

## Challenges, Opportunities and Barriers to Sustainable Transport Development in Functional Urban Areas

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**Abstract.** The process of identifying urban areas in OECD countries uses population density to identify urban cores, and travel-to-work flows to identify the hinterlands as the “worker catchment area” of the urban labour market, outside the densely inhabited core. As the travel-to-work analysis seems to be an important issue for creating coherent functional urban areas, the main determinants of daily commuting in a sub-regional scale should be investigated. There is a common opinion, that residents of the suburbs are bound to use individual forms of transportation, and public transport does not meet their needs. That is why the aim of this research is to identify the main challenges, opportunities and barriers to sustainable transport development in functional urban areas, in order to avoid the adverse effects of urbanisation.

For the purpose of the article, a comparative analysis for selected Polish functional urban areas was conducted, and both short-term and long-term prospects of transport development are depicted. The article includes statistical, spatial and descriptive analyses based on Central Statistical Office data, Regional Operational Programmes for 2014–2020, made for the Polish provinces, as well as selected development strategies, due to inter-municipal cooperation within delimited functional urban areas. As a result, on the basis of the compared and transformed information, the sustainable development scenarios for a selected functional urban area are built.

**Keywords:** functional urban areas, transport, sustainable development.

**Conference topic:** sustainable urban development.

### Introduction

Functional urban areas are sub-regions emerged from the strong impact that cities have on their hinterlands, with temporary transformation processes in land use, settlement, labour market and most of all population. Urban areas in OECD countries are defined using population density to identify urban cores, and travel-to-work flows to identify the hinterlands whose labour market is highly integrated with the cores. The “hinterland” can be defined as the “worker catchment area” of the urban labour market, outside the densely inhabited core (OECD 2013). According to this definition, the travel-to-work analysis seems to be an important issue for creating coherent functional urban areas.

Suburbanization in the hinterland of cities, used to have links to traffic (Sýkora, Ouředníček 2007; Krisjane *et al.* 2012; Kotus 2006; Tammaru 2005) and this dependence have been observed in functional urban areas too. Therefore, sustainable transport development in FUA should be a priority in every country interested in creating territorial cohesion and sustainability. In addition, accessibility became the most important factor in landscape change, and even in the remote countryside the urbanisation processes can be noticed when the region is disclosed by transportation (Antrop 2004). That is why the aim of this article is to identify the main challenges, opportunities and barriers to sustainable transport development in functional urban areas, as this could help avoid the adverse effects of urbanisation.

According to the World Commission on Environment and Development (WCED, UN 1987), humanity has the ability to make development sustainable to ensure that it meets the needs of the present, without compromising the ability of future generations to meet their own needs. Integrational equity is a central element of sustainability. If there were no future generations, then climate change and finite resources would not be issues (Greene, Wegener 1997).

An efficient and reliable transport system is the backbone of the development of any national or regional economy (Li *et al.* 2016). Within the aspect of transport, the main problems of unsustainability can be identified as affecting urban areas. These are excessive traffic congestion, pollution and a demand for more infrastructure. Without strategic planning highlighting the needs for development in various means of transport, the residents of the suburbs seem to be bound to use individual forms of transportation, as public transport does not meet their needs. Some researchers emphasise (Ricciardi *et al.* 2015) that it is necessary to develop a measure to identify spatial gaps in transit services based on the needs of vulnerable groups. As suburban transport in Poland depends mostly on car ownership, some groups like children and elderly residents might be suffering if the transport system in functional urban areas does not

improve. With the increase in the population of the FUAs (with particular emphasis on FUA hinterland population), the authorities face challenges of creating a sustainable transport system meeting their needs.

### **Challenges, opportunities and barriers to developing sustainable transport**

It should be emphasised that there are challenges and barriers to the development of transport in the FUA hinterland. Most common are the environmental barriers. Although cities and regions are still fighting to be linked to motorways and high speed rail networks, more and more large-scale infrastructure projects are stalled or delayed for environmental reasons (Greene, Wegener 1997). We can also call these natural barriers.

