Spatial implications of climate actions – the role of spatial planning for climate change adaptation in Poland and Ukraine

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Key words: resilience to climate change, land management, land use patterns, planning provisions, green infrastructure, cities

SUMMARY

Spatial planning and land management play pivotal roles in addressing climate change, as highlighted by the IPCC. Recognized as a priority sector for adaptation, spatial planning holds the potential to contribute significantly to the development of resilient urban structures. In both Poland and Ukraine, local climate adaptation plans are crafted by cities to coordinate multisectoral efforts. Given the spatial implications of numerous planned actions, spatial planning emerges as a crucial mechanism for effective coordination.

This comparative study aims to delve into the spatial dimension of actions outlined in local climate adaptation plans and explore how they can be translated into spatial planning instruments and tools for practical implementation. The research will involve a comprehensive review of climate adaptation plans, focusing on spatially related actions, and will analyse planning provisions in selected case studies from Poland and Ukraine. The objective is to showcase the most commonly employed planning tools and assess their alignment with the objectives outlined in climate adaptation plans. The emphasis will be put on the green infrastructure planning sector. Through this examination, the study seeks to contribute valuable insights to the intersection of spatial planning and climate adaptation strategies in the context of urban development in Poland and Ukraine.

1. INTRODUCTION

Spatial planning and sustainable land management play a pivotal role in addressing climate change, as emphasized by IPCC Report (2022). Recognized as a priority sector for adaptation, it has the potential to significantly contribute to the development of resilient urban structures through the implementation of green infrastructure.

Poland and Ukraine, neighboring countries in middle-eastern Europe, are both signatories to the Paris Agreement (2015) and the UN Agenda 2030 for Sustainable Development (2015). In Poland, a member of the European Union (EU) community, and Ukraine, aspiring to join the EU, consider cities crucial for socio-economic development as they are primary contributors to national income.. Poland's 979 cities house over 60% of its population (GUS, 2023), while Ukraine's 461 cities accommodate nearly 70% (ДССУ, 2021). This urbanization trend is projected to grow by 10% by 2050 according to UN data (UN, 2018).

Urban adaptive capacity building is a goal outlined in the EU Climate Change Adaptation Strategy (COM, 2013b). Member States are encouraged to adopt global adaptation strategies and action plans, modeled after the Covenant of Mayors, supported by funding for enhanced adaptability. This includes fostering awareness in decision-making processes by addressing knowledge gaps through the European Climate Adaptation Platform (COM, 2013a). This commitment is continued in the "Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change" (2021). Given that green infrastructure is a crucial tool for climate adaptation (COM, 2013c), there is a pressing need to incorporate it into urban governance and planning agendas using policy instruments such as spatial planning (COM, 2021, COM, 2020). However, there is a literature gap regarding the practical use of specific policy instruments to promote green infrastructure adoption (Mendonça et al., 2021).

This comparative study aims to delve into the spatial dimension of actions outlined in local urban climate adaptation plans and explore how they can be translated into spatial planning instruments and tools for practical implementation. The emphasis will be put on the green infrastructure planning sector. Through this examination, the study seeks to contribute valuable insights to the intersection of spatial planning and climate adaptation strategies in the context of urban development in Poland and Ukraine.

2. SPATIAL DIMENSIONS OF CLIMATE ADAPTATION

Geospatial data for climate action serves two main purposes: the diagnostic stage and the strategic stage. The diagnostic stage includes exposing and inventorying vulnerabilities related to precipitation distribution, flooding, inundation areas, landslides, erosion, soil sealing, land use/land cover (LULC), and the spatial distribution of population density (IOŚ-POB, 2023b). Additionally, it covers land surface temperature (LST) and Urban Heat Island Intensity (UHI).

Strategic actions encompass administrative, technical, or educational measures. Administrative actions involve the synergy of strategic planning documents, such as spatial policy documents, local spatial master or revitalization plans, as well as reviewing and/or developing urban standards in line with climate adaptation principles. Legal protection of natural systems and ventilation corridors is also included. Technical instruments pertain to green-blue infrastructure planning, covering rainwater sustainable management, planning or modernization of open spaces and recreation areas, and protecting, developing, and managing urban forests. The adaptation actions catalogue (IOŚ-POB, 2023a) also includes actions on ecosystem restitution, renaturalization, and the redevelopment of degraded areas. Educational climate actions aim to build community awareness and involvement.

