TRACC
Transport Accessibility at Regional/Local Scale and Patterns in Europe

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Volume 3

TRACC Regional Case Study Book

Part F
Baltic States case study

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Table of contents

Figures

Tables

1 Introduction

The ESPON project TRACC (**TR**ansport **ACC**essibility at regional/local scale and patterns in Europe) aimed at taking up and updating the results of previous studies on accessibility at the European scale, to extend the range of accessibility indicators by further indicators responding to new policy questions, to extend the spatial resolution of accessibility indicators and to explore the likely impacts of policies at the European and national scale to improve global, European and regional accessibility in the light of new challenges, such as globalisation, energy scarcity and climate change.

The Transnational Project Group (TPG) for the ESPON project TRACC consisted of the following seven Project Partners:

- Spiekermann & Wegener, Urban and Regional Research (S&W), Dortmund, Germany (Lead Partner)
- Charles University of Prague, Faculty of Science, Department of Social Geography and Regional Development (PrF UK), Prague, Czech Republic
- RRG Spatial Planning and Geoinformation, Oldenburg i.H., Germany
- MCRIT, Barcelona, Spain
- University of Oulu, Department of Geography (FOGIS), Oulu, Finland
- TRT Trasporti e Territorio, Milan, Italy
- S. Leszczycki Institute of Geography and Spatial Organisation, Polish Academy of Sciences (IGSO PAS), Warsaw, Poland

This report is part of the TRACC Final Report. The TRACC Final Report is composed of four volumes.

- Volume 1 contains the Executive Summary and a short version of the Final Report
- Volume 2 contains the TRACC Scientific Report, i.e. a comprehensive overview on state of the art, methodology and concept, and in particular results on the global, Europe-wide and regional accessibility analyses and subsequent conclusions of the TRACC project.
- Volume 3 contains the TRACC Regional Case Study Book. Here, each of the seven case studies conducted within the project is reported in full length.
- Volume 4 contains the TRACC Accessibility Indicator Factsheets, i.e. detailed descriptions of all accessibility indicators used in the project.

This report on the Baltic States case study region is one of the major parts of Volume 3 TRACC Regional Case Study Book. The report starts with a short description of the case study region. Then, the results for six different accessibility indicators will be presented and discussed, first for the whole case study region and then in more detail for selected subregions, so called zoom-in regions. This analysis of the current accessibility conditions in the region for car travel as well as for public transport is followed by an analysis of how the planned trans-European transport networks would change the accessibility pattern within the region.

The design of the case study analysis was made in a way that all seven case studies are highly comparable as the definition of the accessibility indicators and its implementation were handled in a rather strict way. Also, the way results are presented in maps, diagrams and more general in the case study reports is highly comparable. A comparable analysis across all case studies is provided in Volume 2, the TRACC Scientific Report. All reports are available at the ESPON website www.espon.eu.

2 The Baltic States case study region

Global and European accessibility are important location factors for firms and working and leisure activities of people. However, for the daily life of citizens, regional/local accessibility to jobs, services and public facilities may be more important than global or European accessibility. One part of the TRACC project is therefore concerned with regional accessibility in a set of regional/local case studies in order to gain systematic knowledge on accessibility patterns in different types of regions throughout Europe.

One of the seven case studies of the TRACC project is the Baltic States case study region[1]. This case study region was selected as it represents peripheral, sparsely populated regions in the new EU Member States, with rigorous climates that underwent a transition phase from republics of the Former Soviet Union to independent countries.

In order to be of comparable size with the other six case studies in terms of area and population coverage, all three Baltic States were together selected as one case study.

2.1 Spatial structure

All the three Baltic States are primarily rural countries with generally low population densities, lacking a system of cities and agglomerations. Only the capital city regions and to some extend the seaports are agglomerated areas, concentrating most of the private and public services and capital. The other parts of the countries are rural areas, with small and medium-sized towns with population of less than 25,000 inhabitants (Figure 2), often less than 5,000 inhabitants, resulting in extremely poor population densities of less than 50 people per km^2 (Estonia: 30 inh/km^2, Lithuania: 52 inh/km^2; Latvia: 35 inh/km^2) (Wikipedia, 2012a; 2012b; 2012c). The population density figures are also reflected in the settlement density (Figure 1), where it can easily be seen that settlements in Estonia and Latvia are sparsely distributed compared to Lithuania.

Altogether, nowadays some 6.7 mio people live in the three Baltic States, with 3.2 mio people in Lithuania, 2.2 mio people in Latvia and 1.3 mio people in Estonia. In all three countries, population is clearly concentrated in the capital regions (Figure 2); only few other cities are of substantial size, which are the Baltic Sea ports, and some regional hinterland cities.

Most of the cities and towns in the Baltic States experienced a population decline in the last decade (Schmitt et al., 2008, 19), only the capital cities remained stable in terms of population in this period. In case of Klaipeda and Riga city regions, some suburbanisation processes could be observed since the year 2000, where the surrounding smaller towns increased population over-proportionally compared to the core city.

2.2 Socioeconomic situation

Despite its annual economic growth rate of 5-6% since 2000 (from very low levels, though), the economic performance of the overall macro region is still poor, experiencing employment rates and GDP per capita figures of only 25-50 % of the EU27 average. Only the three capital city regions reach the European average.

GDP per capita is highest in the macro region for Estonia (15,850 US$), followed by Lithuania (14,273 US$) and Latvia (11,985 US$) (Wikipedia, 2012a; 2012b; 2012c). The dominance in the primary sector, in particular in Latvia and Lithuania, underlines the predominantly rural character of the macro region. The human development index (HDI) is quite high for all three countries,

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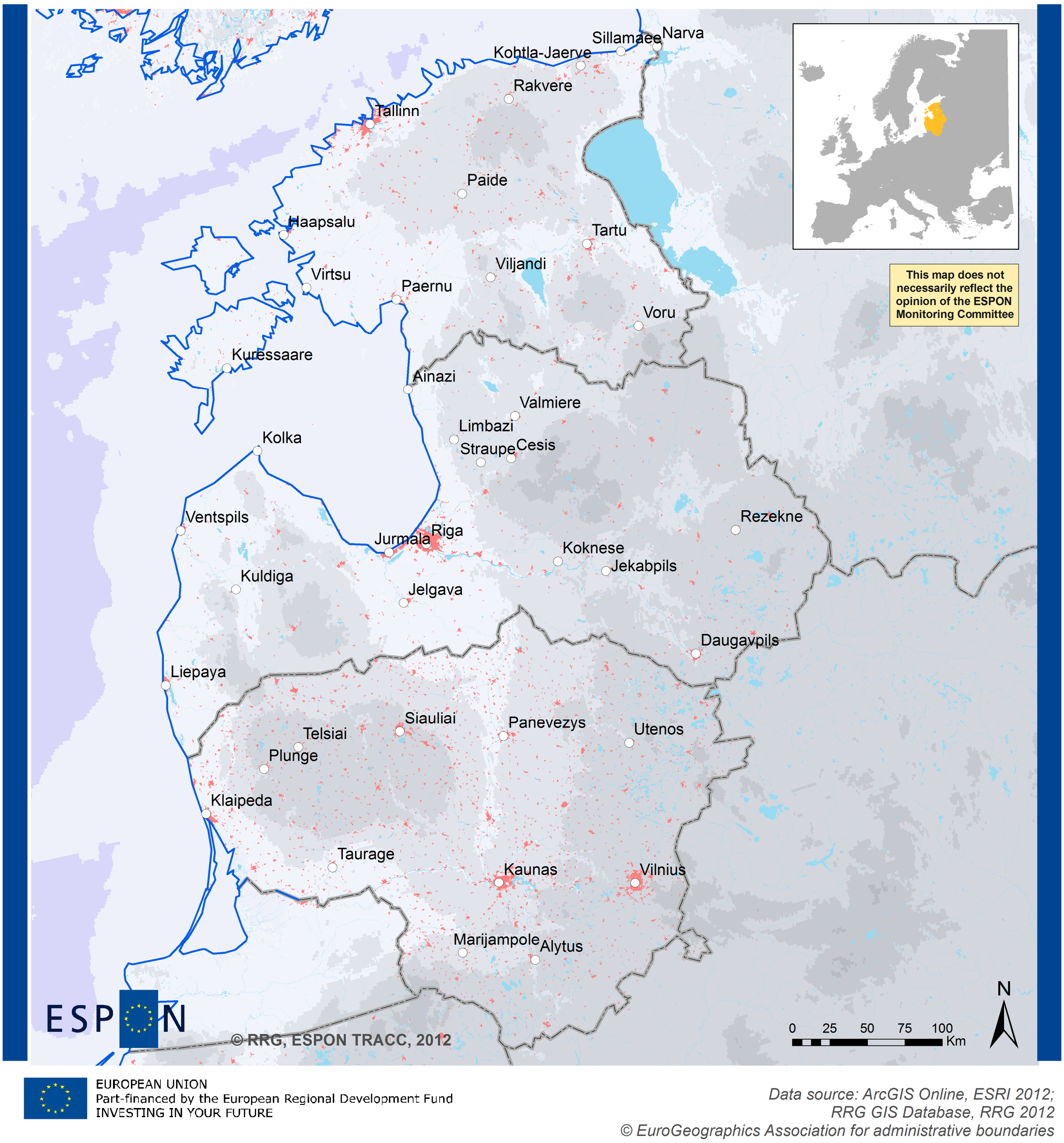
[1] The other six case study regions in this project are Finland, Poland, Czech Republic, Bavaria (Germany), Northern Italy and the Euramed region. Similar case study books are available for each of these case studies.

ranging from 0.769 for Latvia to 0.812 for Estonia, compared to other continents, but at the lower end of the spectrum compared to the European Union average, where most countries show HDI numbers above 0.85 (UNDP, 2012).



Data source: ArcGIS Online, ESRI 2012; RRG GIS Database, RRG 2012
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Baltic States Case Study
Physical map

○ Main city

🟥 Settlement area

Figure 1. The Baltic States case study region

In Estonia about 60% of the national GDP is generated in the greater Tallinn area (Harjumaa), for trade and services alone this share is even 70%. The primary sector is concentrated in central and southern Estonia, while the energy sector is concentrated in the Northeast close to the Russian border.

In all three countries there is a high concentration of employment in the capital city regions, as well as in the ports (Pärnu, Ventspils, Liepaya, Klaipeda). There are only few landlocked cities such as Tartu (Estonia), Daugavpils, Rezekne and Valmiere (Latvia), and Siauliai, Panevezyz and Kaunas (Lithuania) acting as regional economic and employment centres for their rural hinterland (Figure 3).

Previous accessibility studies have revealed that only the capitals gained accessibility levels above the EU27 average, while all other parts of the countries lagged significantly behind, in terms of population potential, accessibility to population and also accessibility to GDP, with accessibility levels in the European context similar to those of peripheral territories in northern Scandinavia, not only due to the extremely low population densities, but also due to a lack of high-quality transport infrastructure.

2.3 Transport aspects

Generally, the transport systems in the Baltic States to a large degree still reflect the infrastructures of the past, when the three countries were part of the Soviet Union. Density, quality and orientation of the main transport arteries to date represent former traffic and goods flows. After the transition from Soviet Union to independent states, the transport systems reveal some severe immanent problems:

- A major obstacle to transport is the general layout of the main transport infrastructure: for historical reasons all main road and rail infrastructures are west-east oriented, connecting central parts of Russia with the Baltic Sea seaports. Until today, this remained the main trade flow direction in this area (see Böhme et al., 1998). In contrast, north-south oriented transport arteries are very scarce and, if they exist, are often of poor quality. For instance, to date there is no direct north-south train connection from Poland to Tallinn (Dubois and Schürmann, 2009, 549). This is a major obstacle for the three capital city regions of Vilnius, Riga and Tallinn to move closer together.
- All three countries are lacking high-level transport systems, such as motorways or high-speed train sections. There are only few motorway and dual-carriageway sections, opened to traffic only recently, and almost no high-quality rail lines (Figures 4 and 5). The remaining road networks are preliminary designed to meet regional transport demand rather than long-distance inter-city traffic.
- A recent survey of UN ECE revealed that the secondary road networks developed differently in the three countries: While for Lithuania (140%) and Estonia (125%) these networks increased significantly since the beginning of the 1990s, the lengths of these networks in Latvia declined to 92% in the same period (UNECE, 2008)[2].
- While the general density of the road networks is quite good, the density of the rail networks is rather low in the Baltic States, which is obvious when comparing Figures 4 and 5. Apart from the main railway lines connecting the capital cities with the main ports and with Russia, almost no substantial rail links are available (RRG, 2012). In addition, many of the existing lines suffer from poor conditions due to a lack of maintenance.

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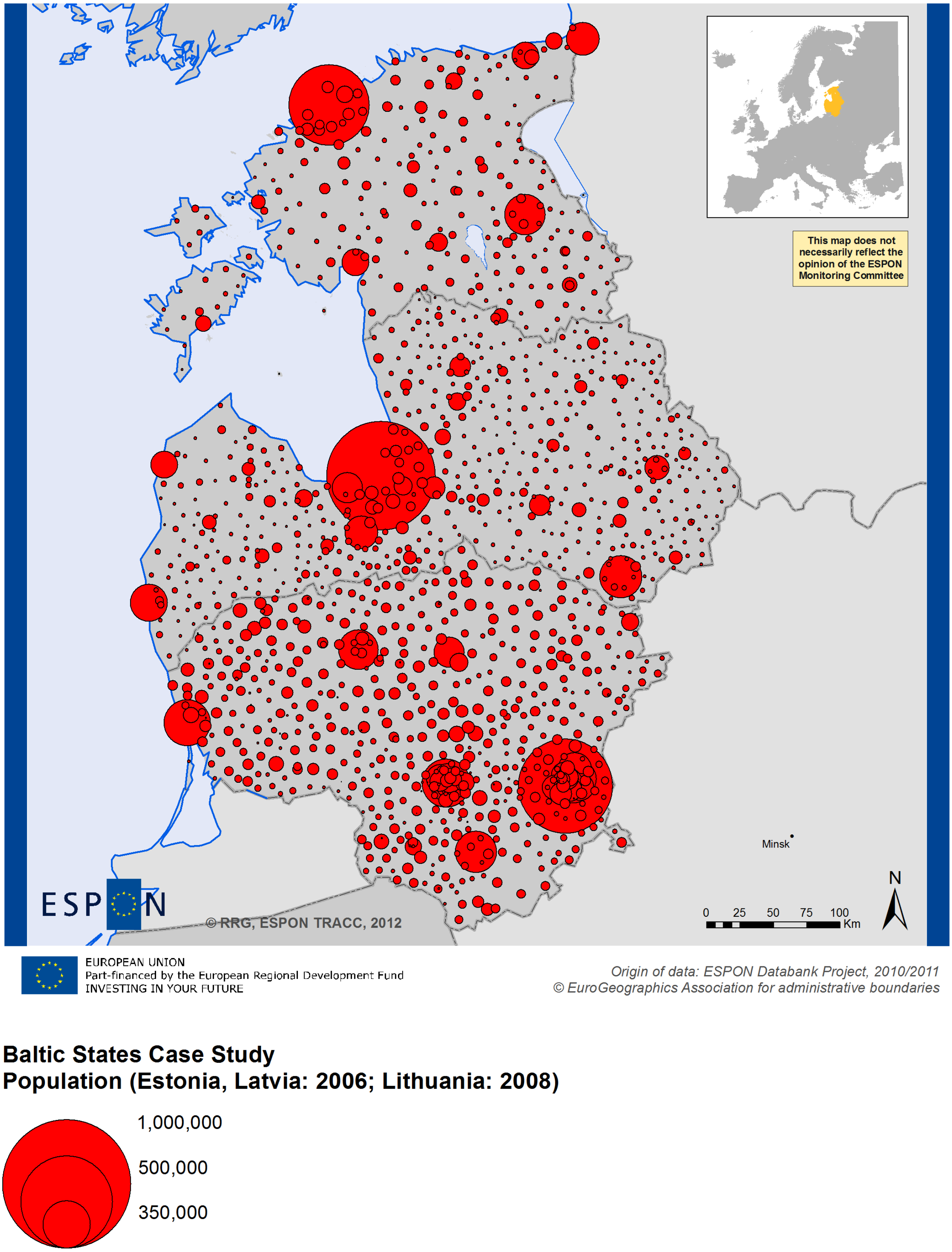
[2] UN ECE did not provide any reasons for these different developments. It might be that the numbers for Latvia are statistical artefacts due to changes in the road classification schemes.



Origin of data: ESPON Databank Project, 2010/2011
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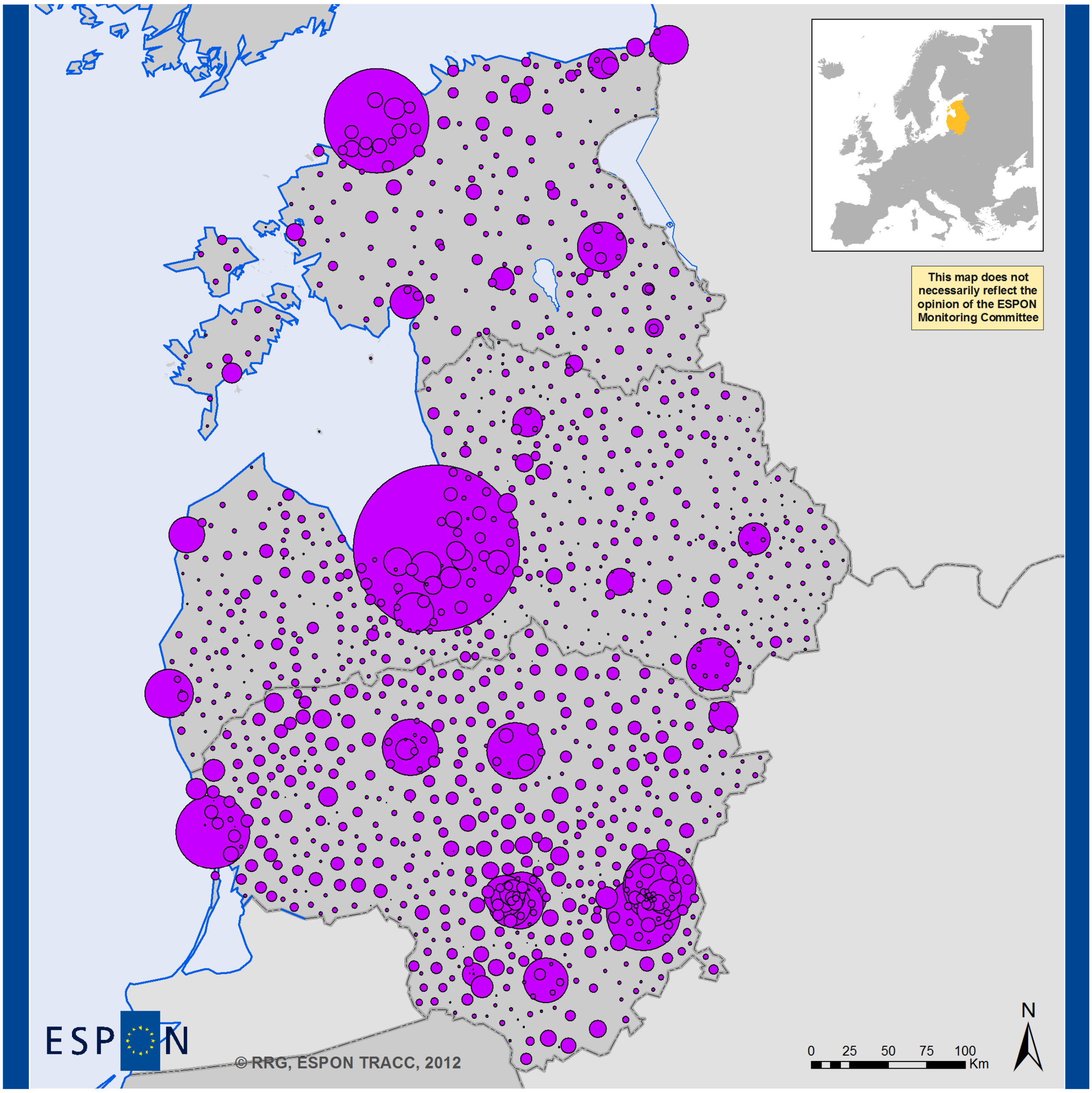
Baltic States Case Study
Population (Estonia, Latvia: 2006; Lithuania: 2008)

Figure 2. Population distribution



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Baltic States Case Study
Number of employees

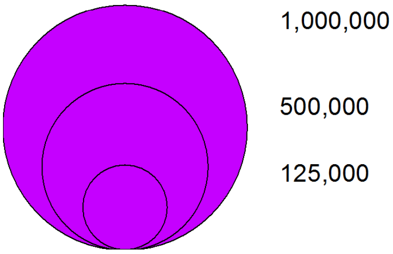

Figure 3. Job distribution

- All three countries have at least one major ferry seaport, which is tightly embedded into Baltic Sea shipping networks, but none of the countries has any inland waterway network, which would allow feeder-shipping services from/to the main ferry hubs. Therefore, all incoming goods must be transhipped in the ferry seaports to road and railway services. Unfortunately, the hinterland connections of these ports are of low quality as well. Some of the ferry services connecting to the Baltic seaports belong to the top 25 connections in terms of number of weekly ferry services (for instance, Helsinki-Tallinn ferry ranked 3 with 392 weekly ferry services in 2007) (Schmitt et al., 2008, 83).
- Each of the three countries has one international airport in the capital city region[3]. Even though these airports provide quite a number of services to various countries, the number of direct destinations served is rather low compared to major airports in Central Europe (OAG, 2012). Since there are no other commercial airports in these countries except the three main ones, all commercial air services have to go through these three, which requires good accessibility of these airports in a regional context. Unfortunately, this is the case only to some degree.

Altogether, there is no high-quality transport infrastructure interconnecting the three Baltic States. The present TEN-T outline plans try to overcome this handicap by implementing new prioritized road and rail axes in North-South direction, connecting Tallinn in the north with Poland in the south (European Commission, 2011)[4].

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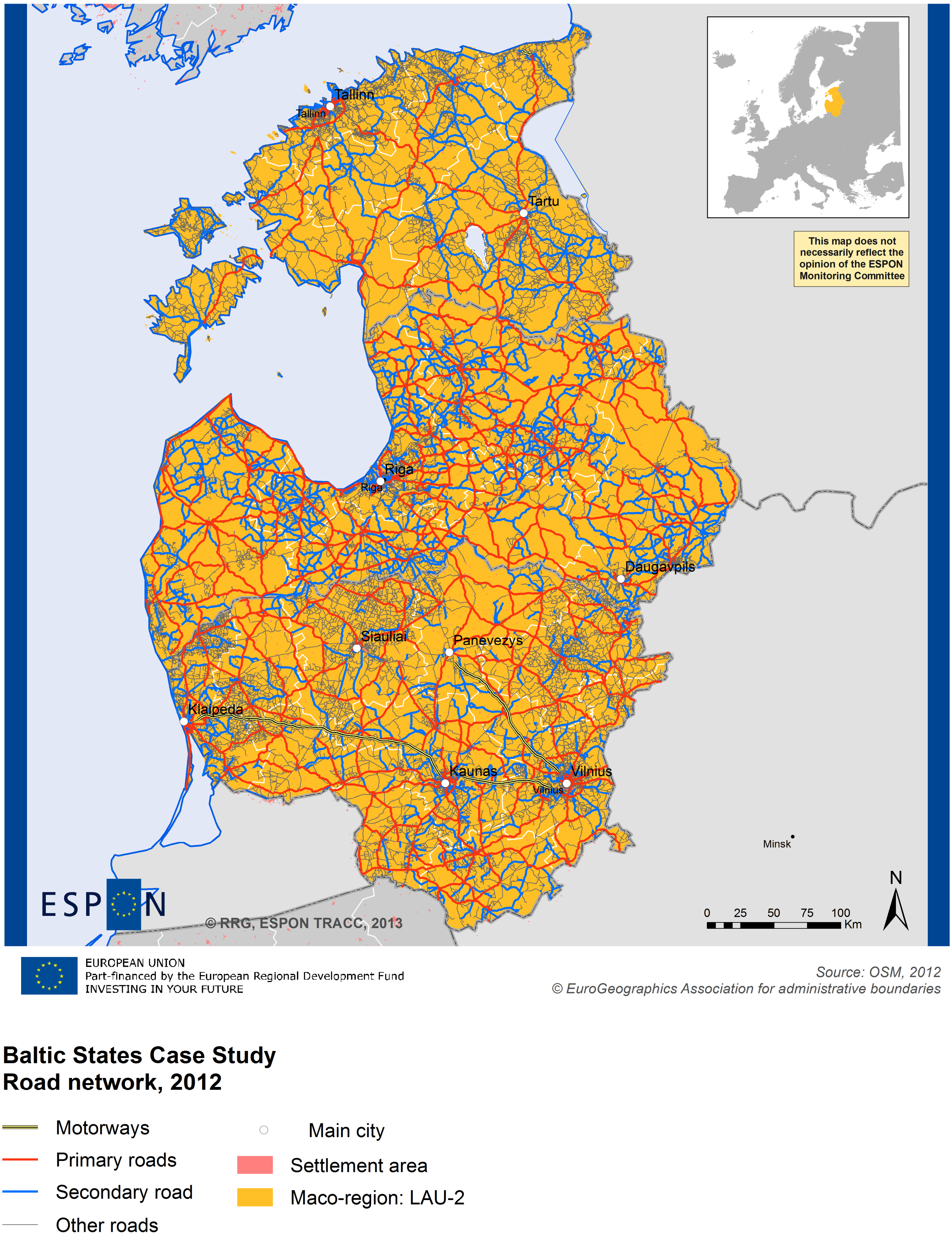
[3] It is worth mentioning that the TEN-T networks altogether include 12 airports in the Baltic States (see TenTAC Geographic Information System; http://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/main.jsp); however, only the three airports in the capital regions are well embedded into international flight schedules. Apart from these three, only the airports of Kaunas and Palanga have some rare international flights (according to 2011 summer flight schedules).

[4] see Chapter 5 of this book for an impact discussion of these outline plans



Source: OSM, 2012
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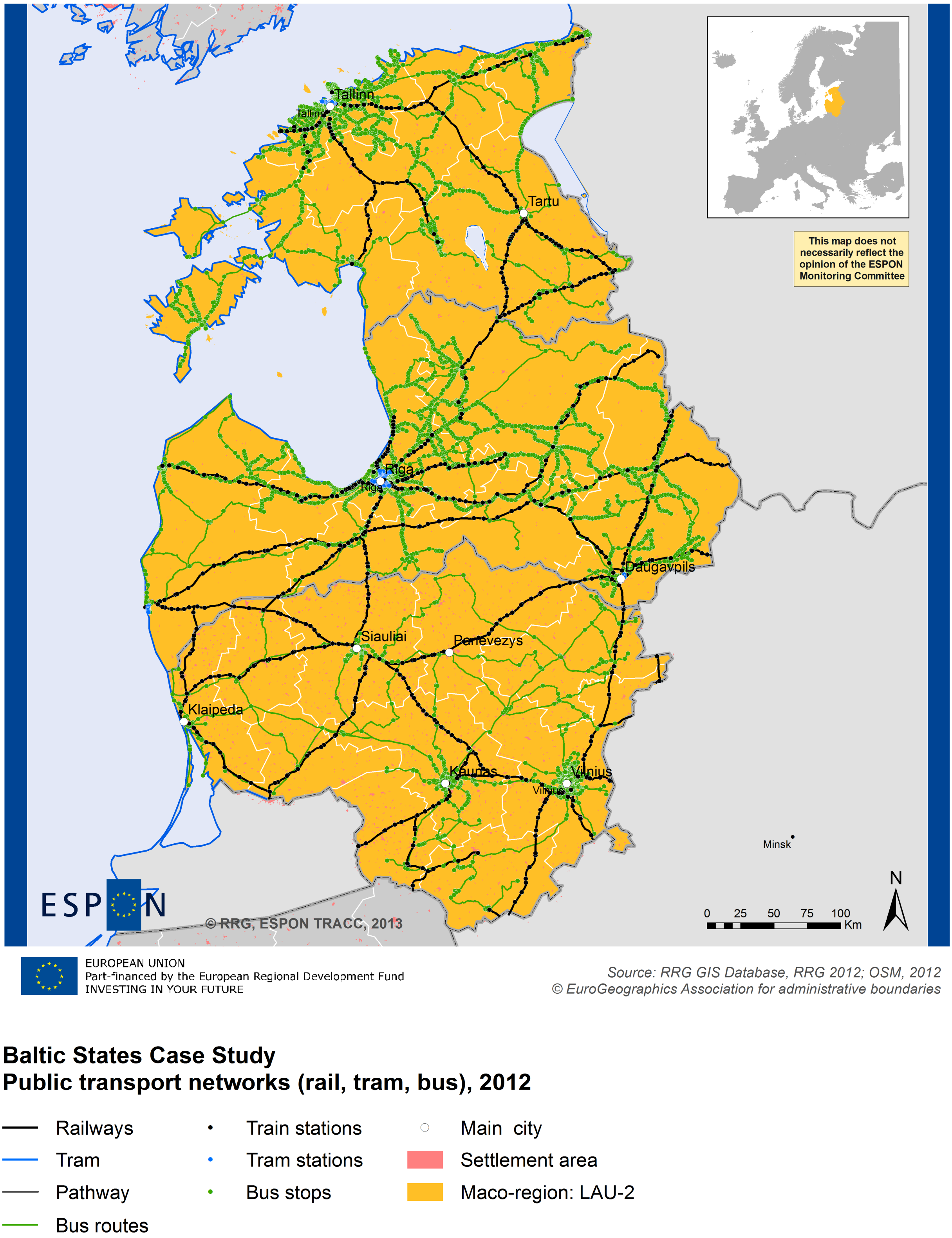
Baltic States Case Study
Road network, 2012

Figure 4. Road network



Source: RRG GIS Database, RRG 2012; OSM, 2012
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Baltic States Case Study
Public transport networks (rail, tram, bus), 2012

Figure 5. Rail network

3 Accessibility patterns at regional and local scale

In order to analyse the accessibility patterns at regional and local scale for the Baltic States, a set of six different accessibility indicators has been defined, of which three indicators belong to traditional accessibility indicators, and another three indicators belong to new type of indicators measuring access to services of general interest. The following indicators have been identified:

- *Access to regional centres*. How distant or how far is the next regional centre? Proximity to an urban centre has often been used as a proxy for accessibility to jobs and different services such as higher education, health care, commerce etc. For each raster cell of the case study region, the minimum travel times by road and public transport to the next urban centre are calculated.
- *Daily accessibility of jobs*. How many jobs can I reach from my place of residence? This indicator approaches the opportunities of the regional labour market from the point of view of the population. For each raster cell the amount of jobs reachable within a maximum commuting distance of 60 minutes by car and by public transport are estimated.
- *Regional potential accessibility.* What is the regional population potential of any point in space? In order to evaluate the different locations within a region from the viewpoint of economic actors, e.g. firms assessing the regional labour market, or retail industries assessing the market area, the population potential of each raster cell within the case study region is analysed. As for the other spatial levels the population potential is calculated as the sum of people in destination areas weighted by the travel times to go there. Modes considered are road and public transport.

The second set of more advanced indicators considers destinations of specific relevance for daily life, i.e. services of general interest:

- *Access to health care facilities*. What is my travel time to go to the next hospital? Travel times for each raster cell by road and by public transport show the spatial diversity in access to important health care facilities.
- *Availability of secondary schools*. Do I have access to secondary schools in reasonable travel time and do I have a freedom of choice to select between different options? For each raster cell travel time contours of 30 minutes by road and by public transport are calculated, and it is assessed how many secondary schools are reachable within this travel time.
- *Potential accessibility to basic health care.* What is my locational quality with respect to basic health care? Using general practice surgeries as destination activity in a potential accessibility indicator allows assessing the relative distribution of health care provision of different areas within the case study region. For each raster cell, the potential value is calculated as sum of general doctors located in the case study region weighted by travel times by road and public transport.

All indicators are calculated for road and for public transport, where the latter one includes railways, light urban rails, and busses. The road and public transport networks as shown in Figures 4 and 5 are used as input for the calculations.

First, all indicators are calculated at raster level with a resolution of 2.5x2.5 km. The Baltic States macro region is thus subdivided into approx. 27,000 raster cells. Later, raster results were aggregated to LAU-2 level (municipalities)[5] as population-weighted average. Annex 2 provides more information about the used databases, while Annex 3 gives detailed information about the applied accessibility model.

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[5] The LAU-2 delineation as of 2006/2008 has been used in this study. By way of consequence, the outcome of the administrative territorial reform in Latvia carried out on 1st July 2009 has not been considered, since statistical data for the new entities were not yet available at the beginning of this study.

3.1 Access to regional centres

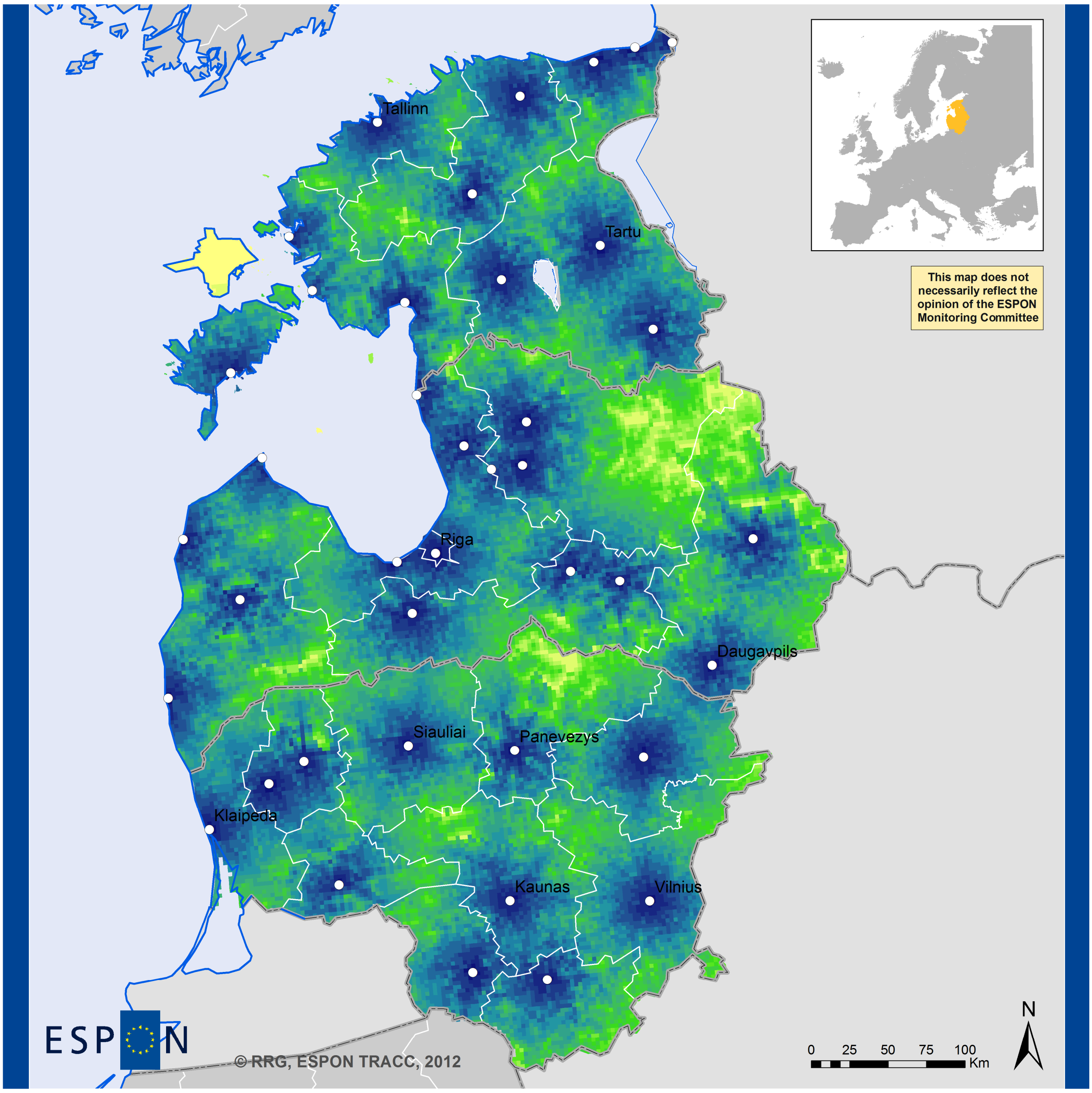
This indicator analyses the travel time to the next regional centre by road and by public transport. All cities with more than 50,000 inhabitants or cities representing a centroid of a NUTS-3 region are considered as relevant destinations for this indicator.

For road, regional cities in the macro region can be reached from many places in less than 30 minutes (Figure 6). Major road arteries extend these highly accessible areas far into the hinterland (see, for instance, Kaunas or Siauliai), generating star-shaped accessibility surfaces. Plateaus of high accessibilities are spanned in Latvia in Riga-Jelgava-Jurmala and Valmiere-Cesis-Straupe-Limbazi city systems, as well as in the Kaunas-Alytus-Marijampole city triangle. From places within these plateaus, people can reach more than one city in less than 30 minutes car travel time. In Northern Lithuania, the six regional cities form a necklace of stars with short travel times, which is interrupted by areas with lower accessibilities with travel times in between 30 and 60 minutes. In Estonia, highest accessibilities can be found in the coastal areas where travel times to the ports are shortest. In addition, the regional cities of Paide, Viljandi, Tartu and Vöru serve the rural hinterland of the country. From none of the resident places in Estonia people can reach more than one regional city within reasonable travel time, i.e. there is just one centre serving the area.

Apart from these areas with high accessibility, there are also extensive parts in the Baltic States where travel time to the next regional city exceeds 100 minutes. These areas are first of all represented by the border areas (i.e. between Lithuania and Latvia, and Latvia and Estonia, but also towards the borders with Russia and Belarus), but there are also some ‘inner peripheries’ in the middle of the countries such as the area between Kaunas, Taurage, Parnevezys and Siauliai in Lithuania, or the area between Rakvere, Paide and Tartu in Estonia. Eventually the longest travel time to next regional centre can be found for the Estonian islands, in particular for the island of Hiiumaa.

For public transport, the situation is quite striking and highly different from road (Figure 7). Most areas in Lithuania and Latvia, and to a lesser degree but still remarkable also in Estonia, yield travel times of more than 100 minutes to the next regional centre. Actually, many of these can be considered to be inaccessible by public transport since working or cycling distances to the next bus stop or to the next railway station is beyond every reasonable time. In the contrary, there are small and distinct areas of high accessibility with travel times of less than 60 minutes, forming the main public transport axes (for instances, axis from Tallinn via Paide to Tartu, an axes from Riga via Koknese and Jekabpils towards Rezekne, or another southbound axes from Klaipeda to Taurage, just to mention three of them). In the rural parts of the countries there are individual distinct ‘spots’ of high accessibilities around the bus stops of the cross-country busses or around railway stations, which are surrounded by areas of extremely low accessibility. Such spots are typically spatial patterns generated by public transport systems. Unlike road, public transport does not span plateaus of high accessibility, but there are only individual service areas and axes. This means that if people can reach a regional centre at all within 60 or 30 minutes travel time, they can only reach one city.