A natural barrier refers to a physical feature that hinders travel. Natural barriers have been important factors in human history, by obstructing migration and invasion. West European nations have been the dominant powers of the last 500 years because Europe's many natural barriers divided it into competing nation-states, and this competition forced the European nations to encourage innovation and avoid technological stagnation (Diamond 1997). Mountains, steep slopes, swamps, deserts and icefields can isolate a city, a region or a whole country by making human and resources transport difficult.

Rivers are a little more ambiguous. They have been used for transport purposes since ages, but some riversides are less suitable for building roads and railways because of seasonal floods. Therefore, the sustainable transport development process and transport planning must include the identification of the main natural barriers, and must create different options for local and regional transport in order to bypass the barriers or eliminate their influence.

The development of transport systems in environmentally valuable areas also faces challenges. Environmentally valuable areas are vulnerable to exceeding emissions of gasses coming from industry and warming, as well as transportation. That is why it is necessary to quantify the degree of damage to these important habitats, and relate it to sources of emissions (Brown *et al.* 1995). This aspect has been considered in feasibility studies prepared for new routes and transport linkages for recent decades.

Apart from environmental (natural) barriers, there are also financial constraints. There are both internal and external funds for transportation development. Still, the need for partial financing by local and regional governments may lead to excessive burdens on their budgets. In spite of the threat of financial imbalance, municipalities, districts and provinces raise funds or accept funds from EU Programmes for transport development. In order to improve this gaining process, new tools are introduced. According to Cohesion Policy 2014–2020 of the EU, the Common Provisions Regulation has introduced new integration tools that can be used to implement territorial strategies on the ground, linking the thematic objectives identified in the Partnership Agreements and Operational Programmes and the territorial dimension: community-led local development (Articles 32–35 of the Common Provisions Regulation) and integrated territorial investments (ITI) (Article 36 of the Common Provisions Regulation) (European Commission 2014). The definition of ITI in the same publication assumes that it is a tool to implement territorial strategies in an integrated way. It is not an operation, nor a sub-priority of an Operational Programme. Instead, ITI allows Member States to implement Operational Programmes in a cross-cutting way and to draw on funding from several priority axes of one or more Operational Programmes in order to ensure the implementation of an integrated strategy for a specific territory. That is why ITI may be implemented for transport development in FUA within the territory of several communes.

Finally, the social trends and demographic circumstances should be discussed. The urban lifestyle is gradually spreading, even in small and remote rural settlements. When urbanites are spreading more loosely into the countryside, they change the traditional lifestyle there and make the distinction between urban and rural to become very diffuse (Antrop 2004). The urban function most noticeably affected by this phenomenon, and strongly connected to transport mobility, is the residential one (Żróbek–Róžańska, Zadworny 2016). Other trends, both for the city core and the hinterland, are also observed for car ownership, the way of commuting, the use of different means of transport related to varied groups of residents and their residential locations. Car ownership is higher for rural than for urban households. On average, rural households have about 0.3 more cars than comparable urban households (Dargay 2002). High levels of automobile ownership are associated with urban sprawl, and increasing levels of automobile travel (Handy *et. al* 2005).

As illustrated in Dargay and Vythoulkas (1999), the lifecycle effect predominantly reflects differences in income, household size and composition over the lifecycle. Both real income (as measured by total weekly expenditures in constant prices) and the number of adults (of driving age) increase over the lifecycle, until the head reaches his/her early 50s and declines thereafter – a similar trend as that noted for car ownership. However, an understanding of how households choose the number of vehicles to own, based on where they live, is of vital importance to urban planners and decision makers (Potoglou, Kanaroglou 2008). No less important is whether they have the choice of other means of transport, or whether they use a car due to a lack of public transport.

## Methods and data

The study includes statistical, spatial and descriptive analyses based on CSO data, ROP for 2014–2020 made for Polish provinces and selected development strategies, due to inter-municipal cooperation within delimited functional urban areas. The obtained data was processed and compared using cartographic methods, presented as cartograms and cartodiagrams on maps. The ability to use geostatistical methods is also presented in the further part of the article. The main phases of the research are presented in Figure 1.