According to Rędzińska and Piotrkowska (2020), planning and design adaptation tools fall into four categories: 1) zoning, 2) urban design indicators, 3) urban structure, and 4) technical/nature-based solutions. Zoning helps establish the proper distribution and size of green infrastructure areas. Urban design indicators, such as the biologically active areas index and surface runoff indicator, shape conditions for natural processes in built areas and form the basis for urban composition. Urban structure relates to urban design composition, including building height and layout, green area layout and size, and vegetation structure. Technical solutions embedded in planning provisions include small nature-based solutions like green, blue, or cool roofs, green and cool walls or facades, cool pavements, permeable surfaces, surface reservoirs, water squares (rainwater harvesting ponds), wetlands, constructed wetlands, bioretention basins, infiltration basins and trenches, and rain gardens. These solutions modify land surface albedo and temperature, improving urban cooling and rainwater retention.

3. METHOD

Our study comprises three stages: 1) analysis of the legal framework for urban climate adaptation, based on national, regional, and local strategical documents and the spatial planning system; 2) a comprehensive review of climate adaptation plans, with one exemplary case study for each country, focusing on spatially related elements of diagnosis and planned actions. This is based on available European and national guidelines (COM, 2013a, IOŚ-POB, 2023b, Bertoldi et al., 2014) and observed practice (IOŚ-POB, 2023a); 3) presentation of planning provisions in selected case studies from Poland and Ukraine.

In Poland, we analyzed the case study of Krakow, the second-largest city in the country, facing challenges such as air pollution and a low percentage of green areas (11%, with forests at 4.3%). Krakow is actively undertaking climate actions, signing the Covenant of Majors in 2022 and participating in the EU Climate Neutral and Smart Cities mission. Planning documents analyzed include Municipal Climate Adaptation Plan (WGKiK, 2019), Green areas development strategy (WKŚ, 2019), Environmental Protection Program (WKŚ, 2021), Socio-economic development strategy (WSPiMI, 2023), Spatial development policy (WPP, 2014).

In Ukraine, the city of Lviv serves as a case study. Lviv is among the ten largest cities in the country, with a population of 783,065 and an area of 315.6 km2. The city faces challenges such as surface water pollution, low energy efficiency of buildings, and the harmful effect of climatic mines on natural resources. Documents analyzed for Lviv include "Vulnerability assessment and adaptation measures to climate change. Lviv" (Шевченко and Власюк, 2015), "Sustainable energy development and climate action plan of the Lviv urban territorial community" (within the "Agreement of Mayors") (ЛМР and ІМ, 2022). "Strategy and development project of the Lviv agglomeration until 2027" (Кошелюк, 2023), Green City Action Plan Lviv 2020-2035 (EMPRESS/ENVIROS, 2020)."Comprehensive Strategy for the Development of Lviv 2012-2025" (ЛМР, 2012)

4. RESULTS

1.1. Legal framework for urban climate adaptation and spatial planning

Poland and Ukraine have recognized the imperative for urban climate adaptation and underscored it in various national-level strategies. Key documents include the Strategical Climate Adaptation Plan for vulnerable sectors by 2020 with a perspective to 2030 (MKiŚ, 2013), the "National Urban Policy 2030" (2022) in Poland, and the Environmental Security and Climate Adaptation Strategy until 2030 (КМУ, 2021) in Ukraine.

In both Poland and Ukraine, cities develop local climate adaptation plans to coordinate multisectoral efforts. In Poland, the MPA44 project was instrumental, producing 44 climate adaptation plans for cities with over 100,000 residents. All 44 plans from this project follow a unified methodology (IOŚ-POB, 2023b). 122 Polish cities are Covenant of Mayors signatories. In Ukraine, the Covenant of Mayors has played a pivotal role in climate change adaptation, involving the development of Sustainable Energy and Climate Action Plans. Currently, 103 cities in Ukraine have developed adaptation plans (CoMEast, 2023) in line with European Commission guidelines (Bertoldi et al., 2014). National guidelines for elaborating climate adaptation plans were also established in Ukraine (Лящук and Гузенко, 2023).

