Expert insight into the spatial aspects and challenges facing metropolitan regions in Central Europe – Case study Bratislava region

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Abstract. Territorial development of metropolitan regions is broadly problematized in several international documents, strategies and policies. Following from their analysis there is a pending requirement of safeguarding sustainable development as the basis of any urban and metropolitan development concepts. Although there are several concepts addressing particular aspects of sustainable urban development in the world, all of them are basically framed by a square defined by four core concepts. Two of them are more structural, focused on spatial patterns and two processual addressing the life processes of socio-ecosystems of cities. These four concepts - Compact City, Polycentric City, Smart City and Eco / Green City, are mentioned in the New Leipzig Charter – The transformative power of cities for the common good published by the European Commission in 2020. Currently, there is no consensus on defining the criteria for identification of metropolitan regions and their territories that would reflect the diversity and specifics in metropolitan regions across the EU Member States. The OECD favours the definition of a metropolitan region not as an administrative unit but as a nodal territory. In addition, the definition of metropolitan regions clashes with the fuzzy nature of their borders, which change over time and in relation to the aspects of their identification. Paper handles the issue of metropolitan regions in Central Europe with the focus on Bratislava metropolitan region. The paper is based on research project Territorial Prognosis Bratislava 2050 developed by Spectra Centre of Excellence with the aim to identify and describe crucial trends and challenges for the development of the Bratislava region based on global megatrends and local specifics and processes and to identify principles for future sustainable development of the region until 2050. Within the broader relations, it is necessary to take into account the development in the functional urban area of the Bratislava-Vienna agglomeration, the so-called core territory of Central European metropolitan region, which also extends to the neighbouring self-governing regions (Nitra and Trnava), the federal states of Burgendland, Niederoesterreich and Vienna and the county of Gyor-Moson-Sopron in Hungary. The outcome of the case study defines trends and their projection for the future territorial development of the Bratislava region based on thematic analysis of economy, social ecology, socio-cultural and environmental, transport, housing, services, social infrastructure, technical infrastructure and energy.

1. Introduction
Metropolitan regions as the engines of social and economic development face multiple challenges. The pressure on competitiveness in globalised world in the combination with climate change implications,
global demographic change and Industry 4.0 revolution requires not only particular innovative responses but, much more today than in the past, strong strategic background in their development management.

The dynamics of their development and life processes accelerates and in the long run, the transformation of society from industrial to post-industrial and knowledge-based civil society will bring not only new quantitative and qualitative parameters of their physical structures, but new spatial-temporal structures will emerge (e.g., telematics clusters) and the differences in the way of life between the urban and rural population will be to a significant extent blurred [1]. The basic characteristic of the urbainity of society ceases to be physical presence of the population in the city. These overall features of the change can be identified in many metropolitan regions around the world, but especially there, where the dynamic metropolitan development meets the multiple challenges of societal transition and the needs of protecting special natural environment values. The Bratislava region as a part of Central European Metropolitan region with the core agglomeration Vienna - Bratislava is significant example of such metropolitan regions.

2. Selected concepts of the spatial development of metropolitan regions

Sustainable urban development is well described in numerous literatures, coping with several concepts addressing particular aspects of sustainable urban development. The analyses in the frame of the project Territorial Prognosis Bratislava 2050 [2] shows that it can be claimed in general that all of them are basically framed by four core concepts described later on. Two of them are more structurally focused (on spatial patterns) and two others more processual, addressing the life processes of urban socio-ecosystems. These four concepts - Compact City, Polycentric City, Smart City and Eco / Green City, are indirectly addressed by the New Leipzig Charter – The transformative power of cities for the common good as well [3].

2.1. Smart City

The concept of Smart Cities, represents one of the most comprehensive approaches to the development not only of cities themselves but of urban regions. The development and implementation of integrated and inclusive strategies for a smart city as the common good, including impact assessments with long-term effects, is an EU priority defined by the New Leipzig EU Agenda [3]. This concept covers all areas of society, such as infrastructure, the environment, energy, culture, social services, etc. Within each sector, it pursues several objectives, which are interlinked and together form unified system based on the principles of sustainable development.

