

TRACC

Transport Accessibility at Regional/Local Scale and Patterns in Europe

Applied Research 2013/1/10

Final Report | Version 30/06/2013

Volume 3

TRACC Regional Case Study Book

Part B

Northern Italy case study



This report presents a more detailed overview of the analytical approach to be applied by the project. This Applied Research Project is conducted within the framework of the ESPON 2013 Programme, partly financed by the European Regional Development Fund.

The partnership behind the ESPON Programme consists of the EU Commission and the Member States of the EU27, plus Iceland, Liechtenstein, Norway and Switzerland. Each partner is represented in the ESPON Monitoring Committee.

This report does not necessarily reflect the opinion of the members of the Monitoring Committee.

Information on the ESPON Programme and projects can be found on www.espon.eu

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

This basic report exists only in an electronic version.

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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 Northern Italy 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 Northern Italy case study region

The case study area consists of Northern Italy, including the following administrative regions: Valle d'Aosta, Piemonte, Liguria, Lombardia, Veneto, Trentino Alto Adige, Friuli Venezia Giulia and Emilia Romagna. The area covers around 120,000 Km² (figure 1).

The macro region is north-bounded by Alps, which form a natural border with neighbouring countries (France, Switzerland, Austria, Slovenia). This barrier is however crossed by several natural or artificial passages (like the Frejus tunnel, the Simplon tunnel or the Brenner tunnel) that connect Northern Italy with Northern Europe by road and rail. Improvements of North-South corridors are being undertaken (new rail Gotthard basis-tunnel) or are planned (new rail Brenner tunnel) even if corresponding investments on the Italian territory are lacking. Neighbouring regions of France, Switzerland, Austria and Slovenia can be reached also through a number of smaller customs crossing the borders.

South border of the study area is more an administrative separation, especially on the south-eastern side, where there is a clear territorial continuity with other regions. On the south-western side of the study area the Apennines are a physical barrier but both road and rail connections are well established and further improved after the opening of the high speed rail track in 2009.

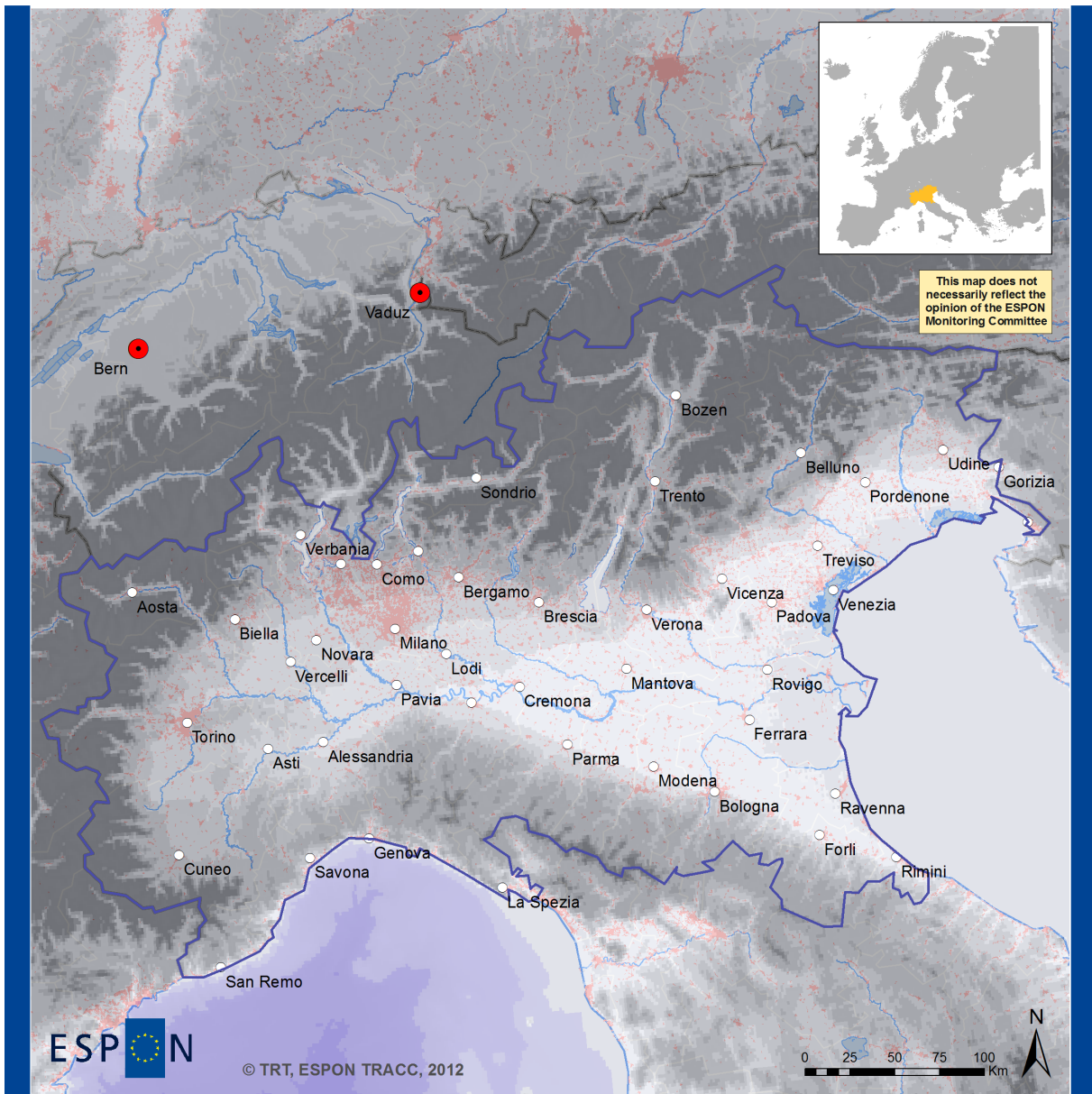
2.1 Spatial structure

Despite 46% share of the territory of Northern Italy is classified as 'mountain', the average population density is 230 persons per km², above the national average of 200 persons per km². The dominant spatial feature of Northern Italy is the 'enlarged city'. Especially in northern part of the area just below the Alps, on the west-east axis between Turin and Venice, urbanisation is virtually continuous (figure 2) to form what has been called 'Padan megalopolis' (Turri, 2004). Another 'enlarged city' can be identified in the southern part of the area, on the axis Turin-Bologna. In between urbanisation is less predominant and several medium cities (20,000 to 50,000 inhabitants) characterise a more polycentric structure. The 'enlarged city' model is reflected in the absence of a dominating centre. Milan is the biggest city in the area with about 1.3 Million inhabitants (i.e. less than 5% of the overall population in macro region). Other large cities are Turin (0.9 Million inhabitants), Genoa (0.6 Million), Bologna (0.38 Millions). This means that the main four cities of the area account for just a bit more than 10% of the overall population in the region. The largest part of the inhabitants populate the 'enlarged city' made of a number of small municipalities, many of which are separate entities only from an administrative point of view.