The Polish case study analyzed in this paper focuses on one of the 44 cities in the Feel the Climate Project (MPA 44), while the Ukrainian case study exemplifies the approach of the Covenant of Mayors.

Given the spatial implications of numerous planned actions, spatial planning emerges as a crucial mechanism for effective coordination. However, even though climate change adaptation is well recognized at the strategic level, the Polish and Ukrainian spatial planning system does not directly address this issue. It requires the provision of proper living conditions and the maintenance of ecological balance.

Key instruments from the climate adaptation perspective in Poland are spatial policy planning documents with local urban design standards and facultatively accessibility (to green areas) standards, as well as local spatial development master plans (RMRP, 2001, RMRP, 2003, RMRP, 2023). At the local level, the spatial planning policy specifies the model of spatial-functional structure by establishing zones such as open zones, green areas and recreation zones, agricultural production zones, or multifunctional zones with various types of housing, etc.

Among urban design standards are maximum building density and height, maximum building area share, and minimum share of biologically active area (RMRP, 2023).

Similarly, in the current planning system in Ukraine, at the local level, the core instrument is the Comprehensive Plan for Municipality. It provides a long-term planning and development strategy and zoning. On a district level, a Detailed Plan is drafted based on local terms of reference and has to adhere to the overarching plans. The Detailed Plan describes the volume and height of the development, functional use of land plots and/or buildings, transport, and social infrastructure schemes (Anisimov et al., 2023). Ukrainian legal regulations address the preservation of ecology, zoning, and the provision of public access to green areas in the field of architectural and urban planning activities (ДБН, 2019, ДБН, 2011, ДБН, 2021).

In both countries, the strategic environmental impact assessment is an integral part of the system.

1.2. Spatially related diagnosis in climate adaptation plans

The adaptation plan for the city of Krakow (WGKiK, 2019) contains a diagnostic and strategic part. Cartographically, the city was characterized by its location in the context of geographical mesoregion units, natural relief (numerical terrain model), and hydrological conditions, including surface and groundwaters, without showing the catchments. Based on the spatial-functional structure of the city and vulnerable sectors indicated in SPA (MKiŚ, 2013), 11 vulnerability areas were identified (Fig. 1).

Vulnerability areas then served as aggregation units for the social and environmental conditions analysis. Data on population density with a focus on vulnerable groups such as children under five years old and elderly people 65+ distribution in the city (fig. 2-4) were aggregated to vulnerability units. Similarly, the data on the share of biologically active areas and soil sealing level were aggregated to vulnerability units. Moreover, information on building density ratio was provided. The vulnerability analysis of the City of Krakow was performed for 11 sectors/areas to select the four most sensitive sectors/areas to climate change and to identify the components that, due to their vulnerability or insufficient adaptive potential, should be subject to adaptation measures. However, the results were provided descriptively without cartographic illustration.

The diagnostic section describes climatic phenomena and their derivatives affecting the city (such as heat, frost, precipitation, floods, drought, wind, etc.) based on historical data from weather stations. Climate change forecasts were also presented. The exposition on climatic threats was presented descriptively, based on climatic data and flood risk estimation. However, maps were not provided. The exposition of the following risks was diagnosed: heatwaves, drought, torrential rains causing urban floods and flooding from rivers, cold waves, storms, including thunderstorms and associated strong winds. Significant threats also included the concentration of air pollution and the occurrence of smog. High-intensity development areas, including green areas, were indicated as one of the four most vulnerable city sectors/areas, next to public health, transportation, and water management. One of the criteria for the city’s vulnerability assessment was the systematic protection and planning of urban ecosystems (blue-green infrastructure).

