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Planning for Urban Development in the Context of Climate Change. Evidence from Poland and Romania

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A B S T R A C T

Climate change effects are becoming increasingly noticeable especially in the dynamic and overcrowded city areas. The frequency of occurrence and ways of appearance of natural risks along with the negative effects of intensive economic activities, energy conventional production, unsustainable transportation and energy consumption determine increases in dysfunctions that must be managed by the local authorities in the long term. This study addresses climate change in relation to policy and regulatory framework for urban planning. The article portrays several climate change-related threats that usually occur in urban areas, which are emphasized in the scientific literature, but also exemplifies practical solutions formulated by planners in their strategy for sustainable urban development as counteracting the current specific threats. The selected case studies are the cities of Kraków in Poland and of Cluj-Napoca in Romania. Results of the literature review show that the main risks related to sustainability of the urban areas, as effects of the climate change and man-made actions, are correspondingly visible and addressed in the main strategic plans at the local level, adopted by the city authorities as practical measures and actions to be implemented by 2030 aiming to limit the effects of the climate changes that arise, as well as to limit the causes that generate these changes. By implementing the proposed measures and by achieving the objectives described in the presented action plans, both of the selected cities prove their engagement in the European mission of climate change adaptation and mitigation.

1. INTRODUCTION

Due to human activity, the risk of irreversible climate changes on the globe is continuously increasing. The phenomenon of climate warming is highly debated in many environmental studies, ranging from many years of temperature studies from meteorological stations (Royé et al., 2020) to the detection of climate change using satellite data (Sobrino et al., 2020). Today, climate change can be observed even overnight

(Sippel et al., 2020). The greatest threat from climate change is its increasing pace, which does not allow plants, animals, and humans to adapt to the new conditions. Climate change also threatens the places where people live, in particular, urban environments with a large concentration of residents. An increase in temperature, the suddenness of weather phenomena, social problems related to the increasing number of city residents, or intensive energy-consuming economic activities are some of the drivers for the occurrence or maintenance of cities' dysfunctions. These, in fact, have been subject of the strategies and plans for development, independently or not of the climate change phenomenon. Planning for urban development in relation to climate change should therefore become a regular must in maintaining the functionality of an urban or metropolitan area, while engaging altogether relevant local and regional stakeholders and the local community in communication, education and action for sustainability.

The global strategic context for sustainable development prioritizes urban areas as the main pillars for sustainable and smart development in a larger territory. Through its 11th objective - Sustainable cities and communities – the global aim is to reach a stable level of resilience, safe and sustainable for the human settlements (UN, 2015). Thus, the 17 synthetic objectives of Agenda 2030 (SDGs) have become a reference framework for the subsequent strategic plans for territorial development at any spatial scale. The Urban Agenda for the urban areas in the European Union, with the founding document – the Pact of Amsterdam launched in 2016, establishes the main themes to be considered in setting up the regulatory framework, policies and strategies for the planning and development of urban areas. Thus the EU brings cities at the forefront of a more cohesive socioeconomic territorial development at the European level. This initiative aimed to help urban authorities concentrate on 12 priority themes consisted by the EU 2020 strategy for smart and inclusive growth, including air quality, adaptation to climate change (together with green infrastructure solutions), energy transition, and urban mobility (EC, 2016). The European Green Deal (2019) adds to the European policies the emphasis on reducing the CO_2 emissions in the society's attempt to mitigate the negative effects of intensive consumption of conventional resources in economy and for public and private facilities and implicitly the impact on the climate. Under the new and adjusted European Climate Law, the focus is on becoming climate-neutral economies and societies by enhancing the carbon-free energy approach, including measures and actions towards ecological and innovative technologies, carbon-free electricity, decarbonized buildings and transportation and higher quality environmental standards. Hence, the aim to develop climate-neutral cities becomes one of the main priorities in the long term.

Studies on the strategic planning for development by considering the climate-change effects and the suitability and opportunity of the proposed measures in urban areas have been conducted internationally. For instance, Pietrapertosa et al. (2019) showcased the level of awareness and commitment of local authorities of Italian cities regarding climate planning, either engaging particularly in implementing specific local climate-change adaptation plans or putting into effect climate change mitigation plans elaborated voluntarily in the framework of the EU Initiative – Covenant of Mayors. Based on a study on eight cities, Boyd et al. (2022) analysed the opportunity of mitigation co-benefits when implementing measures proposed in urban climate-change adaptation strategies, finding that the alignment of adaptation with development is a more common aim than the alignment of adaptation and mitigation. To enhance and multiply the co-benefits, cities have to integrate their immediate development objectives with the medium and long term climate objectives. Thus, through the planned goals, objectives and actions, they should deliver multiple benefits to several interrelated sectors.