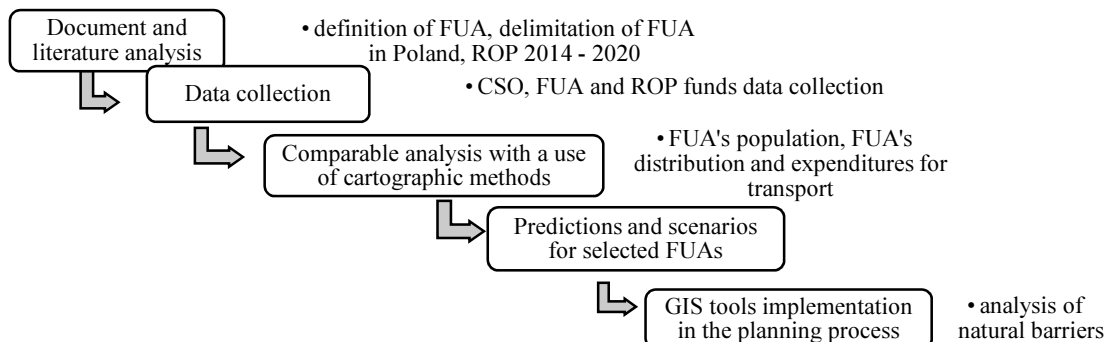


Figure. 1. The research procedure (Source: own work)

As a result, the sustainable development scenarios for a selected functional urban area are built on the basis of compared and transformed information.

## Circumstances in Polish provinces for transport development in FUA

### *Operational and strategic planning for transport development*

The development of sustainable transport has become one of the priorities in Polish regional development strategies. The comparable analysis of current documents collected in DEVELOPMENT MONITORING SYSTEM STRATEG (Strateg.stat.gov.pl 2014) shows that seven Polish provinces made sustainable transport development one of their strategic objectives. For the same number of provinces it is an operative objective, and for three it is a direction in their regional development strategies.

The importance of transport development, supported by EU Funds, led to transport and its development being highlighted in the Regional Operational Programmes for the 2014–2020 perspective. After a detailed analysis of the Regional Operational Programmes, the priorities for Polish Provinces related to the development of transport are set out in Table 1.

Table 1. The ROP 2014–2020 priorities related to transport in Polish provinces (Source: authors' own work based on Portal Funduszy Europejskich 2014–2017)

Province	Priority axis
Dolnośląskie	V – Transport
Kujawsko-pomorskie	V – Internal cohesion and external availability of the region
Lubelskie	IV – Regional mobility and ecologic transport
Lubuskie	V – Transport
Łódzkie	III – Transport
Małopolskie	VII – Transport infrastructure
Mazowieckie	VII – The development of the regional transport system
Opolskie	VI – Sustainable transport for the residents' mobility
Podkarpackie	V – Transport infrastructure
Podlaskie	IV – Improving transport accessibility
Pomorskie	IX – Mobility
Śląskie	VI – Transport
Świętokrzyskie	V – Modern communication
Warmińsko-mazurskie	VII – Transport infrastructure
Wielkopolskie	V – Transport
Zachodniopomorskie	V – Sustainable transport

### Functional Urban Areas in Poland

According to the definition and OECD conditions for the delimitation of **functional urban areas** (OECD 2016), a list of 58 functional urban areas in Poland has been drawn up, and their ranges are shown on the map (Fig. 2). As intended in the definition of a FUA both city cores and commuting zones are included. As shown in Figure 2, the ranges of commuting zones vary, but in most cases the travel-to-work distance and time might increase and require the need for improvements in the transportation system.