2.2 Socioeconomic situation

Northern Italy is the richest and most populated area of the country. About 27 million inhabitants live in the case study region, i.e. nearly one half of the whole Italian population. Also, about 60% of the national Gross Domestic Product is generated in this area. The industrial structure mainly consists of a number of small or even familiar firms spread over all the territory. Therefore, also jobs are quite distributed across the study area (with the exception of mountains). Even though most populated centres also concentrate many jobs (figure 3), the ratio between jobs and inhabitants is not bigger than in small villages. There are several 'districts' specialised in specific productions (e.g. silk, glasses, ceramic, shoes). Nevertheless, beginning with 1970s, the industrial production has decreased making room for the growth of services and tertiary activities. Milan is the major economic centre in Italy. Formerly an industrial area, it is now a service and financial centre, the site of the Italian stock exchange and of most of the Italian offices of international companies as well as one of the world fashion capitals.

The contribution of births to population development is almost null and population has slightly increased in the last years especially because of immigration from Southern Italy and from abroad. In the agricultural and industrial sectors immigrants (especially from Eastern Europe, North and Central Africa) represent a significant share of manpower (despite official statistics are lacking).



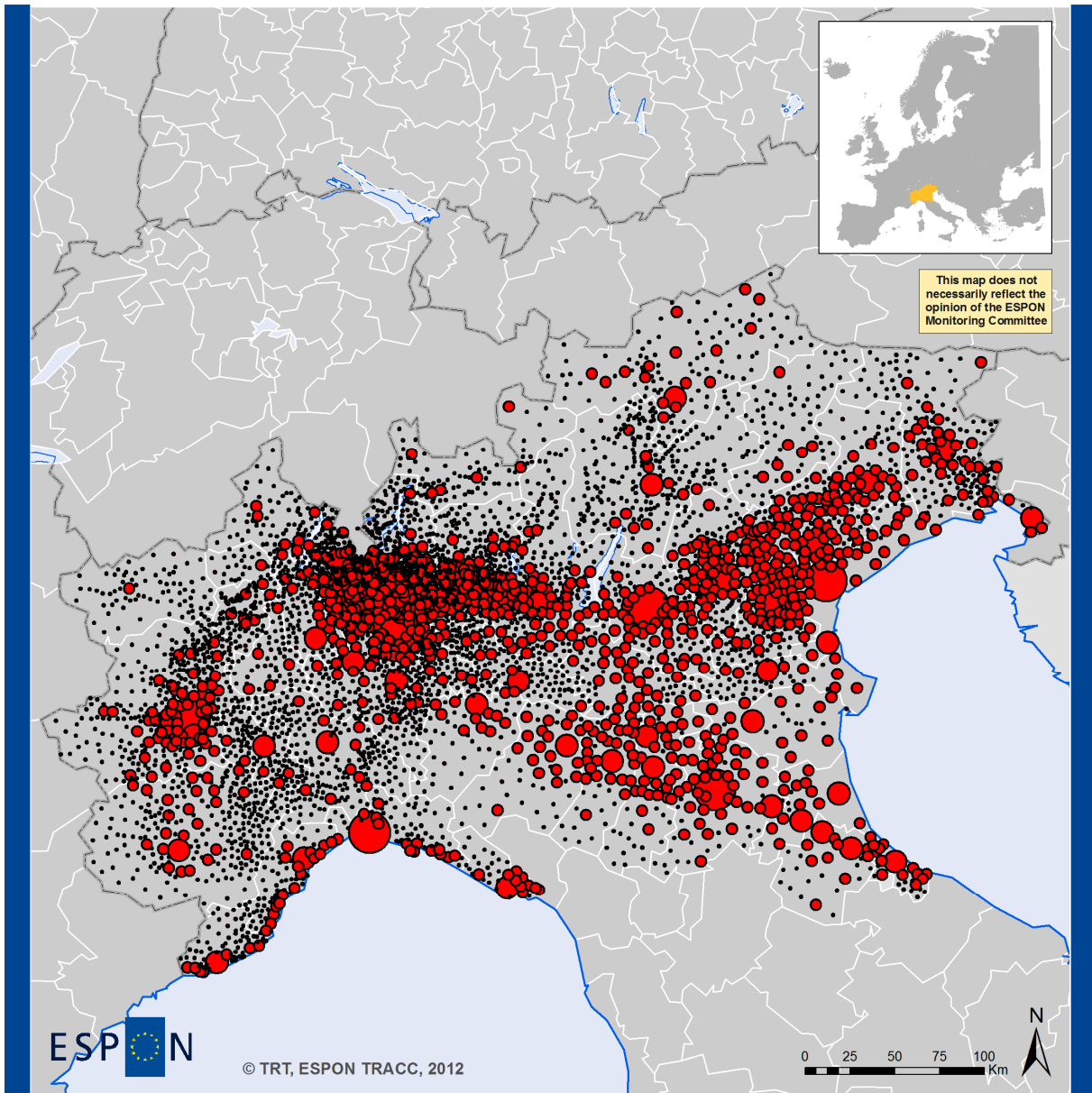
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Source: NOAA 2009; ESRI 2008; EEA 2006
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Northern Italy Case Study Physical map

- Settlement area
- Rivers
- Lakes
- National borders
- Capital city
- NUTS3 Capital

Figure 1. The Northern Italy case study region.



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Northern Italy Case Study Population