An aggregated analysis by different types of urban and rural regional typologies (Figure 8) once again revealed the generally longer travel times by public transport compared to road; moreover, as expected, the chart highlights that for both modes travel times to next regional centres are shortest for urban regions and for intermediate regions close to a city, while travel times are significantly longer for intermediate remote and rural regions. For instance, for urban regions the 25th percentile for cars (public transport) is about 20 (40) minutes and the 75th percentile is about 40 (100) minutes, while for rural remote regions the 25th percentile increased to 25 (62) minutes and the 75th percentile increased to 44 (135) minutes.



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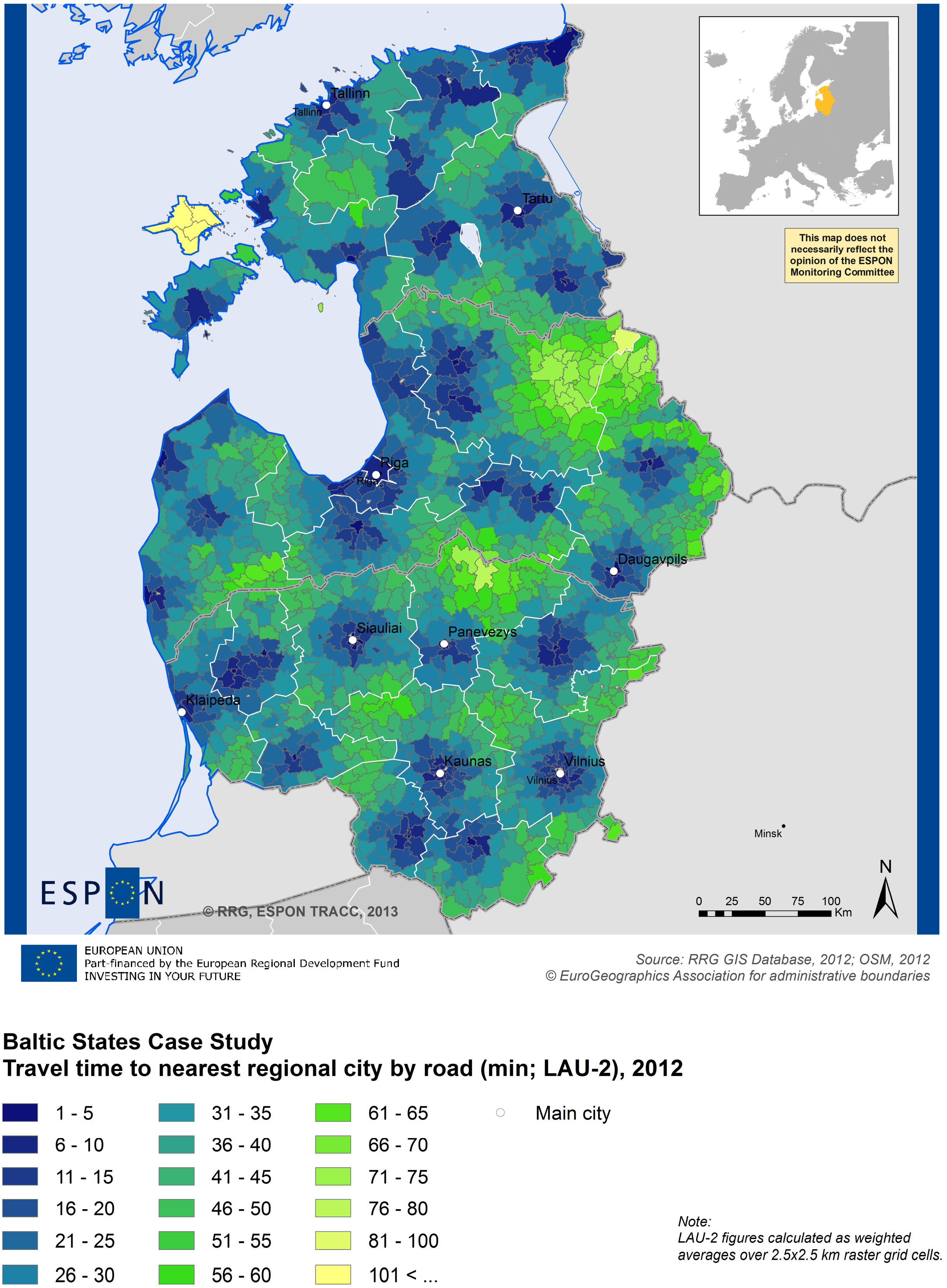
Baltic States Case Study
Travel time to nearest regional centre by road (min; 2.5x2.5 km raster), 2012

🟦 0 - 5
🟦 6 - 10
🟦 11 - 15
🟦 16 - 20
🟦 21 - 25
🟦 26 - 30
🟦 31 - 35
🟩 36 - 40
🟩 41 - 45
🟩 46 - 50
🟩 51 - 55
🟩 56 - 60
🟩 61 - 65
🟩 66 - 70
🟩 71 - 75
🟩 76 - 80
🟨 81 - 100
🟨 101 < ...
○ Regional city

Figure 6a. Travel time by car to next regional centre (raster level)



Source: RRG GIS Database, 2012; OSM, 2012
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Baltic States Case Study
Travel time to nearest regional city by road (min; LAU-2), 2012

Note:
LAU-2 figures calculated as weighted averages over 2.5x2.5 km raster grid cells.

Figure 6b. Travel time by car to next regional centre (LAU-2 averages)

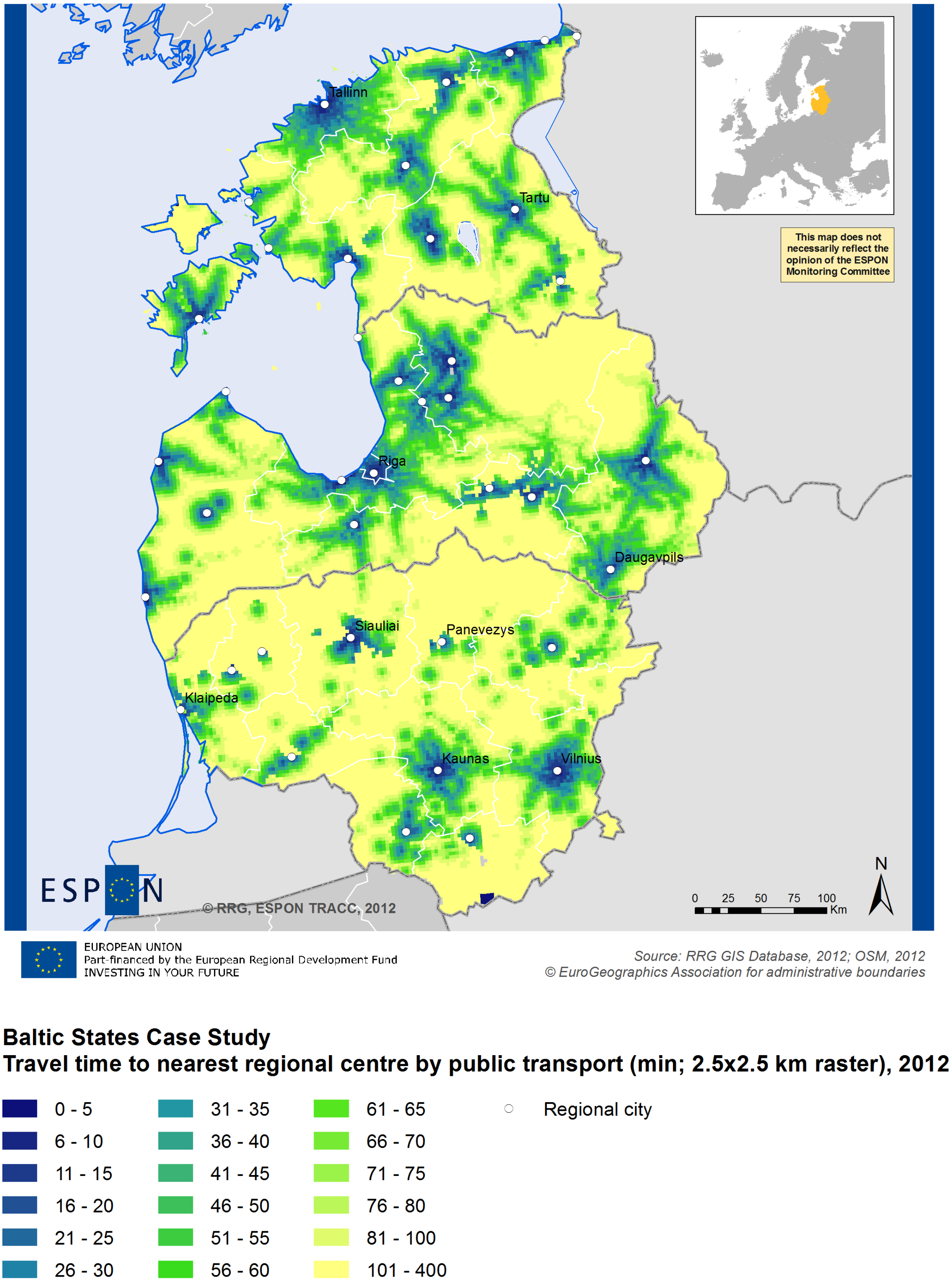


Figure 7a. Travel time by public transport to next regional centre (raster level)

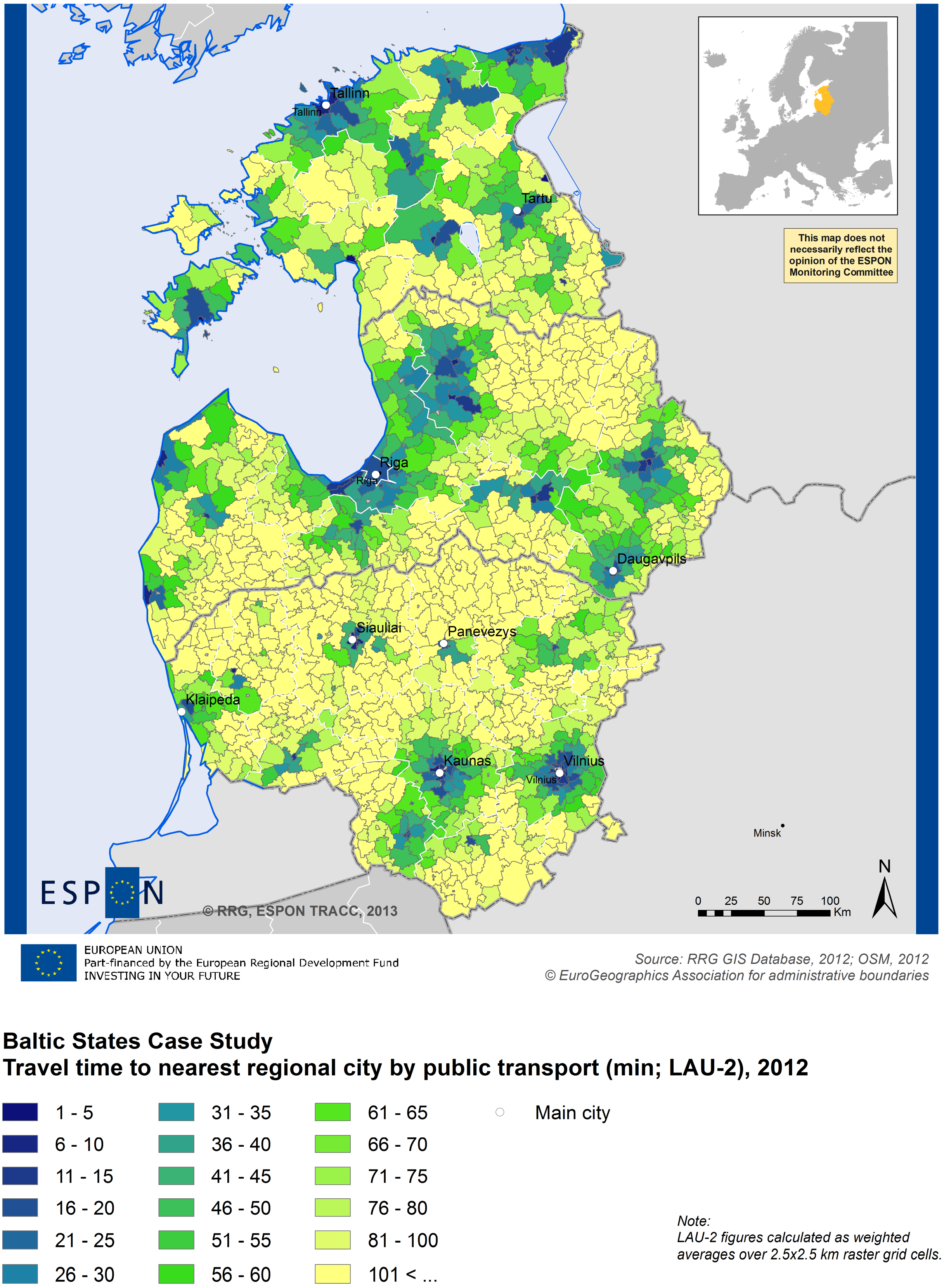


Figure 7b. Travel time by public transport to next regional centre (LAU-2 averages)

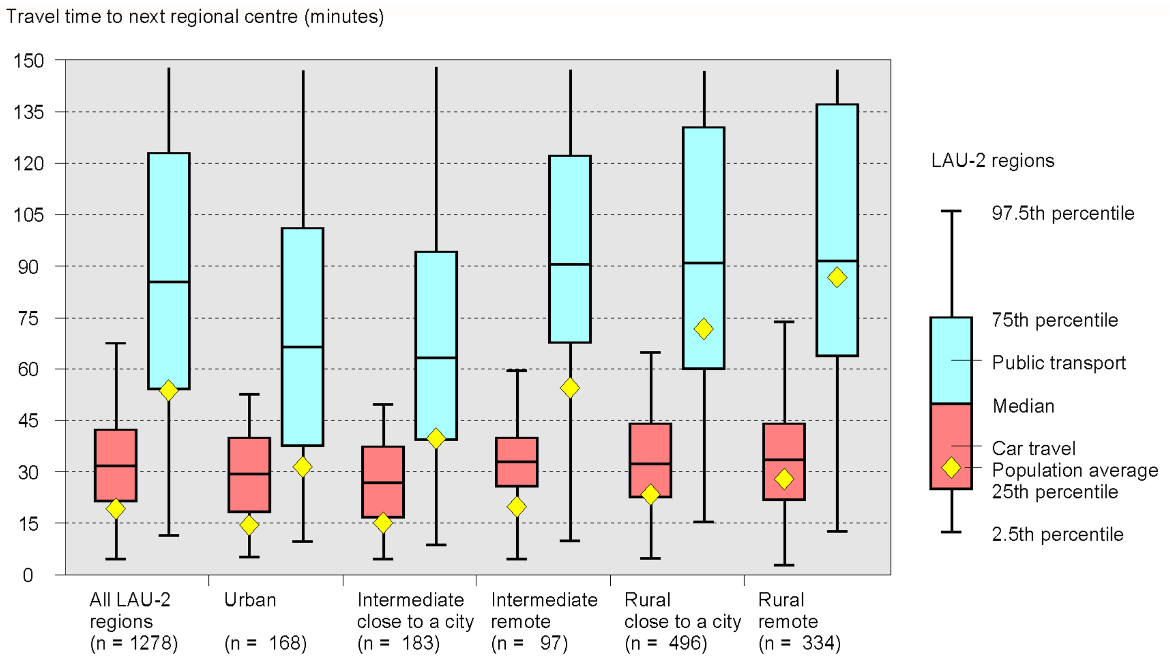


Figure 8. Travel time to next regional centre, by urban-rural typology

The cumulative population distribution as shown in Figure 9 illustrates that for cars 100% of the population of the entire case study area can reach a next regional centre in less than 75 minutes; for public transport only 70% of the overall population can reach a city in the same period. For urban and intermediate regions 50% of the population can reach the next city in less than 10 minutes (public transport: approx. 17 minutes), and 100% of the population within 60 minutes (public transport: more than 150 minutes). In other words, while the service quality for about 50% of the population is almost similar for both modes for all types of regions, there is a significant drop in accessibility for the remaining predominantly rural population, which experience extremely poor service qualities in public transport.

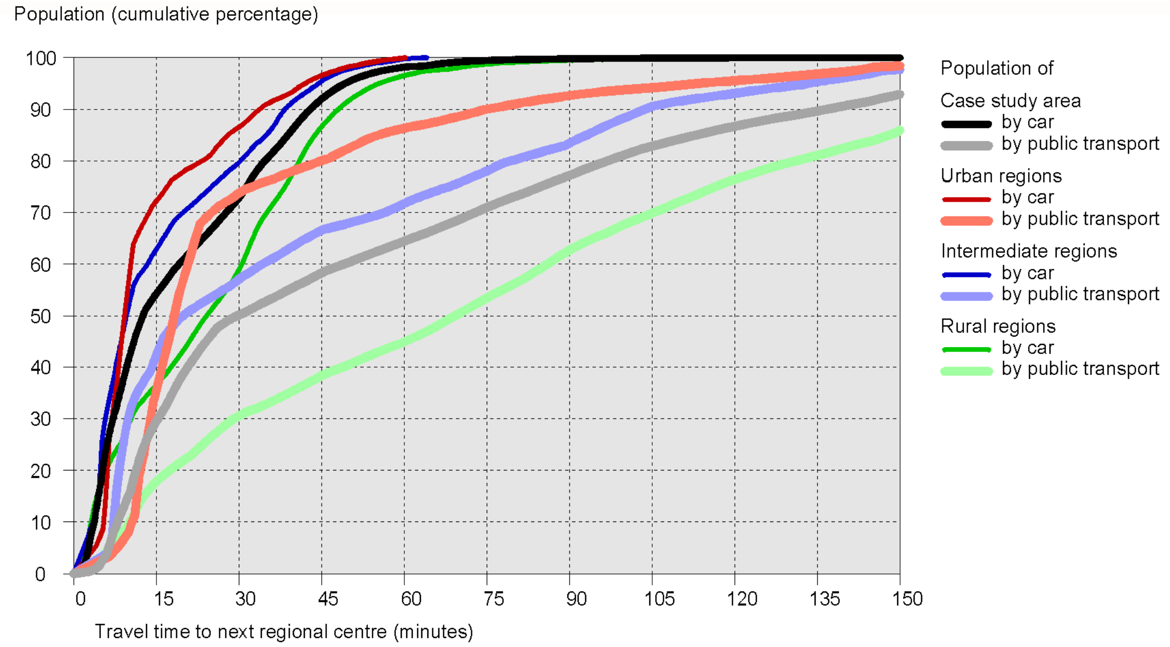


Figure 9. Travel time to next regional centre, cumulative distributions

3.2 Daily accessibility of jobs

This indicator approaches the opportunities of the regional labour market from the point of view of the population. For each raster cell the amount of jobs reachable within a maximum commuting distance of 60 minutes by car and by public transport are estimated.

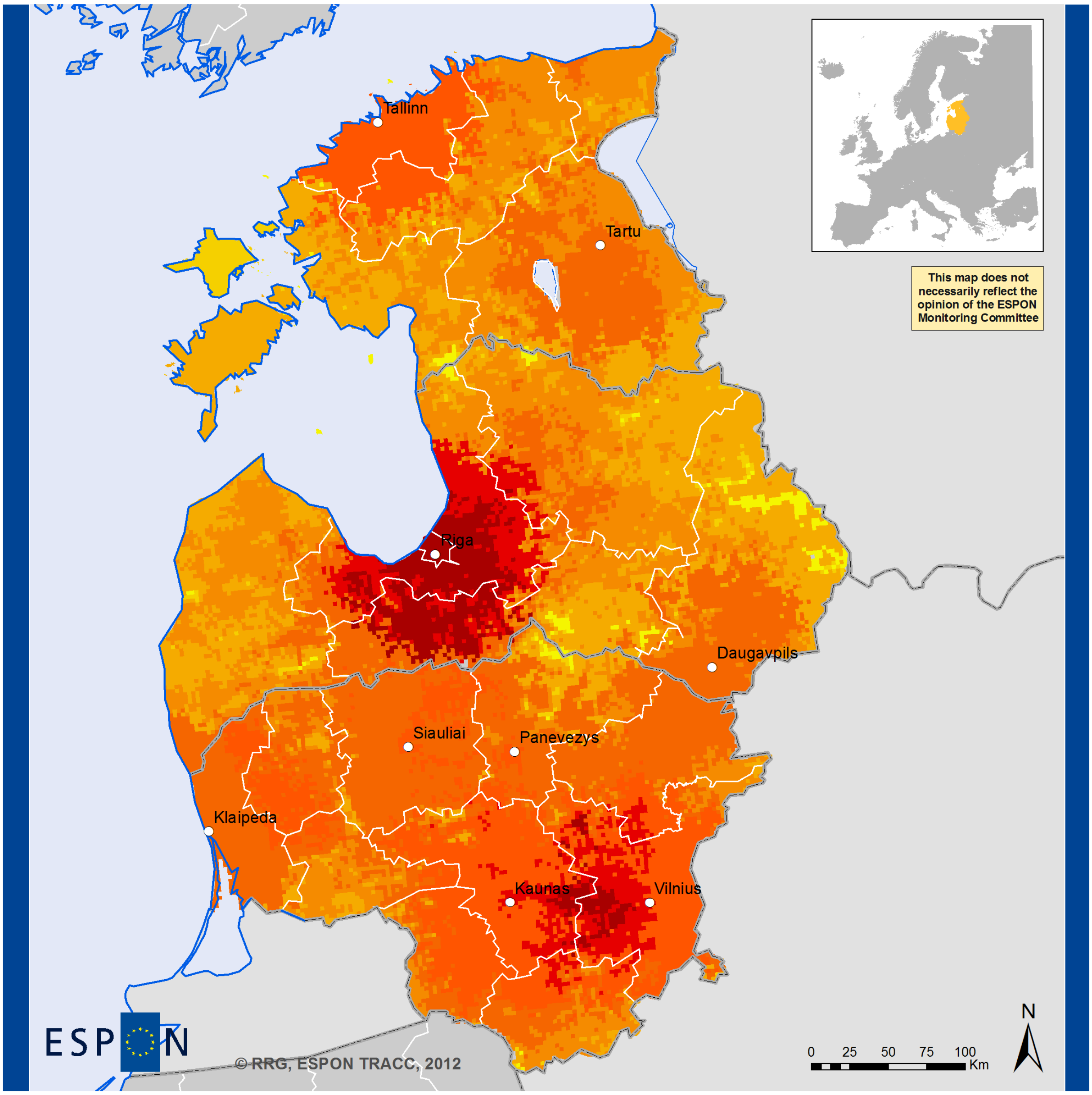
There are large differences in jobs accessibility, even for road (Figure 10). While from places along the borders people can only reach up to 5,000 jobs, in contrary from the highest accessible places people can reach more than 750,000 jobs within 60 minutes car travel time. The latter areas are the greater Riga agglomeration, as well as the area between Kaunas and Vilnius in Lithuania. Estonia has two labour market centres, which are Tallinn and Tartu, however, due to the generally lower population numbers of Estonia these two areas do not yield as high accessibility figures as the other two areas mentioned. While Riga is dominating the accessibility surface for Latvia, the situation in Lithuania is more interesting since the centres of Klaipeda, Siauliai and Parnevezys form individual distinct labour markets where people can reach between 100,000 and 500,000 jobs. While the accessibility ranges between minimum and maximum are highest in Latvia, Lithuania on average shows the highest general accessibility level throughout the entire country. Apart from the two main labour market areas mentioned, the job accessibility in Estonia is rather low with most places yielding rather small numbers between 10,000 and 100,000 jobs.

As expected, accessibility levels for public transport are generally lower for the entire macro region (Figure 11). For large areas in all three countries, 5,000 jobs can hardly be reached within 60 minutes. For these areas public transport cannot be considered as real option for daily job commuting. These low accessibility areas are, however, often interrupted by distinct axes of higher accessibilities along the public transport corridors (which are mainly rail corridors). Accessibility is highest in star-shaped axes connecting the agglomeration centres into their hinterland (for instance, for Riga, Tartu, and Vilnius), which means that train services extend the areas of high job accessibility into the countryside. The agglomeration of Riga clearly shows the highest public transport accessibility within the Baltic States with up to 750,000 jobs, followed by the agglomerations of Vilnius, Kaunas, Tallinn, Klaipeda, Daugavpils and Tartu. However, compared to road, the overall number of jobs to be reached is much lower for all these areas due to the longer travel time with public transport.

The remarkable differences between road and public transport accessibility for this indicator are replicated by looking at aggregated results for regional typologies (Figure 12). The differences between both modes are striking not only for the entire case study area, but also for individual region types such as intermediate remote regions, rural regions close to a city or rural remote regions, where only a small number of jobs are within reach by public transport. In urban areas, as well as in intermediate regions close to a city, the number of jobs reachable by public transport is quite high, though clearly smaller compared to road accessibility. But even for road the value range between regions with lowest and highest accessibility is remarkable; for instance, over all regions the value range (i.e. range between 2.5 and 97.5th percentile) is between 20,000 and 780,000 jobs. In other words, the regions with highest accessibility can reach almost 40 times as many jobs as regions with lowest accessibility.

Fifty percent of the population in the entire case study area reach 280,000 jobs by car, but only 60,000 jobs by public transport (Figure 13). On the other hand, in urban regions some five percent of the most privileged population can reach up to 800,000 jobs by car and 700,000 jobs by public transport. In rural regions, 90% of population reach 500,000 jobs by car and 110,000 jobs by public transport at maximum, illustrating the great differences in accessibility surfaces between the two modes but also between the different types of regions.

In brief, this accessibility indicator yields not only obvious differences and specific spatial patterns between the three Baltic States, but also between the two modes and the types of regions, with a strong concentration on the agglomerations.



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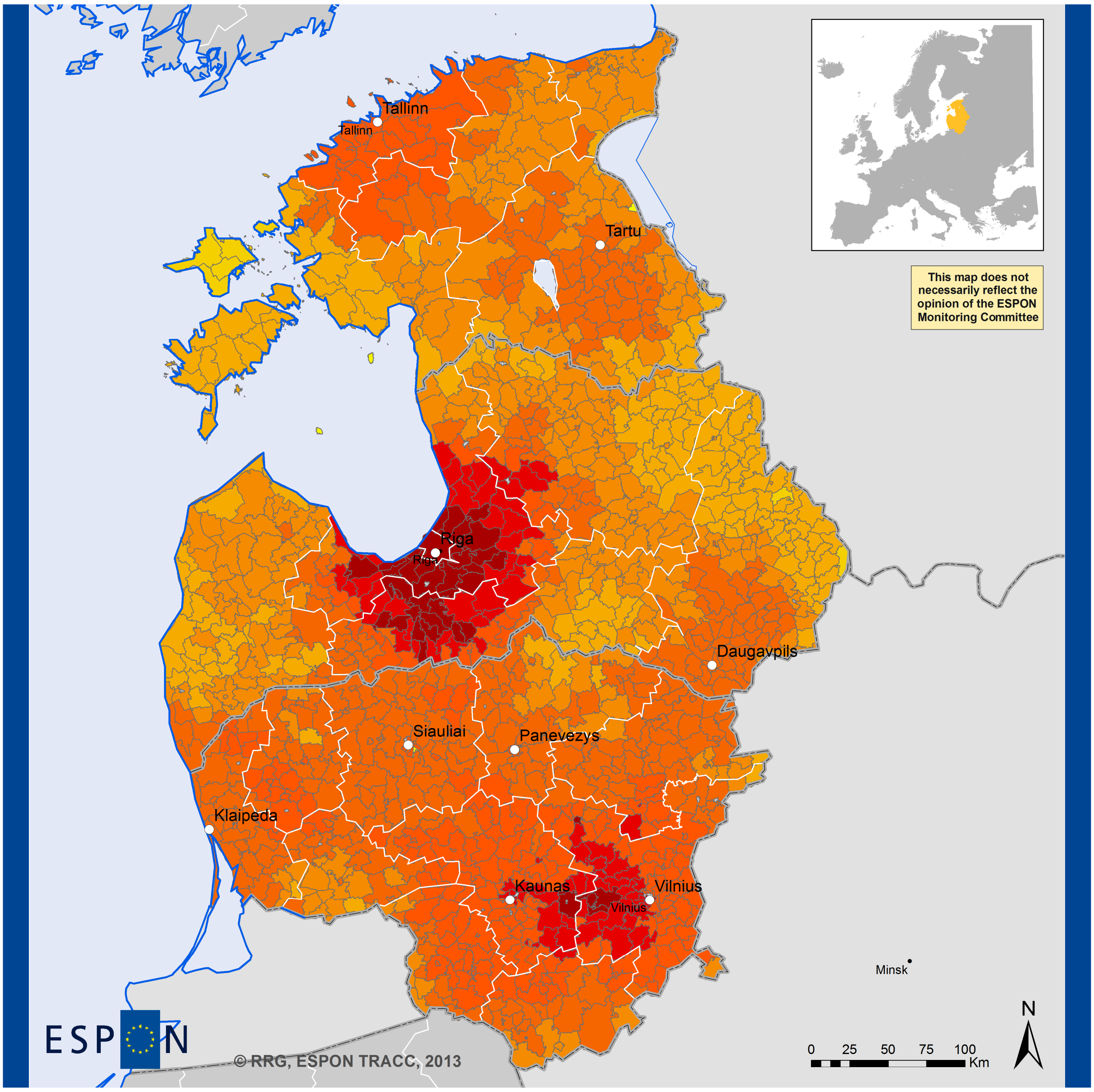
Baltic States Case Study
Daily accessibility of jobs by road (2.5x2.5 km raster), 2012

🟨 0 - 5,000
🟨 5,001 - 10,000
🟧 10,001 - 50,000
🟧 50,001 - 100,000
🟧 100,001 - 250,000
🟧 250,001 - 500,000
🟥 500,001 - 750,000
🟥 750,000 < ...

○ Main city

Figure 10a. Jobs accessible by car within 60 minutes (raster level)



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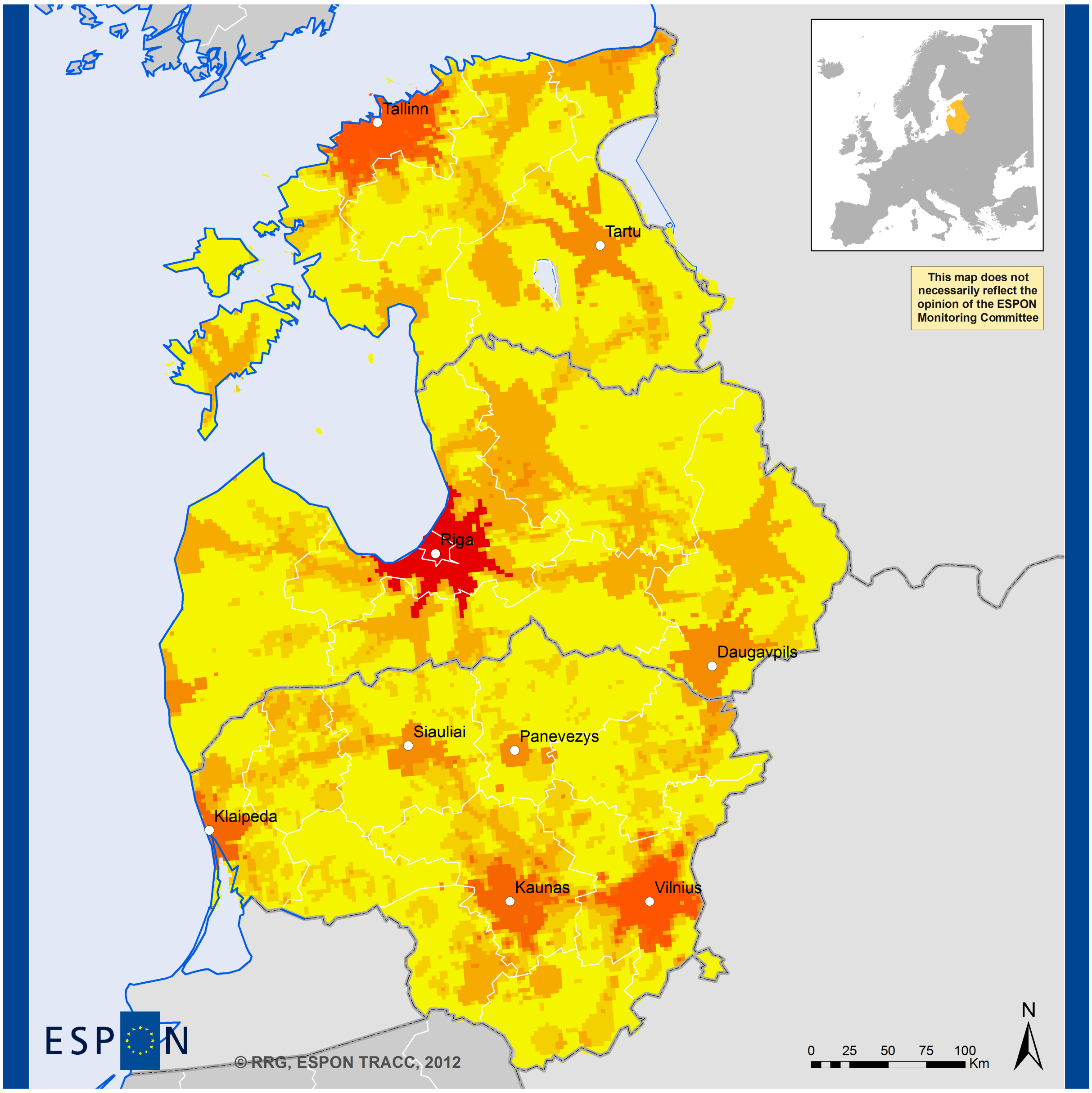
Baltic States Case Study
Daily accessibility of jobs by road (LAU-2), 2012

🟨	0 - 5,000	○	Main city
🟨	5,001 - 10,000		
🟧	10,001 - 50,000		
🟧	50,001 - 100,000		
🟧	100,001 - 250,000		
🟧	250,001 - 500,000		
🟥	500,001 - 750,000		
🟥	750,001 < ...		

Note:
LAU-2 figures calculated as weighted averages over 2.5x2.5 km raster grid cells.

Figure 10b. Jobs accessible by car within 60 minutes (LAU-2 averages)



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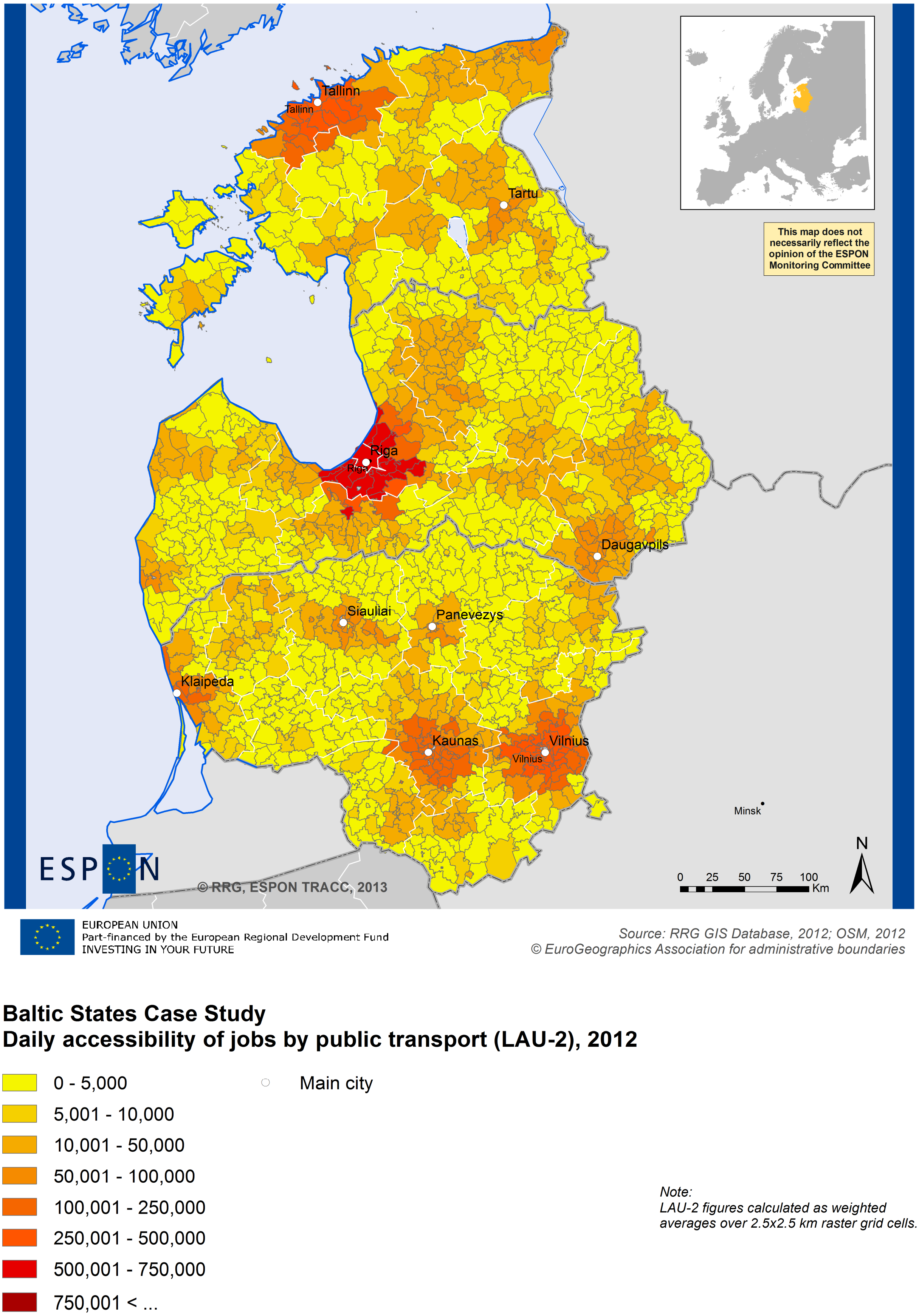
Baltic States Case Study
Daily accessibility of jobs by public transport (2.5x2.5 km raster), 2012

🟨 0 - 5,000
🟨 5,001 - 10,000
🟧 10,001 - 50,000
🟧 50,001 - 100,000
🟧 100,001 - 250,000
🟥 250,001 - 500,000
🟥 500,001 - 750,000
🟥 750,000 < ...

○ Main city

Figure 11a. Jobs accessible by public transport within 60 minutes (raster level)



Source: RRG GIS Database, 2012; OSM, 2012
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Baltic States Case Study
Daily accessibility of jobs by public transport (LAU-2), 2012

- 🟨 0 - 5,000
- 🟨 5,001 - 10,000
- 🟧 10,001 - 50,000
- 🟧 50,001 - 100,000
- 🟧 100,001 - 250,000
- 🟥 250,001 - 500,000
- 🟥 500,001 - 750,000
- 🟫 750,001 < ...
- ○ Main city

Note:
LAU-2 figures calculated as weighted averages over 2.5x2.5 km raster grid cells.