While collaborative efforts between various relevant stakeholders are recognized as being one of the key factors for the creation and implementation of development strategic plans, Göpfert et al (2020) underlines the need of institutional reorganization in the departmental structure of the city councils for better results in the policy design for climate-change mitigation and adaptation, in addressing the concerning issues, and in the challenging process of setting up priorities for action at the local level, arguing in favour of joint organizational structure and therefore a joint approach of the climate mitigation and adaptation.

The manner in which cities approach climate change in their urban planning documents reveal limited inclusion of climate change mitigation and adaption action despite the urgency of taking action and address this concerning issue at global level (Hurlimann et al., 2021). Therefore, increase efforts should be made to integrate urban policy provisions with climate change policy especially when planning for land use and socioeconomic development. This is in line with the conclusions of Grafakos et al. (2020) who also argue for the urgent considering of climate change mitigation and adaptation actions in urban planning due to the magnitude of energy consumption and GHS emission in the cities that have become areas of high concentration of people, industries, buildings and technical infrastructures. Much more, solutions for creating synergy between adaptation and mitigation measures are provided in the specialist literature. To increase the resilience and decrease vulnerability in the urban areas planners should focus on proactive rather than reactive measures. In this sense, the classification model of soft, gray, and green measures proposed by Pasimeni et al. (2019) or the Nature-Based Solutions described by Nassary et al. (2022) are relevant when considering what type of approach is more suitable for a city strategy.

The aim of this study is to portray the major measures, actions and objectives set up by the public authorities of two selected cities in their strategies to be implemented by 2030 with a view to enhance their contribution to a more sustainable and climate-neutral urban environment. Thus, the results aim to provide an insight on how the public authorities plan to make use of the available financial resources in their attempt to tackle the major climate-change related dysfunctions at the city level and deliver better management of resources and innovative solutions for their residents and local economy.

2. THEORY AND METHODOLOGY

2.1. Case study

The cities selected for this analysis are Kraków, Poland and Cluj-Napoca, Romania. Kraków is a city located in southern Poland on the Vistula River, the second-largest city in the country in terms of population and area. It is the capital city of Lesser Poland Voivodeship (Małopolskie), with a population of over 750,000 people in 2022. Cluj-Napoca is the most important city in the North-West region of Romania, former capital city of Transylvania region, with a city population of about 330,000 people in 2022 (460,000 altogether in the metropolitan area) (NIS, 2022), ranked second in the national hierarchy. It is the main economic and trade centre of Transylvania and one of the main transportation hubs in Romania. Both cities have joined the EU mission towards achieving climate neutrality by 2030 (two of the 100 European Mission Cities) and become inspiring examples for other European cities to engage in this endeavour by 2050 (EC, 2022a). Poland and Romania are part of the EU member states benefitting from supplementary European funding (European Green Deal - Modernisation Fund) in their efforts to accelerate the transition to clean energy by implementing projects for the modernisation of energy systems and improve energy efficiency, to decrease greenhouse gas emissions in the sectors of energy, housing industry, transport and agriculture (EC, 2022b). The strategic planning documents for local urban development proposed for analysis are the Climate Change Adaptation Plan by 2030 of the city of Kraków (UMK Kraków, 2019) and the Integrated Strategy for Urban Development of Cluj Metropolitan Area. Horizon 2030 and 2050 (Cluj-Napoca City Council, 2021). These strategic plans consist of mitigation and adaptation measures proposed to be implemented by 2030, which are in line with the provisions of the national strategies for adaptation to climate change.

2.2. The main climate change threats and planning solutions

Cities are created entirely by people. A few natural elements are very rarely left in urban areas. In most cases, people adjust the area of residence to their convenience, aesthetics, and economy. The ground surface and low-height vegetation are replaced by concrete pavements or rock slabs to eliminate the mud that occurs after rainfall and during spring thaws. Watercourses flowing through the city are concreted, rectilinear; riverbanks are paved to reduce the effects of erosion. Complex networks are designed to drain rainwater from large areas previously covered with impermeable concrete. Natural green areas are exploited in pursuit of valuable land for further investments. Higher and higher buildings become dominant, gradually replacing low-height buildings, making it difficult to ventilate the city. The unplanned growth of the city's population triggers increased consumption of energy and water, and an increased number of facilities are set up to meet the needs of the residents. All the above-mentioned activities carried out in an uncontrolled and thoughtless manner lead to disasters to a greater extent. Floods, uncontrolled temperature rise, water and energy shortages, or constantly increasing air pollution are factors that critically affect the urban environment. And their effects are opposite to the intended one - improving the quality of life in a given area.