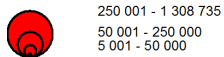
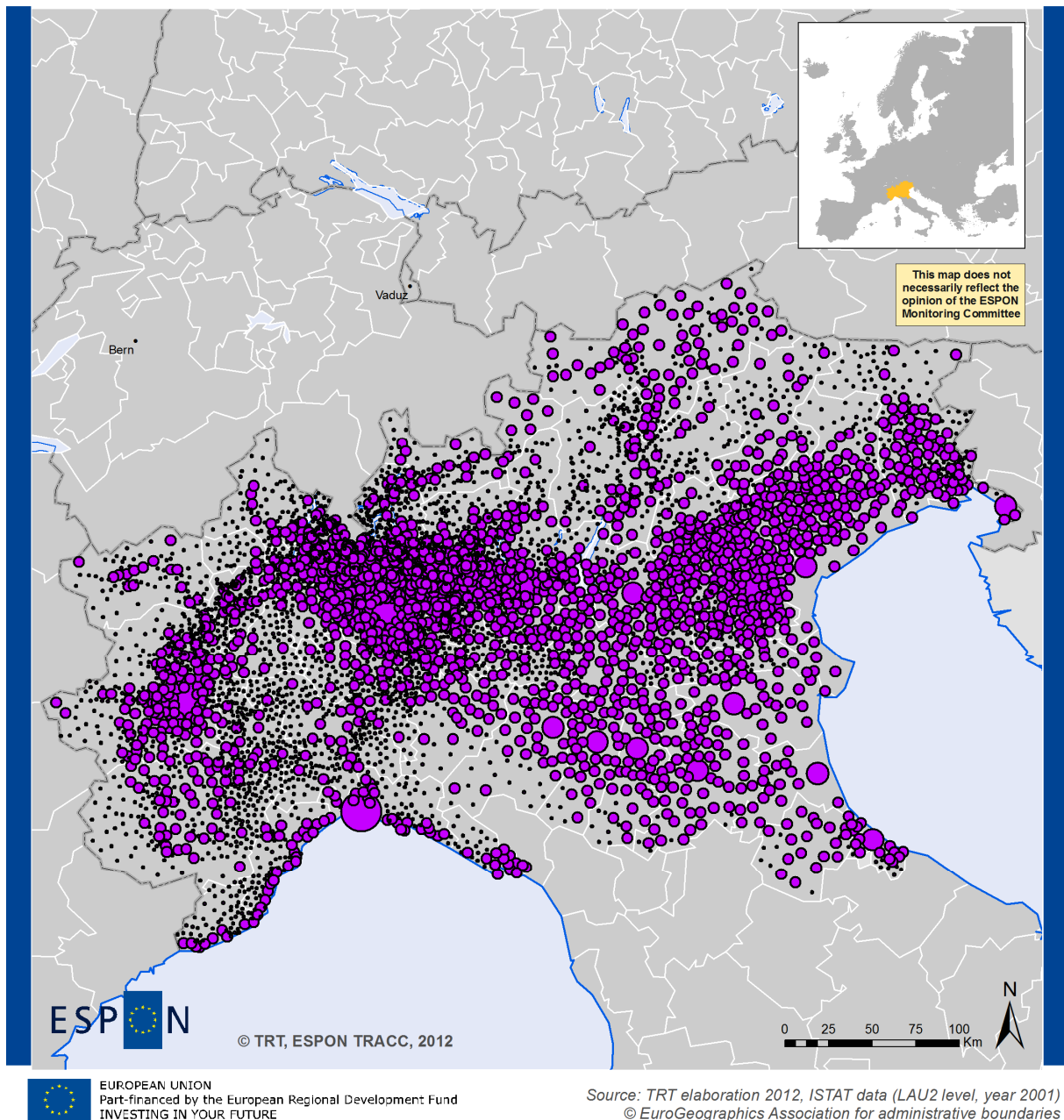


Figure 2. Population distribution



Northern Italy Case Study Number of employees (ths.)

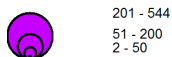


Figure 3. Job distribution

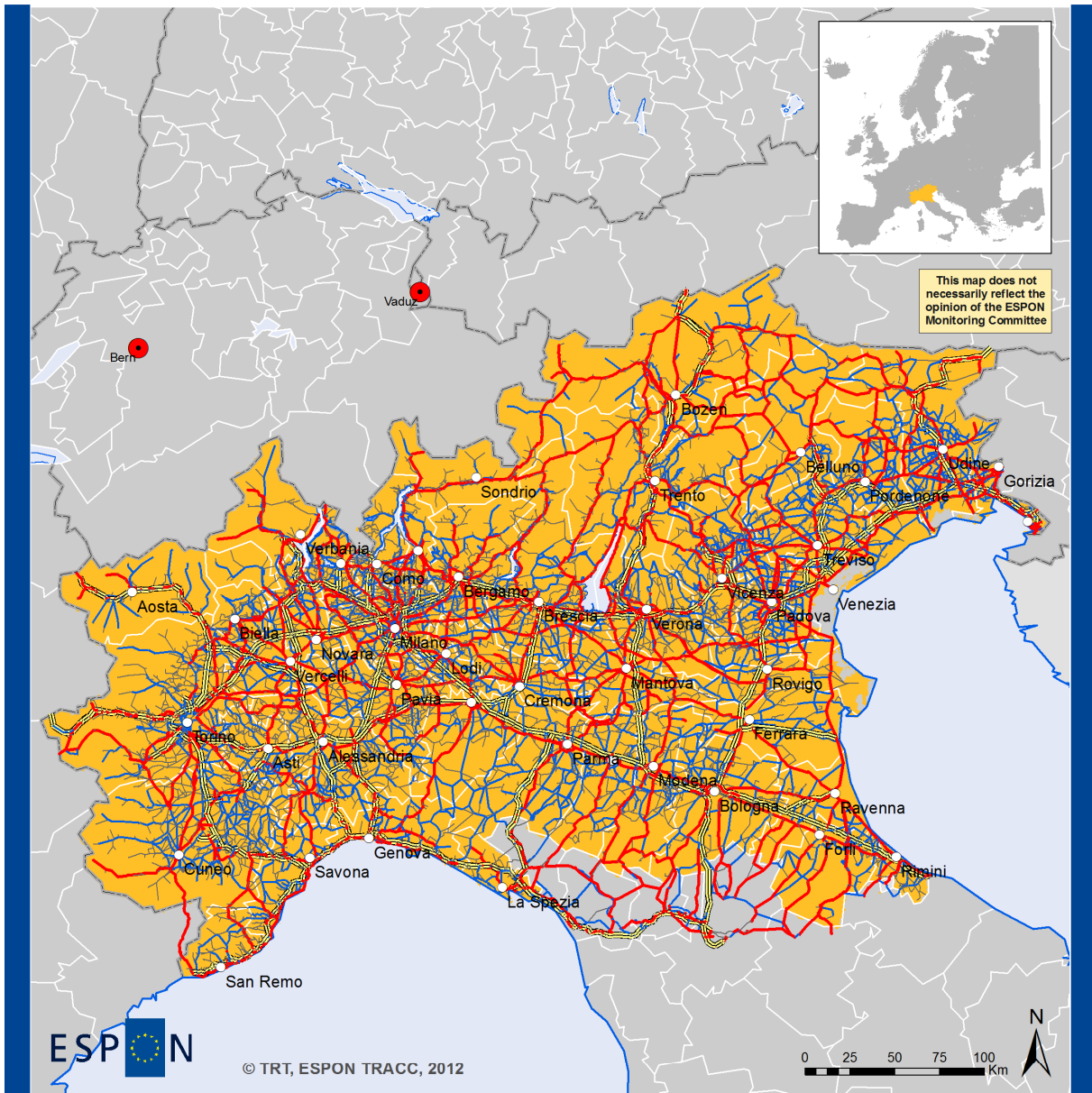
2.3 Transport aspects

Transport infrastructures and services are generally well developed in Northern Italy. However, the high population density coupled with the 'enlarged city' form of urbanisation and the economic structure made of many small firms generate a large amount of transport demand that gives rise to congestion problems.