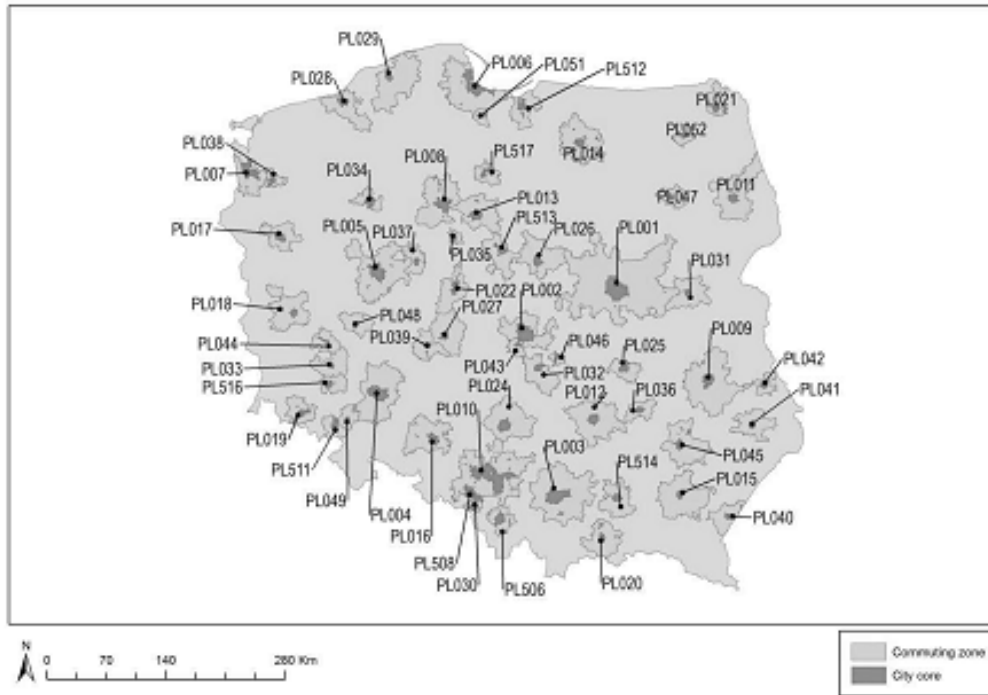


Fig. 2. FUA in OECD countries: Poland (Source: OECD 2016)

### Demographic circumstances resulting from FUA population changes in Poland

The most important factors taken into account in the delimitation of functional urban areas in Poland were the population and population density of the inhabitants. FUA areas show the most visible changes in population, resulting from migration and aging processes. Therefore, the comparable analysis for FUA in Poland included:

- a) changes in FUA's population between 2000 and 2014 in divided into provinces (total change of all FUAs in the province),
- b) distribution of FUA within four steps resulting from population number (taking into account the OECD classification):
  - Small urban areas with a population between 50,000 and 200,000,
  - Medium-sized urban areas with a population between 200,000 and 500,000,
  - Metropolitan areas with a population between 500,000 and 1.5 million,
  - Large metropolitan areas with a population above 1.5 million.

The data collected from the OECD and CSO sources are transformed and shown on the cartographic background with the use of maps acquired from Central Documentation Centre of Geodesy and Cartography (Codgik.gov.pl 2010–2017). In order to show the distribution of both changes in FUA populations and FUAs from various levels in Polish provinces, the methods of cartograms and cartodiagrams are used. The cartogram uses marks and patterns to illustrate classes, and the cartodiagram uses grey scale of filling (Fig. 3).