Figure 11b. Jobs accessible by public transport within 60 minutes (LAU-2 averages)

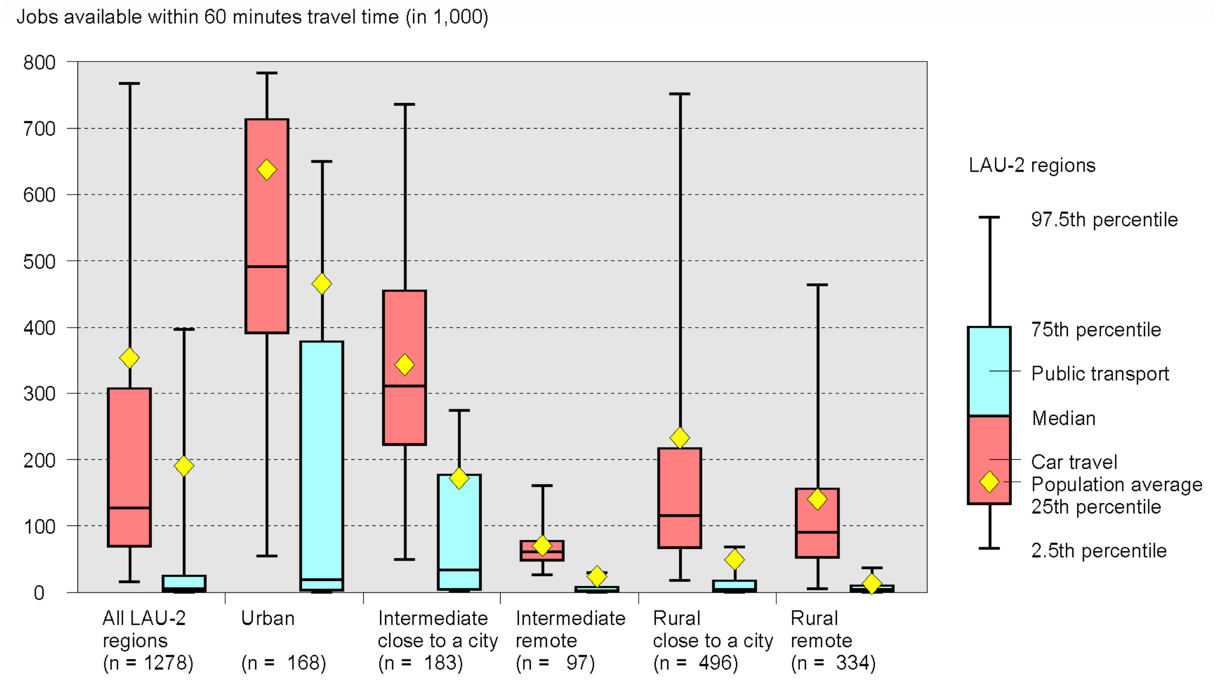


Figure 12. Jobs accessible within 60 minutes, by urban-rural typology

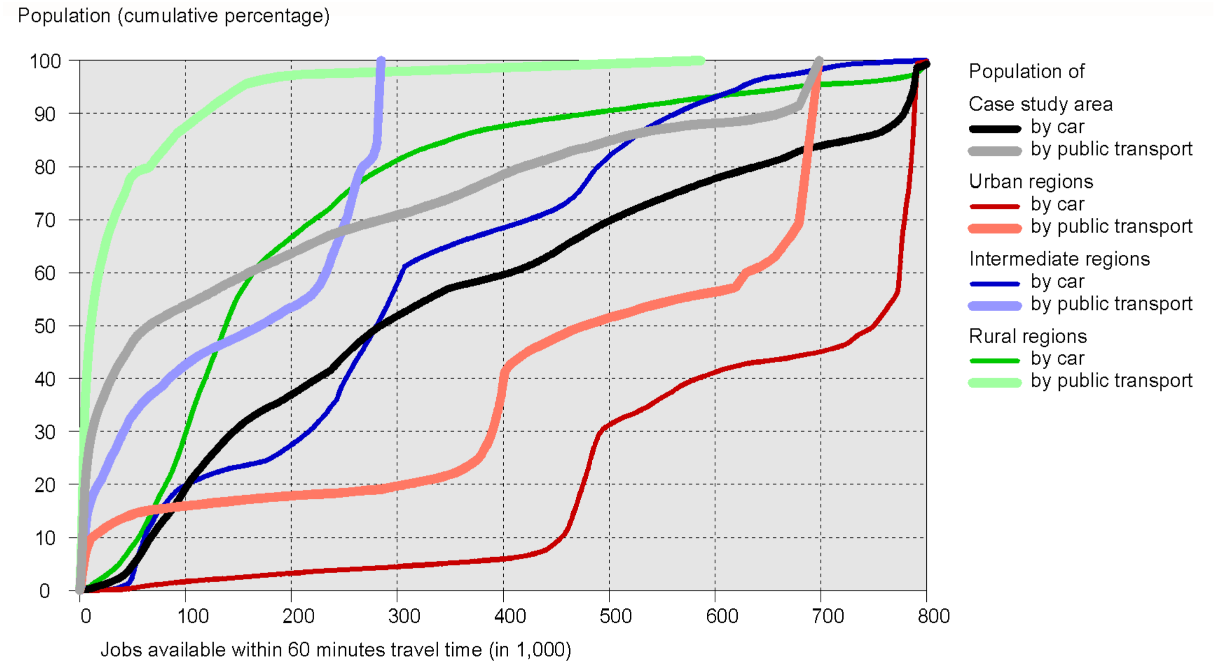


Figure 13. Jobs accessible within 60 minutes, cumulative distributions

3.3 Regional accessibility potential

What is the regional population potential of any point in space? In order to evaluate the different locations within a region from the viewpoint of economic actors, e.g. firms assessing the regional labour markets and locational advantages, or retail industries assessing the market area, the population potential of each raster cell within the case study region is analysed. The population potential is calculated as the sum of people in destination areas weighted by the travel times to reach them. Modes considered are, again, road and public transport.

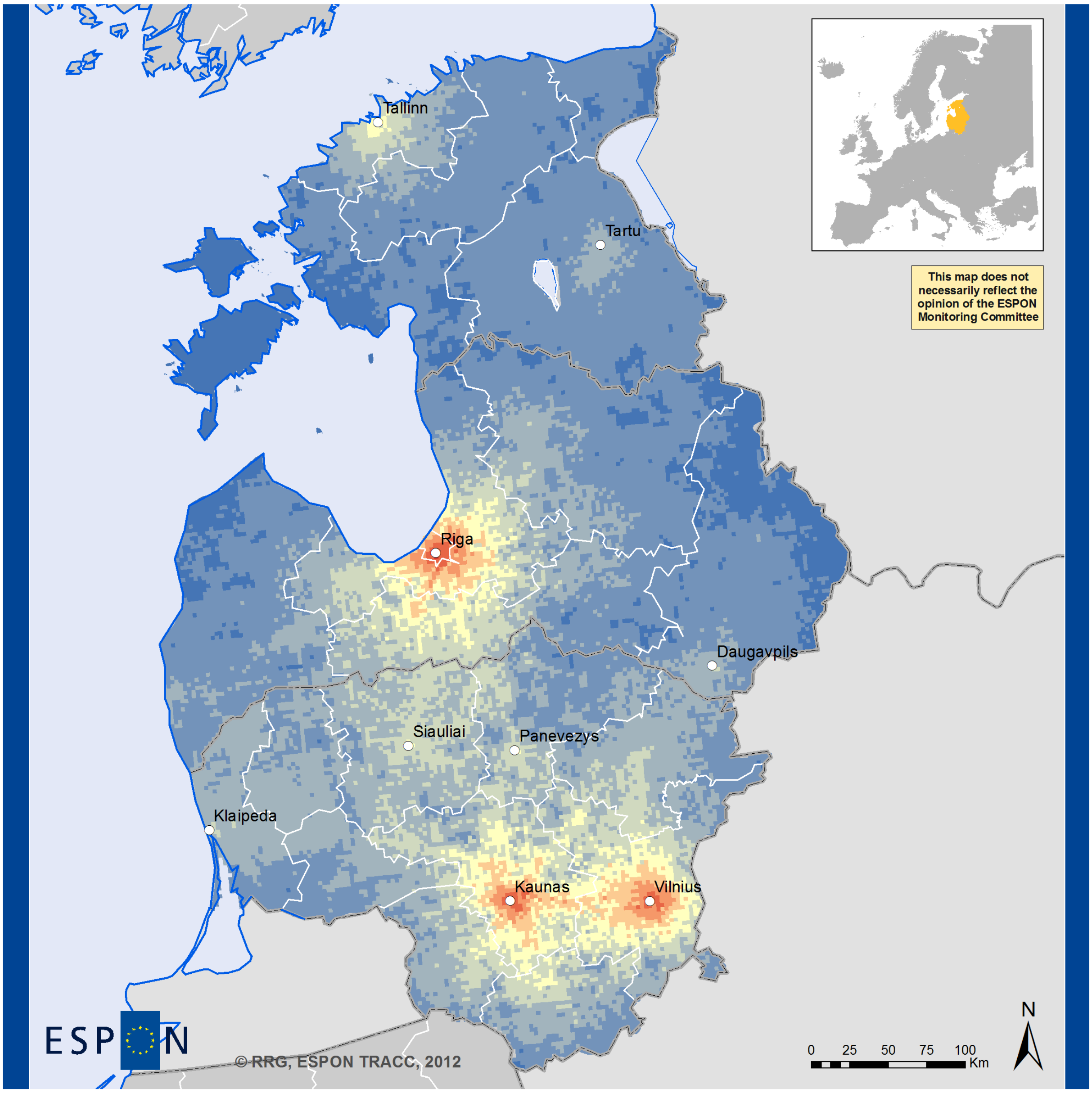
For both modes (Figures 14 and 15), the regional potential accessibility to population is much higher in Latvia and Lithuania compared to Estonia, due to the generally lower population densities in Estonia. The capital city regions clearly dominate the accessibility patterns in all three countries. For road, the accessibility surface around the major cities (Riga, Kaunas and Vilnius) form plateaus of high accessibility, with stretches into the rural parts along main transport axes. This effect is visible for road (Figure 14), but all the more illustrative for public transport (Figure 15) where the inner plateau of high accessibility (i.e. index value above 150) is much smaller than for road but with longer stretches (fingers) into the hinterland.

Apart from the four leading agglomerations Tallinn, Riga, Kaunas, and Vilnius, areas of average potential accessibility can be found around the regional cities of Klaipeda, Siauliai, Parnevezys, Daugavpils and Tartu. All other territories of the three Baltic States show accessibility levels far below the average, reaching only up to a quarter of the Baltic States average. As expected, the latter areas are much more extensive for public transport (Figure 15) compared to road, since good accessibility levels for public transport is limited to small bands around the public transport arteries (mainly railways), whereas due to the generally even distribution of streets road accessibility is forming seamless areas.

This is also reflected in the levels of accessibility for both modes. The Baltic States average for road (363,811) is more than double the public transport average (161,088), and also the minimum (38,412 vs. 37) and the maximum (835,794 vs. 537,532) numbers are remarkably higher for road compared to public transport. So, not only the spatial patterns significantly differ between both modes, but also the general accessibility level for road is a quantum leap. By way of consequence, when standardizing the public transport figures at the road average (Figure 15a), only the four biggest agglomerations (Tallinn, Riga, Kaunas, Vilnius) stand out, while the rest of the case study area falls into the lowest class (0-25). In contrast, when standardizing the public transport figures at the public transport average (Figure 15b), the map looks more distinctive since the transport arteries and areas of high accessibilities are now becoming visible.

These findings are also reflected when analysing the performance of different types of regions (Figure 16). Potential accessibility by road is significantly higher for all region types than potential accessibility by public transport. The latter one only shows significant accessibility levels for urban regions and for intermediate regions close to a city, while for intermediate remote and for rural regions public transport accessibility is very poor yielding only small portions of road accessibility.

In consequence, 50% of population in rural regions gain only index value of mere 10 for public transport and 45 for road (Figure 17), which means these regions are heavily underperforming compared to the overall average of the study area. In contrast, 50% of population in urban regions observe accessibility index values of 110 for public transport and almost 170 for road, i.e. perform significantly above the average. The maximum index values for public transport that are reached are 48 for rural regions, 160 for intermediate regions and 138 for urban regions, while the same indices for road account for 122 (rural regions), more than 200 (intermediate regions) and 185 for urban regions. The astonishing effect that intermediate regions belong to the best performers can be explained as intermediate regions between two major cities (like the area between Kaunas and Vilnius) benefit from short travel times to both cities, while either of the two cities itself has longer travel times to its counterpart.



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Baltic States Case Study (2011)
Regional potential accessibility by road (2.5x2.5 km raster)

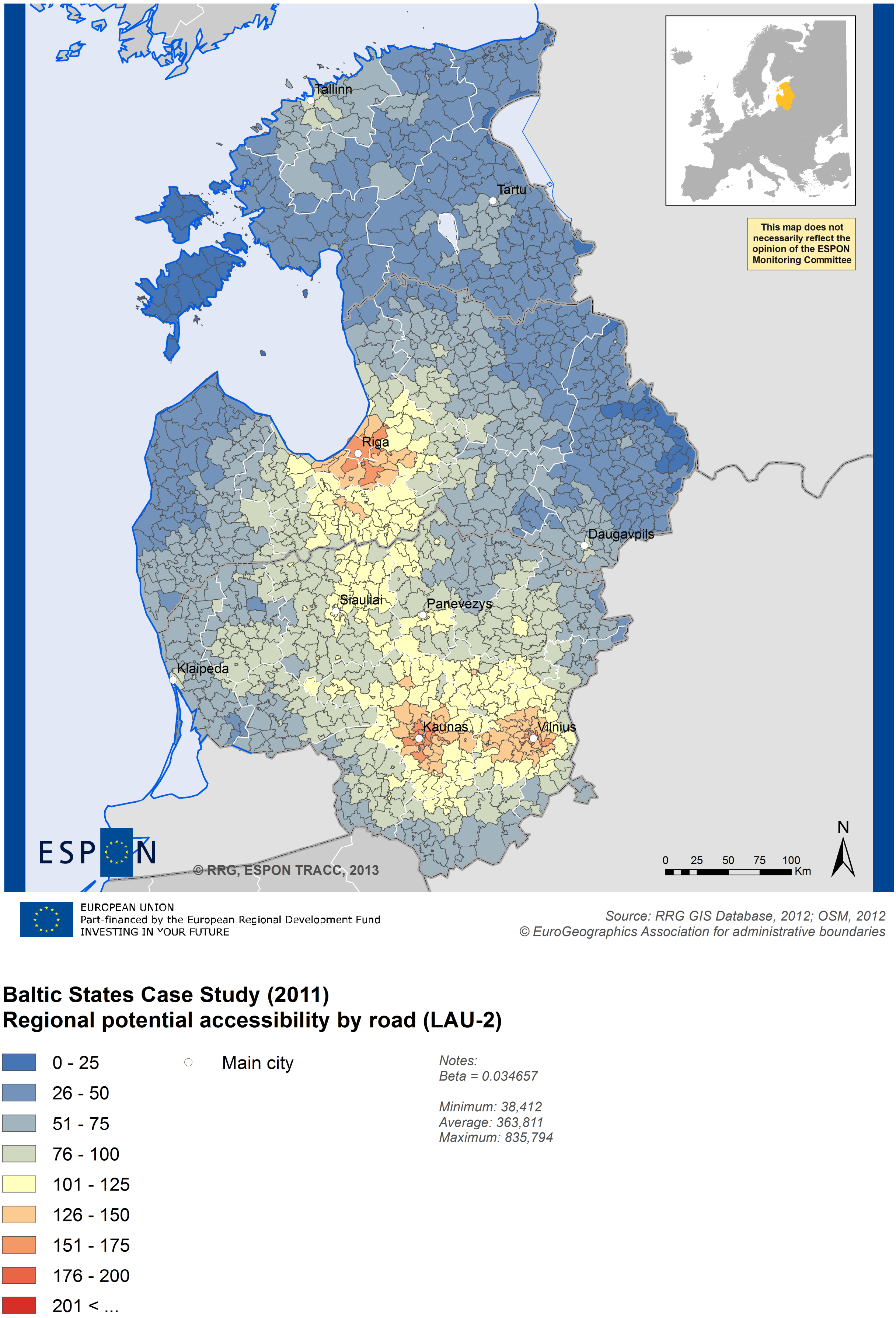
🟦 0 - 25
🟦 26 - 50
▨ 51 - 75
🟩 76 - 100
🟨 101 - 125
🟧 126 - 150
🟧 151 - 175
🟥 176 - 200
🟥 200 < ...

○ Main city

Notes:
Beta = 0.034657

Minimum: 38,412
Average: 363,811
Maximum: 835,794

Figure 14a. Potential accessibility to population by car (raster level)



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Source: RRG GIS Database, 2012; OSM, 2012
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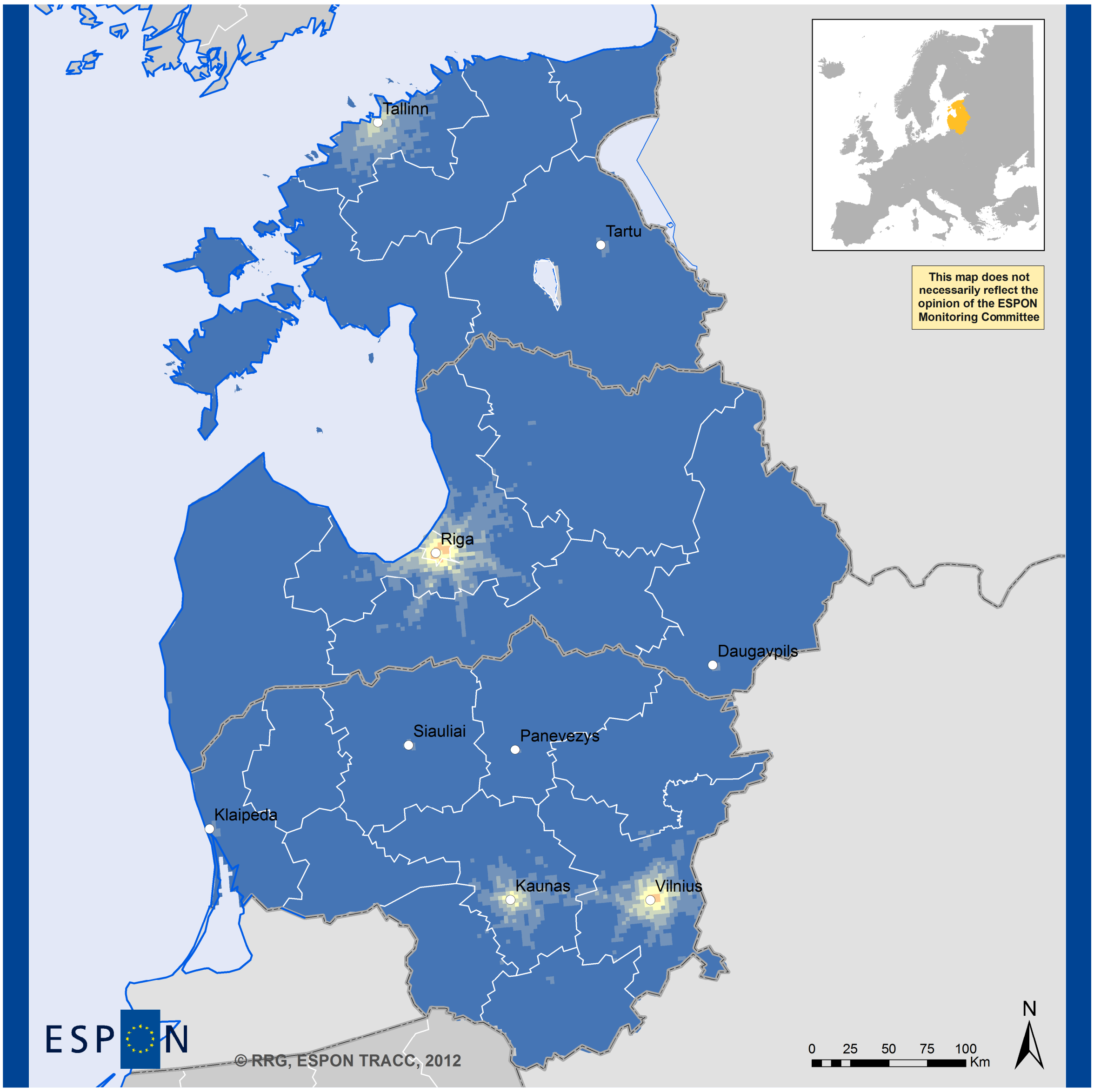
Notes:
Beta = 0.034657

Minimum: 38,412
Average: 363,811
Maximum: 835,794

Figure 14b. Potential accessibility to population by car (LAU-2 averages)



This map does not necessarily reflect the opinion of the ESPON Monitoring Committee

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Baltic States Case Study (2011)
Regional potential accessibility by public transport (2.5x2.5 km raster)

- 🟦 0 - 25
- 🟦 26 - 50
- ▨ 51 - 75
- ▨ 76 - 100
- 🟨 101 - 125
- 🟧 126 - 150
- 🟧 151 - 175
- 🟥 176 - 200
- 🟥 200 < ...

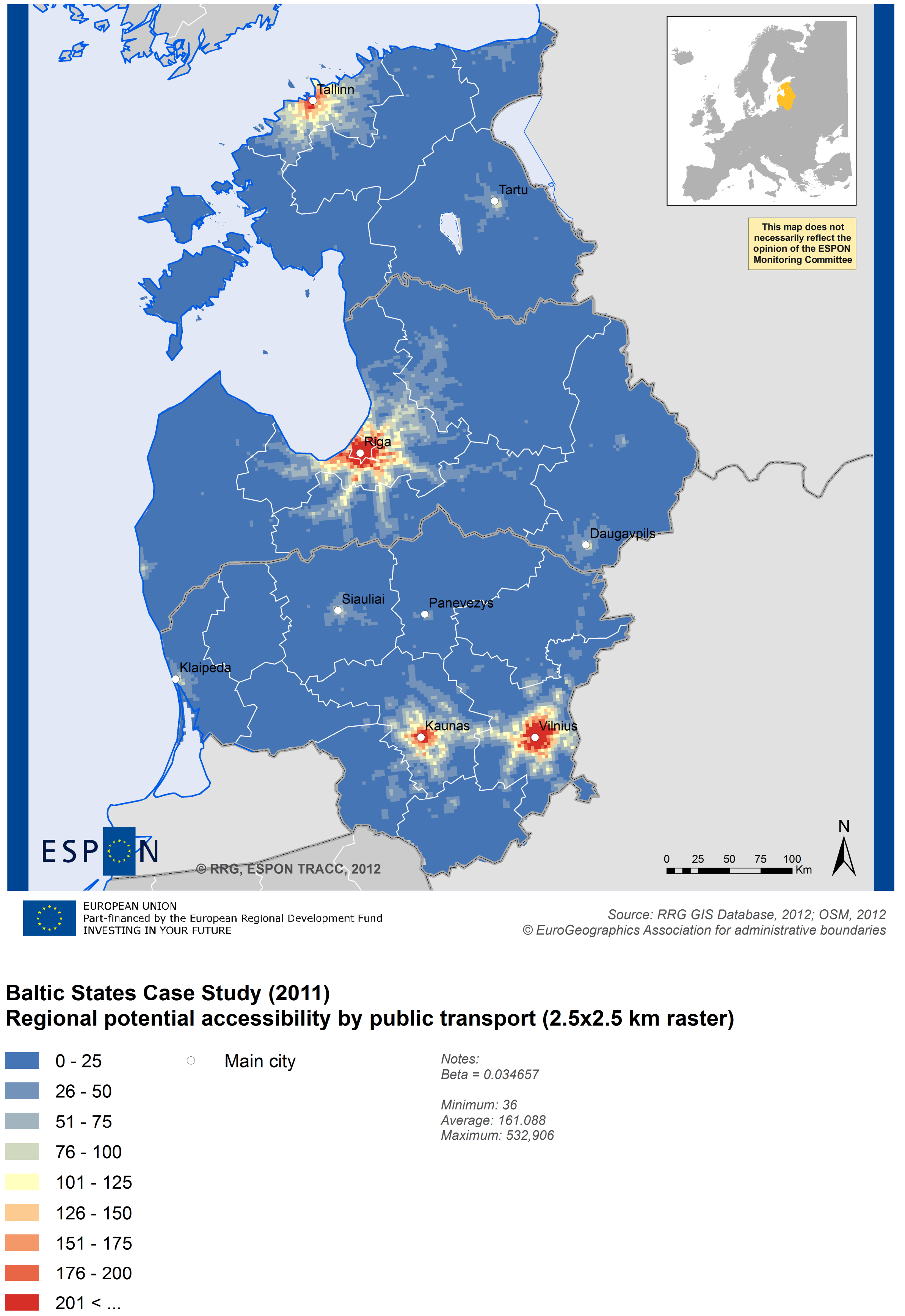
○ Main city

Notes:
Beta = 0.034657

Minimum: 36
Average: 363,811
Maximum: 532,906

100 = 363,811 = road average

Figure 15a. Potential accessibility to population by public transport (raster level, standardised on road average)



Source: RRG GIS Database, 2012; OSM, 2012
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Figure 15b. Potential accessibility to population by public transport (raster level, standardised on public transport average)

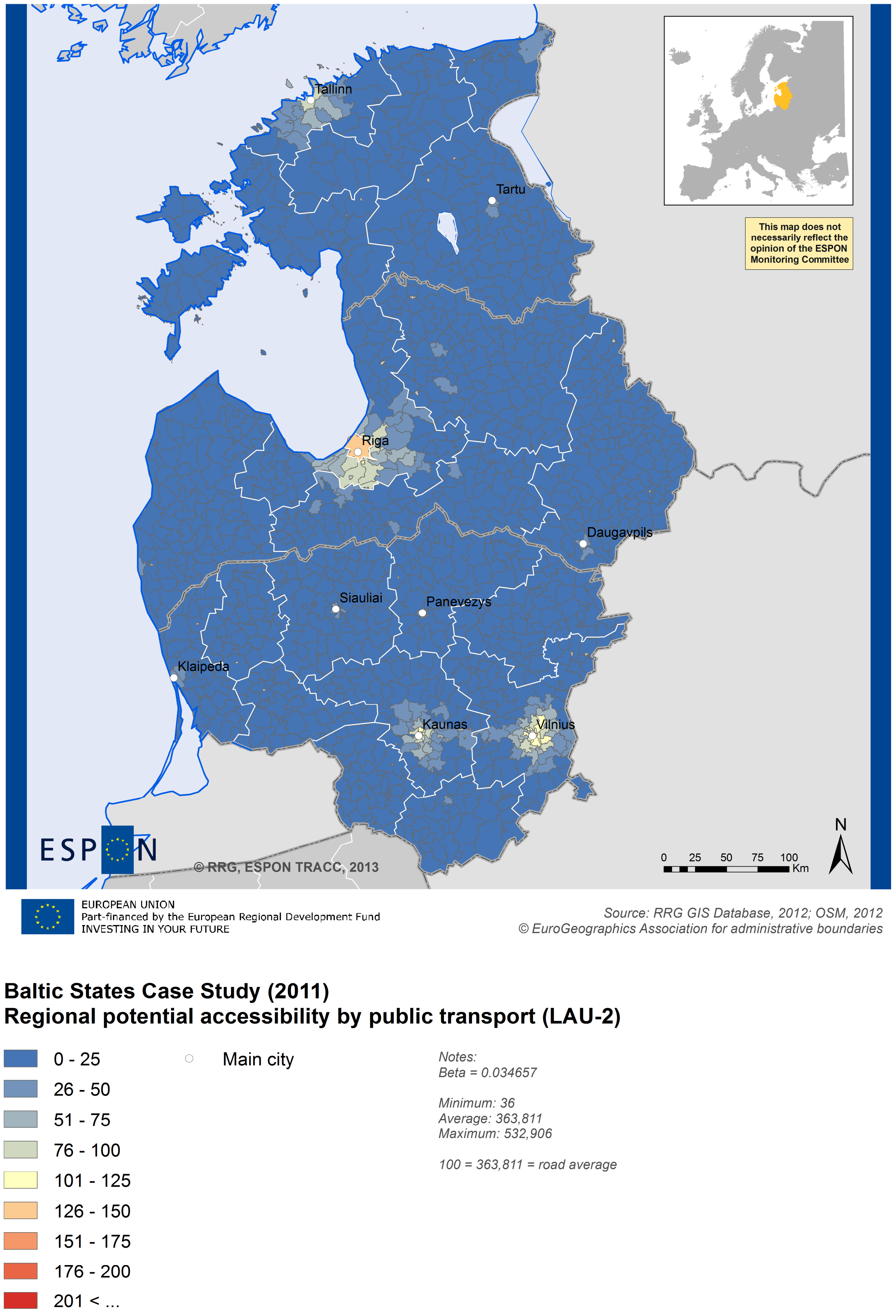
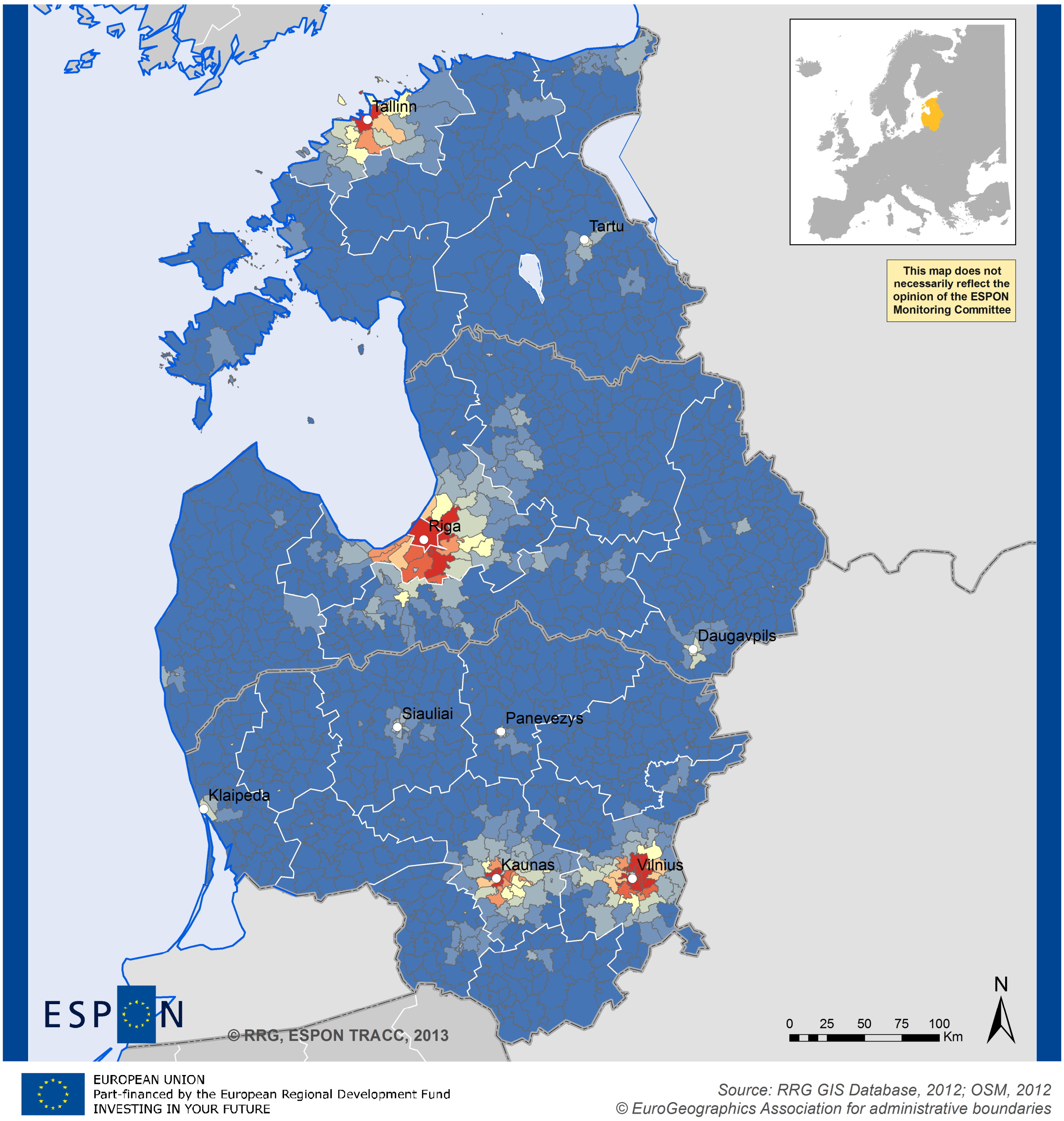


Figure 15c. Potential accessibility to population by public transport (LAU-2 averages, standardised at road average)



Source: RRG GIS Database, 2012; OSM, 2012
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Baltic States Case Study (2011)
Regional potential accessibility by public transport (LAU-2)

- 🟦 0 - 25
- 🟦 26 - 50
- 🟦 51 - 75
- ⬜ 76 - 100
- ⬜ 101 - 125
- 🟧 126 - 150
- 🟧 151 - 175
- 🟥 176 - 200
- 🟥 201 < ...

○ Main city

Notes:
Beta = 0.034657

Minimum: 36
Average: 161,088
Maximum: 532,906

Figure 15d. Potential accessibility to population by public transport (LAU-2 averages, standardised at public transport average)

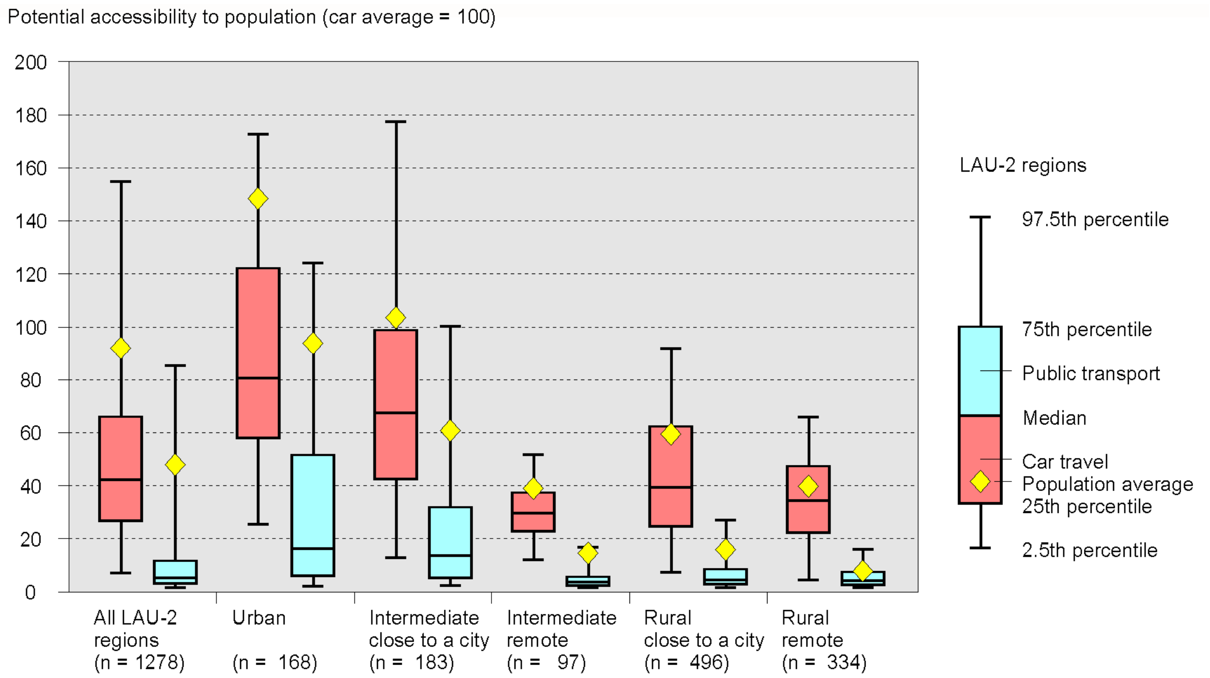


Figure 16. Potential accessibility to population, by urban-rural typology

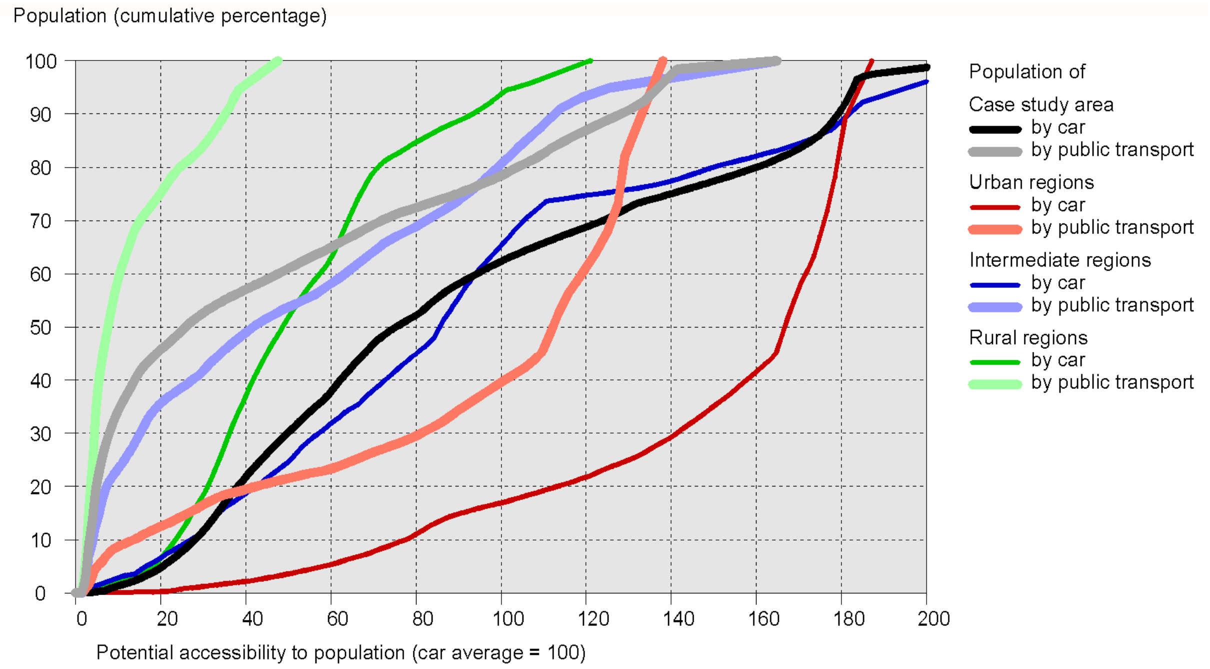


Figure 17. Potential accessibility to population, cumulative distributions

3.4 Access to health care facilities

Hospitals are one of the main general services of public interest. This indicator measures the travel time to go to the next hospital. Travel times for each raster cell by road and by public transport show the spatial diversity in access to these important health care facilities. All hospitals offering general stationary and surgical treatments are considered as destinations, while specialized clinics are not considered.

While Lithuania and Latvia have a rather dense and equally distributed network of general hospitals, even in rural parts, the situation in Estonia is somehow different as hospitals are concentrated only in selected regional cities.