The major road infrastructures are the west-east A4 and the A1 north-south motorways, but on both axis other motorways exist (figure 4). Nevertheless, especially A4 it has been often subjected to severe congestion problems. Recently the opening of a fourth lane between Brescia and Milan has relieved traffic. Furthermore the building of new infrastructures started between 2009 and 2010, namely the 'Brebemi' motorway, linking the city of Milan to Brescia via Bergamo and the 'Pedemontana' motorway, connecting the A4 motorway from Dalmine to the Malpensa airport crossing the provinces of Lecco, Monza and Como. Other motorways projects are still in a more or less advanced planning phase.

Besides motorways, an extensive network of national and regional roads connect all parts of the macro-regions. Also mountain areas are generally very well connected since many of them are tourist resorts especially in winter time.

Railways in the macro-region are especially developed around the Milan node, but most of the municipalities in the area (at least those not located in the mountains) are reasonably close to railways (figure 5). However, infrastructures are basically those developed in the first half of XX century (indeed, some railway lines existing until mid 1960s have been abandoned so that total railway length is today a bit shorter than 50 years ago). Railways were built to connect main cities to each other and to connect medium centres to the main poles (especially Milan and Turin) developing according to a radial model. The development of population and activities scattered throughout the territory of the area have seriously disadvantaged railways, which are more suitable for carrying large volumes of passengers (and freight) over fixed paths. Furthermore, in the last ten or fifteen years Italian railways have chosen to develop the high speed network rather than local services. The outcome has been that such services suffer for underinvestment in rolling stock and infrastructures update. They are overcrowded during peak time and renowned for their unreliability (delays). All in all, despite a quite extended railway network, train services are well below the best European standards. Only the recently inaugurated high speed line, connecting Milan to Rome in three hours, can be considered a quality service that has increased the connectivity of the area.



Northern Italy Case Study Road network, 2011








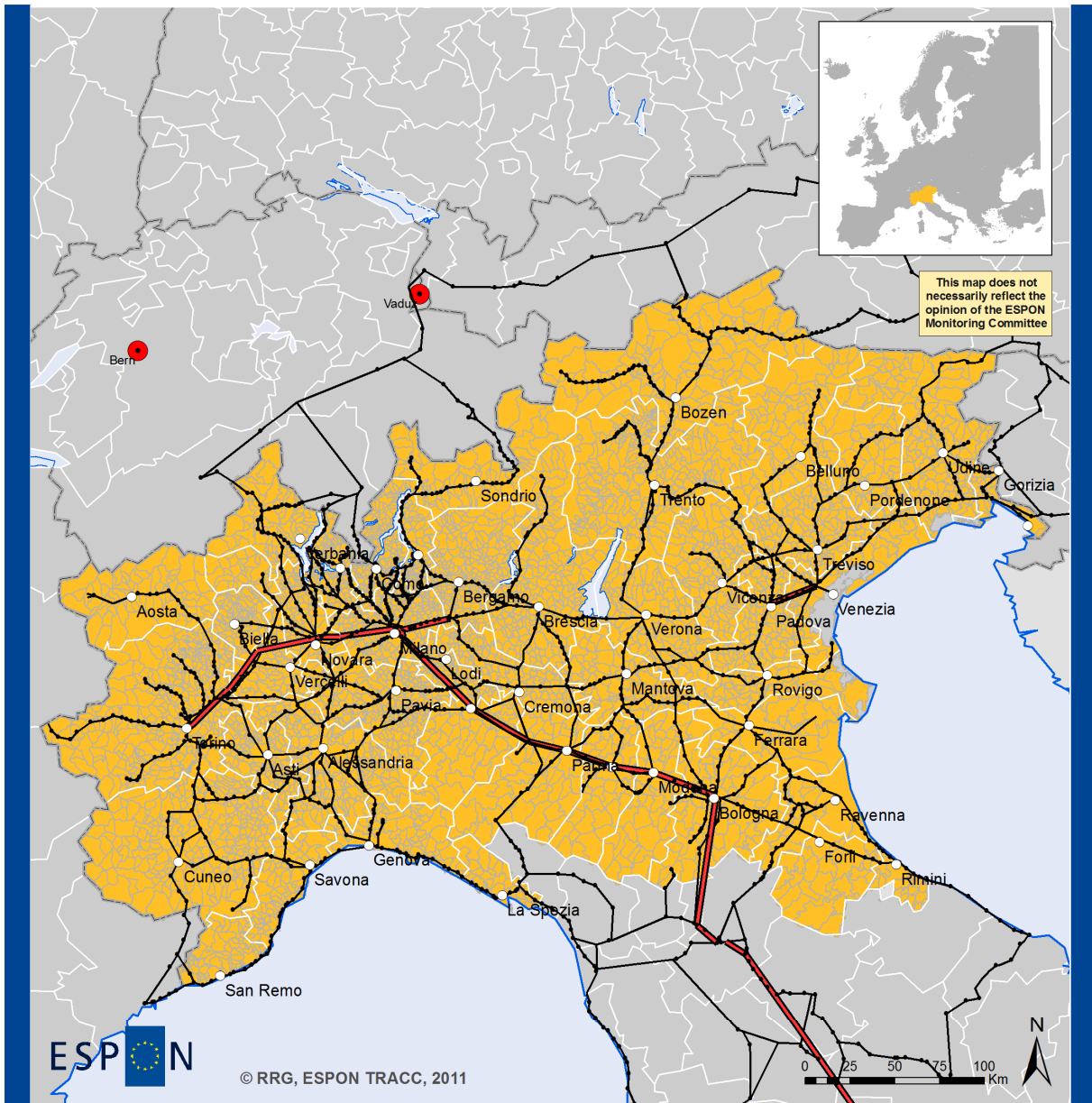
- | | | | |
|---|----------------|---|------------------------------|
|  | Motorway |  | Capital city |
|  | Primary road |  | NUTS3 Capital |
|  | Secondary road |  | Macro-region: municipalities |
|  | Other road | | |

Figure 4. Road network




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Northern Italy Case Study Rail network, 2011

- High-speed railway
- Conventional railway
- Train station
- Capital city
- NUTS3 Capital
- Macro-region: municipalities