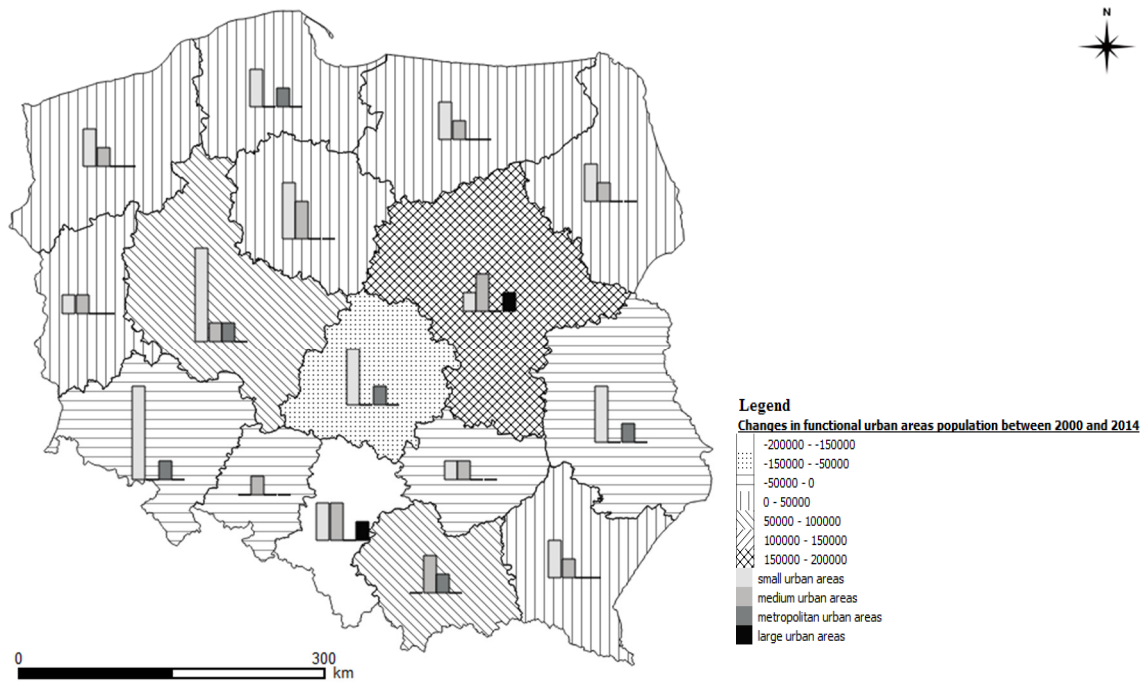


Fig. 3. Changes in functional urban areas population between 2000 and 2014 and the distribution of FUA in Polish provinces (Source: authors' own work based on data from OECD 2016)

According to the differentiation shown on Figure 3, six provinces (Łódzkie, Lubelskie, Śląskie, Dolnośląskie, Opolskie and Świętokrzyskie) are distinguished by a total decrease in FUA population. Two of them, Opolskie and Świętokrzyskie, have only medium and small functional urban areas, which implies that the decrease in population is caused by the aging process and migration to more developed metropolitan areas. Śląskie is a province with five FUAs, but the number of people increased in just one of those. Other provinces are more “swinging”, with increasing populations in metropolitan FUAs, but decreasing numbers in small and medium FUAs.

The majority of provinces recorded an increase in functional urban areas population, most significant in Mazowieckie, with almost 3,700,000 people living in FUAs, and Wielkopolskie with 1,800,000 people (data from 2014). Still, growth might be noticed in less developed regions to the east and north, where there are only medium and small functional urban areas. Significant population growth is related with an increased demand for space (affects changes in land use) and improvements to the transportation system connected with the growing “commuting” population.

### Creating opportunities for transport development in FUA regions by financing from EU Funds

#### *Distribution of funds for transport development in ROP 2014–2020 in Poland*

As the new perspective for 2014–2020 has been introduced for EU countries, Polish authorities at both central and regional levels have decided to place more attention on creating a sustainable transport system through the use of funds from the new perspective. Recent activities (perspective 2007–2013) referred to motorways and the highway system in Poland. At present, funds and activities are more divided into different levels or ranges and meet regional and local needs. Within the priority axes presented in Table 1, objectives have been introduced for various means of transport. Taking these aims into consideration, we can divide the expenditures planned in Regional Operational Programmes for 2014–2020. Each ROP prepared for a Polish province (published on <https://www.funduszeuropejskie.gov.pl/>) was carefully reviewed and the necessary data were extracted. As a result, the distribution of expenditures for common means of transport, such as road and rail, as well as expenditures for transport dedicated to functional urban areas are compared in 16 Polish provinces and presented on a cartographic background (Fig. 4). The cartodiagram presented in Figure 4 displays the contribution of expenditures for transport divides into regional and local roads, railways and transportation in functional urban areas. The most significant expenditures on FUA transport are in Śląskie, Mazowieckie, Opolskie and Świętokrzyskie, while the least are in Podlaskie, Małopolskie, Lubelskie and Zachodniopomorskie. In the authors' opinion, the optimal expenditures should be related to the scale, potential and number of FUAs in the province, which is why the optimal level seems to be reached in Pomorskie, Wielkopolskie, Łódzkie and Mazowieckie provinces. Still, some provinces should “invest” more in order to avoid traffic and raising air pollution caused by transport within the city and its hinterland borders.