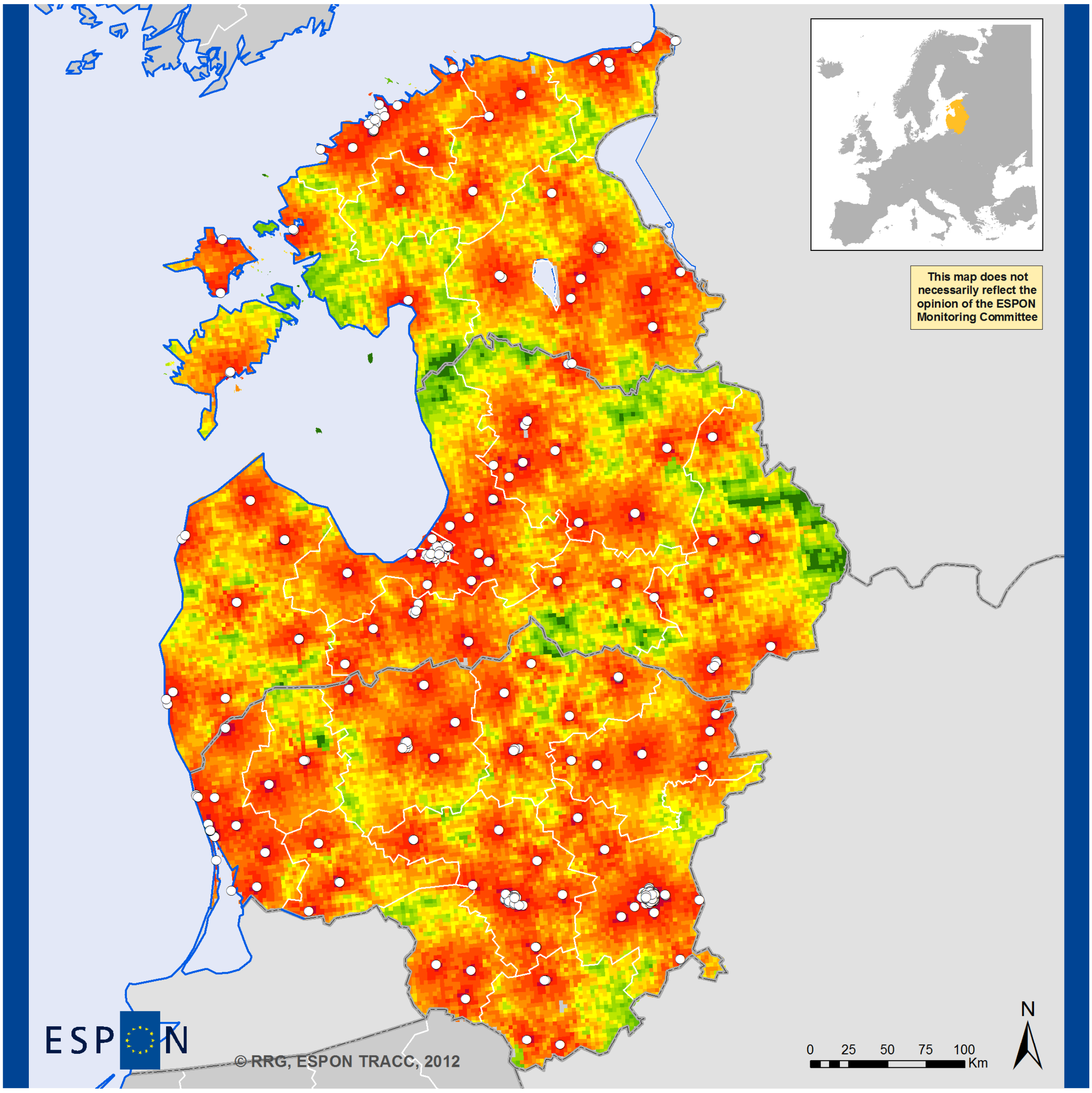
Figure 18 illustrates that the car travel time to the next hospital is less than 40 minutes for almost all parts of the Baltic States. Only small areas along the Russian borders, and along the border between Estonia and Latvia, so as some Estonian islands, yield travel times of more than 40 minutes. While this overall accessibility level can be considered as fairly well, access to next hospital in emergency cases should be much faster than this. Isochrones of less than 15 minutes are, however, rather small around the hospital locations. Due to the large number of hospitals, particular in Latvia and Lithuania, these isochrones nevertheless cover a large part of the population.

For public transport travel times to hospitals form more complex spatial patterns (Figure 19). Cities and bigger towns are well covered with short travel times, so as some public transport corridors between them (for instance, a southbound corridor connecting Riga with Vilnius via Jelgava, Siauliai and Kaunas). But hospitals in smaller towns are often difficult to reach by public transport from the countryside since these towns only offer local bus services and lack intercity bus or train services. Thus, hospitals in small towns mainly serve local needs but they do not span any form of service areas into their rural hinterland. Due to extremely long walking or cycling access times to next bus stop or train station, which in some cases are beyond any reasonable time, many peripheral rural areas actually lack access to health care facilities by public transport. Consequently, trains or busses are no real option for getting to the next hospital.

At aggregated regional level (Figure 20), the median travel time for road lies between 13 (intermediate regions close to a city) and 22 (rural remote regions) minutes. Maximum travel times do not exceed 50 minutes for any type of region. For public transport, performance is significantly lower as the median travel times lies between 45 (intermediate regions close to a city) and 72 (rural remote regions) minutes with maximum travel times up to 120 minutes.

The cumulated population distributions (Figure 21) confirm the spatial patterns illustrated in the maps. For road, 50% of all people in urban and intermediate regions, representing 50% of the overall study area population, have a travel time of less than 10 minutes to the next hospital, and all people reach the next hospital by car in less than 50 minutes. A similar service quality for public transport can only be reached in urban regions, while intermediate regions and regions that are even more rural increasingly lag behind. For instance, in rural regions more than 50% of the population experiences travel times to the next hospital by public transport of more than 50 minutes. If these people do not have access to a car, they practically do not have any access to hospitals at all.

Altogether, Figures 20 and 21 illustrate the extreme spatial imbalance of access to hospitals between urban and rural territories of the Baltic States.



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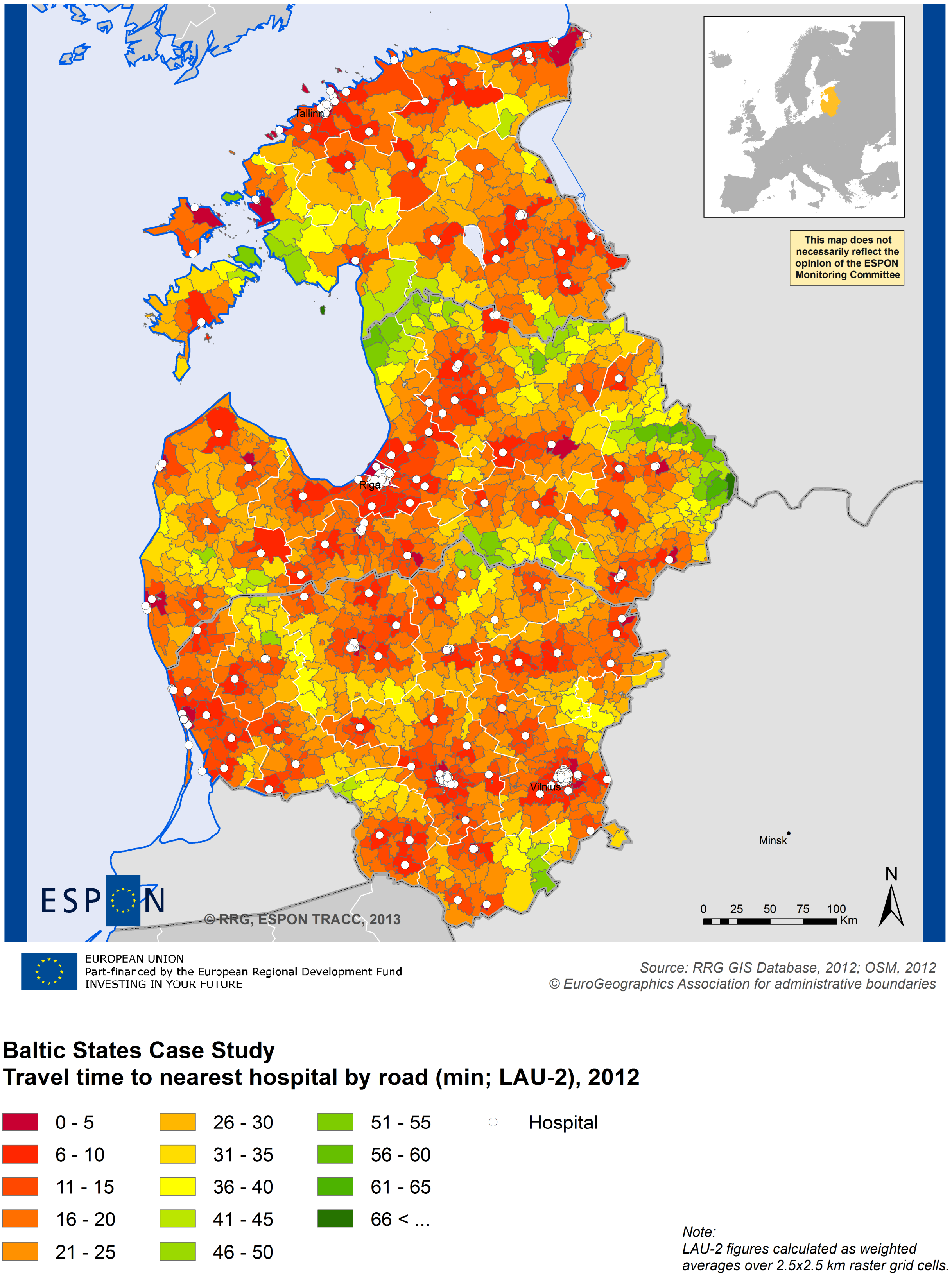
Baltic States Case Study
Travel time to nearest hospital by road (min; 2.5x2.5 km raster), 2012

🟥 0 - 5	🟧 26 - 30	🟩 51 - 55	○ Hospital
🟥 6 - 10	🟨 31 - 35	🟩 56 - 60	
🟥 11 - 15	🟨 36 - 40	🟩 61 - 65	
🟧 16 - 20	🟩 41 - 45	🟩 66 < ...	
🟧 21 - 25	🟩 46 - 50		

Figure 18a. Car travel time to next hospital (raster level)



Source: RRG GIS Database, 2012; OSM, 2012
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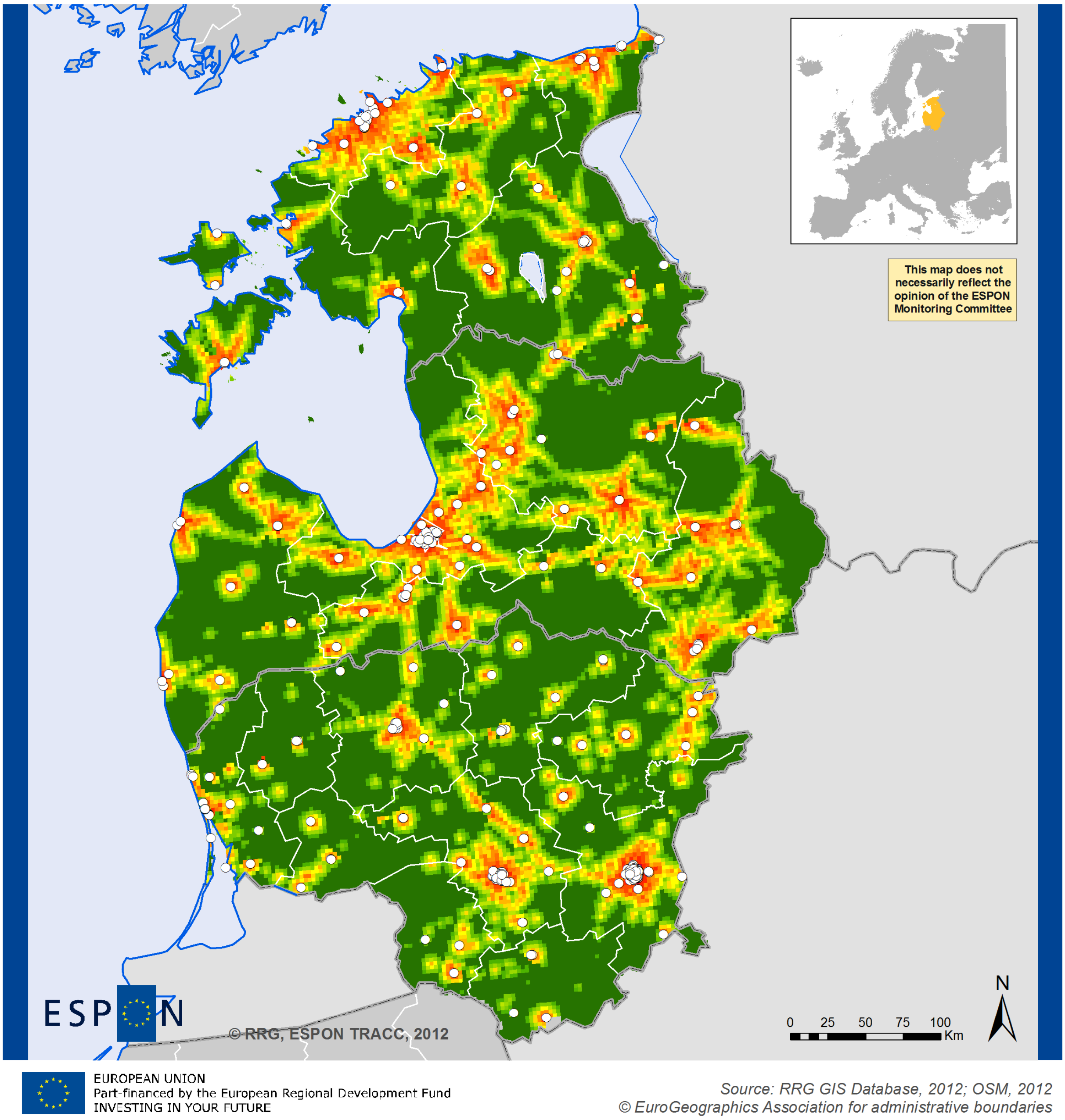
Baltic States Case Study
Travel time to nearest hospital by road (min; LAU-2), 2012

Note:
LAU-2 figures calculated as weighted averages over 2.5x2.5 km raster grid cells.

Figure 18b. Car travel time to next hospital (LAU-2 averages)



Source: RRG GIS Database, 2012; OSM, 2012
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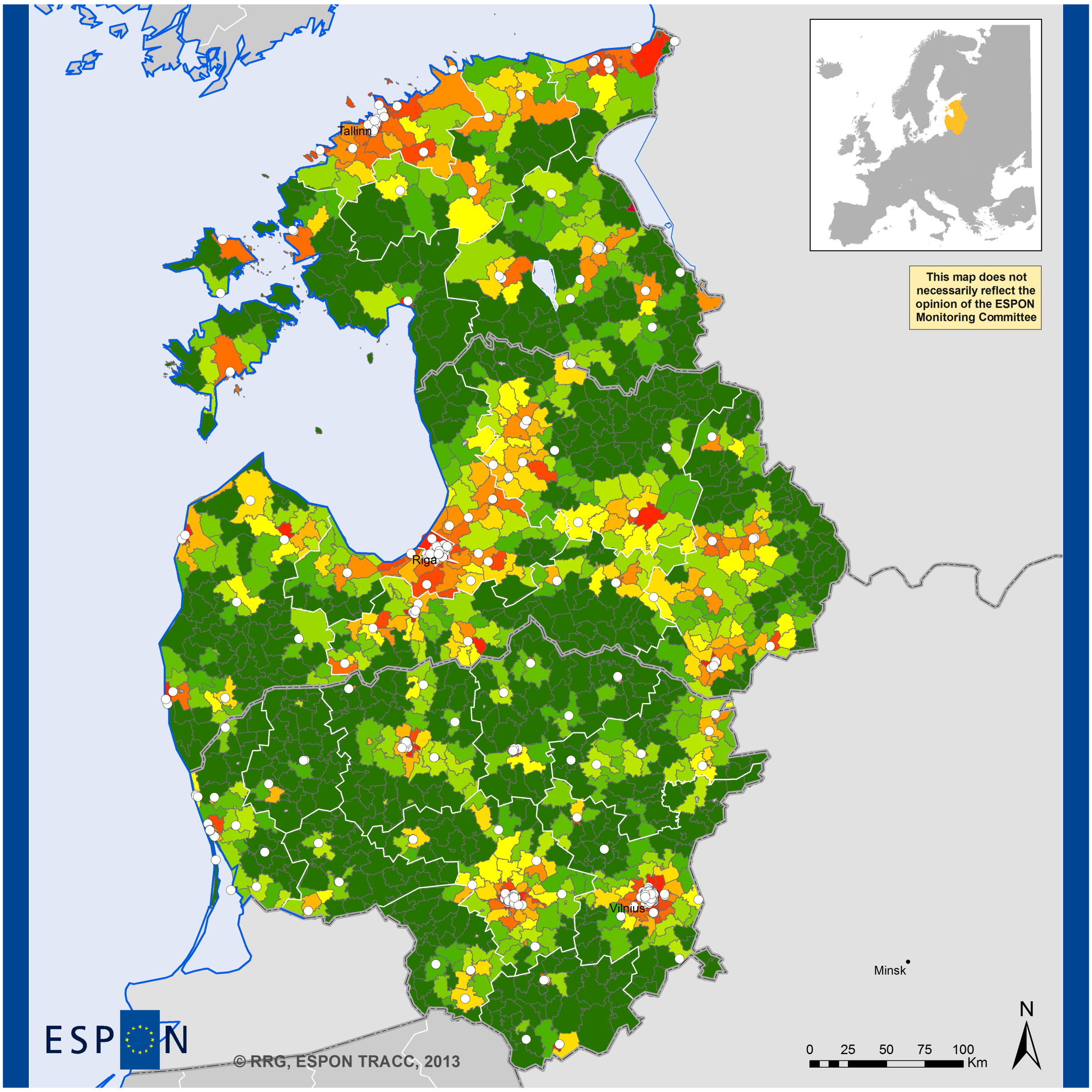
Baltic States Case Study
Travel time to nearest hospital by public transport (min; 2.5x2.5 km raster), 2012

🟥 0 - 5
🟥 6 - 10
🟥 11 - 15
🟧 16 - 20
🟧 21 - 25
🟧 26 - 30
🟨 31 - 35
🟨 36 - 40
🟩 41 - 45
🟩 46 - 50
🟩 51 - 55
🟩 56 - 60
🟩 61 - 65
🟩 66 < ...
○ Hospital

Figure 19a. Public transport travel time to next hospital (raster level)



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Baltic States Case Study
Travel time to nearest hospital by public transport (min; LAU-2), 2012

🟥 0 - 5
🟥 6 - 10
🟥 11 - 15
🟧 16 - 20
🟧 21 - 25
🟧 26 - 30
🟨 31 - 35
🟨 36 - 40
🟩 41 - 45
🟩 46 - 50
🟩 51 - 55
🟩 56 - 60
🟩 61 - 65
🟩 66 < ...
○ Hospital

Note:
LAU-2 figures calculated as weighted averages over 2.5x2.5 km raster grid cells.

Figure 19b. Public transport travel time to next hospital (LAU-2 averages)

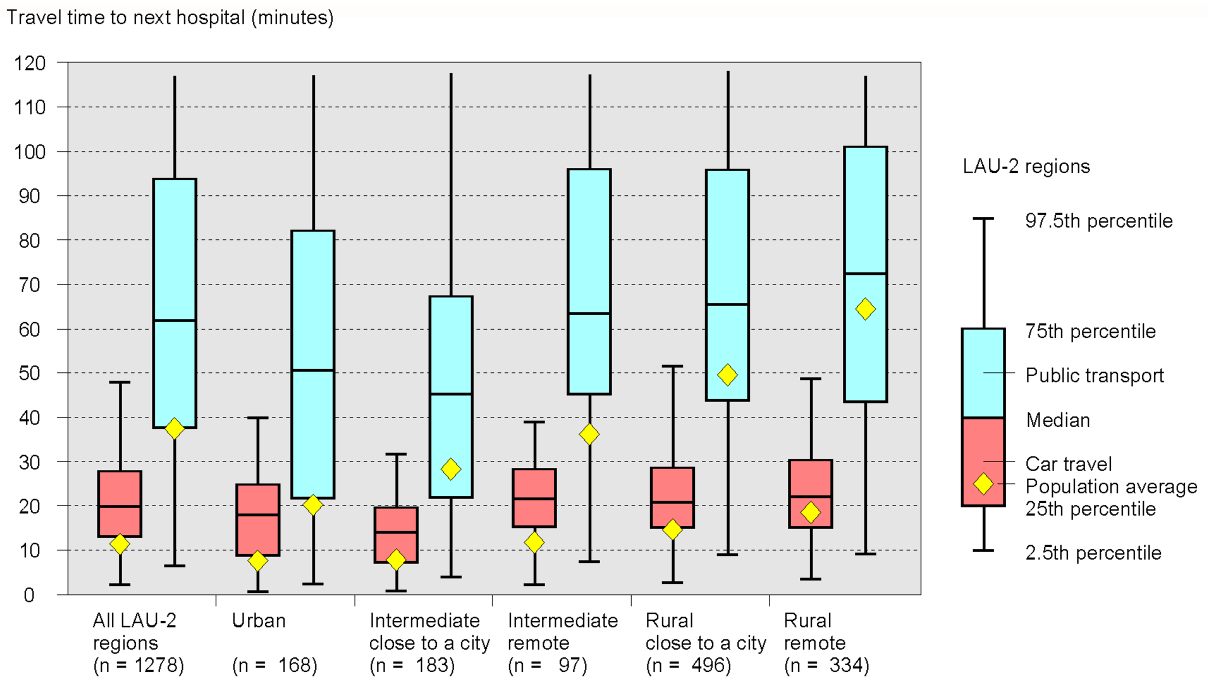


Figure 20. Travel time to next hospital, by urban-rural typology

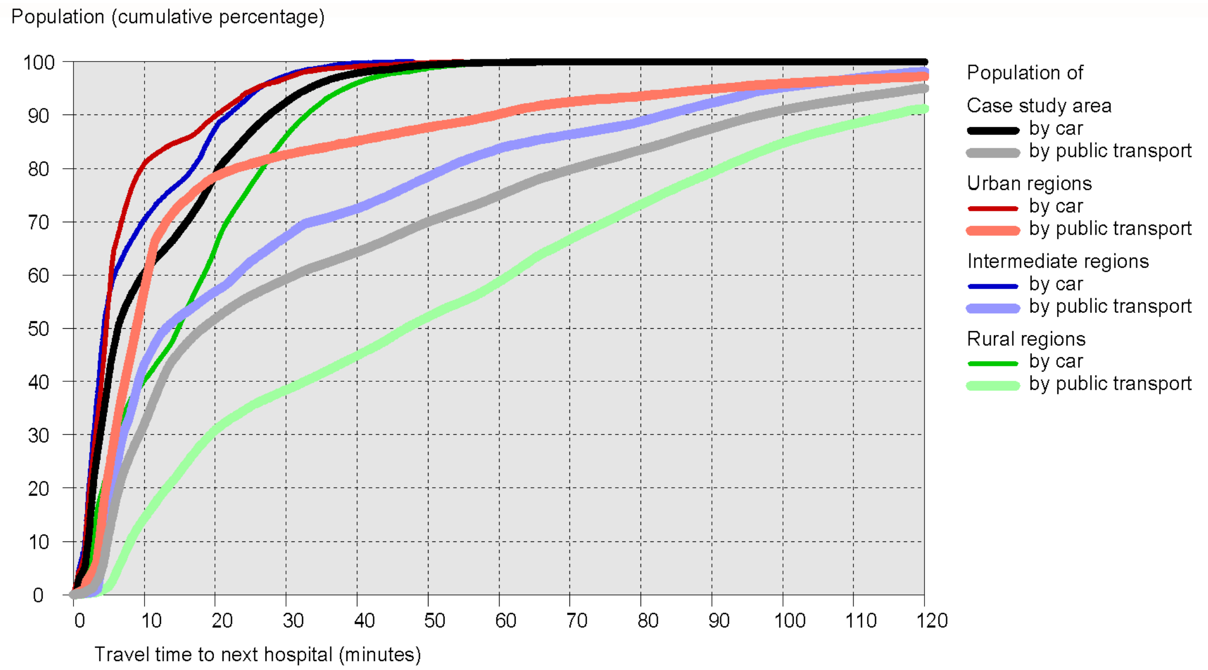


Figure 21. Travel time to next hospital, cumulative distributions

3.5 Availability of higher secondary schools

Do pupils have access to secondary schools in reasonable travel time and do households have a freedom of choice to select between different options? Access to one school will ensure a basic supply, while access to many schools (=several options) allows families selecting that particular school deemed best for their children[6]. For each raster cell travel time contours of 30 minutes[7] by road and by public transport are calculated, and it is checked how many secondary schools are reachable within this travel time. All secondary schools offering a degree to go to a university are considered here as valid destinations.[8]

The 30 minutes road isochrones to secondary school do not cover the entire Baltic States territory (Figure 22). For all three countries, there are quite large areas from where no secondary school at all can be reached in this time. These areas are most extensive in Latvia (particular in its Eastern, Northern and Southern parts), and smallest in Estonia. Nevertheless, from many places in Latvia and Lithuania one or two secondary schools can be reached by car, sometimes even up to five. In case of Estonia, from many places households can choose between more than three secondary schools. Areas with highest accessibility allow reaching more than 10, in the capital cities even more than 100 secondary schools within 30 minutes. These areas of extremely high school accessibility are restricted to few agglomerations, which are the three capitals plus Tartu, Valmiere, Kaunas, Siauliai and Klaipeda. This eventually results in extreme disparities between the rural and urban territories.

School accessibility by public transport[9] is extremely bad in the entire study area, even though the situation is somewhat better in Estonia due to the more even distribution of schools (Figure 23). For Latvia and Lithuania, travel time to next secondary school is longer than 30 minutes for the largest part of their territories. Only in some local hotspots, pupils can reach one secondary school within 30 minutes. More than one school can be reached only from very few places, and more than three schools can only be reached in the big cities or along selected transport corridors. Only the three capital cities offer accessibility levels by public transport similar to those for road. Thus, for public transport disparities are even higher than for road.

The box plots shown in Figure 24 illustrate these disparities: Accessibility in urban regions is for both modes by far highest, compared to the other types of regions. For road, intermediate and rural regions show only small levels of accessibility (compared to urban regions), however, for public transport these regions perform extremely poor. By way of consequence, the good performance of urban regions only little compensates for the other regions so that the overall performance for the entire case study area is also rather poor in terms of number of schools within reach.

Since most of the population in all three countries is concentrated in the four main agglomerations, 50% of the population can reach 10 secondary schools within 30 minutes by car and 6-7 schools by public transport (Figure 25) – thanks to the good performance of the urban regions. While intermediate regions more or less correspond to the average performance, the cumulative population graph illustrates that 50% of the population in rural regions can only reach one or two schools by either mode. In other words, only a basic supply of services is ensured.

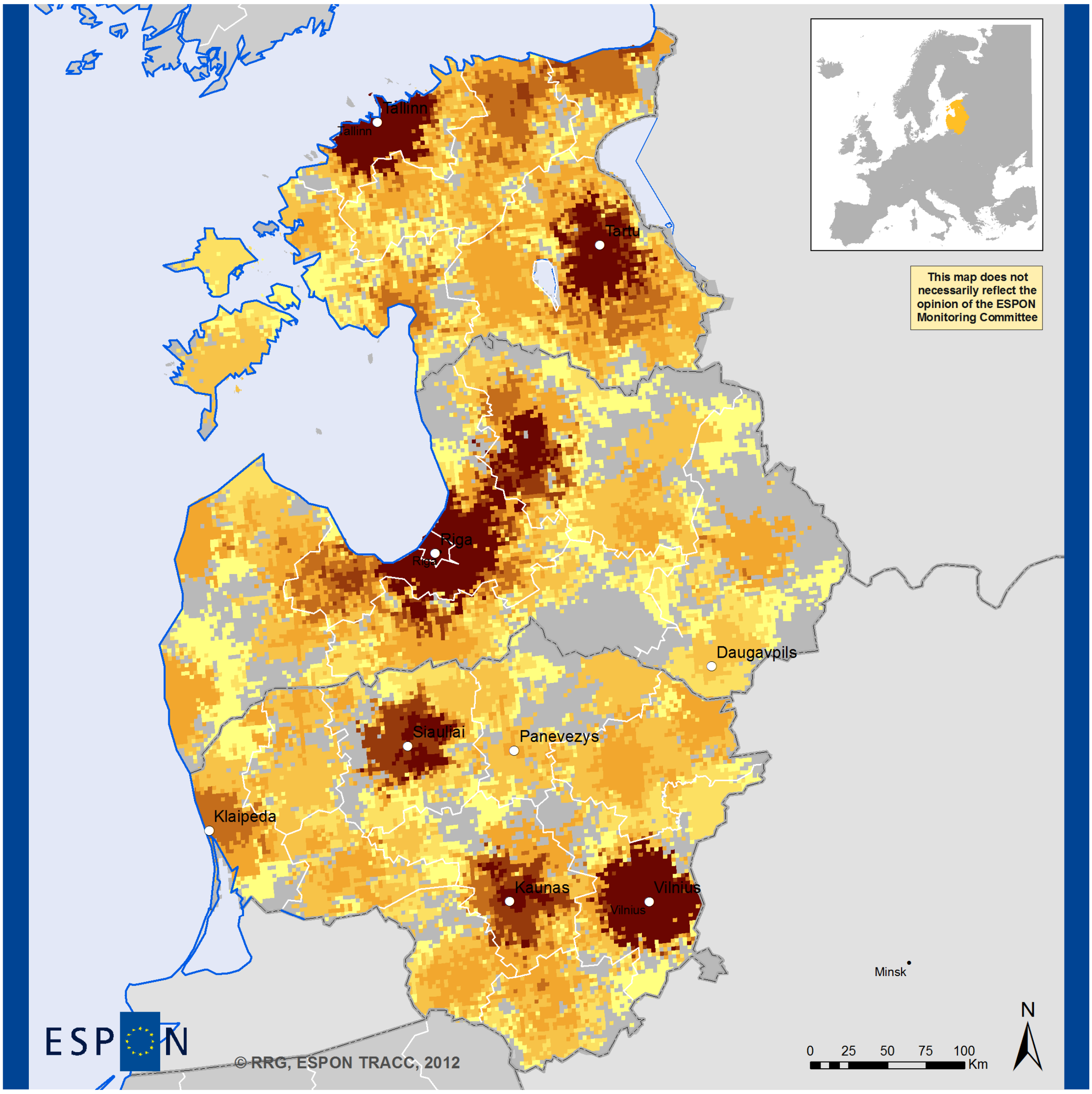
---

[6] in terms of general quality and services offered

[7] 30 minutes for a one-way trip to the next school was considered as a reasonable time, which sums up to one hour travel time a day for each pupil.

[8] Unfortunately, information on the offered degrees was not available for all schools in all three countries. In case of doubt a school was included in the set of destinations for the modelling.

[9] Due to a lack of data, specialized school busses are not included in this analysis. Thus, public transport results must be considered with caution since the inclusion of school busses might have led to better results, i.e. higher accessibilities, particular in rural parts of the three countries.



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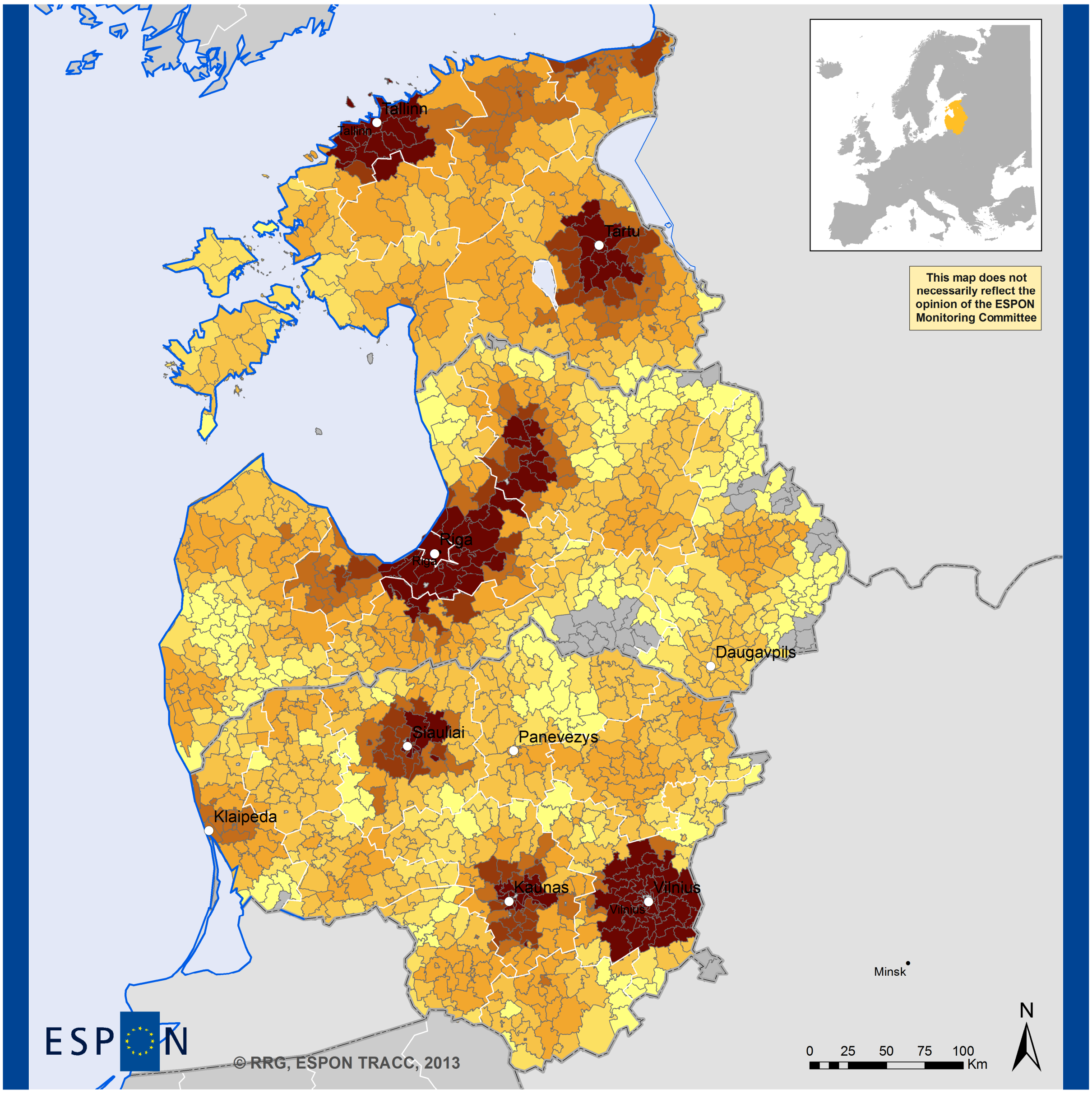
Baltic States Case Study
Availability of secondary schools (2.5x2.5 km raster), 2012
Number of schools within 30 min car travel time

▨ 0
▨ 1
▨ 2
▨ 3 - 5
▨ 6 - 10
▨ 11 - 15
▨ 16 - 20
▨ 21 - 129

○ Main city

Figure 22a. Higher secondary schools within 30 minutes travel time by car (raster level)



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Baltic States Case Study
Availability of secondary schools (LAU-2), 2012
Number of schools within 30 min car travel time

■ 0
■ 1
■ 2
■ 3 - 5
■ 6 - 10
■ 11 - 15
■ 16 - 20
■ 21 - 129

○ Main city

Note:
LAU-2 figures calculated as weighted averages over 2.5x2.5 km raster grid cells.