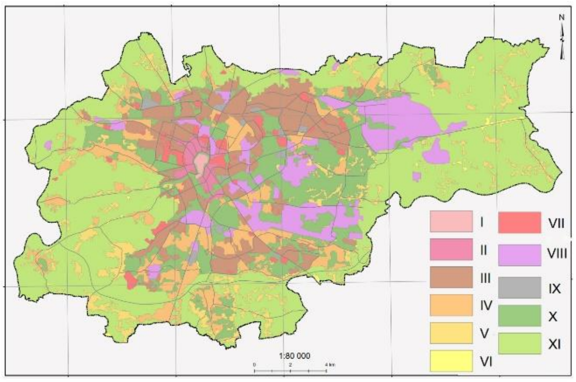

Fig. 1. Urban climate vulnerability areas (WGKiK, 2019)

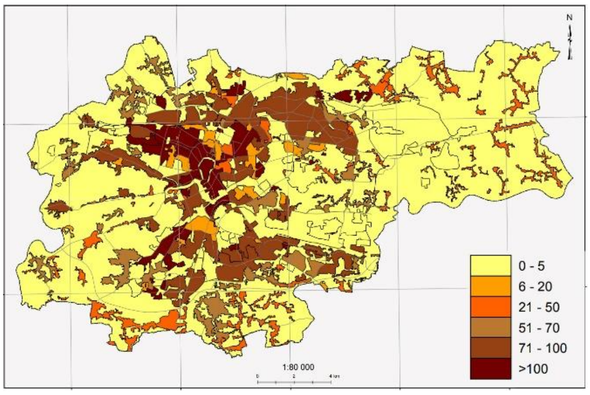

Fig. 2. Population density (person/ha) in vulnerability areas (WGKiK, 2019)

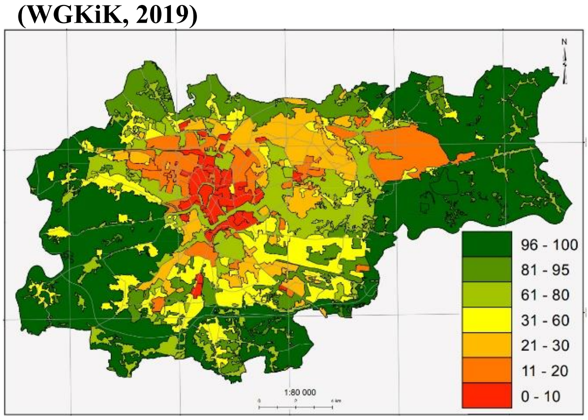

Fig. 3. Biologicaly active areas [%] in vulnerability areas (WGKiK, 2019)

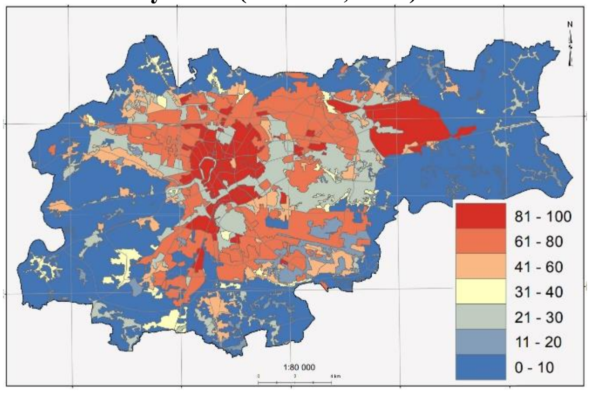

Fig. 4. Soil sealing [%] in vulnerability areas (WGKiK, 2019)

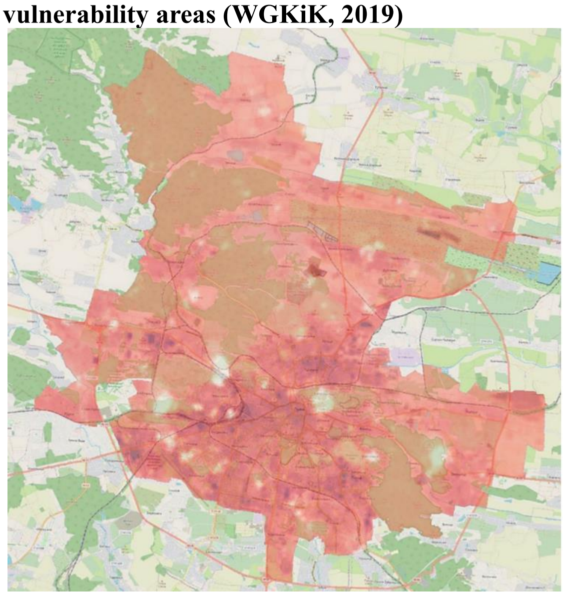

Fig. 5. Land Surface Temperature (ЛМР and ІМ, 2022)