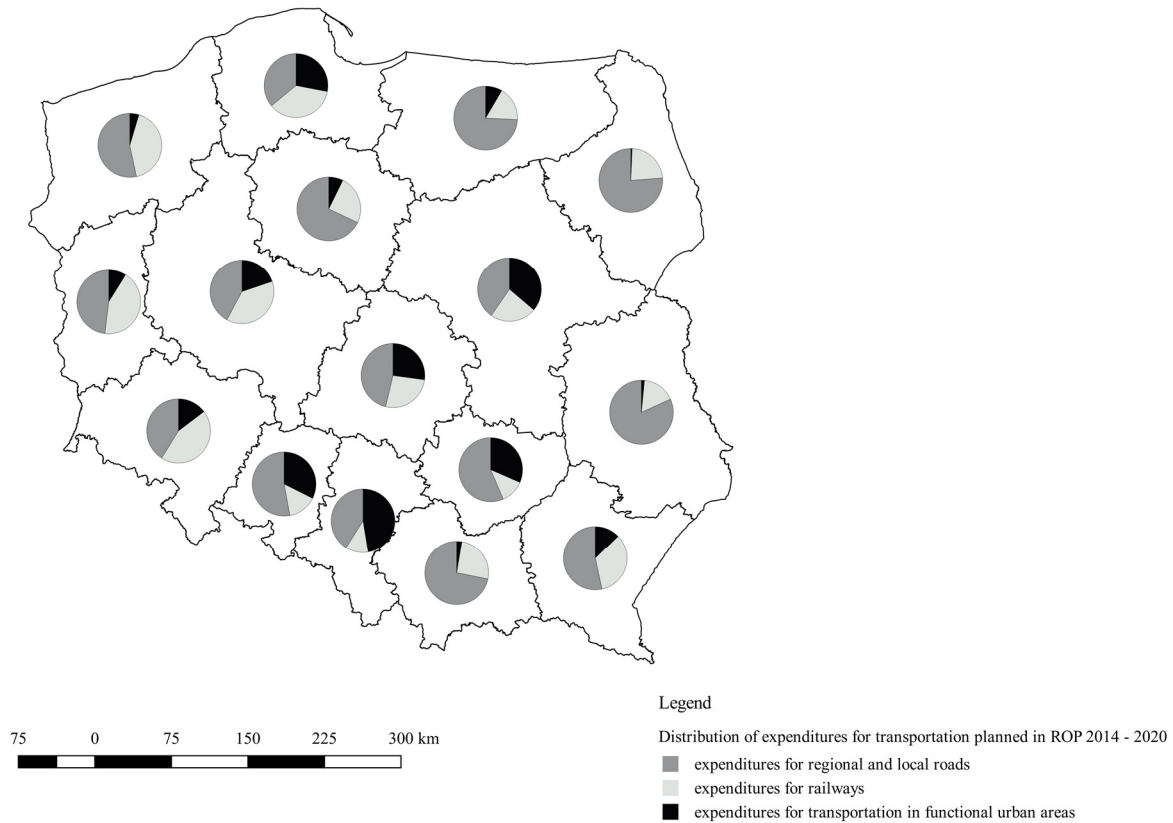


Fig. 4. The distribution of expenditures for transport included in Regional Operational Programmes prepared in Polish provinces for 2014–2020 perspective (Source: authors' own work based on Funduszy Europejskich 2014–2017)

#### *Development of transport system in Warmia and Mazury FUAs – predictions and scenarios*

According to the Detailed Description of The Priority Axis Transport Infrastructure in Regional Operational Programme Warmia and Mazury for 2014–2020, there are three detailed objectives for FUAs in this province – each for a delimited FUA:

- 1) Improving accessibility and internal transport cohesion of the FUA Olsztyn;
- 2) Improving accessibility and internal transport cohesion of the FUA Elbląg;
- 3) Improving accessibility and internal transport cohesion of the FUA Ełk.