Public administration, the private sector, but also civil society enters this interrelated system through participation. On the basis of joint decisions, they pursue the goals of the given Smart City area [3]. At present, unfortunately, there is no internationally unified definition or legal framework for the given concept. Each state and each city is guided by its understanding in dealing with this issue. The key denominator in defining the goals of individual smart concepts is the use of data and technologies in order to improve the quality of services provided to the city's residents in a sustainable way. Gradually, more and more definitions appear, understanding a smart city as a social ecosystem, i.e. a sensible self-learning community that reasonably uses both technological and ecological and social innovations and nature-friendly solutions for the benefit of quality of life.

By 2050, it is recommended to move from technologic to these anthropocentric definitions of Smart City, i.e. the concepts aimed at improving the quality of life or urban population, using innovations as the tools to achieve the goals. The trend by 2050 is to create sensible / smart urban socio-ecosystems including not only core cities but broader urban functional areas, where all sectors - from transport, via advanced digital and nature closed technologies that allow two-way transfer of information between the city, its inhabitants, developers, entrepreneurs, students, researchers and educators, but also visitors.
There are not only technological but social, environmental, institutional, behavioural and other innovations that will represent core changes towards increasing the quality of life for all.

In a close connection with the concept of a smart city [4, 5], one of its dimensions is JUST CITY. A just city within the meaning of the New Leipzig Charter [3] provides equal opportunities and environmental justice for all, regardless of gender, socio-economic status, age and origin. A fair city gives everyone the opportunity to integrate into society. All social groups, including the most vulnerable, should have equal access to services of general interest, including education, social services, healthcare, and culture. Adequate, accessible, safe, and affordable housing and energy supply should meet the needs of different groups in society, including an aging and more diverse population, people with disabilities, young people and families. Socially balanced, mixed and secure neighbourhoods support the integration of all social and ethnic groups and generations. All citizens should have the right to acquire new skills and education. This requires affordable and accessible high-quality pre-school and school education, qualification and training for young people, as well as lifelong learning opportunities, especially in digitization and technology.

Another dimension of the smart city concept is its diversified economy of the PRODUCTIVE CITY, which provides jobs and provides a sound financial basis for sustainable urban development. Productive cities within the meaning of the New Leipzig Charter [3] as attractive, innovative and competitive places need a skilled workforce, social, technical and logistical infrastructure, as well as affordable and accessible space. Ensuring these conditions, including a favourable innovative environment as well as opportunities for local and regional production, should be an integral part of urban planning. In addition to traditional industries, many other economic sectors are increasingly moving towards a digital, low-carbon, service-oriented economy based on the knowledge society and cultural industries. Small businesses, low-emission production and urban agriculture can be encouraged to reintegrate production into cities and urban areas, enabling and supporting new forms of mixed neighbourhoods. The retail sector in European cities is changing due to the growing digitalisation of trade. However, the main goods, and food in particular, should be available at local level in order to offer a good quality of life and to compensate the unfavourable effects of demographic change.

2.2. Eco/Green City

Eco City - Green City or ecological city of the future, is another concept, respectively a new dimension of sustainable urban development as defined by the EU [3]. Its ambition is to build on the now almost forgotten visionary urbanism. It is a concept that primarily aims at implementing ecological principles in the territory, as it follows from the very name of this concept. The concept of Eco City or even Green City is not only about the sustainability of the city’s development, but also builds on technological innovations, urban ecology, bio-regionalism and also implements the organic elements of architecture. The development of a high-quality urban environment for all involves adequate access to green and recreational spaces.