Figure 22b. Higher secondary schools within 30 minutes travel time by car (LAU-2 average)

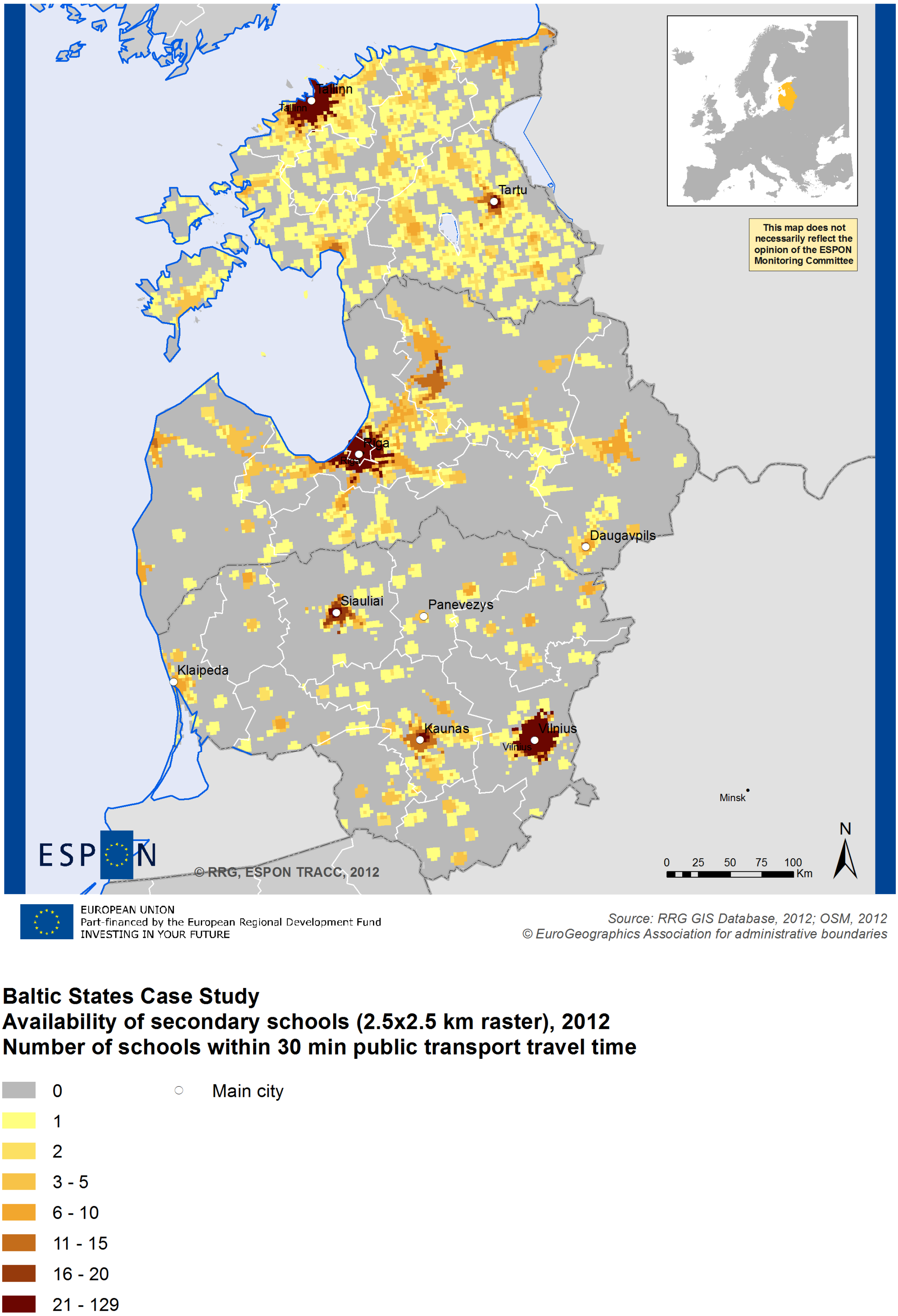
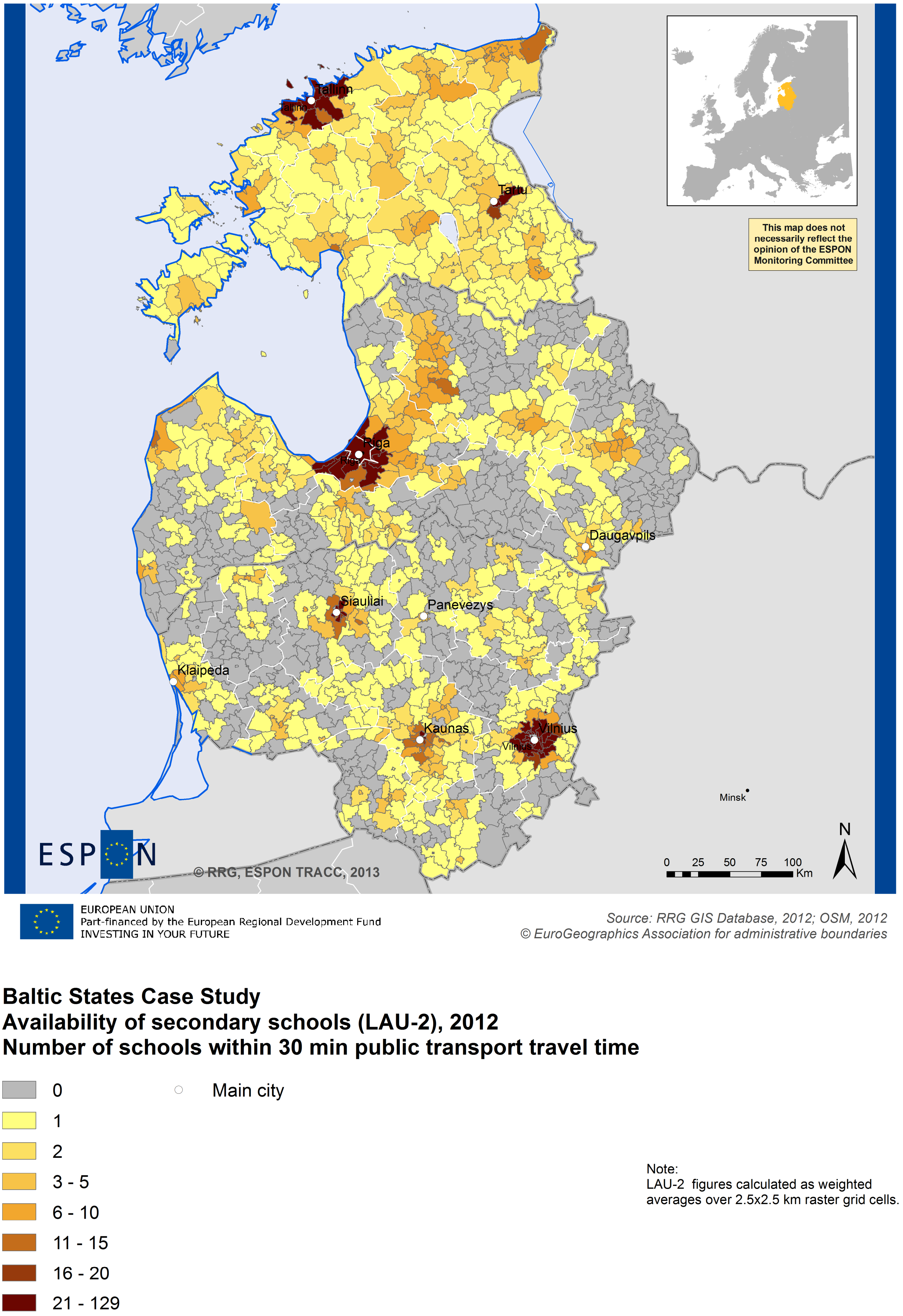


Figure 23a. Higher secondary schools within 30 minutes travel time by public transport (raster)



Source: RRG GIS Database, 2012; OSM, 2012
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Note:
LAU-2 figures calculated as weighted averages over 2.5x2.5 km raster grid cells.

Figure 23b. Higher secondary schools within 30 minutes travel time by public transport (LAU-2)

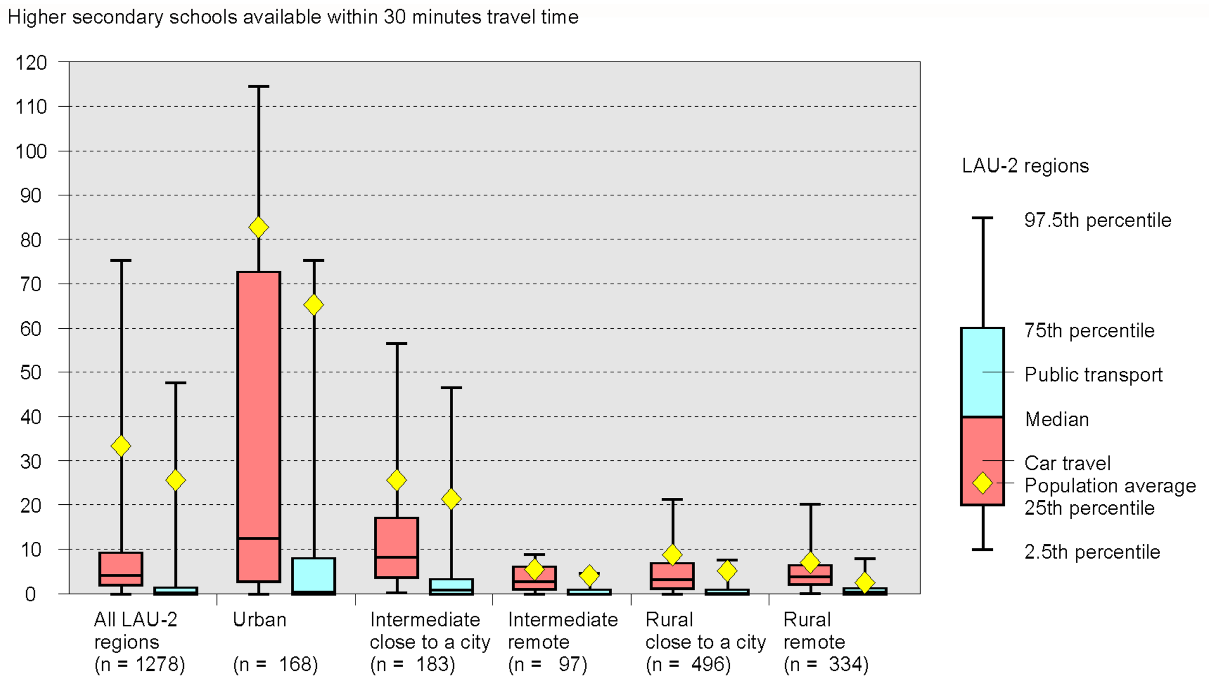


Figure 24. Higher secondary schools within 30 minutes travel time, by urban-rural typology

The most alarming fact is, on top of the previous findings, that for public transport even in urban regions, but even more in intermediate and rural regions between ten and 15% of the population does not have any school available within 30 minutes travel time by public transport. Assuming that most pupils rely on busses or trains, the children are forced to bear extremely long travel times to go to their schools.

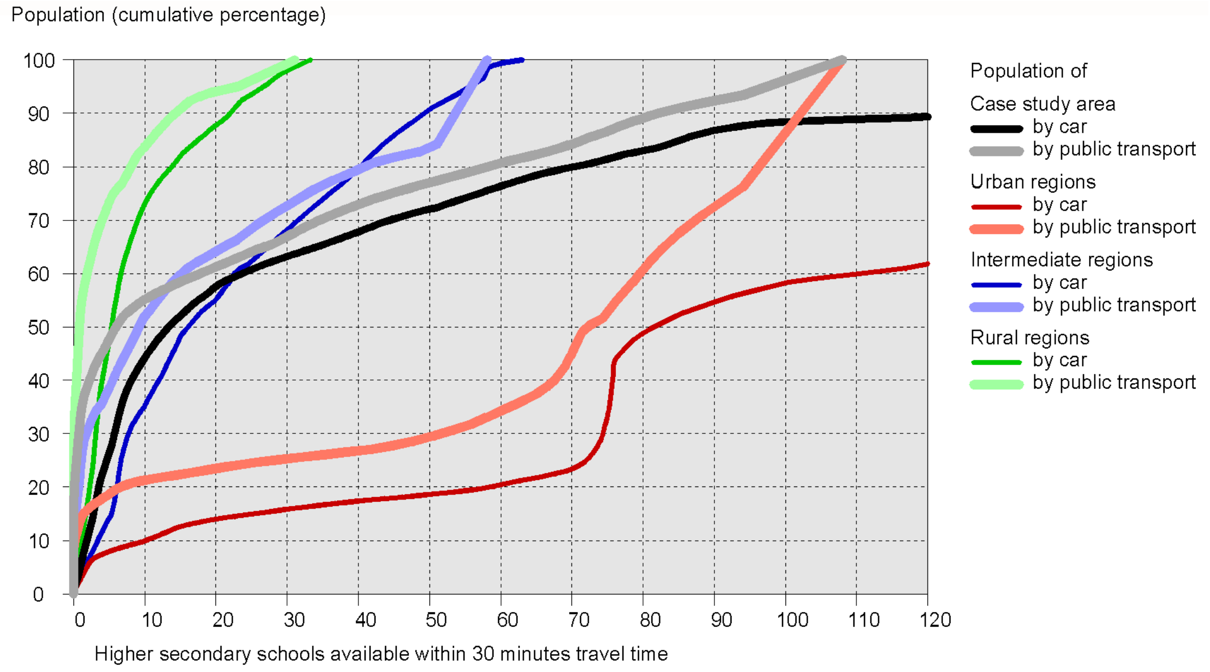


Figure 25. Higher secondary schools within 30 minutes travel time, cumulative distributions

3.6 Accessibility potential to basic health care

What is the locational quality with respect to basic health care? Using the number of medical doctors in general practice surgeries as destination activity in a potential accessibility indicator allows assessing the relative distribution of health care provision of different areas within the case study region. For each raster cell, the potential value is calculated as sum of domestic medical doctors located in the respective country of the origin cell weighted by travel times by road and public transport. Since information on the precise location of general surgeries was not available in the Baltic Sea case study region, the number of doctors per municipality was used instead as destination activity. Standardisation was done by applying national averages, since only domestic destinations were used.[10]

A side effect of using country averages is that the specificities of the different national health care regulations and health care systems are alleviated. For instance, according to the Eurostat Regio Database (Eurostat, 2011) the ratio of doctors per 100,000 inhabitants in 2009 is much lower for Latvia (58) and Lithuania (69) compared to Estonia (82); also, in Estonia and Latvia there is a higher concentration of doctors in the regional centres compared to Lithuania, where there still are reasonable numbers of general surgeries in rural parts of the country.

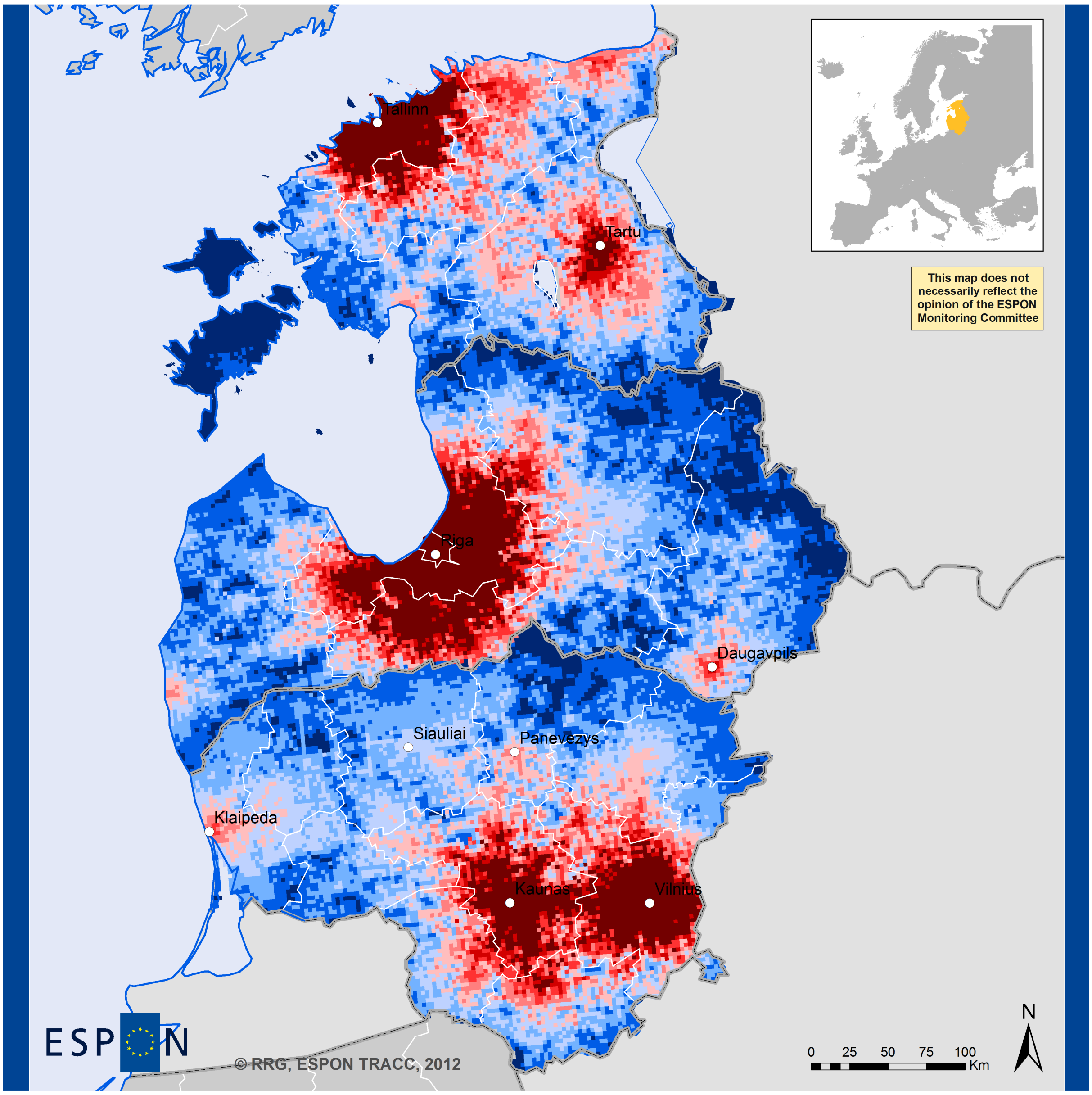
Keeping this in mind the results for Estonia and Latvia for both road and public transport (Figures 26 and 27) illustrate areas of high accessibility around main regional centres (Tallinn, Tartu and Pärnu in Estonia, Riga, Daugavpils, Rezekne and Liepaja in Latvia) and along main transport axes, while the situation in Lithuania is more complex. While for road (Figure 26) a seamless plateau of high accessibilities is formed around the agglomerations of Kaunas and Vilnius, supplemented by areas of high accessibility around Klaipeda and Parnevezys, for public transport (Figure 27) a lot of local hotspots appear around each medical centre, even in small towns and villages, reflecting the service quality even in rural and peripheral parts of the country.

Nevertheless, when standardising the public transport figures at the road averages it becomes obvious that the accessibility levels for public transport are only fractions of those for road, since most parts of all three countries show huge underperforming. Only areas around Riga, Tallinn, Tartu and Daugavpils lie above the average. Apart from these exceptions, using public transport to go to doctor puts additional burdens upon people compared to using a car. Assuming that elderly people visit general surgeries more often than other groups of people, who for various reasons stronger rely on public transport systems, one can imagine that these groups experience some problems in organizing their daily life facing such access obstacles.

The different accessibility levels for road and public transport are also reflected in the box plot diagram comparing the performance of different types of regions (Figure 28). Only in urban areas public transport reaches significant accessibility levels corresponding up to index values of 330; however, the 75th percentile remains at a rather low index value of 30. The public transport performance in other region types is even worse. Notwithstanding that car accessibility is by far better than public transport for all region types, there are even great disparities within one region type for car accessibility. For instance, in urban regions the index value range between the 2.5th percentile and the 97.5th percentile is almost 500. Similar ranges are detected for intermediate regions close to a city. Furthermore, even for cars there is a clear decline in the accessibility levels from urban regions towards intermediate regions close to a city, down to the other region types.

---

[10] Since health care systems are organized along national regulations, it is assumed that for general treatments all people will visit general surgeries within their home country and will not go to a doctor abroad. Thus, this accessibility indicator is modelled to account only for domestic destinations. By way of consequence, and in order to compensate for the national regulations, standardisation is also performed at national averages rather than the Baltic Sea average as a whole.



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Baltic States Case Study (2012)
Potential accessibility to basic health care by road (2.5x2.5 km raster)

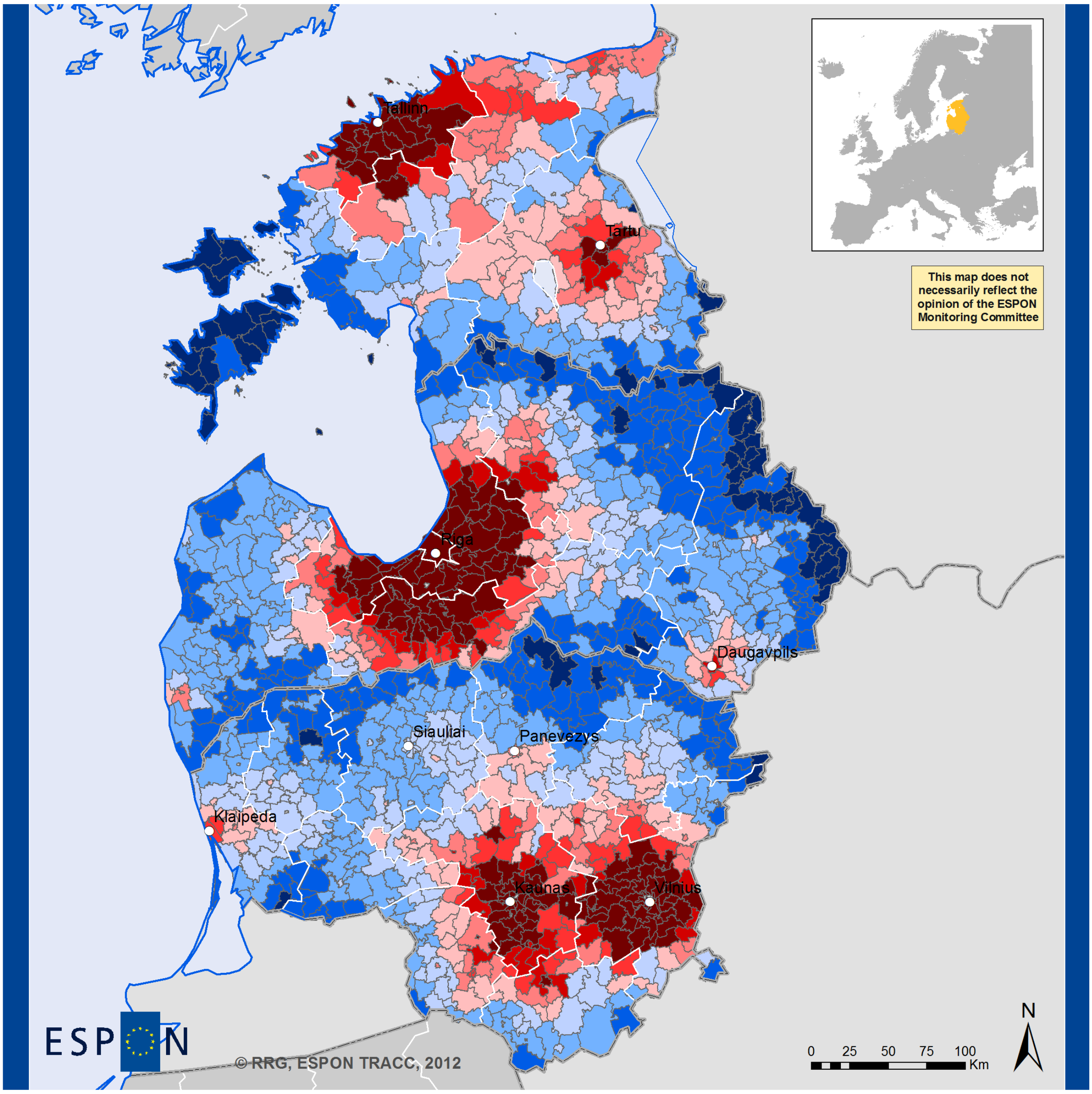
■ 0 - 25
■ 26 - 50
■ 51 - 75
■ 76 - 100
■ 101 - 125
■ 126 - 150
■ 151 - 175
■ 176 - 200
■ 201 < ...

○ Main city

Notes:
Beta = 0.046210

Overall minimum: 0.01
National averages: 38.78 (Estonia), 80.75 (Lithuania), 40.48 (Latvia)
Overall maximum: 437.75

Figure 26a. Potential accessibility to medical doctors by car (raster level)



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Baltic States Case Study (2012)
Potential accessibility to basic health care by road (municipalities)

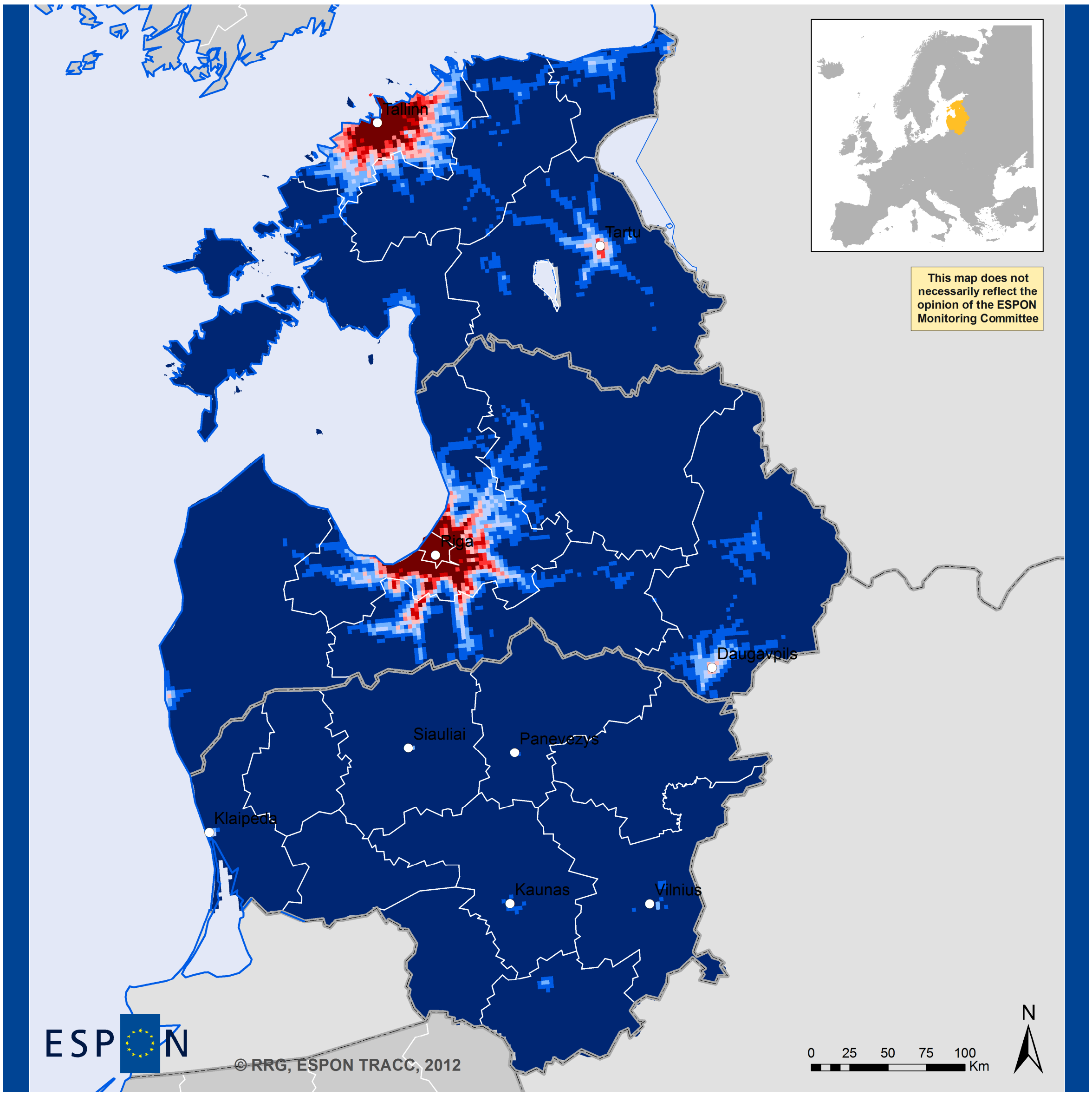
- 🟦 0 - 25
- 🟦 26 - 50
- 🟦 51 - 75
- 🟦 76 - 100
- 🟥 101 - 125
- 🟥 126 - 150
- 🟥 151 - 175
- 🟥 176 - 200
- 🟥 201 < ...

○ Main city

Notes:
Beta = 0.046210

Overall minimum: 0.01
National averages: 38.78 (Estonia), 80.75 (Lithuania), 40.48 (Latvia)
Overall maximum: 437.75

Figure 26b. Potential accessibility to medical doctors by car (LAU-2 averages)



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Baltic States Case Study (2011)
Potential accessibility to basic health care by public transport (2.5x2.5 km raster)

🟦 0 - 25
🟦 26 - 50
🟦 51 - 75
🟦 76 - 100
🟥 101 - 125
🟥 126 - 150
🟥 151 - 175
🟥 176 - 200
🟥 201 < ...

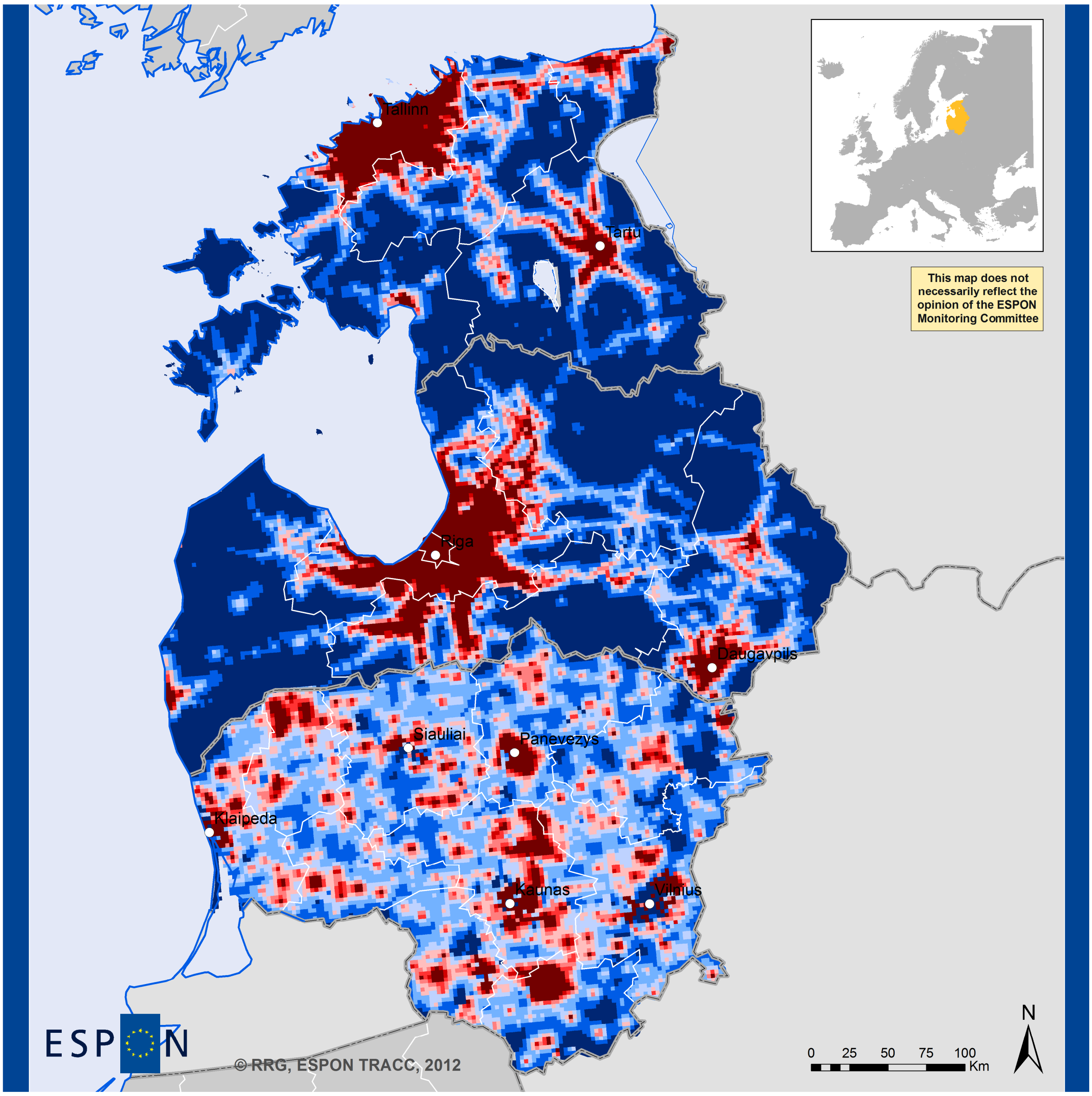
○ Main city

Notes:
Beta = 0.046210

Overall minimum: 0.01
National averages: 38.78 (Estonia), 80.75 (Lithuania), 40.48 (Latvia)
Overall maximum: 372.34

100 = national road averages

Figure 27a. Potential accessibility to medical doctors by public transport (raster level, standardised on road average)



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Baltic States Case Study (2011)
Potential accessibility to basic health care by public transport (2.5x2.5 km raster)

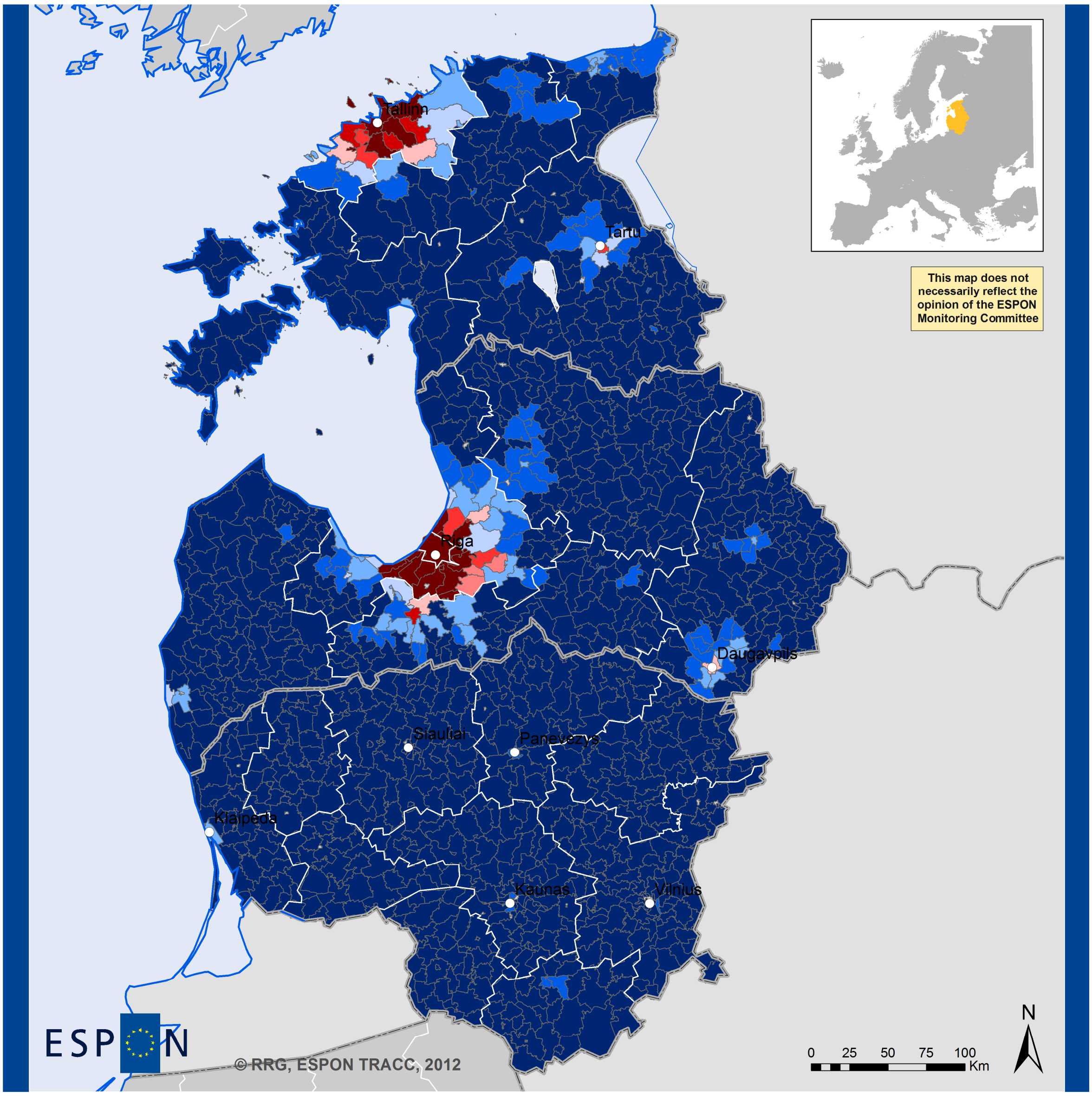
■ 0 - 25
■ 26 - 50
■ 51 - 75
■ 76 - 100
■ 101 - 125
■ 126 - 150
■ 151 - 175
■ 176 - 200
■ 201 < ...

○ Main city

Notes:
Beta = 0.046210

Overall minimum: 0.01
National averages: 8.75 (Estonia), 1.87 (Lithuania), 8.36 (Latvia)
Overall maximum: 372.34

Figure 27b. Potential accessibility to medical doctors by public transport (raster level, standardised on public transport average)



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Baltic States Case Study (2011)
Potential accessibility to basic health care by public transport (municipalities)

- 🟦 0 - 25
- 🟦 26 - 50
- 🟦 51 - 75
- 🟦 76 - 100
- 🟥 101 - 125
- 🟥 126 - 150
- 🟥 151 - 175
- 🟥 176 - 200
- 🟥 201 < ...

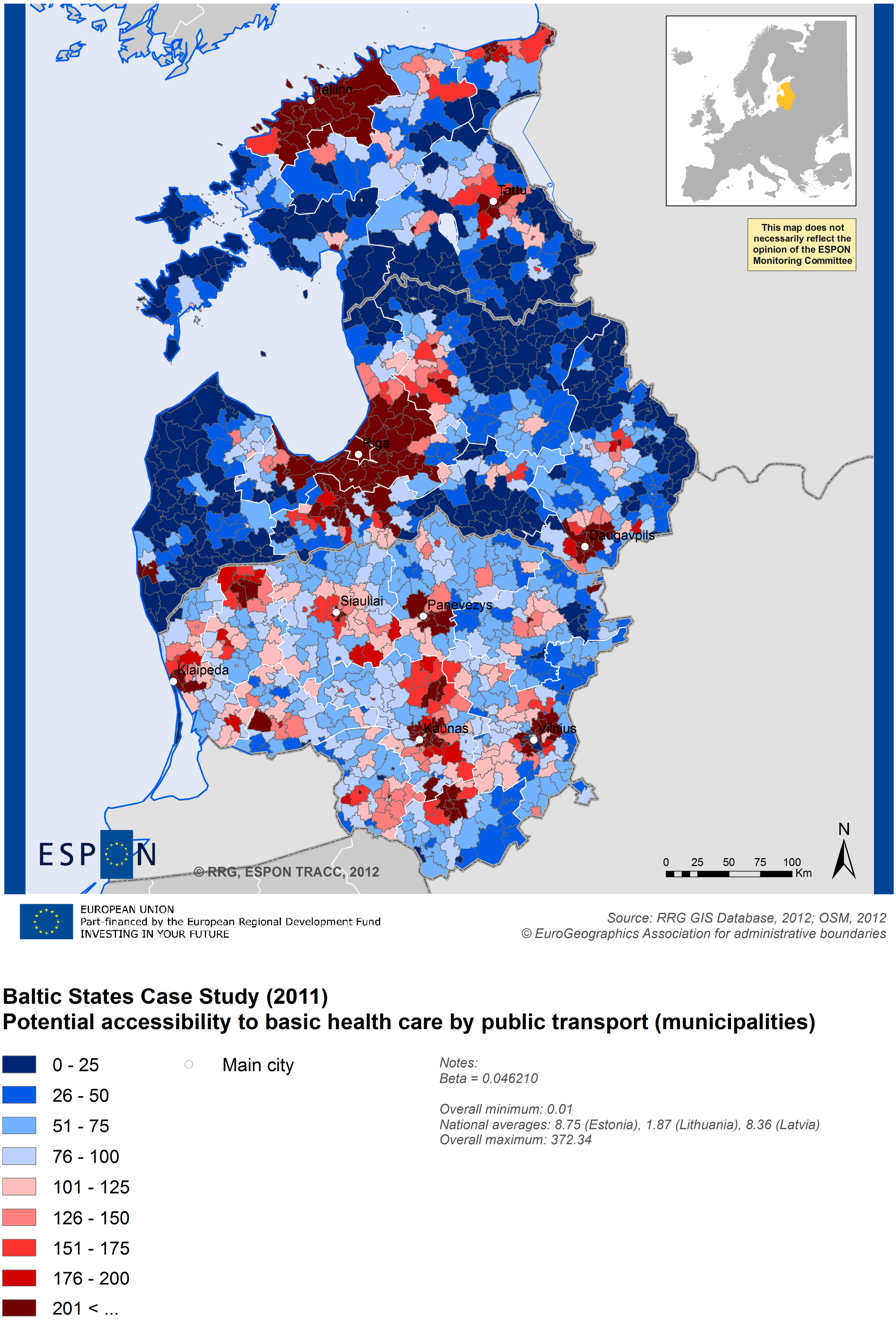
○ Main city

Notes:
Beta = 0.046210

Overall minimum: 0.01
National averages: 38.78 (Estonia), 80.75 (Lithuania), 40.48 (Latvia)
Overall maximum: 372.34

100 = national road averages

Figure 27c. Potential accessibility to medical doctors by public transport (LAU-2 averages, standardised on road average)



This map does not necessarily reflect the opinion of the ESPON Monitoring Committee

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Source: RRG GIS Database, 2012; OSM, 2012
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Baltic States Case Study (2011)
Potential accessibility to basic health care by public transport (municipalities)

Notes:
Beta = 0.046210

Overall minimum: 0.01
National averages: 8.75 (Estonia), 1.87 (Lithuania), 8.36 (Latvia)
Overall maximum: 372.34

Figure 27d. Potential accessibility to medical doctors by public transport (LAU-2 averages, standardised on public transport average)

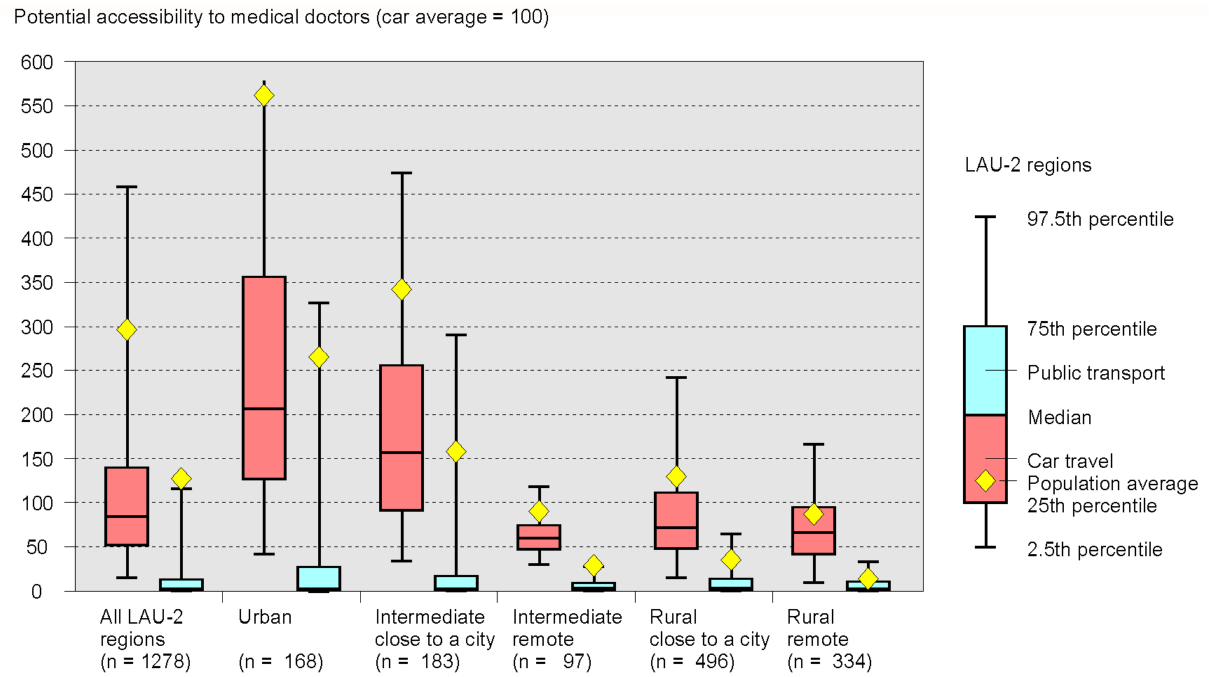


Figure 28. Potential accessibility to medical doctors, by urban-rural typology

Road accessibility for intermediate remote and for rural regions is still higher than for public transport, but is considerably lower compared to the other two region types, indicating a clear divide between rural and urban areas.