Figure 5. Rail network

3 Accessibility patterns at regional and local scale

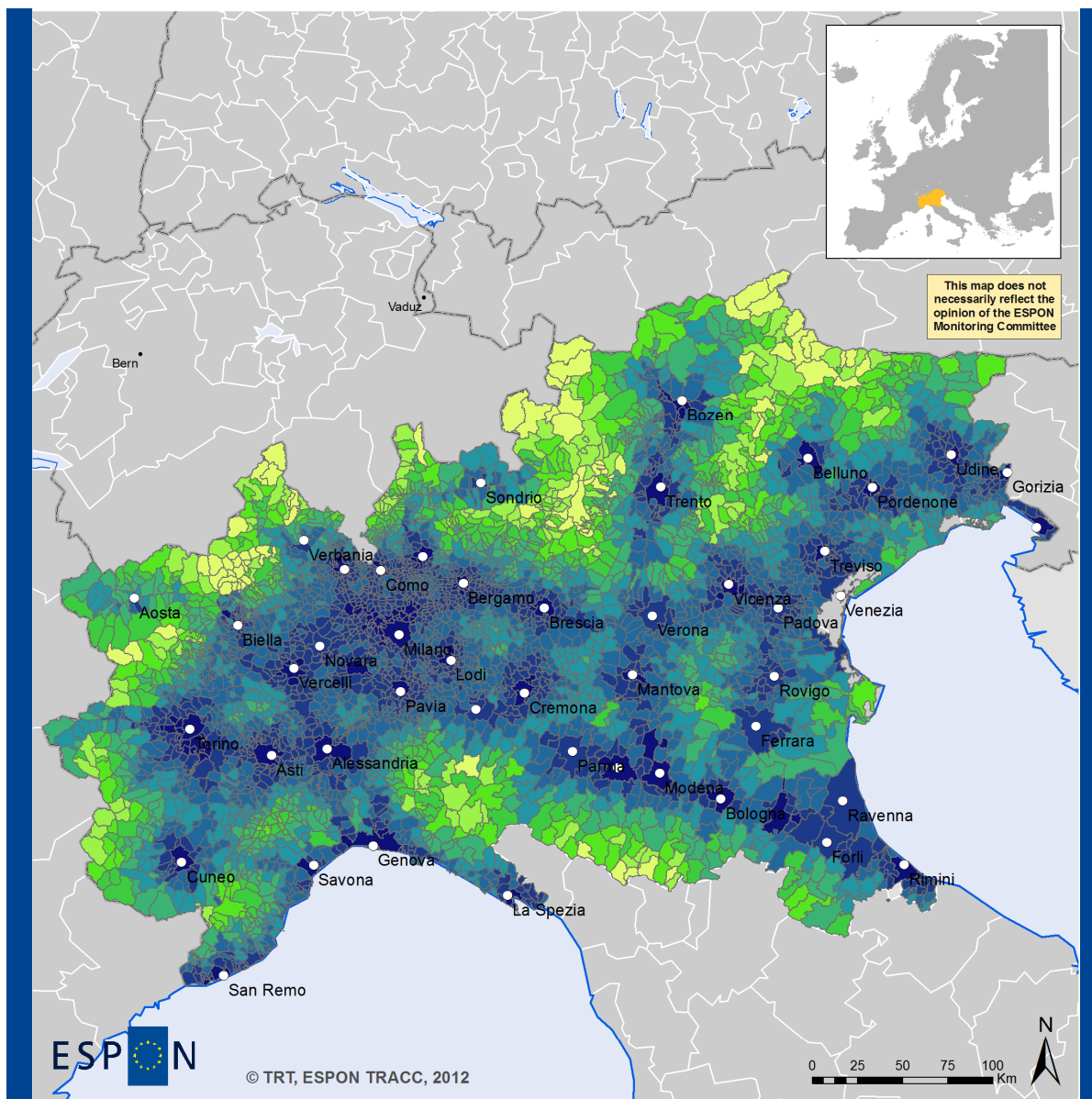
Accessibility analysis at regional and local scale has been performed in the Northern Italy region at a LAU2 resolution. The analysis considers both accessibility by road and accessibility by public transport. The latter includes (interurban) public bus and coach services as well as train services. The various indicators computed are introduced and commented below.

3.1 Access to regional centres

Given the definition adopted (NUTS3 capitals plus cities with more than 50,000 inhabitants), there are 60 regional centres distributed over the whole study area. The accessibility to such centres by car is generally good for most of the LAU2 units (figure 6). The majority of the LAU2 units are within 30 minutes from the closest regional centre by car, corresponding to 81% of the population of the study area. Only some very peripheral municipalities, generally in mountain areas and very sparsely populated (2% of the overall population in the study area), show a travel time larger than 60 minutes. Such peripheral municipalities are comparatively disadvantaged because of their position not because of lack of road infrastructures.

Not surprisingly, the travel time to regional centres by public transport is less good than by car (figure 7). Indeed, travelling by bus or by train is generally slower than using car. In some cases train is faster than car, but such cases occurs in proximity of the major centres (because of higher road congestion) where car accessibility is very good anyway. The zones and population shares with a travel time by public transport to the closest regional centres lower than 30 minutes are 23% and, respectively, 57%. For 22% of the zones and 6% of the population more than 60 minutes are needed to reach a regional centre by bus or train. The map shows quite clearly that low public transport accessibility to the closest region centres is found in mountain areas but also, at a lower instance, in some portions of the study region where the rail infrastructure is underdeveloped in comparison to the rest of the region. Indeed, the median of the distribution of the intermediate remote areas is even above the median of the rural remote areas (figure 8). This is more visible for public transport but it is true for car accessibility as well.

The decreasing level of accessibility when moving from urban regions to intermediate regions to rural regions is clearly displayed in figure 9, where also the gap between car accessibility and public transport accessibility to regional city centres can be appreciated.