Climate-neutral energy supplies, renewables, the implementation of energy efficiency measures, as well as climate-resilient and carbon-neutral buildings will help significantly reduce greenhouse gas emissions and help cities adapt to the effects of climate change and achieve carbon neutrality within two decades. The development of eco-city or green city requires investment in innovative and efficient technologies, as well as fundamental changes in production and consumption, which enable the formation of a circular economy that redefines and ensures sustainable use of resources while significantly reducing waste and carbon emissions. Eco-cities ensure the protection and regeneration of endangered ecosystems and their species and the use of natural solutions where high-quality green and blue infrastructure can withstand extreme weather conditions. Well-designed, managed and interconnected areas of greenery and water are a prerequisite for a healthy environment, adaptation to climate change and the protection and development of urban biodiversity.
Urban transport and mobility systems should be efficient, carbon neutral, safe and multimodal. Active and low-carbon forms of mobility and logistics should be promoted, including modal shift in public transport, walking and cycling. Public transport should be accessible, affordable, clean, safe and attractive to all. In order to reduce the needs in transport and mobility, the polycentric settlement structure should be as compact and densest as possible and should support multiple uses, including housing, retail, production and transport. The goal of the ecological city of the future is to build, respectively change the city so that it is a short distance. The concept delimits the city district with a radius of approximately 500 m. From the centre of the area, any destination can be reached within a 10-minute walk.

Another goal followed by this concept is to optimize the ratio of road transport to non-motorized modes of transport. Cars should give way to more sustainable modes of transport, such as walking or cycling, but the aim is not to completely exclude cars from the city, but to use them only to the necessary extent. What is important is the fact that roads are relatively separated from others by green infrastructure. Another trend of the Eco City concept is the multifunctionality of urban structures, i.e. to export urban neighbourhoods with a mixture of several urban functions, which means that housing estates will provide all the necessary services for the users of the neighbourhood in question - housing, civic amenities, opportunities for recreation, but also job opportunities. Ultimately, the concept evokes an effort to achieve a balance of urban as well as natural components [3, 5].

2.3. Compact City
The compact city, resp. a city of short distances, represents a concept of urban planning - compact urban development, which supports a relatively high population density in mixed / multifunctional land use. This concept of city development is addressed in the New Leipzig Charter [3] in connection with an efficient public transport system and a functional-spatial layout of the city supporting pedestrian movement and cycling, low energy consumption and reduction of air pollution. The number of inhabitants of the city provides opportunities for community life and social interaction, as well as a sense of security thanks to social control of the premises (number of eyes on the street). Residents are less dependent on car traffic, and thus require lower costs to ensure access to infrastructure.

Achieving the quality of a compact city does not mean primarily an increase in the density of buildings, or only an increase in the density of population as such, but an increase in functional density, i.e. more efficient use of all areas in the city. This means, in particular, high-quality sustainable planning to achieve an overall more compact urban design, in order to limit the external expansion of cities and combine this ambition with more efficient use of land resources as well as more effective protection of natural resources. The compact urban model ideally creates benefits that are attractive to modern city life. One of the strengths is the shorter commuting time for services, respectively work, recovery, leisure activities, etc., reduced adverse impact of the community on the environment, as well as reduced consumption of fossil fuels and energy. A critical element of this concept is the danger that not all the inhabitants of the city will have an equally guaranteed increase in the quality of life and that the compact development of the city may result in a restriction of the inhabitants’ access to green spaces, views, recreational places, etc. According to the New Leipzig Charter [3], good urban planning and design should ensure the development of compact, socially and economically mixed cities with well-developed infrastructure and a healthy environment and identification opportunities that contribute to the well-being of all.

2.4. Polycentric City
In accordance with the principles defined by UN, EU and national documents of spatial development policy [3, 6-8] polycentric residential structures with adequate compactness and density in urban and rural areas, with optimal interconnections ensuring that the distances between housing, work, leisure,
education, local shops and services are minimized and that the need for transport and mobility within and between cities and urban sprawl should be minimized.

From our point of view, polycentric territorial urban development is one of the main trends in the future development of settlements in connection with the Smart City concept. Cities, and especially Bratislava itself, will not be able to create sufficient conditions for potential users in the future in order to gain greater attractiveness and ensure better efficiency as well as sustainability of development only within their territory and within their territorial possibilities. In essence, this means that cities will need to reach not only for cooperation and coordination of their further development with municipalities and settlements in their immediate background, but also with other cities in order to ensure sustainable development opportunities [8]. Recently, the Polycentric City concept goes beyond the traditional understanding of structural polycentricism. New dimension in this concept represents the multilevel polycentric governance as the bases of new architecture of urban management.