More than a quarter of population in all types of regions experience extremely low accessibility levels by public transport (Figure 29) with index values of less than 25. Almost 2/3 of the population observes index values of not more than 50 when using public transport.

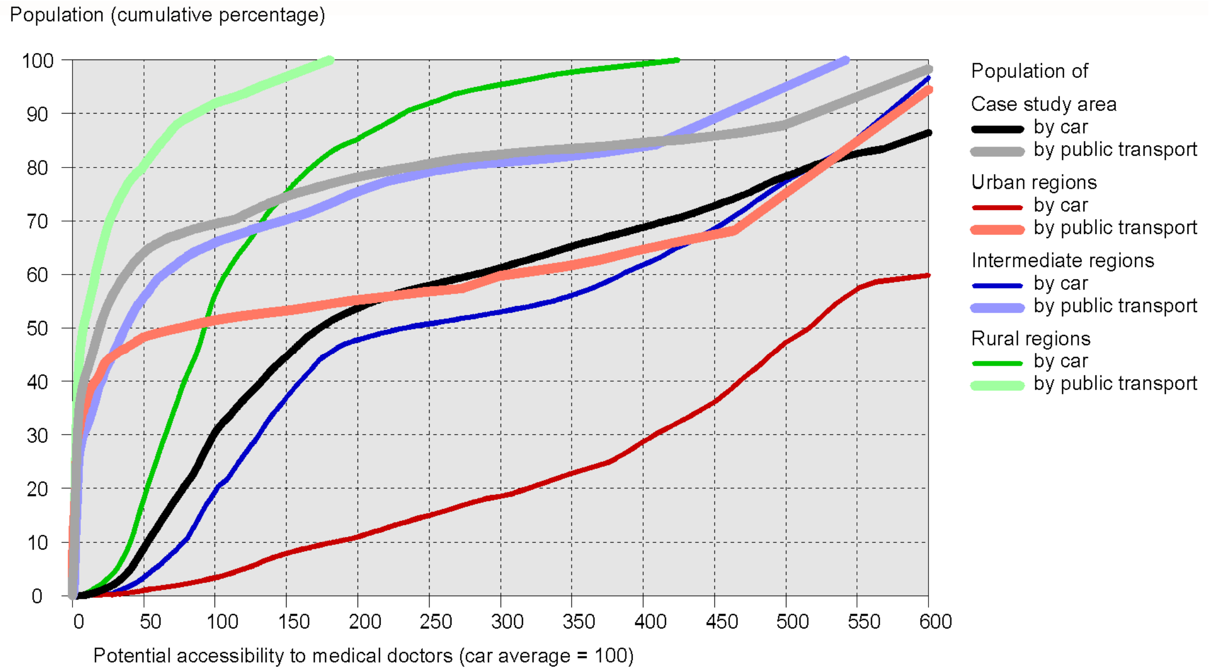


Figure 29. Potential accessibility to medical doctors, cumulative distributions

The service quality for cars is, in contrast, much better since 50% of the population experience accessibility levels of more than 150; another 20% of the overall case study population even have index values of more than 500 for cars, which of course is mainly due to the very good performance of the urban regions.

4 Accessibility situation at different regional subtypes

For further analyses, the macro region of the Baltic States is subdivided into six zoom-in regions, two per country. The zoom-in regions within each macro region should represent different types of regions within the case study area. They are used to analyse the accessibility patterns in a more fundamental way, by contrasting results for these regions to the national and case study averages.

In each Baltic State one zoom-in region represents a seaport region (of which two are the capital regions at the same time), and the other one represents a more peripheral region towards the Eastern border of the countries (Figure 30).

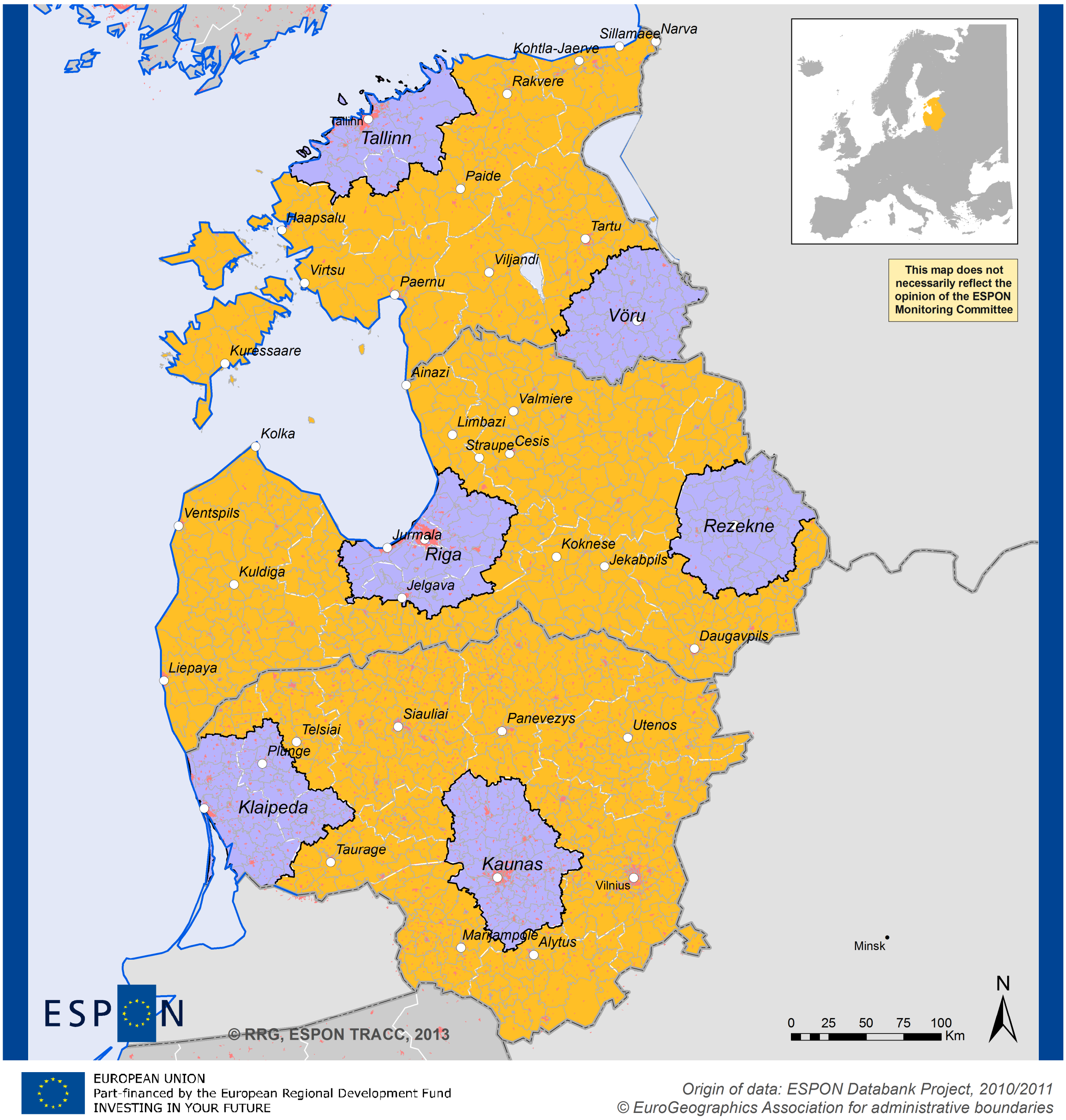
The following zoom-in regions are chosen for the Baltic States case study:

- *Estonia*. The capital city region of Tallinn was selected as it represents the capital and the major seaport of Estonia, with the highest concentration of public and private services and infrastructures, representing the major economic centre of the country. Vöru in turn is a small town in the rural southern part of the country, located at the crossroads of important east-west and north-south transport axes.
- *Latvia*. Similar to the case of Tallinn, Riga was selected as it is the capital and the main seaport of the country, having the highest concentration of services and infrastructures in Latvia. Rezekne is a medium-sized town in the Eastern, rural part of the country towards the Russian border, where the economic performance in terms of GDP per capita is extremely poor compared to the EU27 average, corresponding to the level of Belarus.
- *Lithuania*. Klaipeda was selected as a zoom-in region because it represents the main port of Lithuania, connecting the country to Western Europe and Scandinavia via several ferry services. Kaunas, in addition, is located in the central part of Lithuania at the crossroads of all north-south and east-west transport arteries, being a region with relatively high population densities (at least in the context of the Baltic States).

The delimitation of these zoom-in regions basically followed the NUTS-3 region boundaries. In case of Tallinn and Kaunas the delimitated zoom-in regions more or less correspond to the respective NUTS-3 regions. For Vöru the NUTS-3 region was split into the southern part, so as for Razekne where only the middle part of the large NUTS-3 region was selected. For Riga and Klaipeda, finally, portions of neighbouring NUTS-3 regions were also used to delimitate the zoom-in region.

While the area of the zoom-in regions is quite comparable, ranging from 5,200 km^2 for Vöru up to 6,650 km^2 for Klaipeda, they significantly differ in their population size. As expected, the two rural regions Vöru (118,000 inhabitants) and Rezekne (132,000 inhabitants) have the lowest population figures, followed by Klaipeda (364,000 inhabitants) and Tallinn (539,000 inhabitants), and led by Kaunas (713,000 inhabitants) and Riga (934,000 inhabitants). Consequently, the population densities range from 23 (Vöru) up to 164 (Riga) people per km^2.

How do these zoom-in regions perform in terms of accessibility compared between them and to the case study averages? Figures 31 to 42 as well as Tables 1 and 2 illustrate their performance. First, the results will be discussed indicator-wise, followed secondly by a cross-indicator summary.



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Baltic States Case Study
Macro region and zoom-in regions

- 🟪 Zoom-in regions
- 🟧 Macro-region: LAU-2
- ○ Main city
- 🟥 Settlement area
- ⬜ NUTS-3 region boundary

Figure 30. Zoom-in regions

Performance by indicator

Despite many similarities, the performance of the different zoom-in regions for the selected accessibility indicators shows quite a lot of differences, some of them, which are expected, and some of them, which come to a surprise.

The overall median ***travel time to next region centre*** for the entire study area is about 30 minutes for cars and more than 80 minutes for public transport (Figure 31). For car, the differences among the six zoom-in regions are only marginal, with a value range between the 25th and 75th percentile of only 15 minutes. Average travel times and also the differences are smallest for Riga region; disparities for cars are in contrary largest for Vöru and Rezekne regions. For public transport, the results are quite diverse. While for the Riga, Tallinn and Kaunas regions accessibility levels are fairly good, the public transport travel times may reach up to 150 minutes in Rezekne, Vöru and even Kaunas regions. Transforming these travel times into cumulative population distributions, as shown in Figure 32, yields that for roads 90% of the population reach the next regional centre in less than 45 minutes, 70% even in less than 30 minutes. For public transport these numbers are significantly lower, where less than 60% of the population reach the next centre in 45 minutes, and only 50% of the population in less than 30 minutes. While the population coverage for public transport in the Riga and Tallinn regions are comparably high as for road, the public transport accessibility is particular poor in the Vöru and Rezekne regions, but also surprisingly poor in the Klaipeda zoom-in region.

The ***jobs accessibility*** in the Baltic States is clearly dominated by the Riga region (Figures 33 and 34), followed by the Kaunas region. Only these two regions top the average of all regions. In Riga, up to 800,000 jobs can be reached by car and up to 630,000 jobs by public transport. In the Kaunas region people may reach up to 750,000 jobs by car, and 240,000 jobs by public transport. For Vöru and Rezekne, only up to 110,000 jobs can be reached by car, while by using public transport only fragments of these can be reached. Disparities by car are smallest for the Tallinn region, indicating similar accessibility levels in all parts of this zoom-in region. Looking at the affected population (Figure 34) illustrates the extreme disparities in this indicator. While for Riga 90% of the population can reach more than 750,000 jobs by car (and even more than 550,000 jobs by public transport) within 60 minutes, the situation is quite opposite in Vöru and Rezekne, where 90% of the population cannot reach more than 50,000 jobs by public transport and 100,000 jobs by car. Even though the case study average for both modes is quite steady and homogeneous, the diagrams suggest great internal disparities within the Baltic States for this indicator.

In all zoom-in regions, the ***potential accessibility to population*** by car is much higher than by public transport (Figure 35). The Riga and Kaunas regions show similar structures, as the maximum numbers of accessible population as well as the internal regional disparities are in similar ranges for both modes. The situation in the Vöru and Rezekne regions are also comparable, even though absolutely based on very small numbers. Seventy percent of the population in Riga region (Figure 36) benefit from accessibility levels above 160 (car) or 100 (public transport), while on the other side of the spectrum 70% of the population in the Rezekne region only gain accessibility levels of 15 (public transport) and 35 (car). The Tallinn region is the region, which performs closest to the overall average, for road as well as to some degree for public transport.

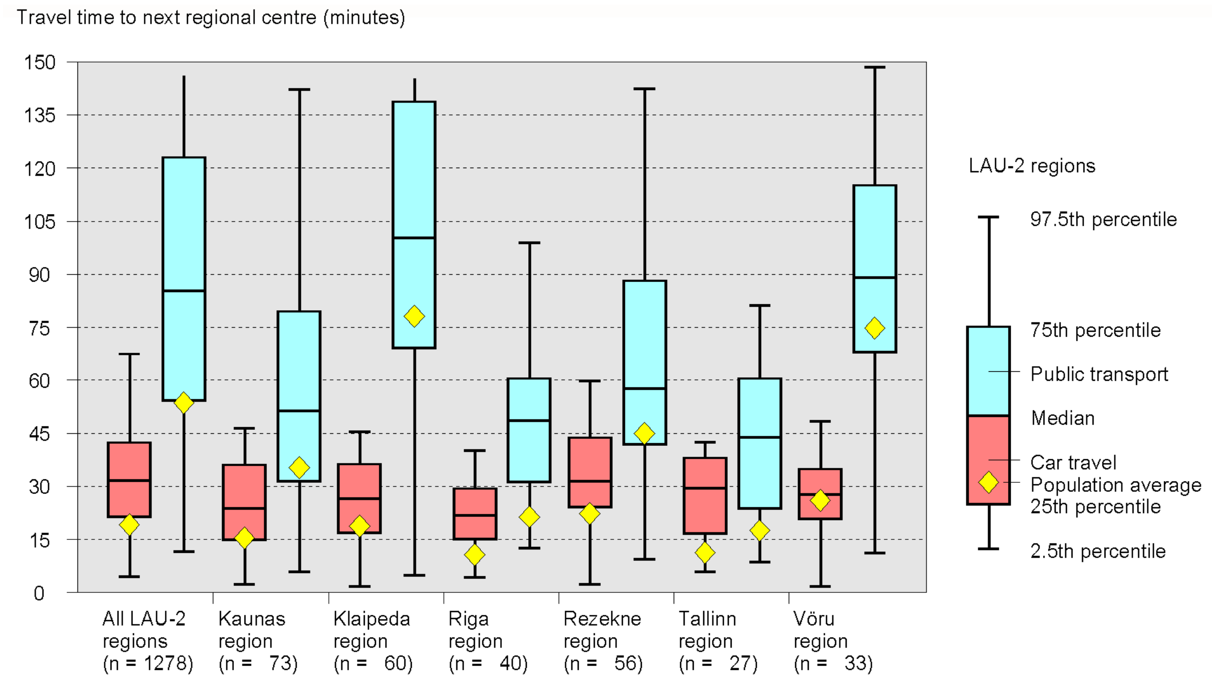

Figure 31. Travel time to next regional centre, by zoom-in region

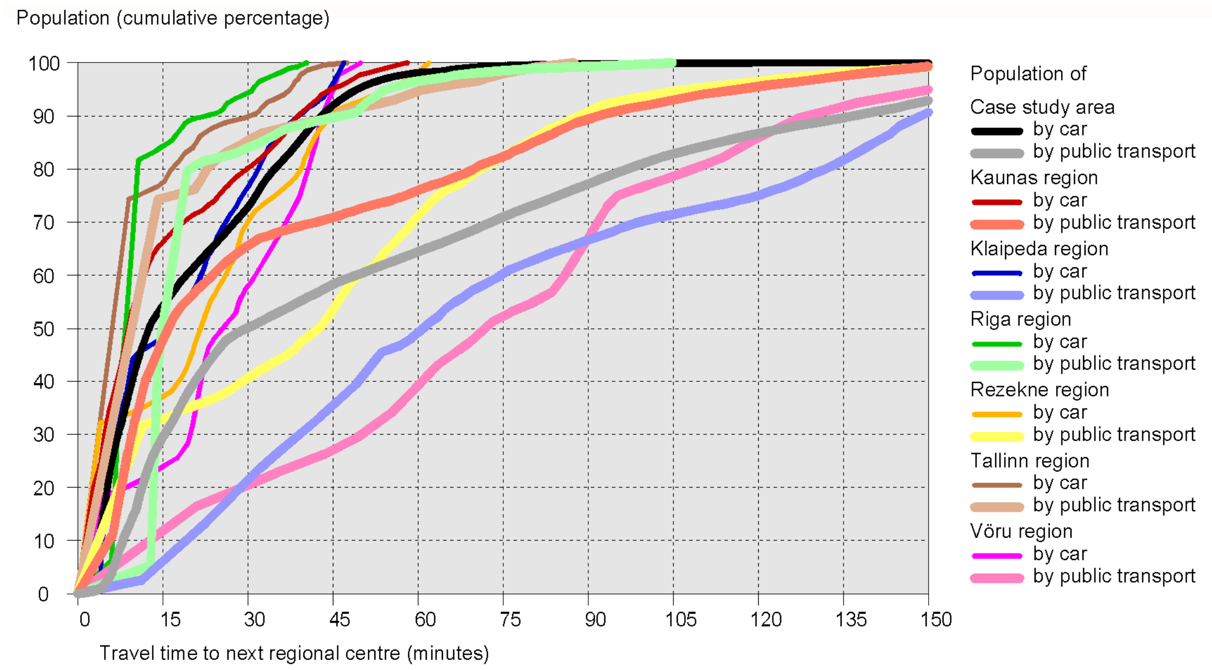

Figure 32. Travel time to next regional centre, cumulative distributions by zoom-in region

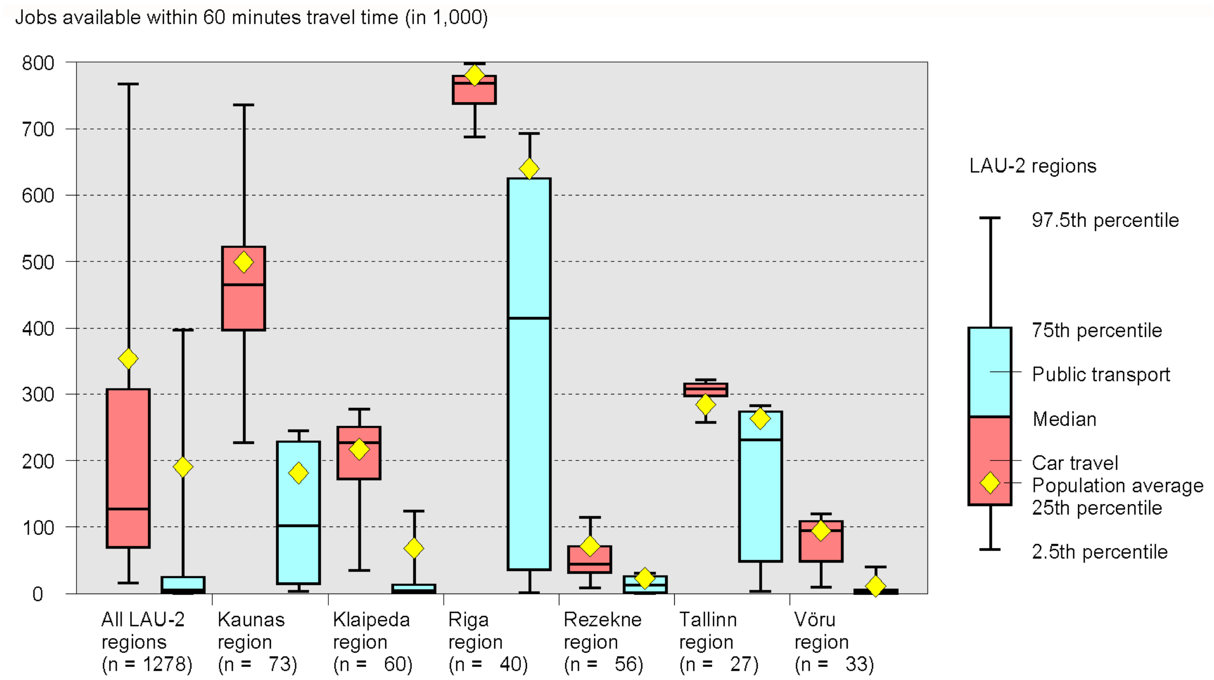

Figure 33. Jobs accessible within 60 minutes, by zoom-in region

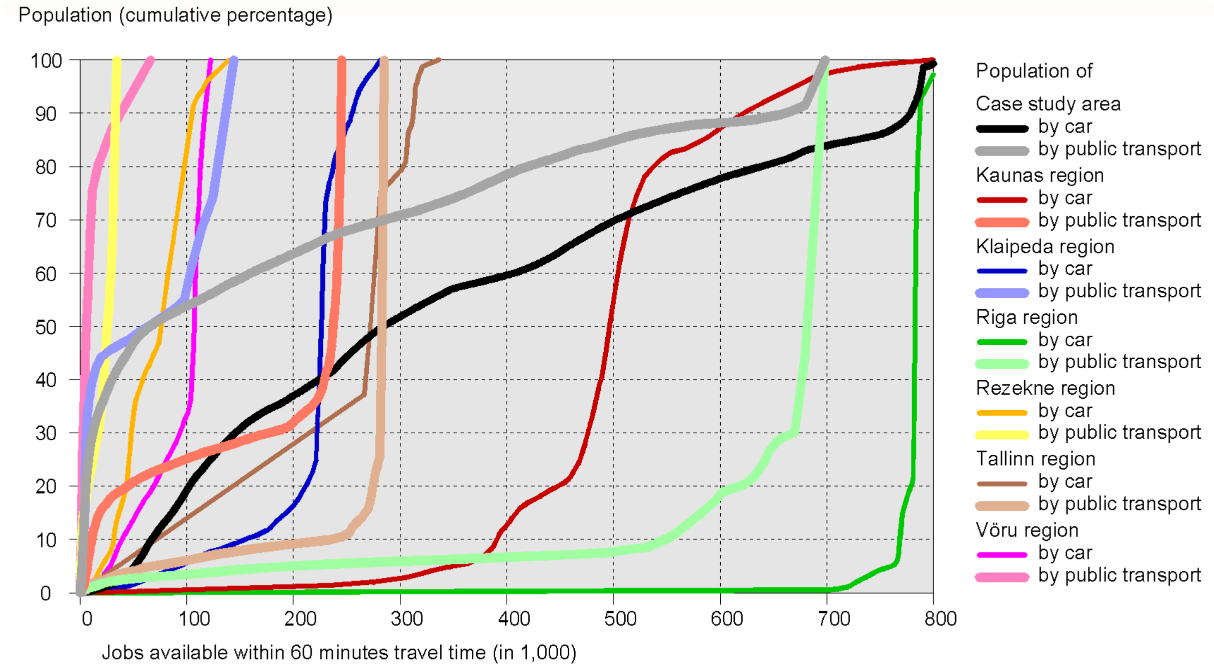

Figure 34. Jobs accessible within 60 minutes, cumulative distributions by zoom-in region

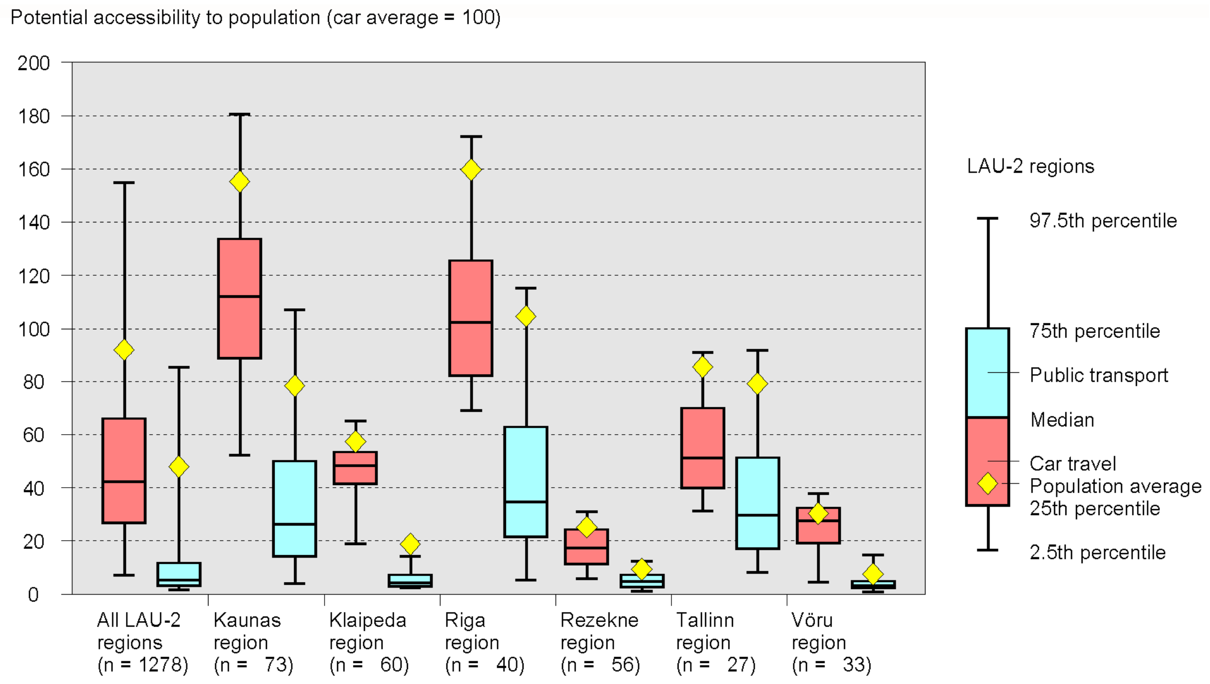

Figure 35. Potential accessibility to population, by zoom-in region

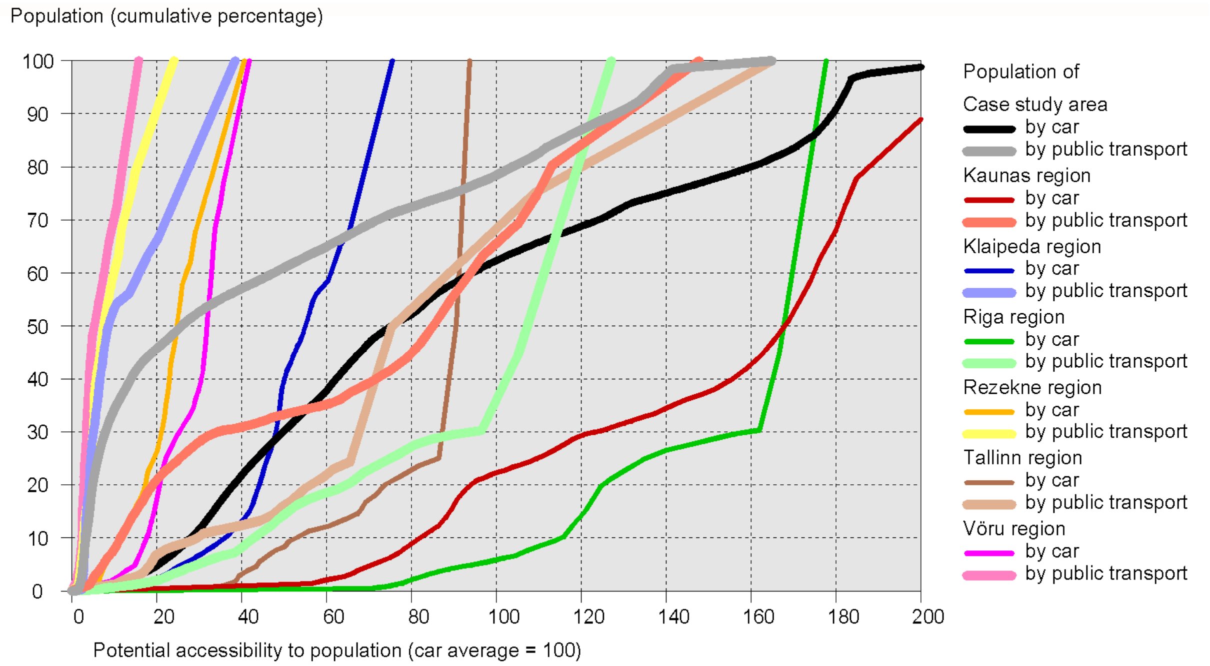

Figure 36. Potential accessibility to population, cumulative distributions by zoom-in region

The results for the indicator ***travel time to next hospital*** show great differences between the two modes (Figure 37), where public transport times are generally higher than car travel times. While the maximum travel time by car to the next hospital is less than 60 minutes (Rezekne region), public transport users may need up to 120 minutes in Klaipeda and Rezekne regions. The overall car median travel time is 20 minutes, while for public transport it is 60 minutes. The smallest disparities for both modes are found in Riga, Tallinn and Klaipeda regions. The excellent accessibility levels for cars are also illustrated by the cumulative population graph (Figure 38) indicating that overall 60% of the case study area population can reach the next hospital by car in 10 minutes. In contrast, the same population proportion reaches the next hospital by public transport in 30 minutes. Riga and Tallinn are outstanding in this indicator, even for public transport, since 80% of the population get to the next hospital within 10 minutes by public transport, and 90% for cars in the same travel time. Public transport performance for the other zoom-in regions, however, is much poorer. For instance, 30% of the population in Klaipeda and Vöru regions so as 20% of the Rezekne population need more than 70 minutes to get to the next hospital. Since nobody expects people to take public transport to go to hospital in emergency cases, car travel times may be used as proxy times in emergency. Using a threshold of 30 minutes car travel time as a reasonable emergency response time, 20% of the Rezekne population and still 5% of the Klaipeda and some 3% of the Kaunas region population are located beyond this response time. Reducing the threshold to 20 minutes increase the proportions to 40% of Rezekne region population, 25% of Vöru region population, 15% of Kaunas and Klaipeda population, and even some 3% of Riga and Tallinn region population.

Results for the indicator on ***higher secondary schools available within 30 minutes travel time*** heavily polarize at the level of zoom-in regions (Figures 39 and 40). Again, Riga region is dominating the distribution with a median of more than 30 schools within reach by using car (5 by using public transport) and up to 115 schools at maximum. The median for Tallinn region is following next with 25 for cars and 3 for public transport. For the other zoom-in regions the box plots confirm that a minimum supply level with 1-2 schools is maintained in all regions, but that for many places there is only limited options to choose between more than 1 or 2 schools. When using public transport, there is often no freedom of choice at all, but even when using cars this freedom is often limited. For public transport, 60% of the region populations of Vöru, Klaipeda, and Rezekne can choose between more than one higher secondary school, while for Kaunas more than 80% and for Riga and Tallinn more than 95% have such freedom of choice (Figure 40). While the results for Kaunas, Riga or Tallinn are promising, the aggregated results for Vöru, Klaipeda or Rezekne hide that out of the 40% without any freedom of choice there is quite a big population share which do not have any access to secondary schools at all, at least when looking at public transport.[11] These results show that access to higher secondary schools should be put on the political for the rural areas.

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[11] One should note that the public transport data used did not include dedicated school busses, since data for such specialized services were not available for the Baltic States. School bus systems may compensate for missing regular bus or train connections, particularly in rural areas.