In the optimal scenario, FUAs would invest around EUR 23,500,000 on their transport development, dividing it into almost EUR 15,000,000 in FUA Olsztyn, almost EUR 5,000,000 in FUA Elbląg and around EUR 4,100,000 in FUA Ełk. Around 85% of these amounts come from the EU allocation, with the remaining 15% collected and prepared within provincial and local budgets (Fig. 5).

Pessimistic and neutral predictions take transitory financial liquidity problems, delays in obtaining funds and technology and design considerations into consideration. This means that, above all, the province would not be able to collect the 15% of internal funds because of internal or external financial barriers. In that case, FUAs would lose both EU and Polish funds for transport development. Secondly, only part of the expected expenditures would be allocated (a reduction of between 30% and 80%). Finally, some technical or construction difficulties would make certain activities within the detailed aim unfeasible, which is why more interest should be placed on monitoring the implementation.

In addition, there should be more discussion on the impact that an FUA's population has on transport development. The "not in my back yard" (NIMBY) trend is becoming more significant in particular FUAs' hinterland. Organisations of inhabitants objecting, for example, to a ring road construction are common. As a result, we face spatial and social conflicts in city cores and hinterlands. Still, their influence is difficult to predict.

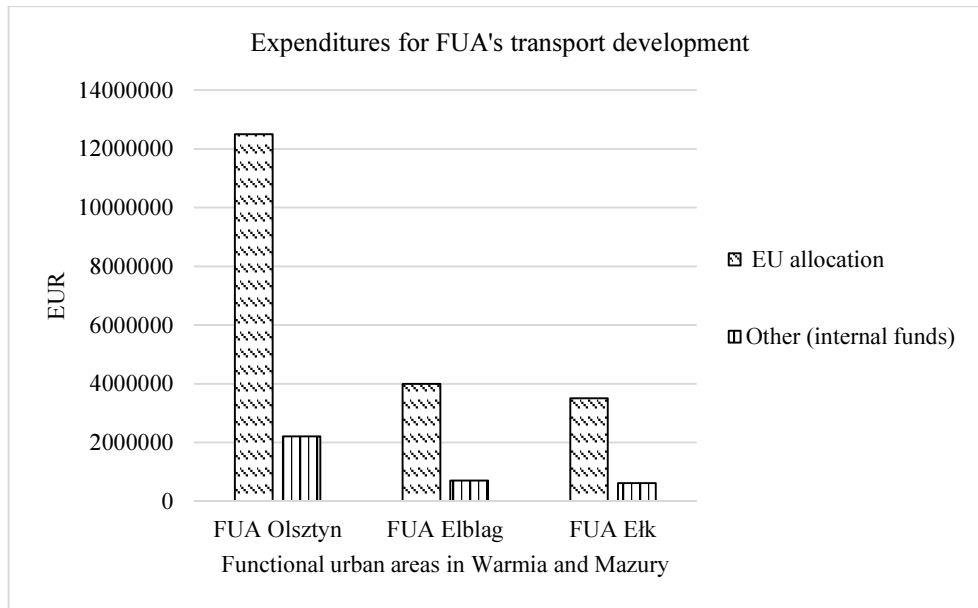


Fig. 5. Expenditures for FUA's transport development in Warmia and Mazury for 2014–2020 (Source: authors' own work based on Funduszy Europejskich 2014–2017)

### Barriers to sustainable transport development in FUA – using GIS tools for planning

As the assumptions of the priority axes are implemented for a period of time, some problems resulting from financial, social and natural barriers are becoming more significant and difficult to overcome. However, the GIS tools help resolve some of them by implementing geostatistic analyses within the preparation and planning process. In particular, natural barriers may be taken into consideration while preparing the feasibility studies and detailed analyses (Ogryzek, Rzaša 2016).

The ArcGIS tools give the opportunity to analyse processes and phenomena that appear in the area with natural barriers. One of the most popular tools is Spline with Barriers, which applies a minimum curvature method, as implemented through a one-directional multigrad technique, moving from an initial coarse grid, initialised in this case to the average of the input data, through a series of finer grids until an approximation of a minimum curvature surface is produced at the desired row and column spacing (Briggs 1974). An example of applying this method is shown in Figure 6, along with the expected results (Fig. 7).