2.5. Specific points for the territorial development of metropolitan regions in Central Europe
In response to the New Urban Agenda [6] and to the EU key documents following the UN Habitat III political conclusion [7, 9-11] several particular challenges related to the identified sustainable urban development trends, specifically for the area infrastructure and services, need to be properly addressed in the interface among four above described concepts:

- transformation of the energy system and the use of raw materials towards savings, recycling and a renewable resource from the construction process through the user cycle, to the borders of moral and physical viability and subsequent revitalization / replacement / modernization of premises and infrastructure;
- maximizing the closure of material and energy cycles (including food) in the territory the city and its immediate surroundings (urban bio-regions, urban farming, etc.) and, at the same time, opening of the city to mutually beneficial cooperation with the environment on the basis of division of labour, sharing and joint provision of vital functions of the city and its hinterland;
- increasing the sustainability and resilience of urban systems by increasing their resilience while flexibility and adaptability (especially in the context of security and climate change) separately urban infrastructure (green and blue infrastructure, water supply, collection and wastewater treatment, waste management);
- increment of the territorial dimension importance for the implementation of EU development strategies, in particular in connection with the strengthening and enhancement of territorial capital;
- integration processes and the increase of territorial cohesion understood as support for trans-European cohesion and competitive / innovative activities, while respecting the principles of sustainable development; and
- spatial concentration manifesting itself at all hierarchical levels of spatial development - European, macro-regional, regional and local.

Increasing the sustainability and resilience of urban systems by increasing their resilience and, at the same time, flexibility and adaptability (especially in the context of security and climate change), especially with regard to the urban infrastructure. Cities and urban systems need flexibility as well as the ability to respond to external disturbances and chronic stress. Robustness of places to cope with changing frameworks conditions should be supported by the ability to learn from past events and be mutually flexible managing places for the common good as well as the balanced implementation of the just, the green and the productive places [3].

Access to cheaper information and communication technologies expands people's perceptual space. Their development is conditional for the emergence of a new "industrial" multimedia sector. In this context, to the forefront the importance of the synergies between urban culture and "Cyberculture",
which will condition the companies and the creation of their closely local networks in urban and suburban spaces [12]. This is conditioned by the new spatial impact of individual activities, both in the level of input (such as traffic gradients) and process output (information - spread of information, impact of goods dissemination culture, emission transfer, etc.) as well as at the gravitational level (attractiveness and supply) and competition. It will become an increasingly important aspect of attractiveness for investment localization in this context the ability of the residential environment to absorb and spread innovation.

It is possible to count on the continued expansion of urbanity into the virtual environment, and thus the transfer some of the city's features into this environment, and the release of the city's physical space for new features. As the focus of IT production volume shifts from hardware zones production into zones characterized by constant innovation of software and content, the interest of this will shift industries from 'Silicon-Valley' similar scientific centres on the periphery of agglomerations to central locations - especially large cities with extensive opportunities for interaction between supplier and client [13].

3. Case study Bratislava
The analyses elaborated in the frame of the project Territorial Prognosis Bratislava 2050 [2] created the base for defining the main development trajectories of the capital Bratislava in the context of Central European metropolitan region and agglomeration Vienna-Bratislava. These contexts are of special importance as the City of Bratislava playing the role of the capital of the Slovak Republic lies on the river Danube directly neighbouring with Austria, Hungary and in close proximity to the Czech Republic. The capital of Bratislava and the districts of Malacky, Pezinok and Senec create the Bratislava Region as the self-governing region at the level of NUTS III and NUTS II. At approximately 2,052 km² there live more than 604,000 inhabitants (11. 2% from the total population of the Slovak Republic) in 73 municipalities incl. 7 towns. Population density reaches 294 inhabitants per km²; degree of urbanisation is 83.5%. The Bratislava Region together with Vienna creates the agglomeration within the heart of Central European Metropolitan Region Vienna – Bratislava – Gyor. Therefore, it is necessary to address the development of Bratislava and the wider hinterland of Bratislava within the metropolitan region in an integrated manner. It is assumed that in the future Bratislava will also have to learn to live in cooperative competition with other settlements in cross-border region to secure investments for the common benefit, respectively they will need to be able to offer a common higher functional complexity.