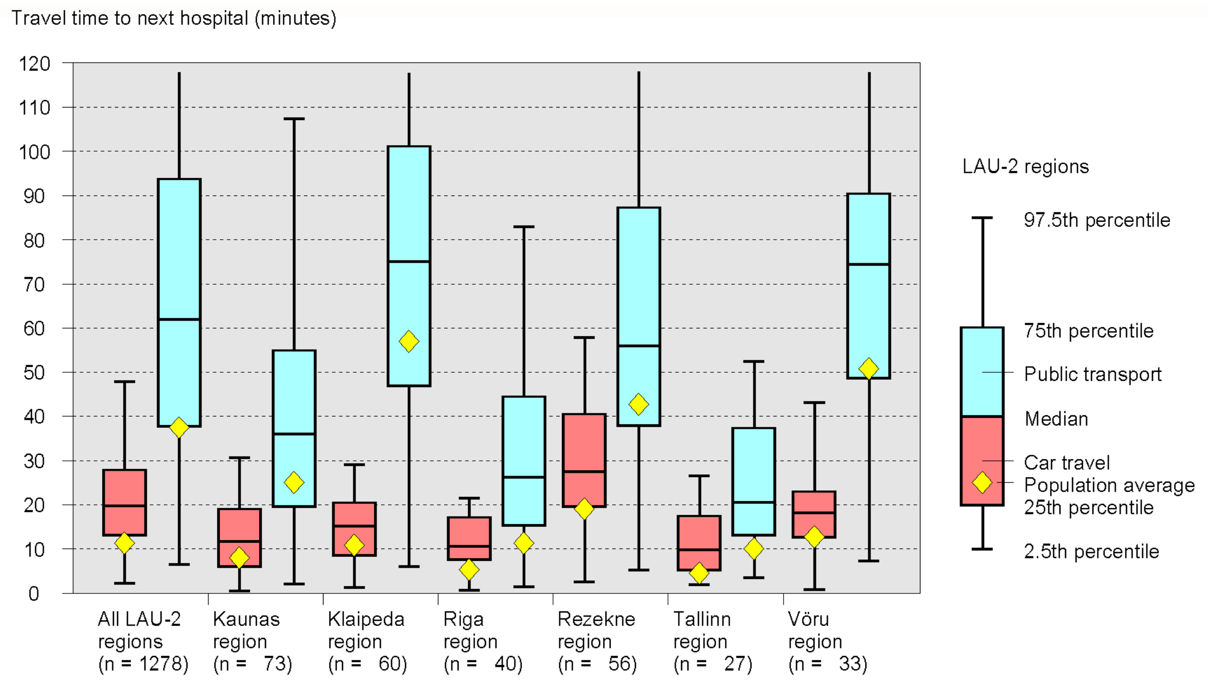

Figure 37. Travel time to next hospital, by zoom-in region

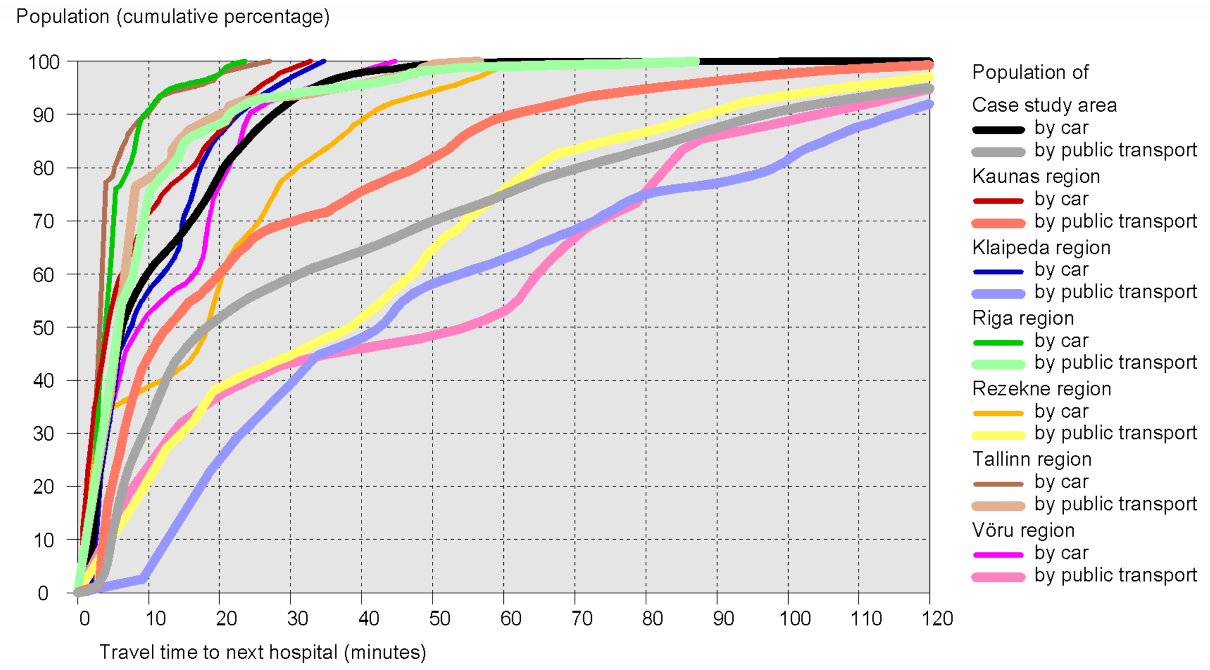

Figure 38. Travel time to next hospital, cumulative distributions by zoom-in region

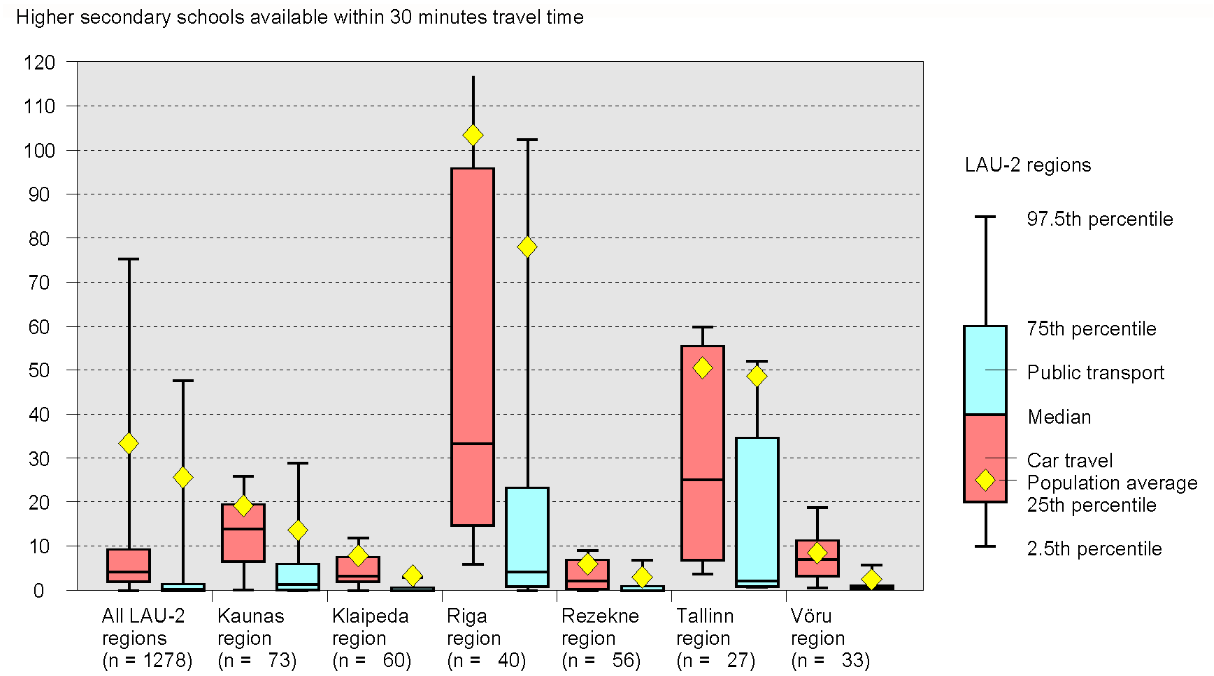

Figure 39. Higher secondary schools within 30 minutes travel time, by zoom-in region

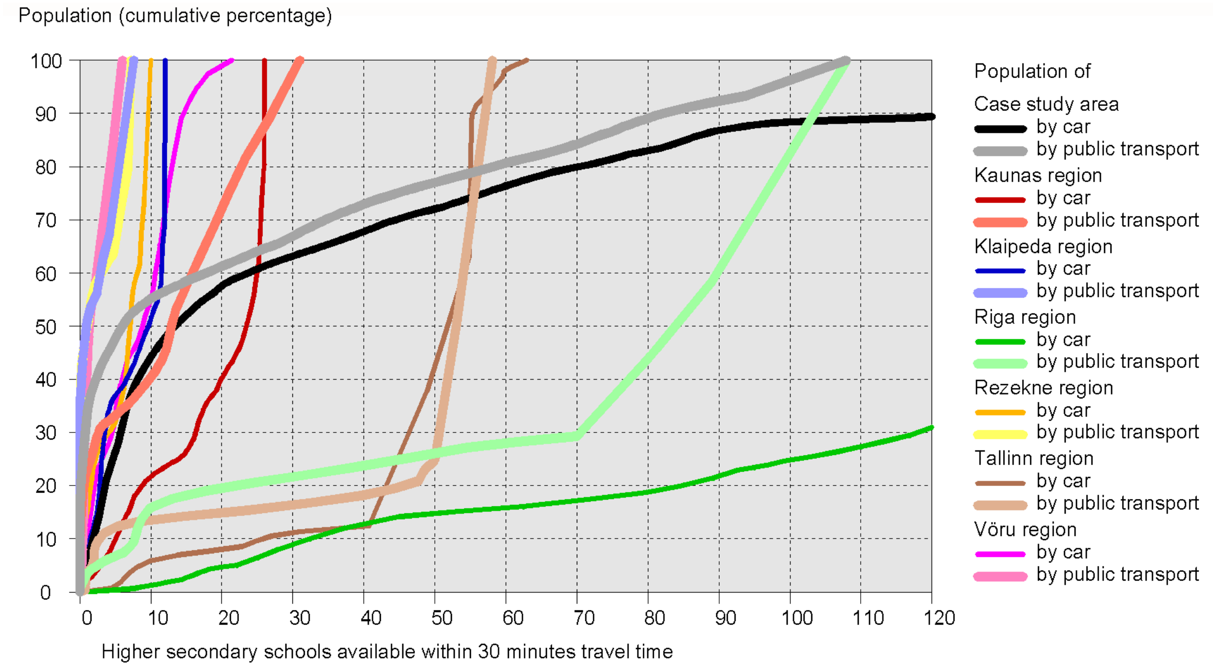

Figure 40. Higher secondary schools within 30 minutes travel time, cumulative distributions by zoom-in region

Potential accessibility to medical doctors is quite diverse among and between the zoom-in regions (Figure 41). Again, the capitals of Riga and Tallinn dominate the distribution with median values of 350 (Riga, cars) and 250 (Tallinn, cars) and 100 (both regions) for public transport. From the remaining regions, only Kaunas follows with a median of 230 for cars. For public transport, accessibility performance for all other four regions is very poor, with only small portions of the road accessibility. The cumulative population distribution (Figure 42) confirms these disparities: While for road, 80% of the population of Riga and Tallinn benefit from accessibility indices of more than 500 (i.e. five times the Baltic States average)[12], 80% of the population in Rezekne and Vöru suffer from only half the accessibility as the Baltic States average for road. For public transport, they only gain less than one tenth of the Baltic States average. Thus, the case study average curves hide the fact that the Baltic States deal with extreme disparities in access to medical doctors between urbanized and rural areas.

The analysis of the accessibility situation in the zoom-in regions of the Baltic States along the selected accessibility indicators can be summarized as follows:

- For all indicators, accessibility levels by car are generally higher as those for public transport; however, in selected urban areas as well as along specific transport axes, public transport provides accessibility levels in the same range as offered by road.
- The agglomeration of Riga is dominating the accessibility of the Baltic States, followed by Tallinn and, with some distance, Kaunas.
- In contrast, the regions of Vöru and Rezekne suffer from extremely poor access to markets and access to services, for both road and public transport. There is a steep decline in accessibility between the regional cities and these rural regions.
- There are great disparities in accessibility even in regions with generally high accessibility levels. For some indicators these inner disparities are even greater than the differences between different regions. Thus, accessibility models should be set up at least on LAU-2 level (if not raster level) to be able to capture these small-scale disparities. Models operating at NUTS-3 level or even more aggregate spatial levels are not able to come up with such details.
- With accessibility being a function of both the transport systems and the destinations to reach, poor accessibility may not necessarily be the result of poor or missing transport infrastructures. In many cases it is instead the result of the spatial distribution of (public) facilities and services, which in turn is quite often the outcome of specific policies (such as health care policies, which for instance determine specific doctors/inhabitant ratios, or determine the distribution of health care centres; or such as education policies determine the location of upper schools)[13]. Thus, the best way of improving the accessibility situation of a region may not necessarily be the construction of new transport infrastructures, but a revision of such policies in conjunction with a spatial re-allocation of facilities and services.

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[12] For public transport the same population share still benefits from accessibility indices of more than 250.

[13] Quite often these policies are a priori *aspatial*, i.e. when developing such policies spatial allocation was not explicitly considered, or politicians were not aware about the spatial dimension of such policies. In reality, the outcome of certain policies then is reflected in changing spatial structures.

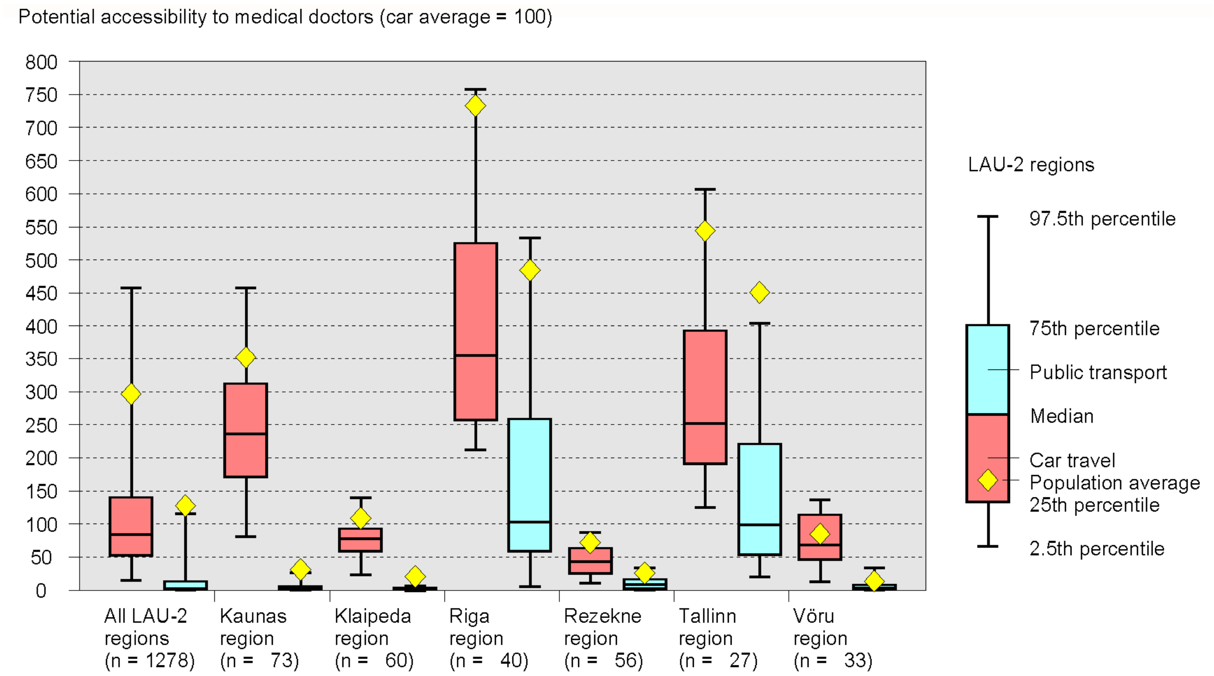

Figure 41. Potential accessibility to medical doctors, by zoom-in region

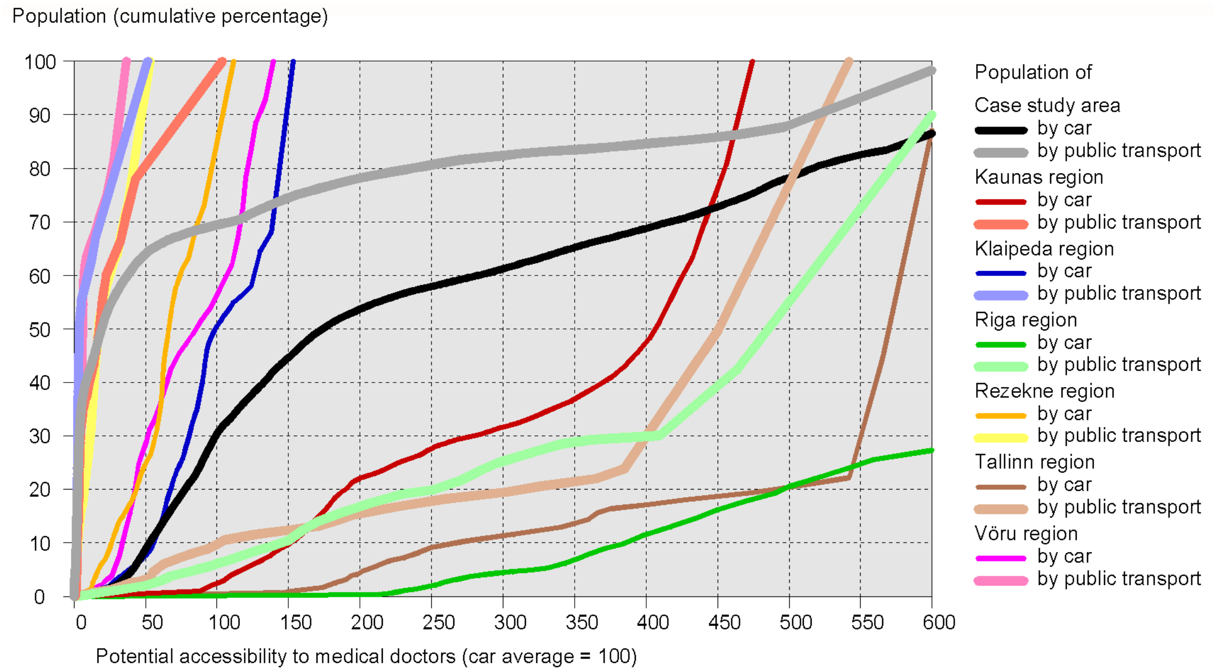

Figure 42. Potential accessibility to medical doctors, cumulative distributions by zoom-in region

Cross-indicator summary

Aggregating the above statistics even more to one average value per zoom-in region allows identifying groups of regions with similar indicator performances within each group, and significant difference between them. The statistics suggest four different groups of regions. Even though this grouping is based upon a selection of only six zoom-in regions, results and interpretations may be transferred to other areas in the Baltic States.

The summary tables (Tables 1 and 2) eventually highlight the four groups of zoom-in regions: Group 1, the two rural, peripheral and sparsely populated regions Vöru und Rezekne generally perform worse compared to the case study averages in all indicators for both modes (exception: Rezekne performs fairly well for the indicator travel time to next regional centre by public transport). Group 2, the seaside zoom-in region of Klaipeda, shows a mixed performance, where the travel time indicators and the potential accessibility to medical doctors perform better than the average, while all other indicators and all public transport indicators are well beyond the average. Group 3, Tallinn and Kaunas regions, perform better than the average for almost all indicators, except for job accessibility by car and potential accessibility to population by car (Tallinn), and access to secondary schools (Kaunas). In case of Tallinn, the reason for this is mainly the comparatively low population density within the region and within the country, which is hindering from an even better performance. Riga, representing the final Group 4, is better off than the case study average for all indicators.

The range of indicator values is quite high for all indicators for both modes, however, expectedly even higher for public transport than for roads. Even though the Riga zoom-in regions performs best altogether, other regions do have specific strengths: For instance, in Tallinn the average travel times to next regional centre and to next hospital are shortest for both modes (12 and 5 minutes for car, 19 and 11 minutes for public transport). Jobs accessibility and the availability for secondary schools are dominated by the Riga region, so as the potential accessibility to medical doctors (index values of 685 for cars and of 714 for public transport). Population potential by car is topped by Kaunas (index 155), while it is headed by Riga region for public transport (index 204).

From the six selected zoom-in regions, the Riga region dominates the accessibility levels for all indicators in the Baltic States, confirming the expectation that Riga is the main demographic and economic centre of the Baltic States and confirming the visual impressions provided by the raster and municipality maps analysed earlier in this report. On the other hand of the spectrum, Vöru and Rezekne experience big problems in access to markets and access to services. These two rural hinterland regions, located at the Eastern border not only of the countries but also of the European Union as a whole, illustrate typical problems of such landlocked regions in the EU. The accessibility problems of these regions are even intensified by the fact that the political, demographic and economic developments clearly focus on the capital regions of Tallinn and Riga, which at the same time are the main transport gateways to Europe for both countries.

In Lithuania the situation is more complex since the two main centres, Vilnius and Kaunas, are located in the Eastern part of the country, while the main freight hub and gateway to Europe, Klaipeda, is located at the Western shore, leading to a more balanced and less polarized accessibility situation in this country.

Table 1. Accessibility by car, deviations of zoom-in regions from case study averages

	Travel time to next regional centre		**Jobs accessible within 60 minutes**		**Potential accessibility to population**	**Travel time to next hospital**		**Higher secondary schools within 60 minutes**		**Potential accessibility to medical doctors**
Area	Minutes	Index	In 1,000	Index	Index	Minutes	Index	Number	Index	Index
Tallinn (EE)	12	60	286,238	84	85.2	5	42	51	42	531
Vöru (EE)	27	135	95,103	28	31.0	13	108	8	26	83
Kaunas (LT)	16	80	499,370	147	154.6	8	67	19	61	350
Klaipeda (LT)	19	95	216,880	64	57.6	11	92	8	26	109
Rezekne (LV)	22	110	61,949	18	29.0	18	150	6	19	72
Riga (LV)	13	65	778,153	230	154.2	6	50	100	323	685
Case study region	***20***	***100***	***338,798***	***100***	***100***	***12***	***100***	***31***	***100***	***100***

Table 2. Accessibility by public transport, deviations of zoom-in regions from case study averages

	Travel time to next regional centre		**Jobs accessible within 60 minutes**		**Potential accessibility to population**	**Travel time to next hospital**		**Higher secondary schools within 60 minutes**		**Potential accessibility to medical doctors**
Area	Minutes	Index	In 1,000	Index	Index	Minutes	Index	Number	Index	Index
Tallinn (EE)	19	35	261,885	151	143.1	11	29	47	204	578
Vöru (EE)	90	164	6,942	4	21.6	60	158	3	13	19
Kaunas (LT)	36	65	179,054	103	167.2	25	66	14	61	168
Klaipeda (LT)	78	142	69,151	40	41.0	56	147	3	13	118
Rezekne (LV)	45	82	21,616	12	34.2	42	111	3	13	40
Riga (LV)	25	45	611,367	353	204.3	13	34	68	296	714
Case study region	***55***	***100***	***173,275***	***100***	***100***	***38***	***100***	***23***	***100***	***100***

5 Accessibility effects of future TEN-T developments

Which impacts will the latest TEN-T outline plans as proposed by the European Commission (2011) in fall 2011 have on regional accessibility patterns in the Baltic States?

In order to evaluate these impacts, the respective TEN-T outline plans were coded into the road and public transport networks, and the indicator *regional population accessibility* was calculated again for a scenario where all TEN-T projects within the case study area were implemented. The impacts of these projects are then illustrated by analysing the relative and absolute increases in accessibility at raster level.

Most of the TEN-T projects in the Baltic States concern improvements in the railway systems (Figure 43). The most important project will be the new high-speed train connection from Tallinn via Pärnu, Riga, and Kaunas towards the Polish border, establishing for the first time a continuous rail connection from North to South, even though only few intermediate stops are foreseen. This project is part of the so-called core network Corridor 1 (Baltic-Adriatic Corridor), connecting Helsinki in the North with Ravenna in the South via Tallinn-Riga, Warszawa, Katowice, Ostrava, Brno, Vienna, Graz, Villach, Udine and Bologna. The other railway projects are concerned with upgrading of existing lines. Plans include upgrading of the links Tallinn-Narva-Russia, Tallinn-Tartu-Russia, Liepaja/Ventspils-Jelgava-Daugavpils, Riga-Daugavpils, and Kaunas-Siauliai. For Estonia and Latvia, these projects represent almost all main rail lines. In Lithuania, there are no road projects foreseen in the current outline plans[14], in Latvia there is only one major road project connecting Riga to the East, while for Estonia a number of projects upgrading existing national roads are planned (for instance, Tallinn-Narva, Tallinn-Tartu, Tallinn-Pärnu).

Figures 44 and 45 show the future accessibility patterns after implementation of these TEN-T projects, while Figures 46 to 49 illustrate the absolute and relative increases in accessibility.

Comparing the maps of accessibility levels before and after implementation of the TEN-T outline plans (Figures 14 and 15 vs. Figures 44 and 45) at a first glance only marginal difference can be detected for both modes, suggesting that the accessibility patterns will not be revised through these projects. For road, the impacts are only gradual, while for public transport some effects are visible along specific axes like Tallinn-Pärnu, Tallinn-Tartu-Vöru, Riga-Siauliai-Kaunas and Riga-Daugavpils. In addition, the accessibility levels by public transport appear to increase for the mentioned agglomerations through the outline plans.

Looking in more detail at the relative increases[15], Figures 46 (cars) and 47 (public transport) reveal that in fact the intended projects will have considerable effects on the accessibility levels of many parts of the study area. For cars, the biggest effects can be found along the road corridor between Tallinn and Tartu, followed by the corridors Tallinn-Pärnu and Tallinn-Haapsalu/Hanila. In addition, accessibility along the corridor Tallinn-Narva will increase considerably. In Latvia, there are only positive impacts measured along the Eastward corridor Riga-Laudona, while the rest of Latvia so as entire Lithuania does not benefit from the TEN-T outline plans due to absence of any road projects. Overall, accessibility by car will increase up to 20% for the most benefitting parts of Estonia.

For rail, the implementation of the TEN-T outline plans will lead to a step change in accessibility. Some areas in all three countries will double their accessibility, while others experience increases

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[14] However, it is worth mentioning that major road projects in Lithuania were recently finished and opened to traffic, so that no further improvements are foreseen in the new TEN-T outline plans.

[15] In reality also decreases in accessibility may occur in situations were in parallel to building new or improving existing infrastructures other infrastructures might be closed such as minor rail links or train services might be deteriorated. In such cases even absolute decreases in accessibility might be detected. Since for this case study no information was available on abandoning transport infrastructures, or changing train services, the implementation of the TEN-T outline plans will consequently lead to increases.

of more than 50%. Benefits appear along all major rail axes; they are strongest in areas North of Pärnu and in the Vöru region (both Estonia), as well as along the corridors Riga-Siauliai-Kaunas (Latvia and Lithuania) and Ventspils/Liepaja-Jelgava-Jekabpils-Daugavpils (Latvia). These findings reflect the two main political objections as regards rail transport in the Baltic States:

(i) To establish an uninterrupted North-South link for the first time from Helsinki to Warsaw via the main agglomerations of the Baltic States (Tallinn, Pärnu, Riga, Kaunas);

(ii) To strengthen the hinterland connections of the Baltic seaports through rehabilitation of the existing East-West freight corridors.

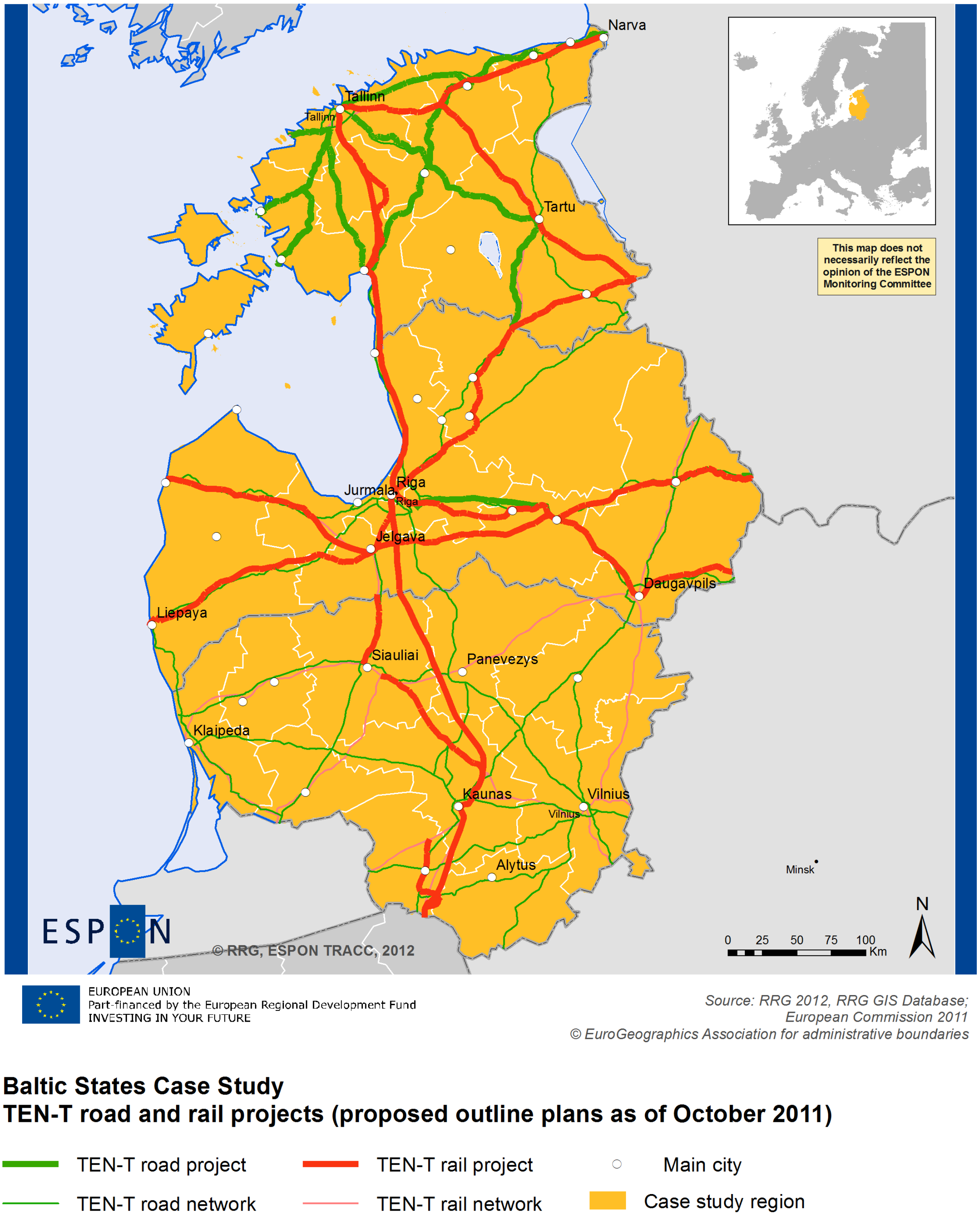
While the maps of relative increases suggest that effects for public transport are larger than those for road, the corresponding maps of absolute change (Figures 48 and 49) illustrate that the situation is more complex.

In case of Estonia, the effects for public transport are clearly restricted to small areas along the railway axes, while intermediate areas between these axes will not benefit. For road, effects of course are highest along the major road corridors, but also the intermediate regions will benefit considerably through spill over effects. As a result, almost all parts of the country gain accessibility improvements.

In case of Latvia, effects for rail are clearly larger than those for road, since almost all rail corridors will be improved or rehabilitated. However, even though the relative difference map for road suggests only small impacts along the Eastward corridor of Riga, absolute increases will not only appear in this corridor but also in corridors Riga-Pärnu and Daugavpils-Laudana-Rauna-Valka-Tartu. Even territories south of Riga towards the Lithuanian border will benefit from the corridor project.

Since the TEN-T outline plans do not include any road project in Lithuania, accessibility improvements focus on improvements in public transport accessibility. These are clearly concentrated in the Kaunas area and along the corridor Riga-Siauliai-Kaunas-Polish border. Interestingly, the capital city of Vilnius will only benefit to a lesser degree from these infrastructure projects, so that in future Kaunas will become the location in Lithuania with the highest accessibility – not only for road but also for public transport.

However, as Figures 44 and 45 have shown, despite all positive impacts on accessibility for rural areas in the case study region and for areas along the major transport axes, the existing agglomerations in all three countries clearly benefit the most from the foreseen infrastructure projects so that in total the accessibility patterns with the Baltic States are consolidated and spatial disparities in accessibility are solidified. For Estonia and Latvia, the capital regions of Tallinn and Riga continue to be the main economic and demographic hubs, by far with the highest market potential and highest accessibility. In case of Lithuania it will be interesting to see if and how Kaunas makes use of its improved accessibility (for instance, acting as logistics hub at the crossroads of all North-South and West-East axes) in relation to Vilnius as being the demographic and political centre of the country.



Source: RRG 2012, RRG GIS Database;
European Commission 2011
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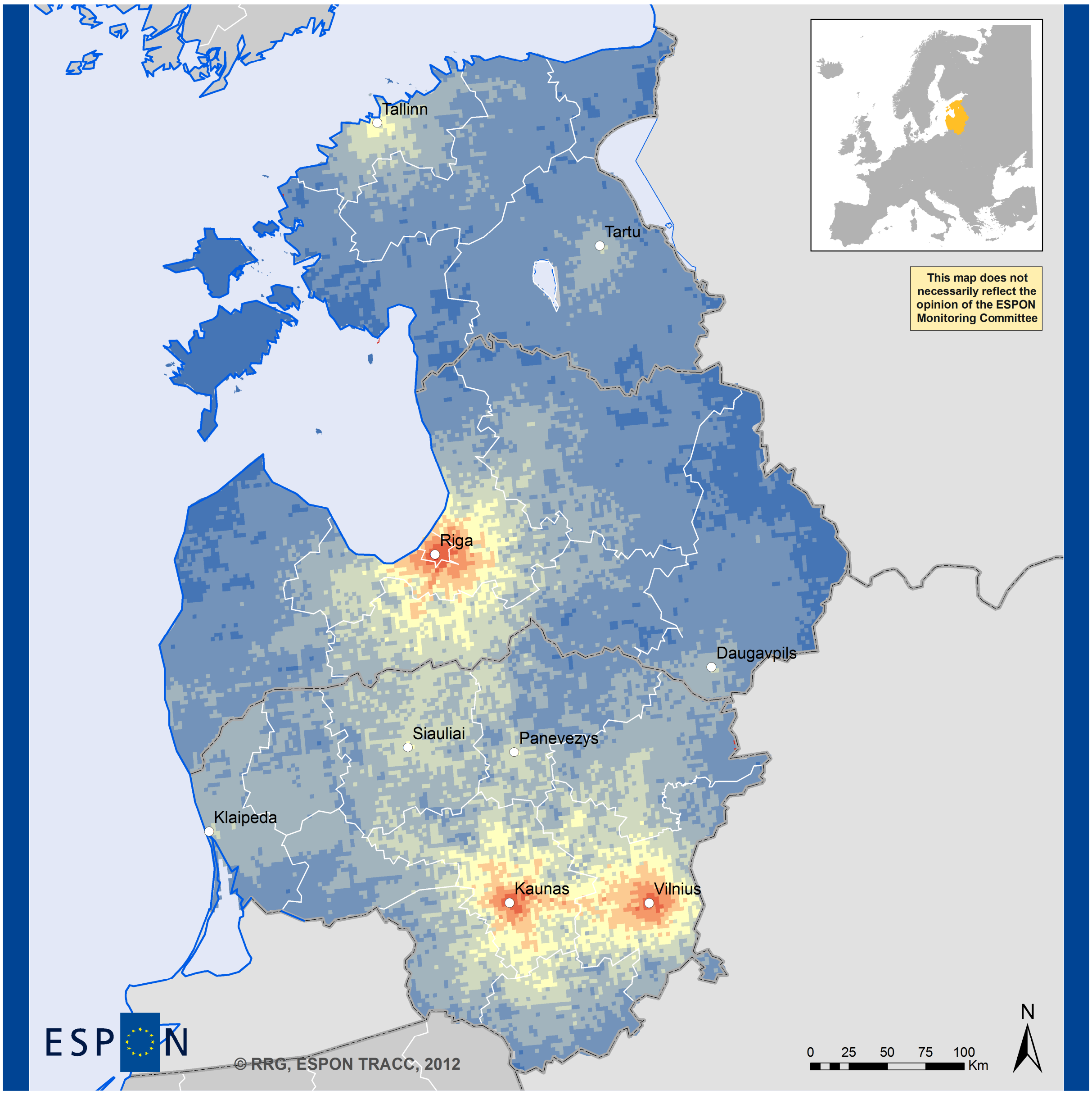
Figure 43. TEN-T road and rail infrastructure projects



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*Source: RRG GIS Database, 2012; OSM, 2012;
European Commission, 2011
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**Baltic States Case Study (2011)
Regional potential accessibility by road with TEN-T projects (2.5x2.5 km raster)**

🟦 0 - 25
🟦 26 - 50
▨ 51 - 75
🟩 76 - 100
🟨 101 - 125
🟧 126 - 150
🟧 151 - 175
🟥 176 - 200
🟥 201 < ...

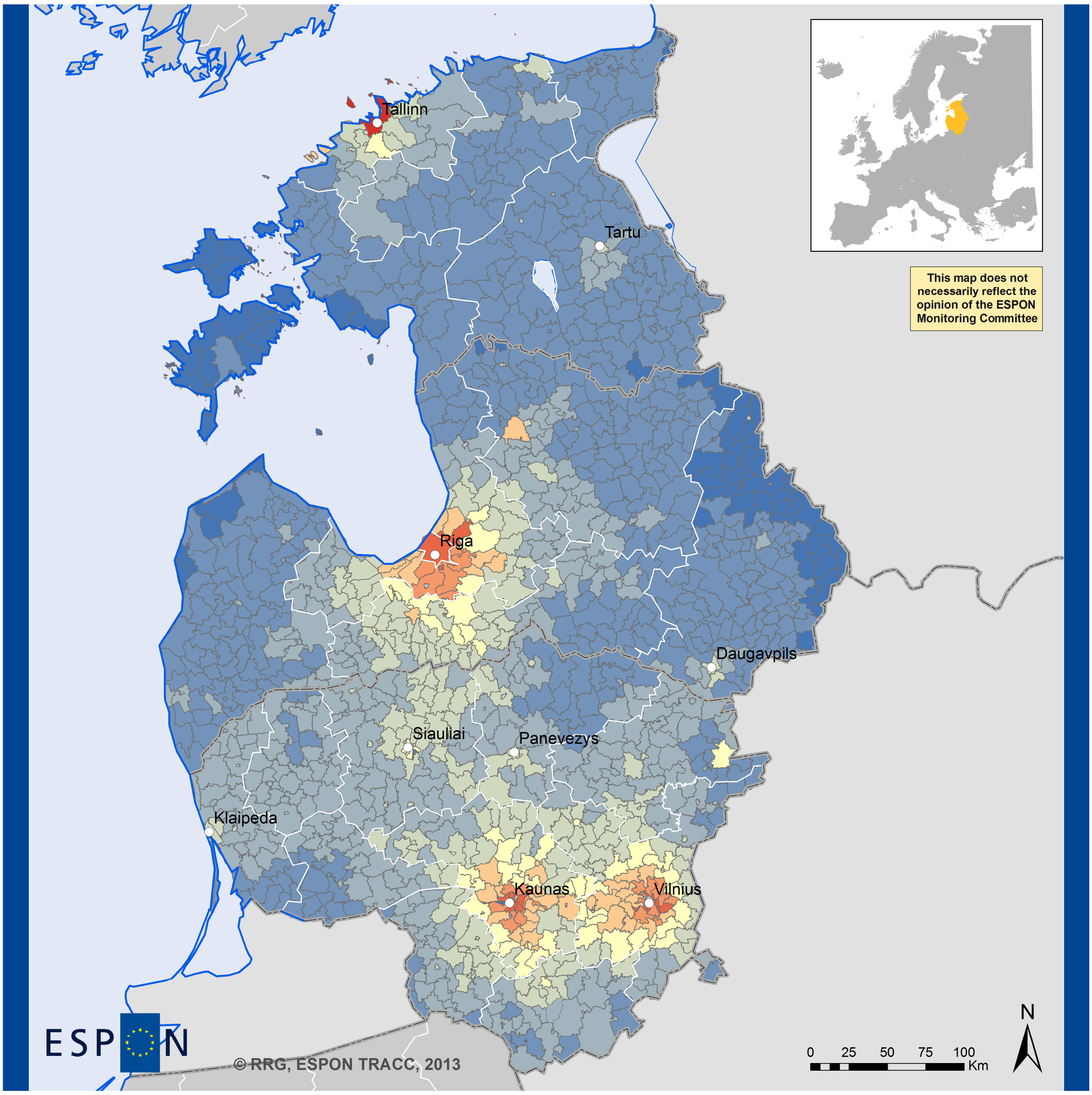
○ Main city

*Notes:
Beta = 0.034657*

*Minimum: 38,412
Average: 363,811
Maximum: 835,810*

100 = 363,811 = car average 2011

Figure 44a. Potential accessibility to population by car with TEN-T projects (raster level)



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Baltic States Case Study (2011)
Regional potential accessibility by road with TEN-T projects (LAU-2)

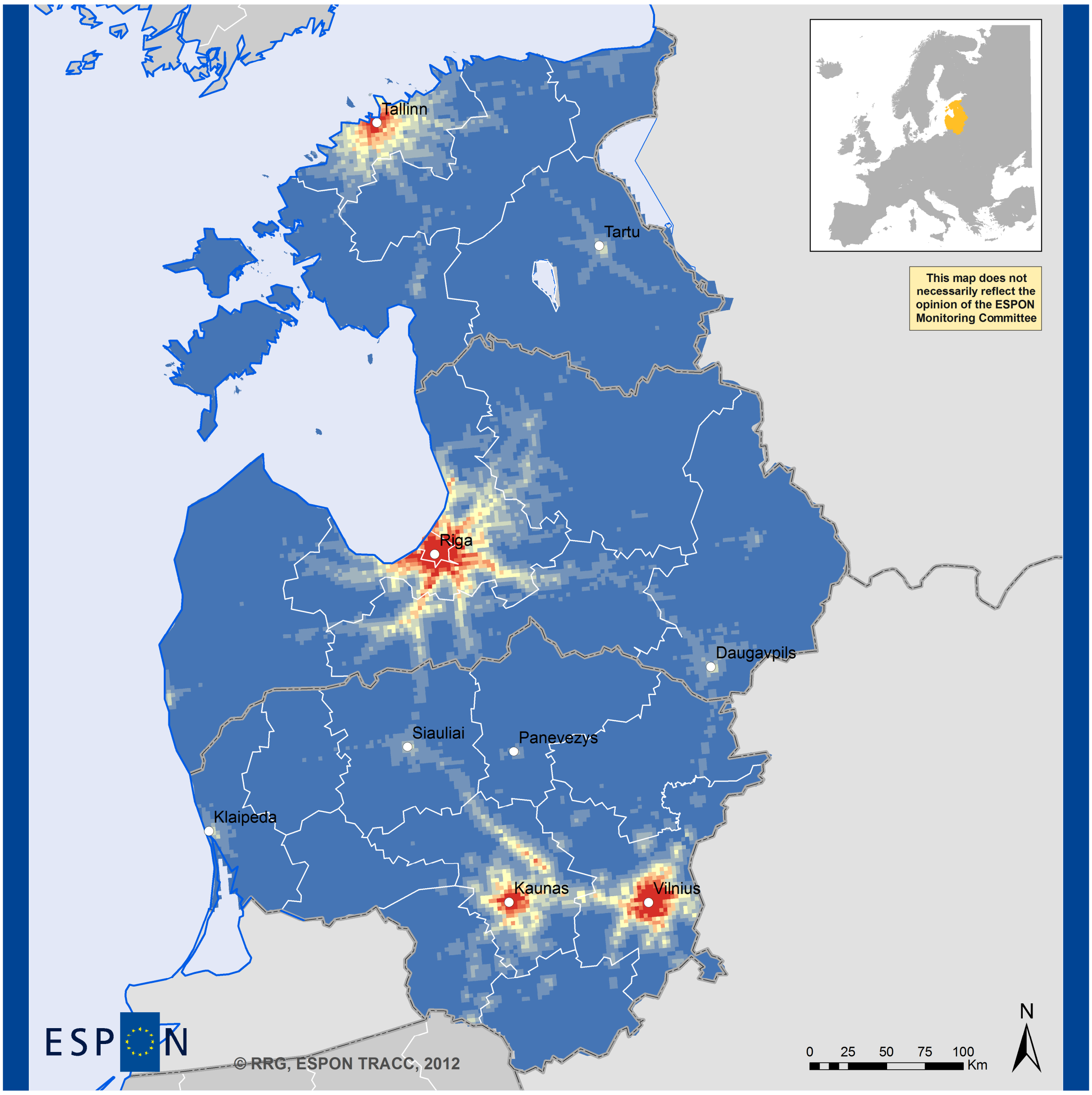
- ■ 0 - 25
- ■ 26 - 50
- ■ 51 - 75
- ■ 76 - 100
- ■ 101 - 125
- ■ 126 - 150
- ■ 151 - 175
- ■ 176 - 200
- ■ 201 < ...

