

the supply of heat and electricity from municipal networks; however, only nine plans allow for other solutions, particularly those using renewable energy sources (i.e., wind, solar or geothermal energy) (the exception is plan no. 2, whose area is covered by a park). Of the three types of renewable energy sources, solar energy is the most popular, and all three are introduced in only three plans (nos. 1, 5, and 8).

All analysed LSDPs include provisions requiring new power lines to be placed underground (cabling), which, in sites particularly exposed to high winds, protects them from damage/breakage.

Also, all the analysed plans establish water supply and sewage collection using municipal networks. It should be emphasised that provisions for rainwater management, grouped under "Water [retention and flooding]", present in all the analysed plans, help protect the sewage system against overload/damage.

5. The "Green spaces" category distinguishes nine groups of solutions that counteract the threats associated with climate change. Skilfully planned green spaces of various sizes play a key role in adapting urban areas to climate change through different mechanisms. Due to the cooling effect of greenery and its ability to retain water, some of the provisions in the "Green spaces" category have already been linked to the "Heat [island]" and "Water [retention and flooding]" categories. Still, they are described in more detail under the "Green spaces" category. The plans ensure the protection of green areas of all sizes, including individual trees. In parks located in areas covered by eight plans (except for plan no. 7 (in which area pocket parks are located) and plan no. 10 (in which a drawing of a sports and recreation area is delineated)), the minimum share of BAA is at 70% or 80%. The plans require the use of solutions that increase the park's retention capacity, in particular permeable surfaces on communication routes, playgrounds, and recreational and sports facilities. In family allotment gardens (which are present within the area of plan no. 1) used for leisure, recreation, and gardening, the biologically active area is at least 80%.

In residential/services areas (in the analysed plans, the residential areas mainly concern multi-family housing), the minimum share of BAA varies from 0% to 50% but in two plans (nos. 6 and 7), areas have been designed, known as green zones or internal courtyards, where this index reaches 60%. There is only one plan (no. 6) that includes small quarters, with the minimum BBA index set to 0%, which means no greenery in this area. Street greenery serving as insulation, implemented as composed greenery and rows of trees, usually occupies at least 10% of the area designated for transportation in the analysed plans; however, the minimum share of BBA ranges from 1% to 40%. For smaller patches of greenery, such as pocket parks and garden zones, delineated in the drawings for plans nos. 6 and 7, the minimum BBA share varies from 60% to 80%.

All plan drawings indicate trees with exceptional natural and landscape values (with a ban on paving the surface in the immediate vicinity of trees, i.e., at less than 1.5 m

from the tree trunk). In three cases (plans with nos. 3, 5 and 8), in addition, the drawings indicate trees that are natural monuments (with protection zones with a radius of 15 m, for which separate regulations apply).

Provisions promoting the development of elements of green and blue infrastructure (BGI) on a microscale overlap with provisions that improve the thermal microclimate and water retention, and they are very popular in the analysed LSDPs. The development of greenery on all non-built-up areas is required in three plans (nos. 3, 5, and 6). In comparison, green tram tracks are introduced in three plans (nos. 3-5), green walls and/or greenery at the elevations of buildings are proposed in seven plans (nos. 4-10), rain gardens, small retention reservoirs, bioretention basins, absorption trenches, filtration ditches or other similar solutions are introduced in all plans.

Of the ten LSDPs analysed, the entire area of one of them (no. 7) is located within the boundaries of a degraded area and a revitalisation area of the capital city of Warsaw. The provisions of this plan, introducing residential and service development areas, guaranteed that a significant part of the area would be designated for green zones, with a share of BBA of at least 60%, with an overall BBA index for the residential and service development areas in the range of 20-50%, which confirms the “good practice” of increasing green spaces in the city.

The LSDPs require the use of tree and shrub species that are adapted to local habitat conditions, and in three cases (plans with nos. 4, 8, and 9), they must be highly resistant to climate change conditions.

As for the provisions protecting natural greenery, they are included in plan no. 6, which covers the area adjacent to the Vistula River. The plan shows the boundaries of the Natura 2000 OSO Dolina Środkowej Wisły (Middle Vistula Valley) area. Establishing the protection of this area in the resolution refers to separate regulations.

The protection and modelling of the network of green areas covered by the plan, together with the areas outside its boundaries (as included in six out of ten analysed plans with nos. 1-6) often includes areas protected under separate regulations (such as the Warsaw Protected Landscape Area (Warszawski Obszar Chronionego Krajobrazu), landscape priority areas identified in the Landscape Audit prepared at the voivodship level of spatial planning system and listed above the Middle Vistula Valley area).