3.1. Specifics of Bratislava – Vienna metropolitan region
An important aspect of the development of settlement structures are the current tendencies of dispersed and unbalanced layout models that often do not take into account the quality of open regional spaces, spaces diversity and quality of open spaces [14]. These tendencies may have an effect also in terms of competitiveness, as they hinder the preservation or development diverse urban scenes and rural parts of the country at short distances that are considered as defined competitive processes of polycentric urban regions for or against large metropolitan agglomerations, in which the metropolitan region Vienna - Bratislava has a huge competitive license.

Bratislava, as one of the two poles of the Vienna - Bratislava agglomeration, is a serious competitor and a significant centripetal pole also in relation to the territory of Austria. Radiation of Bratislava as a pole of attractiveness has an impact on the highest expected population increases in the Austrian border areas of Bratislava within the whole Austria in the years 2010-2030 with a perspective to 2050. Territories between Vienna and Bratislava expect increments of at least 10% but mostly over 20%. [3, 15, 16].

Bratislava is considered, in connection with Vienna within the Danube area, to be one of the 4 cities of international importance together with Bucharest and Budapest. Among the 'settlement nuclear
areas’, which according to the authors have the most favourable positional preconditions for cross-border cooperation, where Bratislava metropolitan region belongs in the first place [8]. Integration within the Vienna-Bratislava agglomeration, the Central European metropolitan region and the CENTROPE region, is a key to the development of Bratislava. The removal of trade barriers and the proximity of Vienna and Bratislava creates a highly dynamic arrangement with a favourable potential for growth and competitiveness at the global level [17, 18, 19].

Modelling of transport and land use proves that the solution of transport in the region Vienna – Bratislava it cannot be a traditional model of providing more infrastructure (roads and parking spaces), as this is the case where the problem only exacerbates and leads to further urban sprawl, but there are necessary more sophisticated solutions This was shown by the 2006 PLUTO project, focused on spatial planning and transport planning aimed at modelling different operational strategies between Vienna and Bratislava, from which both cities could benefit economically [20, 21].

Although Vienna ranks at the top of the rankings comparing indicators, e.g. quality of life, is not one of Europe's biggest economic players. The Vienna-Bratislava metropolitan region with a population of more than 6 million people, a GDP of 250 billion and the presence of universities and research centres, is one of the most competitive regions in Europe [17, 18, 19]. At the same time, Bratislava region has long been one of the 10 most developed regions of the EU according to the Eurostat methodology, whose main and decisive indicator is GDP per capita. in purchasing power parity. According to the results Eurostat from 2019, Bratislava region is classified as the 8th most developed region with a GDP of 179% EU average [2].

In the capital of the Slovak Republic, Bratislava, as well as in the entire metropolitan region, a decrease in the share pre-productive and productive population and a significant increase in the oldest part of the population can be expected. The projected average age of the population in 2035 is expected to be 47.6 years within the BSK, within the capital city even higher [22-28]. Gradual aging of the population and an increase in the post-productive component of the population throughout the metropolitan area reinforces the need for interconnection of social and health services and capacity building aftercare and nursing facilities and palliative care facilities, including reprofiling existing beds for the support of long-term care capacities, but as well services of a preventive and supportive nature - the concept of active aging and measures to maintain the work ability of older people [22, 28-31].