The main threats resulting directly from climate change are floods that flood areas of cities due to precipitation in the upper course of the watercourse flowing through the city, and flash floods resulting from direct precipitation over the city area. It is one of the greatest threats as it can cause large material losses and threaten the life and health of the inhabitants. Droughts, on the other hand, are mainly determined by the lack of rainfall, but the population factor should also be taken into account in the risk of drought. Increasing the city's population that is not followed by increasing the city's water supply may result in water shortages even in the case of short-term droughts. In addition, in low-density areas, drought can cause fires, which are particularly dangerous. Droughts usually occur because of high temperatures, which is the third risk to consider. They do not directly affect the life and death of healthy people but cause discomfort and problems for people in poor health and the elderly. High temperature is not only a nuisance to feel it. Electricity grids supplying homes with electricity may become inefficient due to increased consumption when air conditioning is in use. The growing population living in an inadequately planned city leads to another threat, which is air pollution. Pollution causes the slow destruction of the body by absorbing particles of pollutants. They cause many diseases related to the respiratory and blood systems. All the above-mentioned threats have one thing in common; they can be limited, as impact, by well-thought-out spatial planning.

2.3. Review of planning solutions to mitigate risks in cities

2.3.1. Floods

Floods are caused by rainfall which, depending on the length and intensity of its duration, may cause flooding (Gaume et al., 2016). A flood can cover a large area of the region and even the country, it is caused by rains lasting several days. The main source of water during a flood may also be the flowing river stream, which transports water from regions with high rainfall (Douben, 2006; Kundzewicz et al., 2010; Alfieri et al., 2015). In order to avoid the effects of floods, proper planning strategies should be created (Godschalk et al., 1998). A planning reason that causes a threat is the development of water catchment areas (D'Ayala et al., 2020). Water that has so far spilled over the green, undeveloped areas spills over to buildings and causes damage. This also applies not only to buildings but also to communication routes (Amin et al., 2020). The basic solution is to prevent the development of flood risk areas (Burby and Dalton, 1994). This is the easiest, cheapest way to reduce damage. In cities, in floodplains, to reduce the carefulness of a possible flood, it is possible to design green areas, parks, recreational areas with permanent elements resistant to flooding (Burby et al., 1999). The downside to this approach is that it only works in undeveloped land. If the city area covers a large floodplain, the only solution is to build flood embankments (Hossain and Sakai, 2008; Ryan, 2020). They can protect urban areas against flooding by keeping the water level of the watercourse into protected areas. The disadvantage of this solution is the construction cost as well as the risk of unexpected breakage of the shaft. In addition, the cost of construction is increased by locks and pumping stations of the municipal sewage system, which must be designed to limit the phenomenon of water backflow through smaller watercourses. A comprehensive solution is the construction of storage reservoirs on rivers (Karbowski et al., 2005; Pawattana and Tripathi, 2008; Bezak et al., 2021). The reservoirs are located on the rivers in front of the city, often hundreds of kilometers away. As a result, the runoff of rainwater can be spread over time, and the intensity of the runoff can be reduced. The natural management of the rivers also provides protection against flooding. Today's more and more frequent regulation of river beds is a very negative effect (Wyzga, 1993; Robinson and Uehlinger, 2008).

2.3.2. Flash floods

Flash floods, are the result of brief rainfall over a given small area, often lasting less than an hour (superstorm cells) or several hours (Parker, 2014). It occurs mainly in urban areas (Xing et al., 2019) but also in mountainous rural areas (Bryndal et al., 2017; Pham et al., 2020). It is quite difficult to protect the city against flash floods. The amount of water that falls in a short time is so high that even the most efficient artificial rainwater sewage system will not be able to drain water from urbanized areas. However, there are some ways to significantly reduce the effects of flash floods. The first way is to avoid building up natural water runoff. Using the terrain, the road communication system should be planned in such a way that it does not cause accumulation of run-off water in various places. Viaducts and crossings are particularly sensitive places. If they are not planned before the construction of both intersecting communication routes, they often force the lowering of the area of one communication route during construction, which causes flooding in the event of flash flooding. In a situation where it is not possible to plan a collision-free passage of two communication routes due to the terrain (no possibility of creating a high embankment), a rainwater sewage system with a very large flow should be created or a collision intersection should be created. The intensity of development should be planned to take into account possible threats due to flash floods. This is especially important in the case of evacuation with very heavy floods (Haynes et al., 2009).