To assess the risks and vulnerability of the Lviv urban territorial community, the method of the Agreement of Mayors and the European Commission manual's recommendations (Bertoldi et al., 2014) were used. Among the threats to Lviv associated with climate change, such as heat, drought, deterioration of water quality, extreme precipitation, flooding, snowfall, storms, fires in ecosystems, and atmospheric air pollution, biological threats were analyzed. Increasing urbanization has a negative effect on the temperature regime in the city (ЛМР and ІМ, 2022) (Fig. 5).

The results of the risk assessment are summarized in a table, and among them, Lviv is recognized as highly vulnerable to extreme heat, precipitation, flooding, storms, and fires in ecosystems. It is noted that there is a lack of green spaces and water surfaces in the city. Among other things, the reasons for the frequent flooding of the city are the large number of artificial surfaces and the high density of buildings, which directly follows from the irrational formation of the urban space. The occurrence of fires in peatlands has a particularly harmful effect on the quality of the atmosphere and is caused by rising temperatures and dry periods. The threat of deterioration of the air condition is recognized as medium with a significant impact. From this, we can conclude that increasing the area of greening in the city is extremely urgent.

1.3. Spatially related actions in climate adaptation plans

In Krakow (WGKiK, 2019), the main aim of the urban adaptation plan was to increase and utilize the adaptive potential of the City of Krakow to ensure the protection of the quality of life of residents and further sustainable development of the City under climate change conditions. Operational objectives were focused on increasing the city's resilience to the occurrence of: (1) higher maximum temperatures and heatwaves, compounded by the phenomenon of the urban heat island; (2) occurrence of cold waves; (3) transient temperatures; (4) heavy rains and sudden/urban floods; (5) flooding from rivers; (6) reducing the occurrence of exceedances of air pollution concentration standards, including smog episodes.

We identified seven spatially related actions focused on green infrastructure. Identified actions can be divided into three types: administrative, technical, and educational. Administrative actions encompassed research on gaps in climate adaptation-related knowledge on the city and securing land for urban greenery and valuable natural areas in the municipality's resources by legislation and purchasing. Legal instruments to be used were local land use plans elaborated to provide a system of air exchange and regeneration, protection of floodplains, and reduction of sealed surfaces area. Among technical actions, we found the development and modernization of the City's drainage system and management of rainwater, including green-blue infrastructure solutions. Locations of investments were provided. Another technical actions group was related to green infrastructure in terms of green areas (parks, squares, etc.), where locations of parks were provided, and the development of smaller forms of green infrastructure (green roofs, walls, bus stops and tracks, climbers on noise barriers, pocket parks, and rain gardens), the greening of inner courtyards in the Old Town and compact downtown areas, use green infrastructure in the rehabilitation of degraded areas, including post-industrial, as well as reducing or unsealing impervious surfaces in the city. Moreover, we included in this type of actions the implementation of the county forest cover increase program of the city of Krakow for 2018-2040. Construction and development of parks as a system of blue-green infrastructure were linked to educational and informational activities.

In Lviv, the main tasks within the framework of the sustainable energy development and climate action plan (ЛМР and ІМ, 2022) are to reduce the consumption of energy resources, reduce

CO_2 emissions, increase the share of alternative energy sources, more rational use of resources by residents, energy and economic security, and create conditions for attracting investments for the implementation of energy-efficient measures and programs. Among the proposed measures are those related to green infrastructure. In particular, the expansion of "green" and "blue" zones, the introduction of adaptation measures based on nature conservation solutions, the improvement of conditions for increasing the diversity of flora and fauna. Also, measures that may indirectly be related to the expansion of the city's green infrastructure. These include improving air quality, using renewable energy sources, developing a sustainable water and wastewater management system, creating a sustainable urban infrastructure, and developing energy-efficient buildings. In the direction of education, measures are proposed to increase citizens' awareness of climate change issues.