3.2. Aspects defining territorial development of Bratislava
Bratislava develops as part of a larger integrated system consisting of a 'body' and 'arms' (urban corridors) extending to Northern, Eastern and Southern Europe (the Red Octopus Concept). In addition to radial connections to the center, these arms are also to be connected tangentially, in particular by the European multimodal network of TEN-T corridors. Relevant for the cross-border Bratislava region are the corridors: TEN-T IV: Berlin / Nuremberg - Prague - Bratislava - Budapest - Istanbul, TEN-T Va: Bratislava - Žilina - Košice - Uzhhorod and TEN-T VII: Danube river. In its concept, KURS (Spatial Development Perspective of Slovakia) [8], defines Bratislava Airport as an international airport of strategic importance, while together with Poprad-Tatry Airport they are included in the TEN-T network. From the point of view of the East-West development, two branches of the ‘Red Octopus’ are particularly relevant for the future, namely: Amsterdam / Rotterdam - Ruhr - Braunschweig / Göttingen - Berlin - Poznan - Warsaw and Stuttgart - Ulm - Munich - Salzburg / Linz - Vienna - Bratislava - Budapest - Belgrade [8, 22].

Furthermore, Bratislava will develop as a centre of the highest importance outside all groups of centres, both due to the function of the capital and on the basis of its historical development. Bratislava is a clear centre of international, and in connection with the Vienna agglomeration, of European importance. The proximity to European centres and their agglomerations (Vienna and Budapest) creates
conditions for the possibility of connection to the trans-European transport networks, cultural, historical and educational background, and thus predetermine this centre for the role of the so-called ‘Gateway’ for the whole territory of Slovakia. Thanks to Bratislava, optimal development opportunities arise in the international context, especially for the centres of Trnava and Nitra, and their catchment areas. Following international documents, development axes were defined in KURS. The development axes of the first level are relevant for the catchment area of BSK: Považská development axis (Bratislava – Trnava - Trenčín - Žilina), Záhorská development axis (Bratislava - Malacky - Kúty - border with the Czech Republic) and development axis of the second level: Žitnoostrovno-Dunajská development axis (Bratislava - Dunajská Streda - Komárno - Štúrovo) [8, 22].

In addition to the general requirements for qualitative and quantitative development, and due to the border position of the Bratislava metropolitan region, the territorial development should concentrate in particular on the expansion of cross-border business activities, which means creating territorial prerequisites for: development of economic activities, creation of new border crossings, completion superior transport and other technical infrastructure in accordance with the intentions of international multimodal and complementary corridors, development of combined transport systems, etc. [8].

Broader analyses of the global and specific trends framing the development of settlement structures and especially metropolitan regions [6, 7, 9] mounted into the definition of a set of basic macro-trends relevant for the prognosis of future development of capital Bratislava [2] as follows:

- creation and strengthening of new socio-economic spatial systems (e.g. clusters) at the macro-regional level - in the conditions of Bratislava, for example a completion of the automotive cluster,
- concentration of economic activities and settlement activities in the most attractive locations, strengthening of metropolitan regions and selected centres – in case of Bratislava development policy towards a clear profile and purposeful building of competitiveness on the basis of quality and spatial structure,
- intensification of ties within settlements and regions - extension of the spatial impact of decisions, including localization in the economy and strengthening of their synergetic effects - strengthening of the integration of spatial development management of the capital of SR Bratislava, BSK, TTSK and local governments within the metropolitan region in Slovakia, but also in Austria and Hungary,
- highlighting the importance of the ability of the environment of the settlement structure to absorb and disseminate innovations as a localization factor for investments (link basic research - applied research - implementer - customer) - development of Bratislava must build on the existence of a triple-helix, i.e. cooperation between self-government, academic institutions and the business sector, which must also be reflected in the spatial organization of the city;
- spatial-structural polyfunctionalization (integration of functions within functional spaces and objects within the use of new technologies and time segregation) - strengthening of polyfunctional as the basis of spatial development of Bratislava;
- emergence of new non-geographic peripherality - peripherality ceases to depend on geographical coordinates, but is more dependent on access to communication infrastructure, including ICT - the availability of these services in all areas of the capital and the metropolitan region;
- changes in the localization factors of production, selection of production activities in nuclear settlements and their hierarchization, which means the division of labour between the capital of the SR Bratislava as a nuclear seat and surrounding settlements ensuring the optimization and efficiency of securing the potentials of individual parts of the metropolitan region;
- changing the character of rural settlements - marginalization of agricultural production as an economic base of the countryside, strengthening of landscaping and ecological functions in the
rural economy - transformation of agriculture and forestry within the capital and the metropolitan region towards the complexity of its operation within ecosystem services; and