The problem is people evacuating on their own, often using their own car. Most drownings are caused by getting stuck in a car (Staes et al., 1994). Therefore, it is important to properly plan possible evacuation routes, as well as to properly educate the population about its methods in areas identified as potentially at risk of flash floods. It is important to build an early warning system to give the population time to prepare for an emergency. Preventing large flood damage is also introducing appropriate provisions in the local development plan that defines the method of building construction. In areas at risk of flash flooding, buildings should be built without underground garages or basements, and the first storey should be raised much above the ground. The last important factor is the provision of an adequate amount of biologically active surfaces so that some of the rainfall can be absorbed by soil and vegetation. This relieves the rainwater sewage system to some extent and allows rainwater to soak in

(Kadaverugu et al., 2021). Suitable substrates that absorb water can be planned in the city, as well as mini retention reservoirs that will collect rainwater (Chan et al., 2018; Ghaleh and Ghaleh, 2020). Water management is also positively influenced by green roofs, which can absorb large amounts of rainwater (Kimote, 2020).

2.3.3. Heat waves and the urban heat island

Climate change also increases the temperature and air circulation. In recent years, there has been a continuous increase in temperature in urban areas (Dhorde et al., 2009; Watts, 2017; Huber et al., 2020). The increase in temperature is intensified by the formation of heat islands, above-standard temperatures resulting from the accumulation of solar energy (Garstang et al., 1975). Heat is city-wide, while heat islands cover local areas, often in a street or square. The basic principle of counteracting the formation of heat islands and reducing the nuisance of heat is planning more tall vegetation, namely trees. They allow limiting the temperature by absorbing solar radiation, evaporating water through evapotranspiration, and creating shady areas. Additionally, they help purify the air (Eliasson, 2000; Akbari et al., 2001; Bowler et al., 2010). In city parks, the temperature can drop by 4 degrees compared to other areas of the city (Eliasson, 1996). Roofs account for most of the city's space. On roof surfaces, in addition to obtaining solar energy, vegetation can be developed, which also allows reducing the generation of high temperatures (Niachou et al., 2001). A roof with a high solar reflectance factor also contributes to the improvement of thermal conditions in the city (Takebayashi and Moriyama, 2007).

The higher the albedo, the better the results. The introduction of appropriate provisions to the local development plan to increase the city's tree cover (e.g. introducing a requirement for the developer to plant an appropriate number of trees around the building), as well as ordering appropriate roof management can reduce the effect of heat waves. The heat and heat island is also generated by covering the pavement with various materials that heat up and accumulate heat. For example, a porous, dark-colored paving slab will store more heat than a smooth, light-colored paving slab. Sidewalk material may contribute to reducing the formation of heat islands (Takebayashi and Moriyama, 2007; Scholz and Grabowiecki, 2007; Yang et al., 2016). A local development plan can define what types of pavements and squares surfaces will be created. The structure of the city also plays a role in counteracting the heat island effect. Strong diversification of buildings and use in the city contributes to reducing heat in the city (Cheng et al., 2006). Diversity promotes city ventilation, especially at night, which causes the temperature to drop (Geros et al., 2005).

2.3.4. Drought

Drought is a problem of shortage of rainfall over a longer period of time, leading to the lack of water in large urban agglomerations. Many factors that threaten a city due to drought arise from an erroneous spatial planning policy. One of the threats is the overcrowding of the city. As a result, water supplies are used up faster and with little water shortage, the problems of water shortage become apparent. Planning should take into account the water demand of newly developed urban areas and in the event of network overload, a new source of water supply should be provided. Large amounts of water are consumed by industrial areas, so they should always be considered the most in water supply (DeGaetano, 1999). Drought in urban areas not only reduces the water supply of residents, but can also destroy urban vegetation (Holopainen et al., 2006). In the context of spatial planning, the phenomenon of drought must often be considered for large areas, even regional ones. Water for the city can be drawn from reservoirs and water courses miles away. Human activity may also affect the abundance of water sources, e.g. the activity of opencast mines threatens drinking water sources in the area even tens of kilometers away (Monjezi et al., 2009; Yesilnacar and Kadiragagil, 2013).

2.3.5. Air pollution

Air pollution often leads to global warming (Makkonen et al., 2012; Gustafsson and Ramanathan, 2016). The main sources of air pollution in the city are overpopulation, industry and transport and less often natural sources (Bandhu et al., 2000). Research shows that with global warming, air quality in cities will deteriorate (Füssel et al., 2012). Spatial planning can have an impact on the air quality in the city. As mentioned before, introducing more plants improves air quality. Taking care of adequate ventilation of the city, by controlling the height and density of buildings, can cause any contaminants to be quickly diluted by the air from outside the city. A major challenge is the transition of industry and transport from high-emission to low-emission and carbon-free energy.