In five plans (nos. 1, 3, 5, 6, 10), the green spaces are located within the boundaries of the conservation areas, and in three cases (plans with nos. 5, 6, 10), they are protected under special regulations.

All the LSDPs examined include provisions to address the threats associated with climate change; however, the areas covered by the plans are developed in different ways (i.e., assigned different functions and development conditions) and are located in various districts of Warsaw (Table 2). The provisions of the analysed LSDPs are consistent with the city's strategy to strengthen Warsaw's resilience to climate change, as formulated in the UAP for Warsaw. However, only one plan (no. 2), in light of the legal regulations, required

the inclusion of conclusions and recommendations from the UAP for Warsaw during its preparation.

Based on results from similar studies in the literature, the following can be observed. The results of the current study support the findings of Brandsma et al. [2024] and Uittenbroek et al. [2013], who found that climate change strategies are predominantly incorporated into existing policy instruments, including LSDPs (also known as urban development plans, zoning plans). The integration of adaptation into urban planning increases its effectiveness, as found by Baack et al. [2024], who compared two municipalities in the Netherlands (i.e., Zwolle and Enschede), and emphasised by Nowak et al. [2024].

Similar to Andrzejewska's [2021] analysis concerning the Lower Silesian and Greater Poland voivodships, the analysed LSDPs for Warsaw, among the provisions aiming to counteract climate change, cover both provisions directly related to climate change threats and provisions concerning a sustainable built environment. These provisions implement requirements for protecting the environment, nature, and landscape, and for preserving spatial structure (spatial order).

As in the case of the study of Matuszko et al. [2023] on Kraków and the studies of Yiannakou and Salata's [2017] and Thoidou [2021] on Thessaloniki, green spaces are also at the centre of urban planning in Warsaw to achieve urban resilience to climate change threats, to minimise the UHI. Although Łaska [2021], based on an analysis of 26 plans for Warsaw adopted between 1996 and 2021, which preparation started before the adoption of the UPA for Warsaw, stated that “issues related to the development and protection of green areas are not sufficiently taken into account”. She also noted that these issues have become more critical over the years. The results of the current study confirm this tendency, as the analysed LSDPs whose preparations began after the adoption of the UAP for Warsaw strongly emphasise the need to identify and preserve green areas and to apply solutions based on natural resources.

As in the case study of Davids et al. [2015] on Stockholm, mitigation measures (to minimise the threats associated with climate change) are often implemented in Warsaw, while prevention measures (to avoid threats) are rare. Contrary to the 15 selected zoning plans for the four Norwegian municipalities (i.e. Bodø, Østfold, Stavanger, and Trondheim) analysed by Marini et al. [2025], none of the analysed Warsaw LSDPs mentioned the NBS directly in their resolutions; however, their provisions aiming to counteract climate change refer to the NBS. As in the case of Norwegian documents, Warsaw's LSDPs provisions concern both the so called NBS units such as new spatial mixed vegetation units (namely parks, green corridors), arboreal units (such as urban trees) or technological units (such as rain gardens, green roofs, and infiltration basins) and the NBS interventions understood as “the act of intervening in specific ecosystems or in NBS units by applying measures or techniques to support natural processes and biodiversity” [Castellar et al. 2021].