- emphasis on the importance of intra-settlement space as a space of social communication within extracurricular activities, the basic characteristic of the urbanity of society ceases to be the physical presence of the population in the city - qualitative and quantitative change in the quality of urban spaces of Bratislava as flexible spaces for shared activities and communication of residents and visitors to the city, for creative completion by users and dynamic change of their requirements.

4. Conclusions

Based on above mentioned challenges and trends with special focus on Central European urban agglomerations and key study Bratislava, there can be defined 3 basic scenarios of the development [2].

In Scenario C - Scenario of sustainable smart development of an agglomeration with the core compact city saturating the growing and changing demands of its inhabitants, visitors, entrepreneurs, (including the pressure for extensive growth) by efficient use of space reserves and its urban area, via increasing the dynamics of recycling brown areas / brownfields, including their temporary use, modernization and flexibility structures, the use of intelligent technical and technological solutions, better use of functional areas and their polyfunctionalization (including spatial-temporal dynamic structures and the third dimension of the city), efficient use of ecosystem services resources, and by optimization of the use of potential individual areas. The area of core city will be served by a short-distance transport system connected in multimodal nodes to the transport service of suburban centres. This development concept is able to saturate the quantitative growth of the population in the core city without deteriorating the quality of the settlement environment in the perspective of next 20 years, but later a change in the concept will be needed. This scenario prepares the creation of an integrated monocentric flexible system of strategic and operational management of the development and functioning of the city based on effective and rapid feedback from the territory and ongoing responses to developments in the territory (including developments in external conditions, changes in economic actors, etc.).

Scenario P - Scenario of sustainable smart development of a polycentric city in which the core city will develop by strengthening its polycentric structure of existing and newly created nodal centres by supporting the development of specialized and multifunctional centres in its various parts of well-connected, but relatively autonomous inward ecosystems operating on the basis of walking, balanced energy and ecosystem balance, diversity and socio-eco-connectivity provided by smart nature-friendly solutions. At the same time, the individual nodal centres will be multimodal transport centres, which will enable a combination of efficient short-distance transport service systems within the catchment area of the nodal centre and longer distances - between the nodal centres and the city centre. This concept of the solution will enable the saturation of all the needs of dynamic population growth in terms of models until 2050 and even after this horizon without the need to change it. This scenario makes it possible to strengthen the hierarchical polycentric system of urban development management with sufficient decision-making autonomy enabling very flexible and effective responses to the problems and challenges arising from the functioning and development of the territory (one ecosystem with several interconnected individuals with their own brain and adaptive abilities).

Scenario A - Agglomeration sustainable smart development scenario in which the core city will develop on the basis of functional specialization and division of labour between the core city and settlements in its agglomeration, effectively using its potential as a centre of the agglomeration serving its background by a specific offer of production sector activities, services, leisure activities, ecosystem services, etc. The development of the nuclear city will be concentrated on qualitative changes, economic transformation, quality of the settlement environment, while extensive development will be directed to settlements within the agglomeration fully covering the basic service of the population and connected to the nuclear site by fast and environmentally sustainable transport services. The scenario of
agglomeration sustainable smart development enables a flexible response to all scenarios of demographic development until, even after 2050. This scenario assumes the strengthening of the management system based on inter-municipal cooperation and coordination within the metropolitan region and redefining the specific position of core city (integrating ecosystems with multiple interconnected individuals with their own brain and adaptive abilities).

The defined model scenarios can be understood as framing the trajectories of the development reflecting not only current specific situation but the changes in the framework preconditions of metropolitan development in the future.

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