3. RESULTS AND DISCUSSION

Current development strategies of two rank 1 cities, Kraków (Poland) and Cluj-Napoca (Romania), were analysed by illustrating ways of embedding the provisions of the most current European and national regulations and policies related to climate change mitigation and adaptation, as strategic objectives and actions in their medium and long term strategies for sustainable and carbon neutral urban development. The two urban centres that were selected as case studies are representative for both countries, Kraków (Poland) and Cluj-Napoca (Romania) being rank 1 cities, with regional influence, have recorded high development dynamics and have their strategies ready to be implemented. Although not perfectly matching, since we could not select a Kraków-similar size city in Romania, we believe that Cluj-Napoca City and its metropolitan area most suitably fits the purpose of illustrating the practical measures proposed through the planning strategies to mitigate and adapt to the climate change challenges at the city level, as a rank 1 city in the national urban hierarchy in Romania, based on the number of urban residents.

3.1. The example of Kraków's city adaptation plan to climate change

One of the basic actions for adaptation to climate change (announced in the Strategic Adaptation Plan for sensitive sectors and areas until 2020 with a perspective by 2030) is to prepare adaptation plans for the largest Polish cities. The Ministry of the Environment has prepared the Adaptation Manual for cities, which proposes a methodology for the elaboration of the so-called urban climate change adaptation plans (MPA), and then undertook to prepare them (Szymalski et al., 2019). As part of a special project (44 MPA) in the period 2016-2018, some 44 such strategic documents for the Polish cities with more than 100,000 inhabitants were developed with the support of the European Cohesion Fund (European Environment Agency, 2020). An adaptation plan is a tool for innovative and creative shaping of urban policy for increasing the city's resilience to environmental changes, including climate change. Kraków has its own plan for adapting the city to climate change by 2030 (UMK Kraków, 2019). The main specific objectives of the city's adaptation plan to climate change are:

- to increase the city's resistance to higher maximum temperatures and heatwaves, magnified by the urban heat island phenomenon;
- to increase the city's resistance to the occurrence of cold waves;
- increasing the city's resistance to transitional temperatures;
- increasing the city's resistance to the occurrence of torrential rains and flash / urban floods;
- increasing the city's resistance to floods from the rivers;
- to limit the occurrence of exceedances of air pollution concentration standards, including smog episodes.

The cost of the entire program is estimated at over PLN 8 billion (almost 2 billion EUR). Selected activities related to spatial planning are presented in Table 1. The implementation of the Adaptation Plan will be the responsibility of the commune self-government in cooperation with external stakeholders, both institutionalized and personal. Effective implementation of the Plan will need the design or adaptation of the existing mechanisms and existing solutions to the implementation requirements of the Adaptation Plan. This means that the basis for change may be normative criteria defining the functioning of the city as a local government community, as well as the structures of the office itself.

In addition, it is advisable to develop a network of cooperation both with the city's residents and with entities participating in the creation of the current urban policy in the field of environmental protection (entrepreneurs, social organizations, employee self-governments, industry structures). If external participants are involved, the possibility of implementing the Adaptation Plan will be a manifestation of building a civil society at the micro-level.

Table 1. Selected activities preparing the city of Kraków for climate change and their planned costs.

No.	Description of the action	Estimated cost (million EUR)
1	Activities consisting in the construction of a comprehensive rainwater management system in the city, particularly including an inventory of the existing network, construction of a hydraulic model, based on which to rehabilitate the existing and build new subsystems in the city area. As part of their implementation, where possible, modern techniques will be used, including blue-green infrastructure, infiltration, retention and reuse of rainwater.	38.3
2	Expansion of the Vistula flood embankments and its catchment area with infrastructure.	82.5
3	Continuation of activities already undertaken by the city authority under the Air Protection Program for the Małopolskie Voivodeship, the resolution of the Małopolska Regional Assembly regarding the prohibition of burning solid fuels in the city.	39.5
4	Prohibition of using solid fuels in boilers, stoves and fireplaces not only within the administrative boundaries of the city of Kraków, but in the entire metropolitan area.	42.5
5	Modification of the internal combustion vehicle traffic organization system in the city, which is mainly determined by the lack of further possibilities for the development of road infrastructure in the developed city centre. Construction of transfer junctions, the "Prądnik Czerwony" railway stop.	126
6	Increase the reliability of the water supply system by modernizing the water treatment plant, including the	26.6