1.4. Exemplification on spatial planning provisions

The key instrument in Krakow is the "Directions for the Development and Management of Green Areas in Krakow 2019-2030" (WKŚ, 2019) (Fig. 6). This document provides four types of directions (planning, administration, investment, and protection) allocated to the areas in the geospatial database. The conception of green areas development incorporates the city's natural system established in the Spatial Policy Document (WPP, 2014).

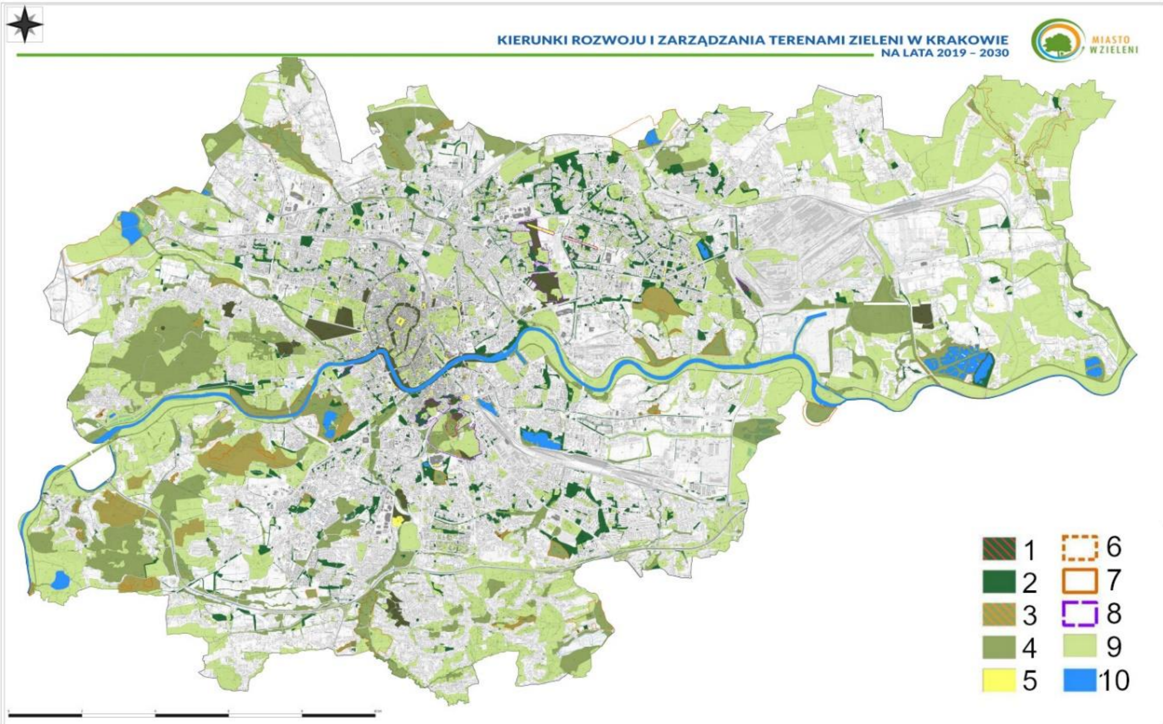

Fig. 7. Direction for green areas development in Krakaw (WKŚ, 2019): 1-5 – public green areas system; 6-8 – areas indicated for protection; 8 – supporting open spaces; 10 – surface waters

The natural system zone includes, among other things, legally protected areas, forests, major urban greenery complexes, major ecological corridors, and major ventilation corridors of the City. Within the zone of the formation of the natural system, areas are designated as protected from development, areas intended for development, in which development standards must ensure a minimum 50% share of biologically active area, and areas of agricultural productive space. The planned system principles include connectivity of the natural system and parks and recreation system, protection of existing and planning of new green areas, as well as an increase in tree canopy. The Environmental Protection Program (WKŚ, 2021) as an operational document allocates actions related to spatial planning, funding, and the development of the geospatial information system. The latest strategy for development (WSPiMI, 2023) provides models of spatial-functional structure in terms of public services and the natural system network. The existing and new green areas are indicated. Kraków has 78% coverage of spatial development master plans, which must be consistent with spatial policy.