The other tool is Kernel Interpolation – a variant of a first-order Local Polynomial Interpolation in which instability in the calculations is prevented using a method similar to the one used in the ridge regression to estimate the regression coefficients. Details on ridge regression can be read, for example, in Hoerl and Kennard (1970). The Kernel Interpolation model uses the shortest distance between points, so that points on the sides of the specified non-transparent (absolute) barrier are connected by a series of straight lines.

Both of these tools might be applied to analyses in different projects concerning transportation development in functional urban areas, whenever there is a natural barrier such as a mountain, river or lake.

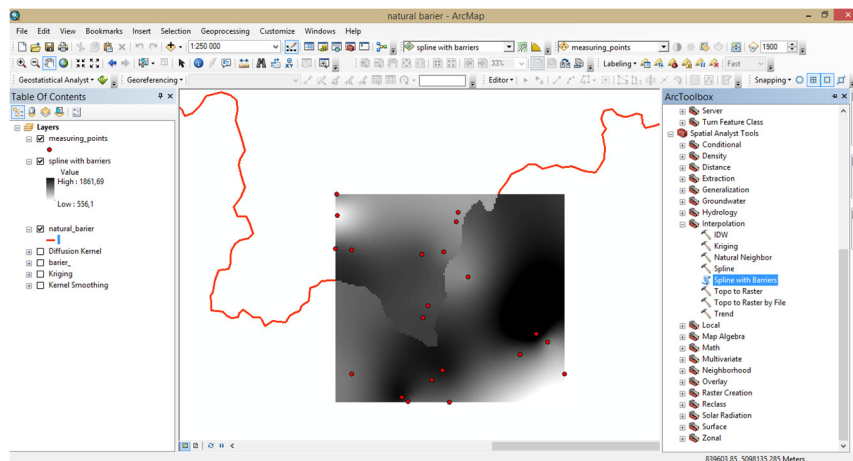


Fig. 6. The use of Spline with Barriers – an example (Source: authors' own work)

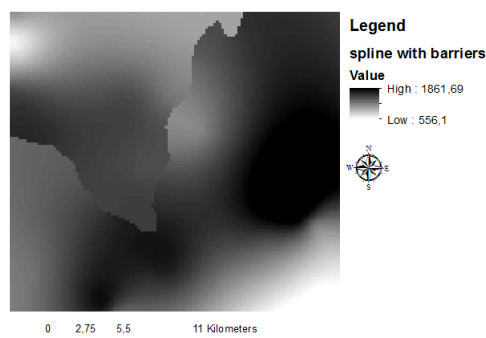


Fig. 7. The use of Spline with Barriers – the results (Source: authors' own work)

## Conclusions

Sustainable transport development in Polish functional urban areas relates to solving many problems and eliminating a wide catalogue of barriers. The influence of some of them can be precisely predicted. There is a seven-year horizon of financing and regular budgeting. We can also use different variants of location in order to avoid the influence of natural barriers. Other catalogues like social conditions are more or less predictable. General trends like aging, migration and ownership might be predicted using short- and long-term analyses. Phenomena such as urban sprawl affect the hinterland and make it more difficult for local and regional authorities to create sustainable transport development. However, the impact that, for instance, NIMBY trends have on transportation development are difficult to calculate or foresee, meaning that the Polish authorities will certainly face challenges during the process of developing sustainable transport. These aspects are also subjects for future studies.

However, it should be emphasised that external and internal conditions are improving. There are new tools, such as ITI, that can be used, and funds for transport development in functional urban areas are more or less secured. Regional and local authorities are likely to achieve their goals through the use of monitoring procedures and proper budgeting. They should also choose verified partners and stick to the schedule as closely as possible. The results from partial analyses show that some provinces should improve their dislocation of expenditures in this horizon or the next, but the documents and versions of ROP 2014–2020 were already updated several times last year, and it seems that some changes might still be prepared in the future.

As the sustainable transport development in FUA is closely related with the “travel – to – work” trends more attention should be put on the everyday flows of commuters and detailed studies should be conducted on this subject. Such approach will help to avoid implementation of misguided, inefficient investments in transportation.

## Disclosure statement

Authors do not have any competing financial, professional, or personal interests from other parties.

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