	modernization and commissioning of new intakes (ensuring sufficient sources of supply), expansion of the distribution network, in particular the main lines closing the ring, two-way supply of areas.	
7	Securing the city's ventilation system, limiting construction on floodplains and limiting the area of sealed surfaces by: - appropriate provisions in spatial development plans (development plans and local plans); - arrangements for the ways of developing the areas that make up such a system; - in special cases, also the acquisition of land for the resources of the Municipality of Kraków.	81.7
8	Conducting works for deep thermal modernization and thermal energy renovation of buildings in the city of Kraków in order to increase their resistance to the effects of long-term heatwaves and coldwaves.	44.9
9	The bright colours of the façades reflect the sun's rays and thus protect buildings from overheating. This increases the thermal comfort of users and reduces the costs of using air conditioners.	31.9
10	Introducing green and blue infrastructure (ZBI) into the urban tissue. Examples of solutions can be pocket parks, greenyards, green walls and roofs, and rain gardens. Green-blue infrastructure should also be understood as larger recreational areas, parks, water playgrounds, etc. The creation of ZBI should also be related to educational and information activities that will introduce the subject to the urban community and present the benefits of using this type of infrastructure.	79
11	Introducing green and blue infrastructure (ZBI) into the urban tissue, including afforestation, which contribute to the greatest extent to the improvement of living conditions in the city: improvement of the microclimate, reduction of air pollution, mitigation of temperature fluctuations or protection against wind.	105.5
12	Increasing the availability of water in the city area (fountains, ponds, drinking water for animals and water curtains, water playgrounds). Construction of water baths and outdoor swimming pools.	23.4
13	Collection of rainwater and development of blue infrastructure as independent facilities, as well as in the form of small and micro-retention and delaying runoff.	2.34
14	Modernization of public transport.	923
15	Preserving undeveloped spaces in the city, and where there is already planned development, taking care of the presence of vegetation, including unsealing of unused areas.	4.26

3.2. The example of Cluj-Napoca strategy for integrated urban development

The first regulatory attempts to engage in practical measures against climate change risk mitigation in Romania were included in the Law 24/1994. In 1999, Romania signed the treaty of Kyoto, and in 2001 adopted Law 3/2001 thus engaging in the decrease of greenhouse emissions in the period 2008-2012 compared to the values recorded in 1989 (Romanian Parliament, 2001). In 2013, the National Strategy for Adaptation to Climate Change 2013-2020 emphasized the need to tackle the environmental challenges by planning actions for the reduction of greenhouse gas emissions in order to achieve the projected national objectives, and for adaptation to the effects of climate change, considering the European Union policy and the relevant regulations and programmes (Ministry of Environment and Climate Change, 2013). In 2018, the National Sustainable Development Strategy 2030 was elaborated and the main targets to achieve the Agenda 30 objectives of sustainable development for 2030 were established at the national level, with the perspective of 2020 and 2030. The main aspects covered and set up as priorities for action were social, economic and environmental aiming to achieve a resilient, equitable, innovative and environmentally-friendly society (Government of Romania, Department of Sustainable Development, 2018). In 2020, Romania completed the elaboration of the 2021-2030 Integrated National Energy and Climate Plan, thus engaging in the efforts to achieve the European Union aim to reach energy efficiency and decrease the level of greenhouse gas emissions by acting on five major dimensions: energy safety, decarbonisation, energy efficiency, the energy internal market, and research, innovation and competitiveness (Ministry of Energy, 2020).

Nevertheless, the successful implementation of all the strategic plans is subject to collaboration between the relevant entities at the national, regional and local level, along with the engagement of the communities. Much more, the local level strategic measures are proposed in accordance with the main provisions established at the national and European level, thus ensuring an integrative and collaborative implementation framework.

In the case of Cluj-Napoca city, the Integrated Strategy for Urban Development was elaborated by considering the global, European, national and regional context, the major five strategic objectives being in line with the aims proposed in the main strategic documents at the national and international level, covering, among others, the following sectors: local, urban and metropolitan development, sustainable development, climate change and environment protection, economic development and innovative technologies, energy and transport.