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Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011), Road Network: OSM (2011), Italian Statistical Office (ISTAT)- Population (2006)
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Northern Italy Case Study (2011)

Access to regional centres: Travel time (min) to nearest regional centre by road

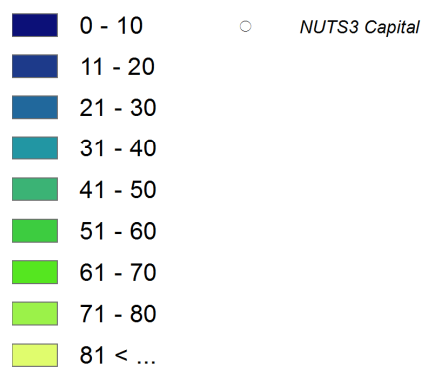
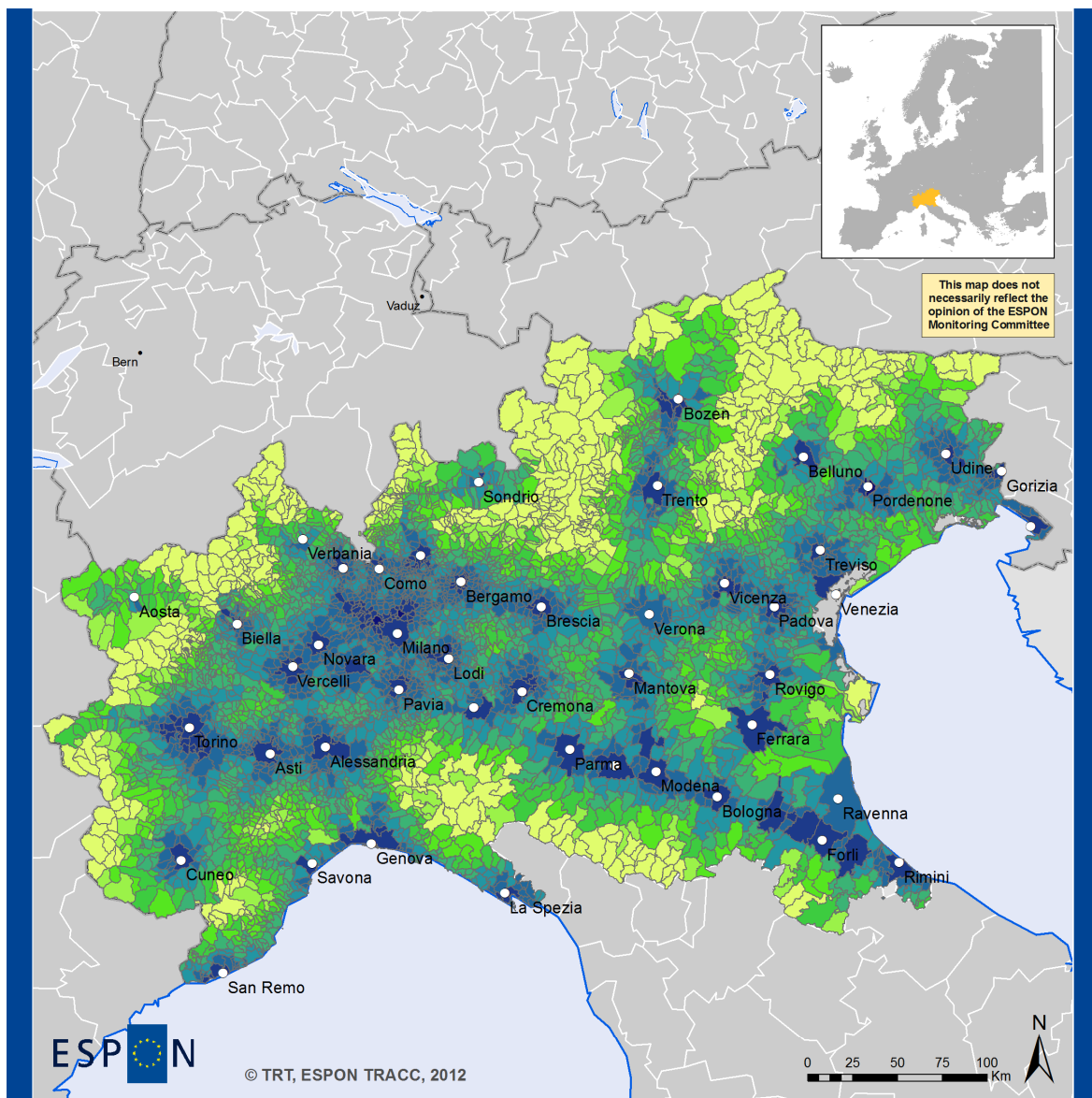


Figure 6. Travel time by car to next regional centre



Northern Italy Case Study (2011) Access to regional centres: Travel time (min) to nearest regional centre by public transport