○ Main city

Notes:
Beta = 0.034657

Minimum: 38,412
Average: 363,811
Maximum: 835,811

Figure 44b. Potential accessibility to population by car with TEN-T projects (LAU-2 averages)



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Source: RRG GIS Database, 2012; OSM, 2012;
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Baltic States Case Study (2011)
Reg. potential accessibility by public transport with TEN-T projects (2.5x2.5 km raster)

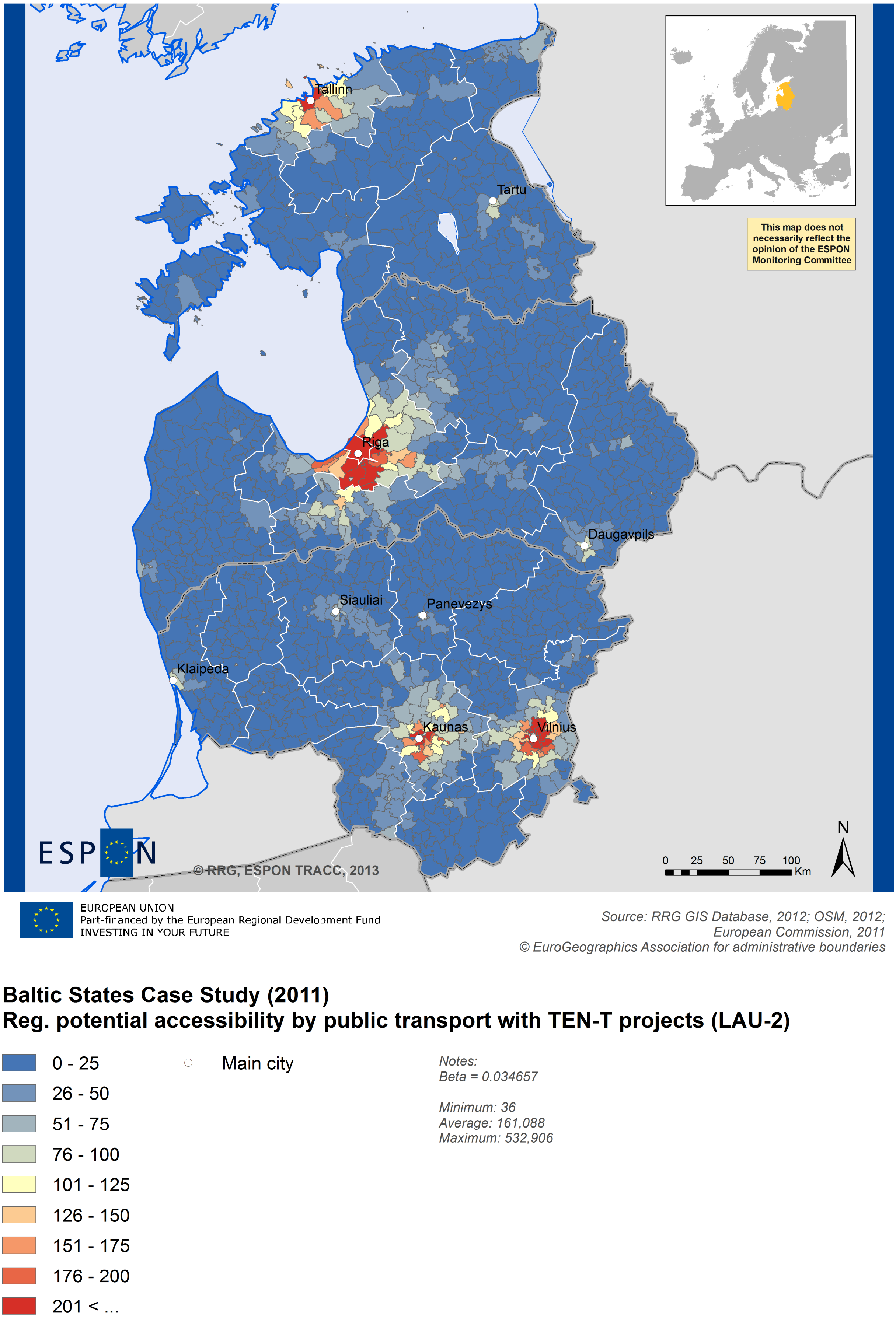
🟦 0 - 25
🟦 26 - 50
🟦 51 - 75
🟩 76 - 100
🟨 101 - 125
🟧 126 - 150
🟧 151 - 175
🟥 176 - 200
🟥 201 < ...

○ Main city

Notes:
Beta = 0.034657

Minimum: 35,743
Average: 161,088
Maximum: 571,601

Figure 45a. Potential accessibility to population by public transport with TEN-T projects (raster level)



Source: RRG GIS Database, 2012; OSM, 2012; European Commission, 2011
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Baltic States Case Study (2011)
Reg. potential accessibility by public transport with TEN-T projects (LAU-2)

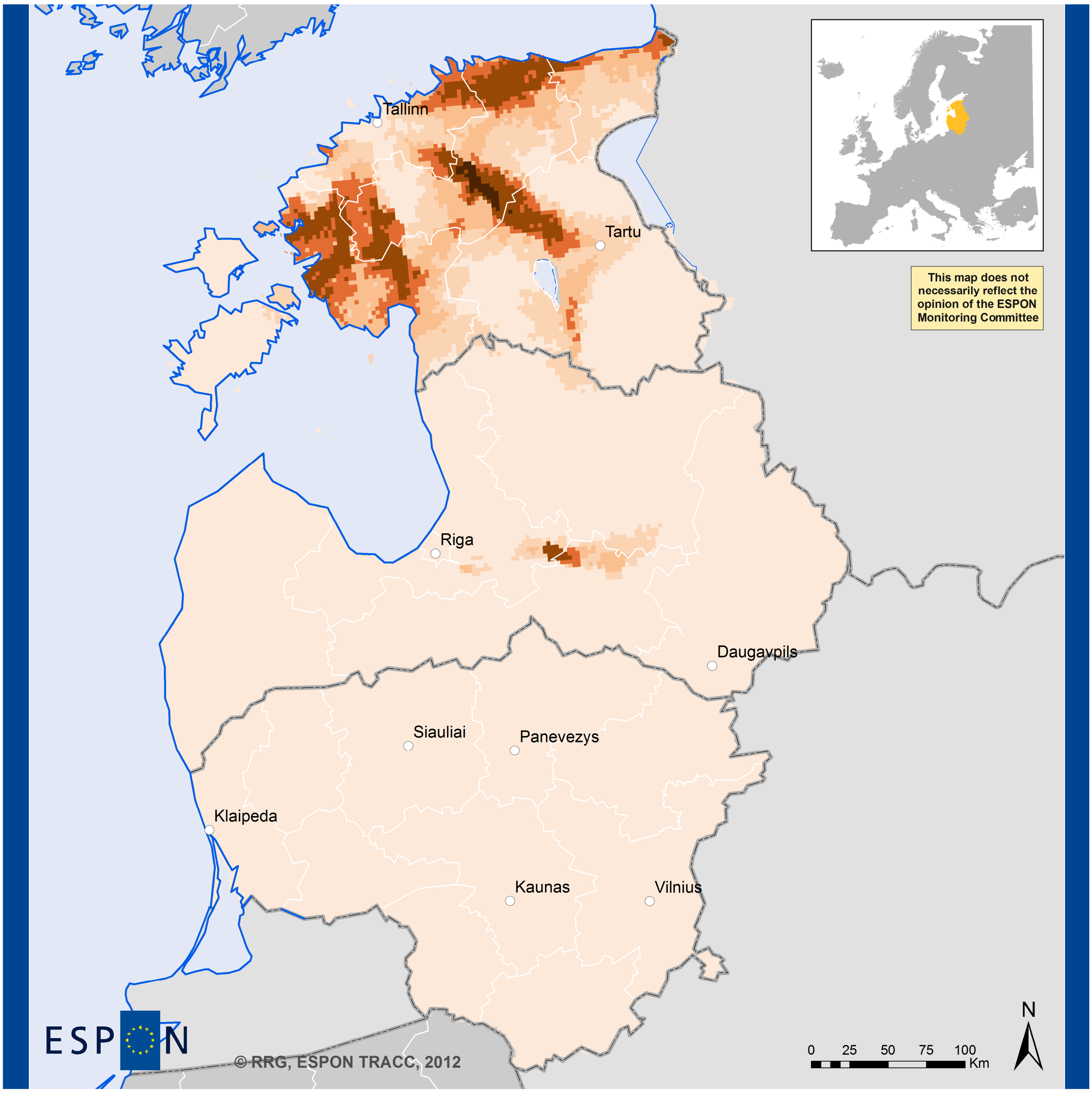
🟦	0 - 25
🟦	26 - 50
▨	51 - 75
▨	76 - 100
🟨	101 - 125
🟧	126 - 150
🟧	151 - 175
🟥	176 - 200
🟥	201 < ...

○ Main city

Notes:
Beta = 0.034657

Minimum: 36
Average: 161,088
Maximum: 532,906

Figure 45b. Potential accessibility to population by public transport with TEN-T projects (LAU-2 averages)



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Source: RRG GIS Database, 2012; OSM, 2012; European Commission, 2011
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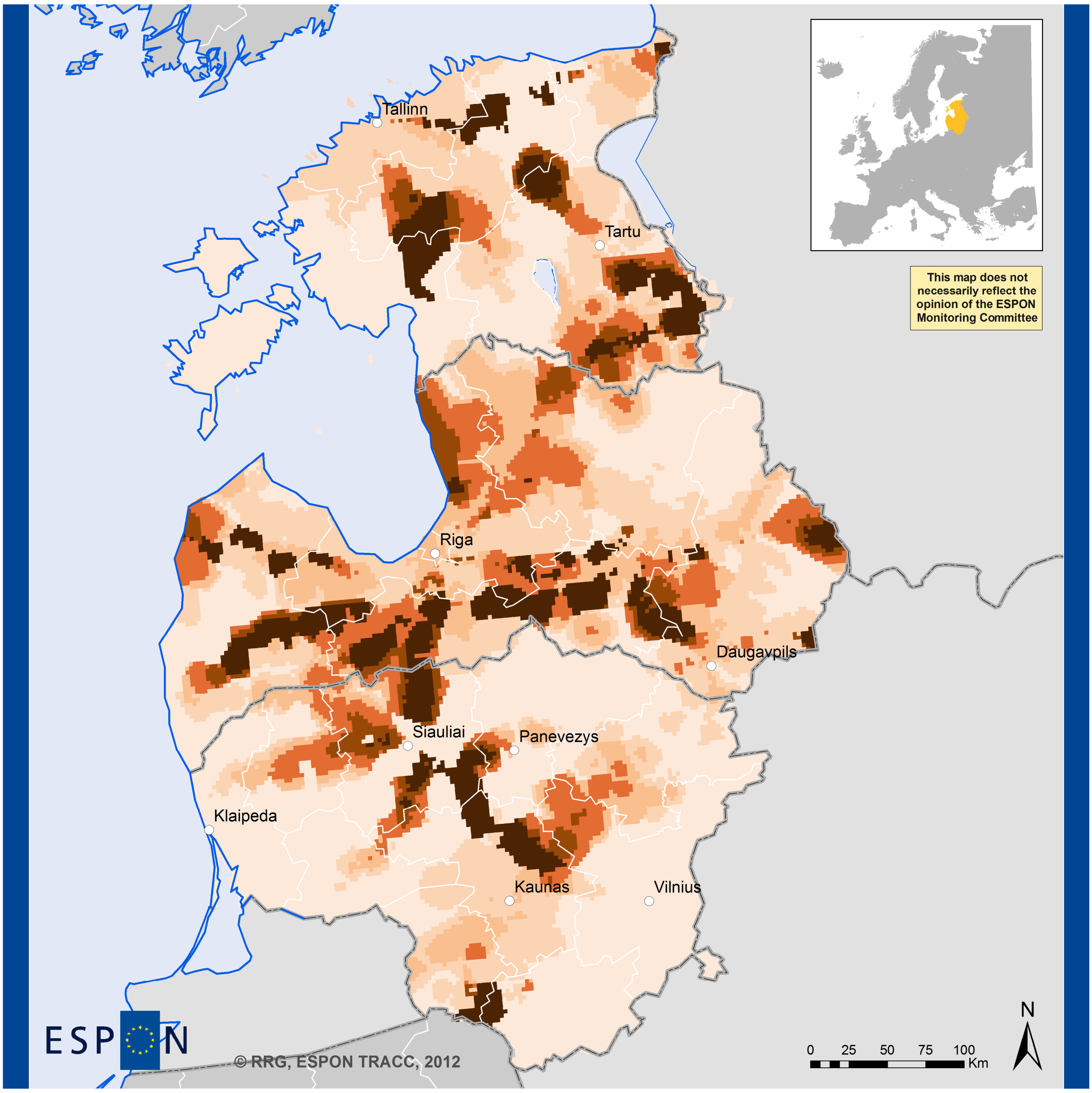
Baltic States Case Study (2011)
Relative increase of potential accessibility by car with TEN-T projects (raster)

- ▨ 0,0 - 2,5
- ▨ 2,6 - 5,0
- ▨ 5,1 - 7,5
- ▨ 7,6 - 10,0
- ▨ 10,1 - 15,0
- ▨ 15,1 - 20,0

○ Main city

Notes:
Beta = 0.034657

Figure 46. Relative increase of potential accessibility to population by car with TEN-T projects



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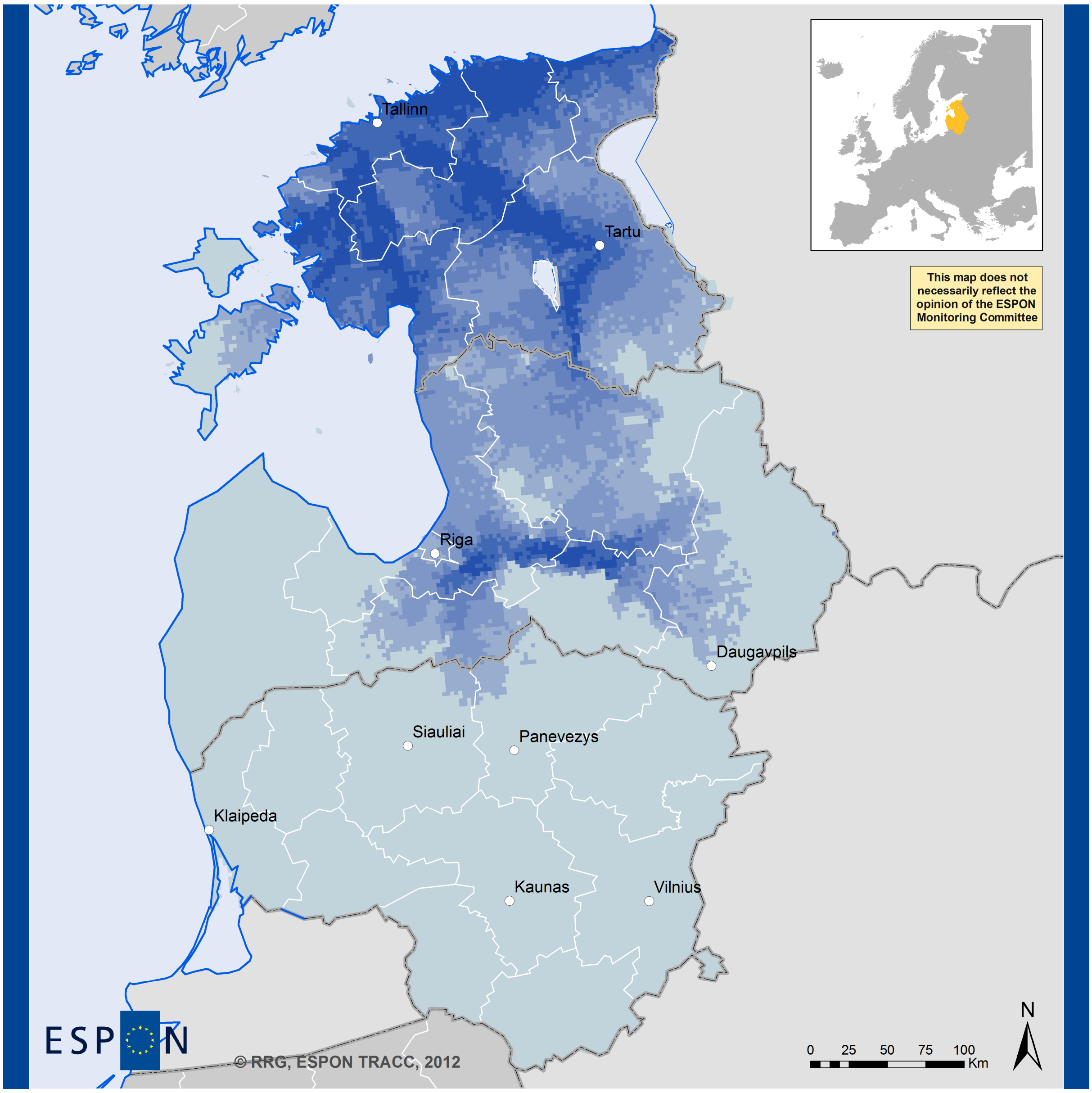
Baltic States Case Study (2011)
Relative increase of pot. accessibility by public transport with TEN-T projects (raster)

- ▨ 0 - 5
- ▨ 6 - 10
- ▨ 11 - 20
- ▨ 21 - 50
- ▨ 51 - 75
- ▨ 76 < ...

○ Main city

Notes:
Beta = 0.034657

Figure 47. Relative increase of potential accessibility to population by public transport with TEN-T projects



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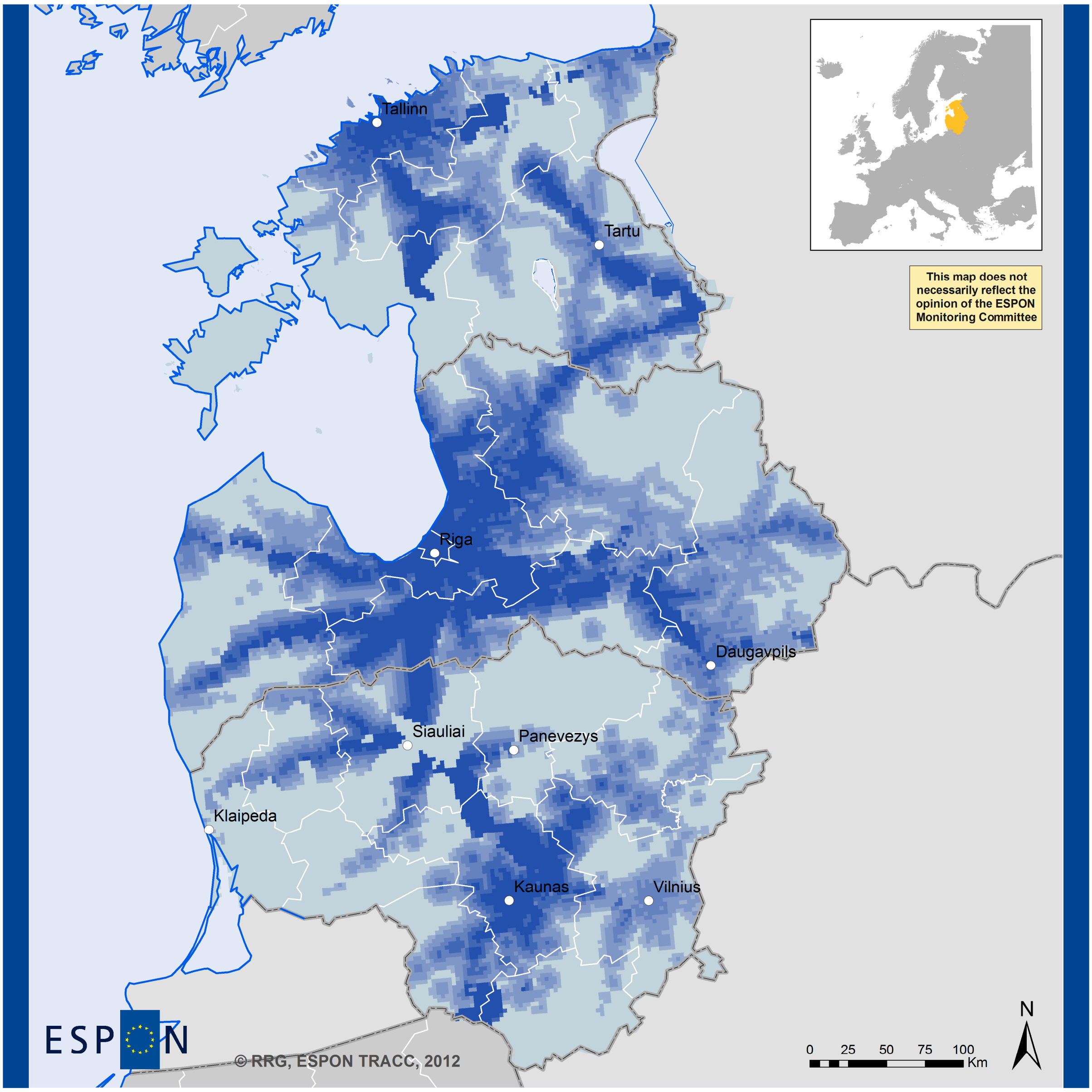
Baltic States Case Study (2011)
Absolute increase of potential accessibility by car with TEN-T projects (raster)

▨ 0 - 500
▨ 501 - 1,000
▨ 1,001 - 2,500
▨ 2,501 - 5,000
▨ 5,001 - 10,000
▨ 10,001 - 300,000

○ Main city

Notes:
Beta = 0.034657

Figure 48. Absolute increase of potential accessibility to population by car with TEN-T projects



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Baltic States Case Study (2011)
Absolute increase of pot. accessibility by public transport with TEN-T projects (raster)

- 🟦 0 - 500
- 🟦 501 - 1,000
- 🟦 1,001 - 2,500
- 🟦 2,501 - 5,000
- 🟦 5,001 - 10,000
- 🟦 10,001 - 200,000

○ Main city

Notes:
Beta = 0.034657

Figure 49. Absolute increase of potential accessibility to population by public transport with TEN-T projects

6 Conclusions

The accessibility analysis for the Baltic States case study proofed to successfully depict the various accessibility patterns for the selected set of indicators. The results illustrate the different accessibility levels for different indicators, for different modes, for different types of regions, for different spatial levels, as well as for different years.

After a general summary of the main findings of the accessibility calculations, conclusions will be given following the technical aspects above, which will be summed up by a short list of recommendations.

General summary

The accessibility indicators reveal quite different spatial patterns and spatial phenomena:

While the ***travel time to the nearest regional centre*** by car is quite short for all parts of the case study area, service quality by public transport is generally poor for most areas, except for the main agglomerations. In fact, many parts of the Baltic States do not have any public transport accessibility to regional cities. The indicator ***daily accessibility by jobs*** marks the dominance of few labour market centres with extremely high job numbers opposed to extensive rural areas where only a fraction of jobs are within reach – for both modes. The absence of jobs in the rural and peripheral areas may, by way of consequence, reinforce migration processes from the peripheral regions towards the main centres. ***Potential accessibility to population*** is dominated by the areas Kaunas-Vilnius and Riga. Estonia, due to its generally lower population density, falls behind the performance of the southern parts of the Baltic States[16]. In addition, accessibility by public transport is much poorer than accessibility by car, for all parts of the case study area. Riga, Kaunas and Vilnius are the largest market areas in the Baltic States, in terms of population potential. The divide in market potentials to the rural regions is that high that one expects all future economic and demographic developments concentrate in these agglomerations. Due to the even spatial distribution of hospitals across the Baltic States, there is good car ***access to health care facilities*** through all parts of the case study area. Only some small areas along the border suffer insufficient access times. In case of public transport the cities and town are well served, covering the largest share of population, while the hinterland often experience some difficulties in getting to a hospital by bus or train. Altogether, this indicator confirms a fair and balanced accessibility surface without any polarization between urban and rural parts. Results for the indicator ***availability of higher secondary schools*** come to some surprise. Even though a minimum access to at least one secondary school is maintained for the majority of population, from large parts of the study area no school at all can be reached within 30 minutes, even by car. Freedom of choice for families between several schools is basically only offered in agglomerations. Results for public transport are even poorer as for cars; however, they have to be interpreted with caution since specialized school busses are not considered due to a lack of data. Finally, while the ***potential accessibility to basic health care*** can generally be considered as good in most parts of the Baltic States, despite the fact that there are significant differences between areas with highest and lowest accessibility, the poor accessibility by public transport needs to be paid attention since many elderly people rely on busses or trains to go to their doctor.

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[16] Destinations abroad which are close to Estonia such as Helsinki and St. Petersburg may partly compensate for missing domestic demand; however, they were not considered in the accessibility calculations for this study.

Accessibility indicators

Accessibility of a region cannot be assessed by just one indicator. In this case study a set of six different accessibility indicators were identified which should help analysing different aspects of access to markets and access to public services. In fact, the results for the different indicators have shown that this broad set is quite useful as the individual indicators are in fact able to depict different facets and different spatial structures. Only results of the last indicator, i.e. accessibility potential to basic health care, seem questionable since this indicator too much reflects the national health care systems rather than locational advantages or disadvantages. Moreover, the definition of this indicator as a potential indicator may be questionable, since one may discuss whether the number of doctors is really a good ‘weight’.

Modes

The results illustrate that a distinction between different modes is clearly needed. Accessibility patterns for cars and public transport differ to a large degree, both with respect to the level and in relation to the spatial patterns, so that modelling results for one mode cannot be used as proxy for the other mode. While accessibility indicators for cars tend to form different types of plateaus, the same indicators for public transport form ‘stretches’ and ‘bands’ of high accessibilities along certain transport axis, interrupted by areas of low accessibilities where public transport is missing. Apart from this, in general as demonstrated by the indicator calculations, the accessibility levels by car are higher than those for public transport, but still in city centres and for along some axes public transport is able to reach as high levels as cars do. Regarding public transport as such, one may furthermore think of even splitting ‘public transport’ mode into individual indicators for rail and bus/tram.

Spatial levels

Traditional approaches to accessibility use NUTS-3 or NUTS-2 regions as spatial units to model at. The present study has proven that even at the level of zoom-in regions significant intra-regional disparities exist, which cannot be detected by the traditional, aggregated models. Such intra-regional disparities are often greater than those between regions, thus accessibility studies should acknowledge these disparities and should find ways how to capture them. For the Baltic States, the raster approach turned out to be very useful, and should be developed further. Raster approaches allow capturing the fine grained accessibility surfaces generated by public transport and also reflect the axial structures caused by high-level transport infrastructures. Another advantage of the raster approach is that results can be afterwards easily aggregated to any spatial level, such as LAU-2 (as done in this study), or higher. In addition, comparisons and crossover correlations with other variables such as population distributions are easy to implement. For this study, a raster resolution of 2.5x2.5 km was applied. One could think about using even finer resolutions of, say, 1x1 km, to obtain higher spatial detail.

Types of regions

Even though the study revealed very interesting, detailed results at raster and LAU-2 level, some general (aggregated) spatial patterns could also be identified by looking at different types of regions[17]. In all countries, accessibilities for capital regions or for main agglomerations differed sig-

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[17] This study differentiates urban regions, intermediate regions close to a city, intermediate remote regions, rural regions close to a city, and rural remote regions in addition to a set of six zoom-in regions, all of which show different characteristics.

nificantly from those for rural, peripheral and landlocked regions, as well as for intermediate areas. Therefore, the aggregation of raster results to different types of regions or to what was called 'zoom-in' regions may provide additional insights into accessibility patterns of a study area. Even though in this study only six zoom-in areas and only five different types of regions were used, interesting findings were obtained. A combination of raster approach with a typology approach deems promising to obtain high-resolution results on the one hand and easy-to-communicate summary results on the other hand.

Temporal dimension

Calculating accessibility indicators for different points in time or for different scenarios allows assessing the impacts of new transport infrastructures or new transport policies. In this case study the actual TEN-T outline plans were used to calculate potential accessibility indicators for a future situation after these plans were implemented. The results confirm that by applying the defined indicator framework and indicator definitions impacts of new transport projects can be modelled and analysed – at raster level so as at LAU-2 level. Even though one infrastructure project is unlikely to completely revise existing accessibility surfaces, significant changes to accessibility may be impacted by one project, as it was shown when looking at the absolute and relative changes. That way the accessibility indicators may also be used to analyse trends of territorial cohesion. In this study the scenario was only assessed by using one indicator (population potential accessibility), in future studies similar exercises should be implemented with a broader set of indicators.

General recommendations

Based on the above conclusions a number of general recommendations can be derived for future accessibility calculations:

- The traditional zone-based approaches should be further developed towards raster-based approaches in order to allow analysing intra-regional accessibility disparities.
- Results at raster level can then be easily aggregated to any higher spatial zone level (such as NUTS entities or different types of regions) to perform additional statistical analyses, map results, or to as a mean for easy communication in political processes. In this sense, a combined raster/zonal approach should be implemented.
- Beyond the traditional accessibility indicators of the potential type, new indicators should also be taken into account better reflecting access to services of general interest. In times of demographic change and globalization, maintaining adequate levels of services of general interest becomes a political challenge. In addition to the indicators applied in this study, access to post offices, banks, or to different types of administrations could also be of interest.
- All accessibility calculations should consider different modes of transport. A restriction only on road is not useful, as accessibility patterns for other modes differ considerably from those for cars.

On top of these recommendations, for the ESPON programme as a whole some additional suggestions can be drawn:

- Some of the indicators presented in this case study book have been modelled in ESPON for the first time in such spatial detail, such as access to hospitals, access to basic health care, or availability of secondary schools. By way of definition, these indicators were only calculated for the case study areas. It would be interesting to see these indicators being calculated for the entire ESPON space.

- In order to enable future European-wide raster based accessibility modelling, ESPON should develop a standard raster system for the entire ESPON space, with a sufficient detailed spatial resolution. Ideally, information on population should also be assigned to this raster system.
- The case study results should feed into political processes. For instance, it would be interesting to apply political thresholds (for instance, maximum travel time by car to next hospital of x minutes) upon the results in order to calculate the share of population living beyond these thresholds (and mapping them!). That way practical recommendations can be developed how to improve the accessibility situation of people.
- It has been demonstrated that it is necessary and possible to keep track of accessibility developments over time. Thus, ESPON should establish means to re-calculate the full set of indicators in regular intervals. Results for different years should then be compared not only with their levels, but in particular relative and absolute difference maps should be generated.

Annexes

Annex 1 References

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Annex 2 Database

In order to calculate the different accessibility indicators for this case study, various input data have been utilized, which can be grouped into network data, origin and destination data and other statistical datasets.

Following gives an overview about the datasets by data group.

Network data

The road network was taken from OpenStreetMap (OSM, 2012). The downloaded OpenStreetMap data were processed to some extent, by extracting relevant network links, assigning speeds, calculating link travel times, and establishing arc-node topologies. This layer also includes all available car ferries (including shipping times) connecting Estonian islands to the main land.

The public transport networks were taken from the RRG GIS Database (RRG, 2012). Rail and tram links, railway stations and tram stops were already included in this database. Bus routes and bus stops were additionally coded into this database based upon input data provided by OpenStreetMap (OSM 2012) and by local web resources such as public transport network plans of the bigger cities and towns. Bus lines include trolleybus services available in the cities of Vilnius, Kaunas, Riga and Tallinn. In rural areas, only regional bus routes operating on main arteries are included, while some local services in remote areas may miss. Information on dedicated school busses were, unfortunately, not available. Railways, tramways and bus routes where then merged into one single public transport layer for the Baltic States. Furthermore, for railways, the RRG GIS Database also includes excerpts from actual train timetables, as well as averaged rail speeds of passenger trains along railway sections. For trams and busses, no timetable information was available so that reasonable assumptions about average operating speeds were used instead.

Data on the frequency of rail, tram or bus services have not been compiled, and were not used in the accessibility model (see Annex 3). Thus, the results of the accessibility calculations represents the best solution based upon fastest connection between A and B. Of course, this ideal situation may be different to some extent depending on the time of the day, and the day of the week (work days vs. weekends).

Origin and destination datasets

All indicators were calculated for a regular raster system with a resolution of 2.5x2.5 km for the entire study area. This raster system was newly established by means of GIS techniques. Population figures by grid cells were transferred from the EEA population grid (EEA, 2012). Municipality codes and zoom-in region codes were assigned to each grid cell by GIS functionalities allowing for aggregation of calculation results.

The six types of accessibility indicators apply different destination activities, i.e. different input datasets had to be collected from various sources.

- *Regional centres:* Geographical position of regional cities were taken from the RRG GIS Database (RRG, 2012). This database already includes the location of all cities and towns in the Baltic States. All cities with more than 50,000 inhabitants as well as all cities representing the centroid of a NUTS-3 region were selected.
- *Employment*: Unfortunately there was no dataset available on number of jobs by LAU-2 for the Baltic States. Instead, data on number of employees per LAU-2 were obtained from ESPON GEOSPECS project. Each municipality with at least one employee was taken as destination, represented by its municipality centre.
- *Regional population*: All populated grid cells were taken as destinations for this indicator. Population figures were transferred from the EEA population grid to the newly created Baltic States grid.
- *Hospitals*: All general hospitals for the Baltic States were coded, based upon information provided by OpenStreetMap (OSM, 2012b) in combination with the following websites:
  - Estonia:
    - Eesti Haigekassa. Estonian Health Insurance Fund (2012): The list of hospitals in Estonia. www.haigekassa.ee/eng/service/specialised-medical-care/hospitals.html
    - Wikipedia (2012d): List of Hospitals in Estonia. http://en.wikipedia.org/wiki/List_of_hospitals_in_Estonia
  - Latvia:
    - Catalog of World Hospitals (2011): Ranking web of World Hospitals - Hospitals of Latvia. http://hospitals.webometrics.info/hospital_by_country.asp?country=lv
    - Hospitals in Latvia by Region (2009)
    - Wikipedia (2012e): List of Hospitals in Latvia. http://en.wikipedia.org/wiki/List_of_hospitals_in_Latvia
  - Lithuania:
    - Hospitals Worldwide (2012): Lithuanian Hospitals Directory - Lithuanian Hospitals and Health Clinics. www.hospitalsworldwide.com/countries/lithuania.php
    - Lietuvos Medicina (2012): List of Hospitals and Clinics. www.medicina.lt
    - Wikipedia (2012f): List of Hospitals in Lithuania. http://en.wikipedia.org/wiki/List_of_hospitals_in_Lithuania

  Specialized clinics were excluded from processing. In case of doubt, the clinics were considered as valid destinations. Hospital locations available in OSM were taken as starting point. Since OSM did not cover all hospitals, additional hospitals were geocoded using the hospital addresses provided in the above sources. It was checked that all general hospitals provided in the above list are coded in the database.
- *Secondary schools*: Similar to hospitals, base information on school facilities was taken from OpenStreetMap (OSM, 2012c). The schools already available there were cross-checked against the following online resources:
  - Estonia:

    - Eesti Hariduse Infosüsteem (2012): Estonian Education Information System. http://www.hm.ee/koolikaart/
    - Wikipedia (2012g): List of schools in Estonia. http://en.wikipedia.org/wiki/List_of_schools_in_Estonia
  - Latvia:
    - Lanet (2012): Schools and school related WWW pages in Latvia. www.lanet.lv
    - Latvian school register 2012, provided through Latvian ESPON Contact Point
    - Neogeo.lv (2012): Latvijas skolu karte. http://neogeo.lv/?p=4278
  - Lithuania:
    - Wikipedia (2012h): List of schools in Lithuania. http://en.wikipedia.org/wiki/List_of_schools_in_Lithuania

  For Estonia, the school locations provided through the education system were directly taken. For the other two countries, the geographical locations as provided through OSM were taken, complemented by address information provided through the GIS resources. Only secondary schools offering degrees allowing pupils to go to university are considered as interesting destinations in this study. However, sometimes information on the type of school was not available or was unclear. In case of doubt the school was included as potential destination.

- *General surgeries*: Unfortunately, a comprehensive (geo)database or list of general surgeries for the three countries concerned was not available. Instead, assumptions were made about the ratio doctors per inhabitants. General figures for 2009 on this ratio provided by Eurostat (Eurostat Regio Database, table hlth_rs_spec) for the three countries were applied to the LAU-2 population numbers in order to derive the number of doctors per inhabitants at LAU-2 level. For Estonia, a ratio of 82.2 doctors per 100,000 inhabitants, for Latvia a ratio of 58.5 doctors and for Lithuania a ratio of 69.1 doctors was applied. The derived LAU-2 numbers were rounded to integers. Furthermore, it was assumed that small towns and villages with less than 1,000 inhabitants do not have any doctor.

Other statistical data

No other datasets have been used for the accessibility calculations in this study.

Annex 3 Accessibility model used

The *RRG Accessibility Model* was applied for the calculation of all accessibility indicators for this case study. This accessibility model actually is a collection of python scripts on top of ArcGIS 10.x software.

First the network layers as described in Annex 2 were converted into so-called *network datasets*. Next, depending on the actual indicator to calculate, the relevant origins and destinations were loaded to the network datasets from the respective layers. Origins and destinations were assigned to the next network node, and appropriate assumptions about the access times were implemented.

For the indicator calculation, the *ArcGIS Network Analyst extension* was utilized. This extension provides different solvers helping analyzing different research questions in transport analysis. In this study, two of six solvers were used, which are the *New Closest Facility* solver and the *New OD Cost Matrix* solver. The RRG Accessibility Model then represents a set of scripts implementing a seamless workflow from data processing to solving of the network analyst, where the different tools provided with the network analyst are embedded into one overall workflow.

Since raster-based accessibility calculations require quite high computation demand with respect to RAM and hard disc consumption, as well as computation times, the *RRG Accessibility Model* was utilized in a way to split the calculation of an individual indicator into different parts, while looping through these parts.

Finally the raster results were aggregated to LAU-2 level and to the level of the zoom-in regions as population-weighted averages by means of standard ArcGIS functions.

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