Out of the five strategic objectives set by the strategy for integrated and environmentally friendly urban development in Cluj-Napoca city and its metropolitan area by 2030, we note the stress on the inclusion of the most essential measures that should be taken to meet the needs of the urban population in accordance with the principle of sustainable urban development and with the aim of reaching the status of a carbon-neutral city and tackling the challenges of climate change. Thus, the first and the third priority objectives stress on ecological transportation and urban mobility, increased quality of life and equal access to water and other public services and facilities, including green areas, more efficient waste management and energy consumption, reduced greenhouse gas emissions (Table 2). Most of the measures proposed by the strategy are established as responses to the major dysfunctions found in the city and the metropolitan area and they are meant to solve the main transportation-, energy and natural risk-related issues or alleviate the negative impact they have on the community and on the urban environment as a whole.

Table 2. Selected actions preparing the city of Cluj-Napoca for climate change and their estimated costs.

No.	Description of the action	Estimated cost (million EUR)
1. Component – air		
1.1	Develop a monitoring system for air, water and soil at the city level	1
1.2	Decrease air and noise pollution by implementing the measures set by the Integrated Plan for Air Quality in Cluj-Napoca City and the measures set by the Action Plan for Reducing Noise in Cluj-Napoca City. Most of the measures are reflecting actions related to sustainable and ecologic transport, energy efficiency in production and consumption, green areas, and blue-green corridors.	N/A
2. Component – Transport and mobility		
2.1	Enhance the use of non-polluting public transport in the city and metropolitan area, namely by expanding the non-polluting public transport network (including metropolitan train or underground transport network) and modernization of the public transport fleet with ecological vehicles	2617
2.2	Promote non-motorized transport within the city and metropolitan area by developing sustainable urban mobility corridors, especially infrastructure for walking and cycling (sidewalks, tracks, parking lots).	515.8
3. Component – Energy		
3.1	Improve energy performance of collective residential buildings through rehabilitation, namely thermal insulation and waterproofing, modernization of heating/ventilation systems, enhancing energy consumption management, increase de number green terraces and green walls and install equipments for green energy production	30
3.2	Improve energy performance of buildings administered by public authorities in accordance with the guidelines of the European Directive for Energy Performance of Buildings (Nearly-Zero Energy Buildings) (EC, 2021), by thermal insulation of walls and roofs, switching to more efficient heating systems based on renewable resources, more efficient lighting, smart appliances etc.	31.5
3.3	Increase the network and energy performance of public lighting system	18.54
3.4	Improve the quality of the district heating system and increase its efficiency by using alternative technology based on renewable energy resources and CO2 capture technology	200
3.5	Increase energy self-sufficiency in public buildings	26.1
3.6	Expand the network of electric vehicle charging stations	2
4. Component – Water		
4.1	Expand and rehabilitate drinkable water network	167.5
4.2	Expand and rehabilitate waste and stormwater networks	109.6
5. Component – environment and biodiversity and blue-green infrastructure		
5.1	Plan and develop urban blue-green corridors, including works on river embankments, and build walking and biking infrastructure	82.5
5.2	Planting trees in public spaces	15.5
5.3	Enhance and preserve urban biodiversity	10
6. Component – waste		
6.1	Integrated waste management, including measures for selective collection and recycling of solid waste and developing specific infrastructure for the collection and disposal of construction and agricultural waste	13.45
6.2	Consolidation of the Integrated Waste Management System at the city and county level	73.1
7. Component - resilience to risks and climate change		
7.1	Enhance land improvement works to reduce soil erosion and landslides	5
7.2	Rehabilitation and development works on watercourses riverbanks for flood prevention, in accordance with the provisions of the Regional Flood Risk Management Plan (i.e., Someș-Tișa Water Basin Administration)	6
7.3	Limit the expansion of urban heat islands and mitigate their effects, through the following actions: - install green roofs and innovative façades for the public buildings administered by the city authority; - implement innovative solutions for private and public works within the city area and the rural areas of the metropolitan area recording heat islands effects, namely by using highly reflective cool pavements and roofs;	33.5

	- maintain and develop urban agriculture; - improve management of watercourses to stabilize water temperature increase and reduce air temperature; - developing regulation and encouragement program (e.g. through local fiscal incentives) of roofs (gardens) and green façades for collective residential buildings in the city of Cluj-Napoca, especially those that are the subject of thermal rehabilitation projects and new collective residential buildings; - develop/rehabilitate the network of small urban green open spaces (gardens between blocks, nature playgrounds, pocket parks on vacant parcels and within new residential developments, etc.) and green corridors in urban hotspots (high temperature areas); - increase the availability of drinking water fountains for free public access of urban residents to water; - add water fountains for cooling and decreasing the urban heat island effect within the city built-up area; - implement water vapours cooling systems in the public transport stations, parks, markets; - develop natural and artificial shadowing on streets affected by extreme heat; - rehabilitate and extend the infrastructure for rainwater, rainwater/storm water bioretention (ponds, basins, infiltration trenches, public and residential rain gardens, green areas along streets and in public areas, bioswales and others; - develop wireless sensor network and smart irrigation systems for monitoring soil moisture in public areas within the city	
7.4	Encourage individual adaptation to climate change and create behavioural patterns favourable to risk reduction and greening of daily activities and actions (online applications with everyday eco-gestures)	N/A
7.5	Functional reconversion and/or reuse of abandoned and unused land and surfaces within cities	7

Source: The Strategy for Integrated Urban Development of Cluj-Napoca City and its metropolitan area.