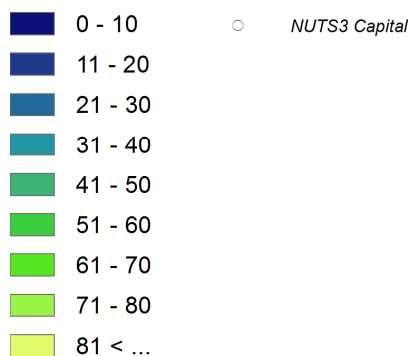


Figure 7. Travel time by public transport to next regional centre

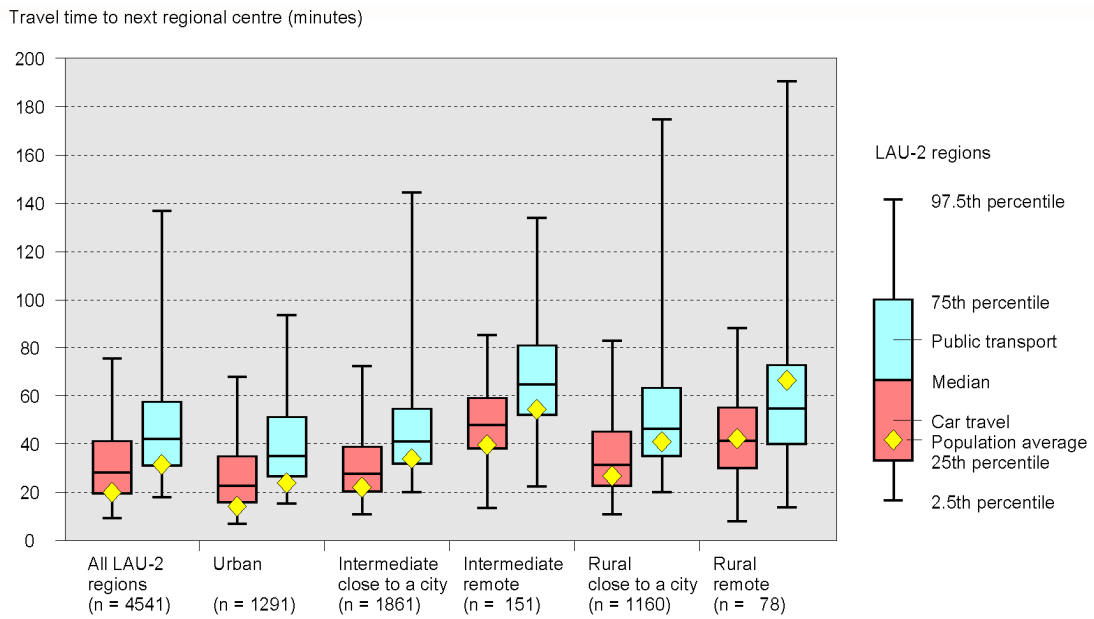


Figure 8. Travel time to next regional centre, by urban-rural typology

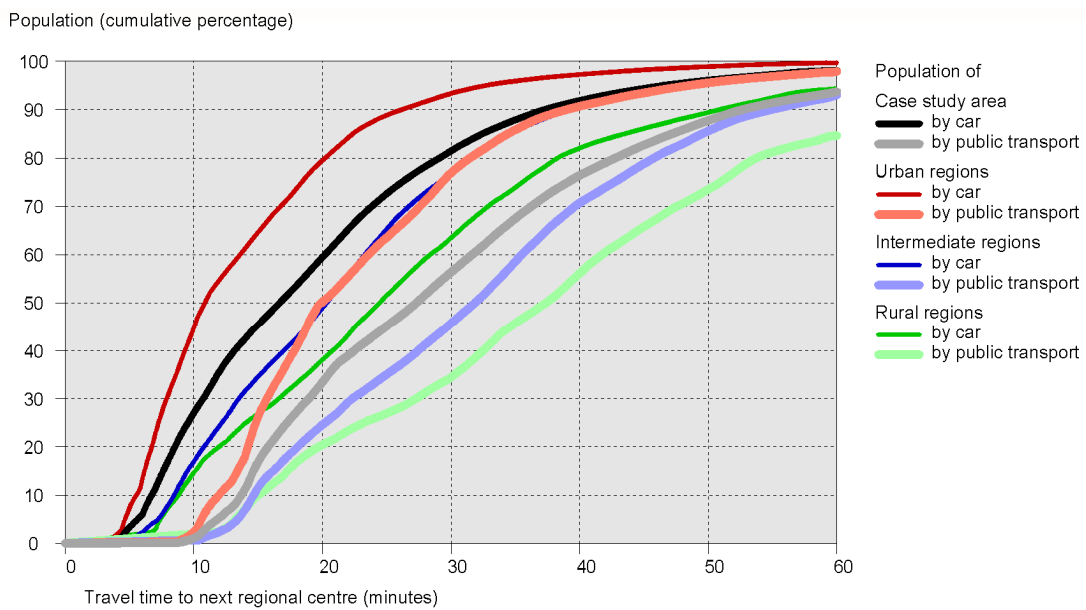


Figure 9. Travel time to next regional centre, cumulative distributions

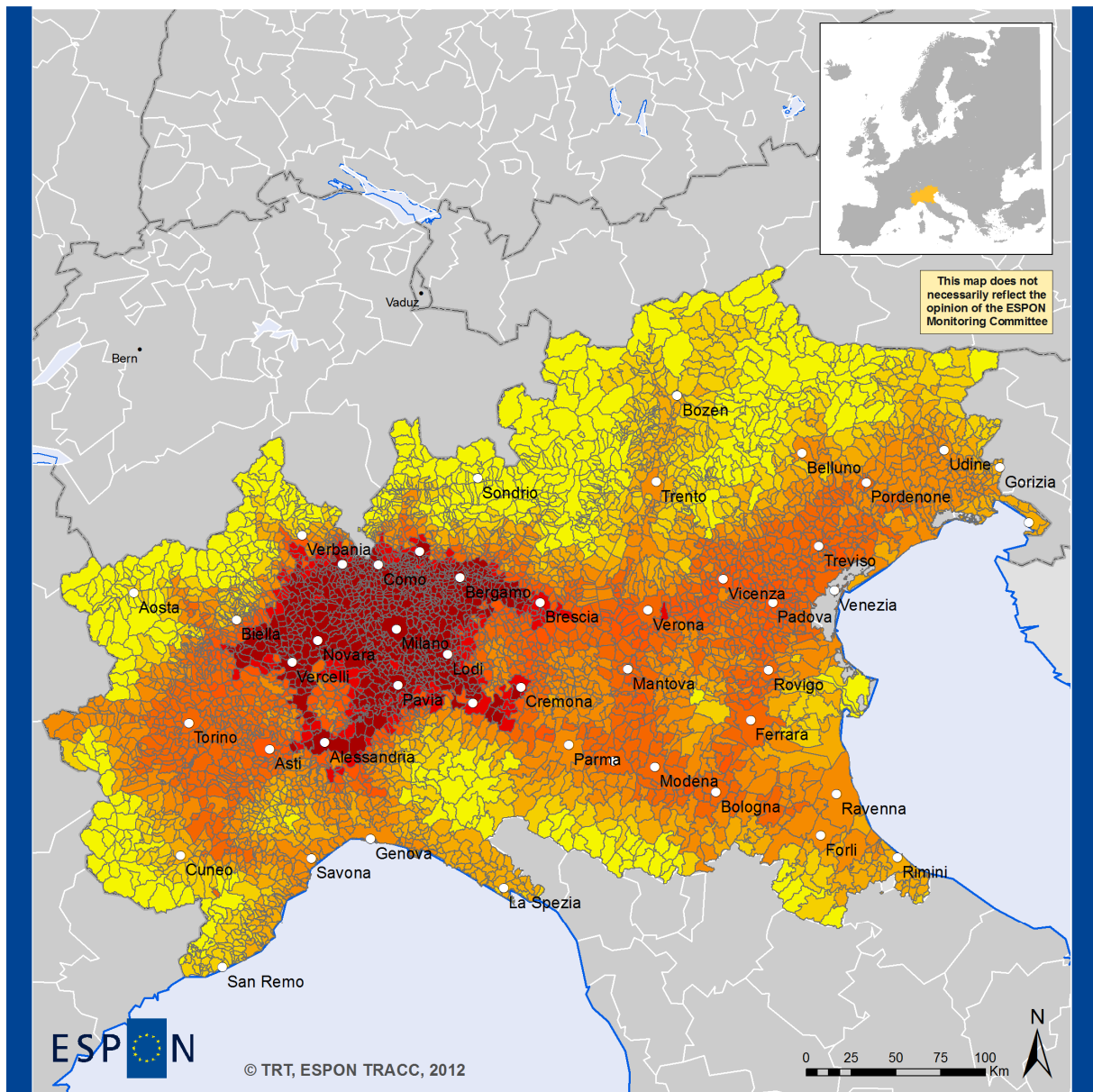
3.2 Daily accessibility of jobs

As already mentioned, the Northern Italy area is rich of economic activities spreading over most of its territory rather than concentrated in a few spots, even if the density of activities (as well as of population) is especially high in the sub-region surrounding the metropolitan area of Milan. As result of this level of density, nearly one half of zones and two thirds of population can reach more than 1 million of jobs in less than one hour by car (figure 10). Only a small share of population, living in a minority of zones mainly located in mountain areas, can reach less than 100,000 jobs within 60 minutes. People living in these areas have definitely less alternatives in terms of jobs availability, with tourism being a major source of workplaces.