For the city of Lviv, green spaces have always been very important (Fig. 8). After 2014, many green areas were revitalized. The city embarked on the development of spaces for pedestrians and the establishment of a network of bicycle paths. In connection with this, the network of small parks with recreational infrastructure is also expanding. Green space development projects are not limited to the city limits. Lviv is included in the system of protected territories of the region. In particular, the "Development Strategy of the Lviv Agglomeration for 2027" (Кошелюк, 2023) includes measures to increase green areas in the city and create and preserve the "green belt" of Lviv (Fig. 9). It should also be noted that Lviv is located in the immediate vicinity of the Roztochchi biosphere reserve and is actually its continuation. Among the operational goals, the preservation of the natural environment and the development of a network of "green" and "blue" spaces are particularly emphasized. According to Maksymenko et al. (2022) green infrastructure system was also implemented in Lviv Master Plan (Fig. 8).

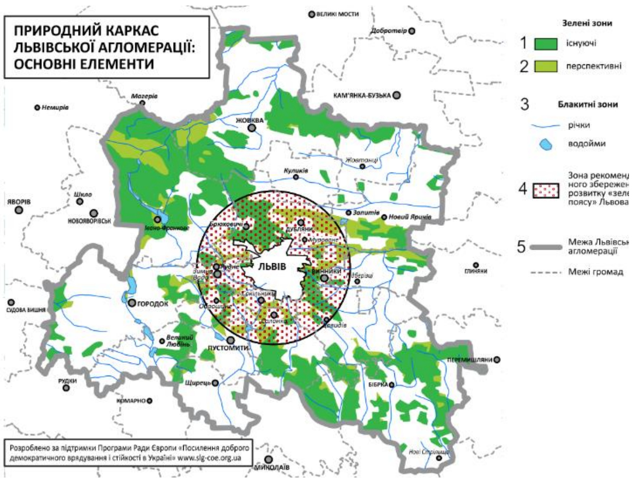

Fig. 9 Strategy and development project of the Lviv agglomeration until 2027 (Кошелюк, 2023)

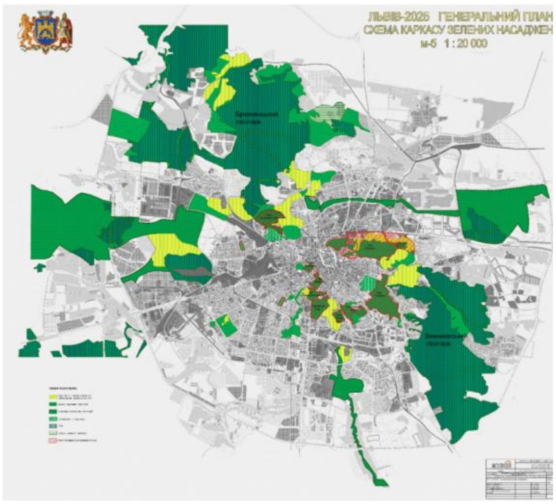

Fig. 8. Lviv Master Plan after Maksymenko et al. (2022)

5. SUMMARY AND CONCLUSIONS

Poland and Ukraine have undertaken climate actions in line with the European Framework and provided national policies and guidelines. In both countries, over a hundred cities have elaborated their climate action plans. While the cities' characteristics and exposure to climatic threats have been spatially imaged, there is a lack of cartographic illustration of vulnerability distribution, as well as spatial prioritization of climatic actions.

The planned actions, including green infrastructure planning and implementation, were crucial targets that involved the deployment of spatial planning instruments and tools. However, spatial planning regulations took climatic and environmental considerations into account only at a general level. The main instruments at the city scale are spatial policy expressed by land use zoning and local urban design standards.

There is a need for geospatial inventory not only in the climate adaptation plan elaboration process but also in the green infrastructure planning process in terms of climatic and hydrological threats, urban cooling, and flooding resilience ecosystem services, as well as the identification of green infrastructure resources. Moreover, optimization, prioritization, and evaluation of solutions are needed. Geospatial data in the form of web portals can inform about resources and threats, as well as build citizens' involvement by using the citizen science concept

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