The selected case studies for Poland and Romania illustrate that the focus of decision-makers and planners and of the planning policies is also and primarily, among others, on the mitigation and adaptation measures to climate change and become carbon-neutral territories, which is in line with the strategic policies and objectives of the European Union and the global aims to achieve sustainable environment and societies. All along, both Kraków (PL) and Cluj-Napoca (RO) are two of the 100 European selected cities involved in the European Union Cities Mission, in the nearest future (2021-2027) acting as experimentation and innovation hubs with the purpose to become smart and climate-neutral by 2030 (EC, 2022) and as frontrunners for other European or national cities.

Mitigation and adaptation measures are found planned both separately, as independent and clearly-focused actions, but also integrated in other actions meant for the sustainable development of the cities. For instance, if in the case of Kraków city, all of the selected measures and actions were part of a climate change city adaptation plan envisioned for 2030, specifically aiming to diminish the impact of climate change on the socioeconomic and natural environment, in the case of Cluj-Napoca city we find similar actions integrated both in several of the strategic objectives, measures and projects/activities for urban integrated development for the period 2022-2030 (2050) and as a specific investment priority to increase the city's resilience against risks and climate change. This priority is integrated in the larger context of ensuring an environmentally-friendly development within the city and metropolitan area by 2030, particularly by decreasing the level of greenhouse gases emissions by 80%, ensure access to drinkable and wastewater infrastructure for at least 99% of the residents of the metropolitan area, increase household recyclable waste collection up to 95% and increase the surface of green areas by at least 200 ha. However, in any cases presented, the benefits of implementation of these actions are to be significant in achieving the common goal of mitigating climate change impact.

Both of the strategic plans approached the main critical aspects necessary to be managed in the urban areas, namely water supply, provision and management (drinkable and wastewater), energy production and consumption, transport and mobility, solid household waste management, precipitation and air temperature with the triggering risks drought, floods, flash floods, heatwaves and urban heat islands, and air polution. This shows consistency between the actions of policy- and decision-makers, the priorities set by the European and national strategic objectives and the critical issues brought forward by the specialists in the field.

4. CONCLUSIONS

This study addressed climate change in relation to policy and regulatory framework for urban planning. The main risks and their negative impact in urban areas were presented, and the main objectives and actions proposed by planners and decision-makers to mitigate risks and adapt to climate change were illustrated for two urban areas, based on the local strategies with the perspective of 2030. A literature review was carried out related to the main phenomena that threaten urban ecosystems, such as heat and heat islands, water level rise and flash floods, effects of long-term droughts and air pollution. The main aim of this research was to provide an explicative theoretical overview on the main natural components in a city that are impacted by climate change along with a synthetic depiction of two practical examples of how the main issues related to these natural components are approached in public planning and strategic actions for urban sustainable development. The practical solutions that can be considered for the sustainable and smart development of cities aiming to react against climate change effects are therefore highlighted as to be replicated in other cities by decision-makers.

In the context of a larger research project on urban areas, in terms of spatial and socioeconomic dynamics and its triggering effects, such an investigation on how the public authorities plan to tackle the challenges and difficulties brought by agglomeration and increased energy consumption in the city area becomes feasible.

This study is not without limitations. Some of them reside in not considering all categories of urban areas, by rank or by economic profile, and not considering but only the most frequent risks that become challenges for the planning and development of urban areas. However, the results are conclusive for the case studies and they reflect and exemplify the reality of the present policies and strategies in use. Although the theoretical framework is not fully inclusive, it is representative for the selected cities under analysis.

We can conclude that all the efforts made by academia in determining the main dysfunctions and risk factors in the cities in relation to climate change are in line with the efforts of policy-makers at the European, national and local levels in their attempt to mitigate the impact of climate change and adapt to the new context by encouraging investments in innovative technologies and solutions for the cities to become sustainable, smart and carbon-neutral, and eventually providing a better quality of life for their residents.

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