Table 3. The results of the content analysis of the set of LSDPs for Warsaw

Category	LSDP's resolution number/ Provisions									
	LXXXVIII/2872/2023	XXIII/887/2025	LXXXVIII/2873/2023	IX/201/2024	LXXXI/2661/2023	XXIII/885/2025	XCVI/3221/2024	XXIII/880/2025	X/307/2024	LXXII/2380/2022
Plan No	1	2	3	4	5	6	7	8	9	10
Cat.1	1. Ventilation of the city: active protection (·), passive protection (◊); no ventilation corridor located in the area covered by the plan (-).									
	-	-	-	-	-	◊	◊	-	-	-
	2. Protection of green areas (G): parks (Ш), allotment gardens (и), cemetery (c), greenery zones in residential and services areas (Δ), buffer green areas in communication areas (), pocket parks (ш), garden zones (ω); groups or rows of trees (♂), individual trees (†); public access (⊙).									
	Ши cΔω♂↑⊙⊙	Ш♂↑⊙	ШΔ ♂↑⊙	ШΔ ♂↑⊙	ШΔ ♂↑⊙	ШΔω♂↑⊙	Δ Ш♂↑⊙	ШΔ ♂↑⊙	Ш♂⊙	Δ♂↑⊙
	3. Thermal comfort in microscale: green areas (G), green walls or vertical gardens (#), green roofs (Λ), green tram tracks (≡); permeable surfaces (...).									
	G...	G...	G≡...	G#Λ≡...	G≡...	GΛ	G#Λ...	G#Λ...	GΛ...	GΛ...
Cat.2	4. Restrictions for buildings: materials (≡), colours (≡); no buildings in the plan area (-).									
	≡	-	≡	≡	≡	≡	≡	≡	≡	≡
	1. Flood protection measures: measures located at the plan area (m); measures located outside the plan area (~); no such measures needed (-).									
	-	~	-	-	-	m	-	-	-	-
	2. Restrictions on high flood risk areas: delineation of areas (⊂), land use – the park (P), natural greenery (-), transportation areas(v)), only construction of park pavilions in the form of temporary structures is permitted (n); temporary commercial structures are prohibited (banned) ⊗; no such areas (-).									
	-	⊂P⊗	-	-	-	⊂Pn-v	-	-	-	-
	3. Water retention systems in the city (R): natural watercourse (≈); larger retention reservoirs (U), drainage ditches (≡) or other artificial retention facilities (f); no larger retention facilities at the plan area (-); larger retention areas (—); the area of the plan within the reach of the groundwater reservoir (ū).									
	-	-	-	-	-	—≈	ū	-	-	-
	4. Water retention solutions in microscale – located within the boundaries of the plot (mR): permeable surfaces (...), rain gardens (↓), small retention reservoirs (U), bioretention basins (e), absorption trenches (—), filtration ditches (—), other solutions (o); prohibition on introducing permanent changes to water conditions (⊙).									
	...↓e—_o	...o	...↓eU—_o⊙	...e—_o	...↓e—_o⊙	U—_o⊙	...Ue—_o⊙	...↓Ueo	...↓Ue—_o⊙	...Ue—_o
	5. Rainwater management (RM): mandatory pre-treatment of rainwater/meltwater from contaminated paved surfaces (≡), drainage of rainwater/meltwater from the plot or building site into the ground (»), "exceptionally" discharging rainwater/meltwater into the sewage system (for example excess water) (↓); permeable surfaces (...); construction of rainwater/meltwater management systems and facilities that, in addition to their retention/infiltration functions, will serve social and recreational purposes (*), vegetation planting to support filtration (i).									
	mR≡»↓...*	...i	mR≡»↓...*	mR≡»↓...*	mR≡»↓...*	mR»↓	mR»↓	mR≡»↓...*	mR≡»...*	mR≡»↓...*
Cat.3	1. Protection zones around trees (○).									
	○	○	○	○	○	○	○	○	○	○
Cat.4	2. Cabling the power lines (⊙).									
	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
	1. Promoting of renewable energy sources: wind (O), solar (☼), geothermal energy (☼); no such provisions in the plan resolution (-).									
	O☼☼	-	☼	☼	O☼☼	☼	☼☼	O☼☼	☼	☼
	2. Cabling the power lines (⊙).									
	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Cat.4	3. Applying rainwater retention solutions to protect the sewage and rainwater collection system.									
	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM

Table 3. The results of the content analysis of the set of LSDPs for Warsaw

Category	LSDP's resolution number/ Provisions									
	LXXXVIII/2872/2023	XXIII/887/2025	LXXXVIII/2873/2023	IX/201/2024	LXXXI/2661/2023	XXIII/885/2025	XCVI/3221/2024	XXIII/880/2025	X/307/2024	LXXII/2380/2022
Plan No	1	2	3	4	5	6	7	8	9	10
Cat.5	1. Protection of larger green areas: min BBA in %; no such areas (-).									
	Parks.									
	70	70	80	70	80	70	-	70, 80	75,80	-
	Allotment gardens.									
	80	-	-	-	-	-	-	-	-	-
	Residential and services areas (with higher values of min BBA in % for zones of greenery or internal backyards).									
	40	-	20 - 30	25 - 40	15 - 25	0 - 45 (40-60)	20 - 50 (60)	25 - 40	25 - 40	40
	Zones of greenery in transportation areas - buffer green areas.									
	1 - 40	-	10, 20	10, 15	10, 20	1 - 30	5 - 40	1 - 20	5 - 35	1 - 15
	2. Protection of smaller patches of greenery: pocket parks, garden zones;no such areas (-).									
	-	-	-	-	-	60, 80	70	-	-	-
	3. Protection zones around trees of exceptional landscape value (♣) and monuments (♣).									
	♣	♣	♣♣	♣	♣♣	♣	♣	♣♣	♣	♣
	4. Development of BGI elements: requiring the development of greenery on all non-built-up areas (%); green walls or vertical gardens (#), green roofs (^); green tram tracks (H); rain gardens (↓), small retention reservoirs (U), bioretention basins (e), absorption trenches (—), filtration ditches (□), other solutions (o);the park covers the whole plan area (**).									
	↓e—o	**o	%H ↓eU—o	#^H e—o	H#↓e—o	%^U—o	%#^Ue—o	#^↓Ueo	^↓Ue—o	^Ue—o
	5. Degraded land transformation into green areas (⌘); no degraded land in the plan area (-).									
	-	-	-	-	-	-	⌘	-	-	-
	6. Selection of species for planting; species composition adapted to local conditions (L), climate change threats-resistant species (R).									
	L	L	L	LR	L	L	L	R	LR	L
	7. Protection of natural greenery (□);no natural greenery in the plan area (-).									
	-	-	-	-	-	□	-	-	-	-
	8. Modelling of natural connection Network (*); restrictions on land use in accordance with separate regulations concerning priority landscapes (j), Warsaw Protected Landscape Area (k), Natura 2000 Middle Vistula Valley area (l).									
	*	*j	*	*j	*	*jk	-	-	-	-
	9. Green spaces within the boundaries of the conservation area with an order to preserve existing greenery (!); land development in accordance with separate regulations (3)									
	!	-	!	-	!3	!3	-	-	-	!3

The UAP for Warsaw [Kassenberg, Szymalski 2019] emphasises that adaptation measures should be integrated with efforts to reduce greenhouse gas emissions. Although this issue is beyond the scope of this strategic document and this study, it was impossible not to notice when reading the adopted LSDPs that they also contain numerous provisions that are related to climate change mitigation measures, such as a ban on the use of fossil fuels for heating, the use of cogeneration sources, the availability of public transport, and the avoidance of scattered development on the outskirts of the city. Similar provisions were acknowledged by Andrzejewska [2021].

As Uittenbroek et al. [2012] stressed, “the policy process including climate change adaptation can expect barriers to or limitations that are social, cognitive, financial, technological and organisational/institutional in nature” (in this categorisation, the ecological and physical barriers are within the technological category as they can be overcome by innovative technology). As they observed, based on the evaluation of two Dutch cases of Schirveste and Westflank, these barriers/limitations occur with varying intensity in different phases of mainstreaming adaptation into projects (they considered following Moser and Ekstrom's [2010] analytical framework for the adaptation

process, which consists of three phases: the understanding phase, the planning phase and the managing phase). It can be expected that, during the implementation of LSDPs in Warsaw's urban space, the practical barriers/limitations mentioned above will arise. With a limited local government budget, investments may be postponed or implemented to a limited extent. The effectiveness and pace of action may be limited in municipalities by procedures that require coordination among many departments within the municipal office. Property owners/investors may also perceive the requirements to increase the share of greenery on plots, manage rainwater where it falls, and limit the building area as restrictions on their rights to develop their land.

As the analysis described in this paper could be further expanded to include other larger cities in Poland, it would be interesting to find out about these barriers/limitations by including in future research other research methods, such as monitoring the implementation in urban space and interviews with planners, municipal authorities, city residents and investors.

4. CONCLUSION

The results of this exploratory study conducted in Warsaw show that the potential of local spatial planning for climate change adaptation is well utilised, and that LSDPs effectively implement the city's strategy to strengthen its resilience to climate change threats, as formulated in the UAP for Warsaw. However, only one of the ten LSDPs analysed, in light of the legal regulations, required the inclusion of recommendations and guidelines from the climate change adaptation plan during its preparation. This confirms that spatial planners developing the LSDPs in Warsaw have been aware of the need for and importance of mainstreaming climate change adaptation into urban development planning before the introduction of legal regulations.

As the study is limited to the capital, it would be interesting to examine the situation in other large cities in Poland and include other research methods in future studies, such as monitoring implementation in urban spaces and interviews with stakeholders involved in the spatial planning process.

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