Jobs accessibility by public transport follows basically the same pattern of jobs accessibility by car, but with a distribution shifted downwards, i.e. the number of workplaces that can be reached within 60 minutes by public transport is generally lower than by car (figure 11).

Not surprisingly, the difference of accessibility to jobs between zone types is dramatic. The median of the distribution of urban zones and other zones close to a city is several times larger than the median for the remote areas (figure 12). Another advantage of urban areas is that public transport accessibility is not that worse than car accessibility. Instead, in intermediate zones the difference is much larger and moving by public transport means a clear drop in median accessibility. In remote areas the difference between car and public transport accessibility is small just because even car accessibility is low.

In terms of population, it is remarkable that the cumulate distribution of rural population regarding car accessibility is basically the same as the cumulate distribution of the overall population in the study area regarding public transport accessibility (figure 13). With a simplification, it might be said that, as far as jobs accessibility is concerned, in rural areas car is needed to enjoy the average accessibility of public transport (which is somewhat limited).



Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011), Road Network: OSM (2011), Italian Statistical Office (ISTAT)- Workplaces (2001)
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Northern Italy Case Study (2011) Daily accessibility of jobs: Jobs (ths.) accessible within 60 minutes by road

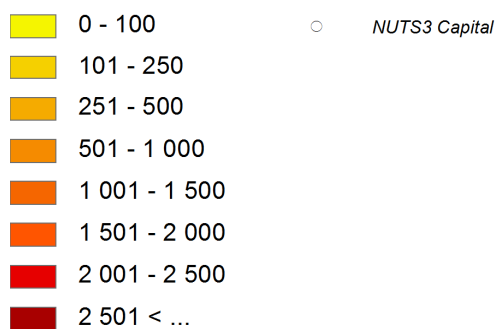
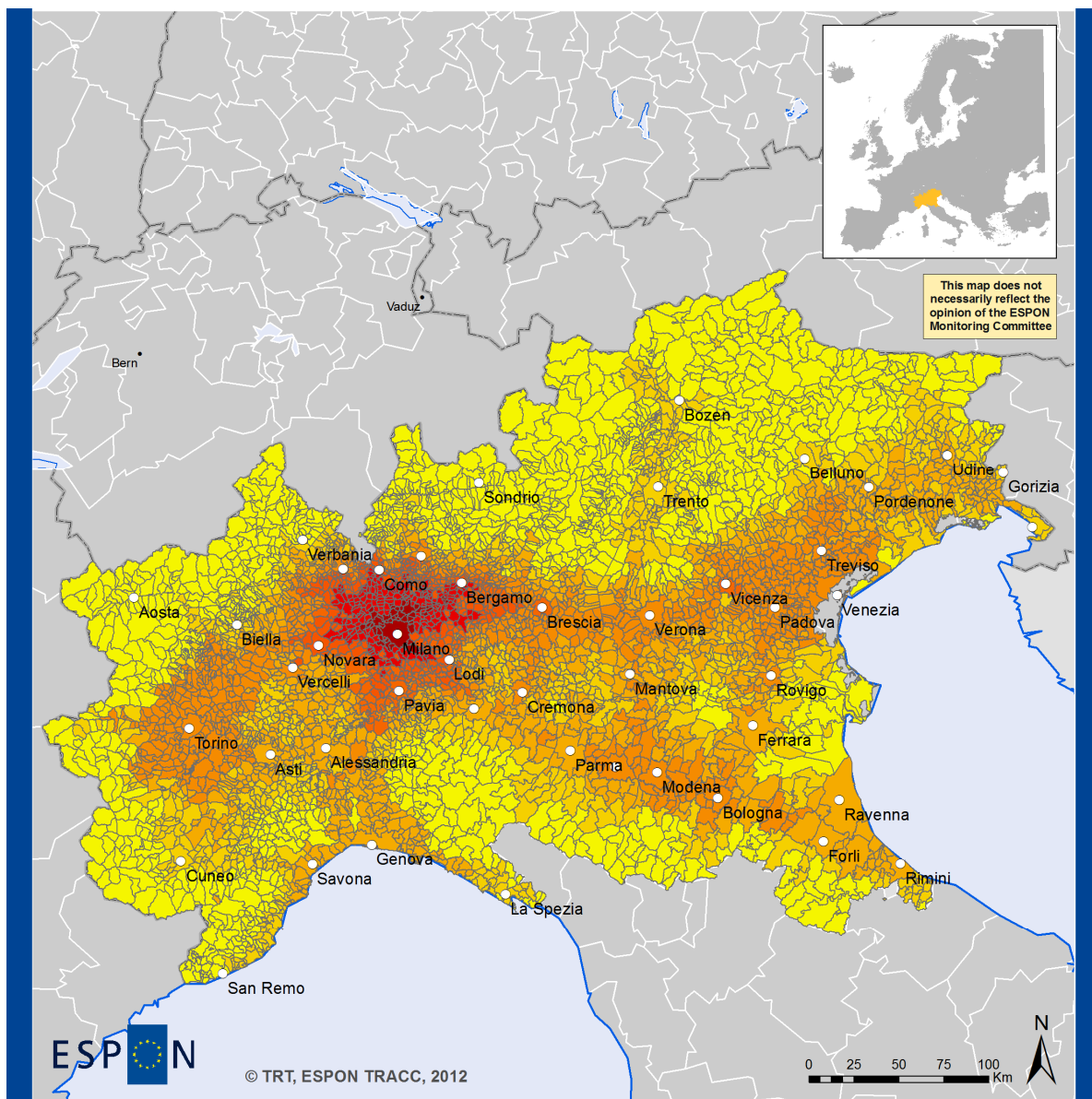


Figure 10. Jobs accessible by car within 60 minutes



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Northern Italy Case Study (2011) Daily accessibility of jobs: Jobs (ths.) accessible within 60 minutes by public transport

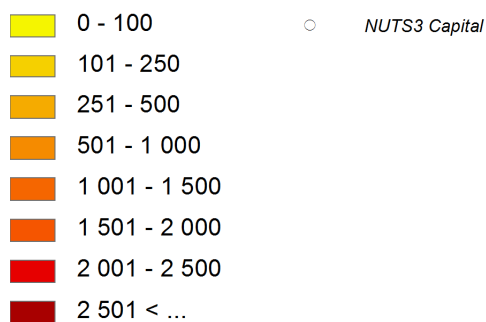


Figure 11. Jobs accessible by public transport within 60 minutes

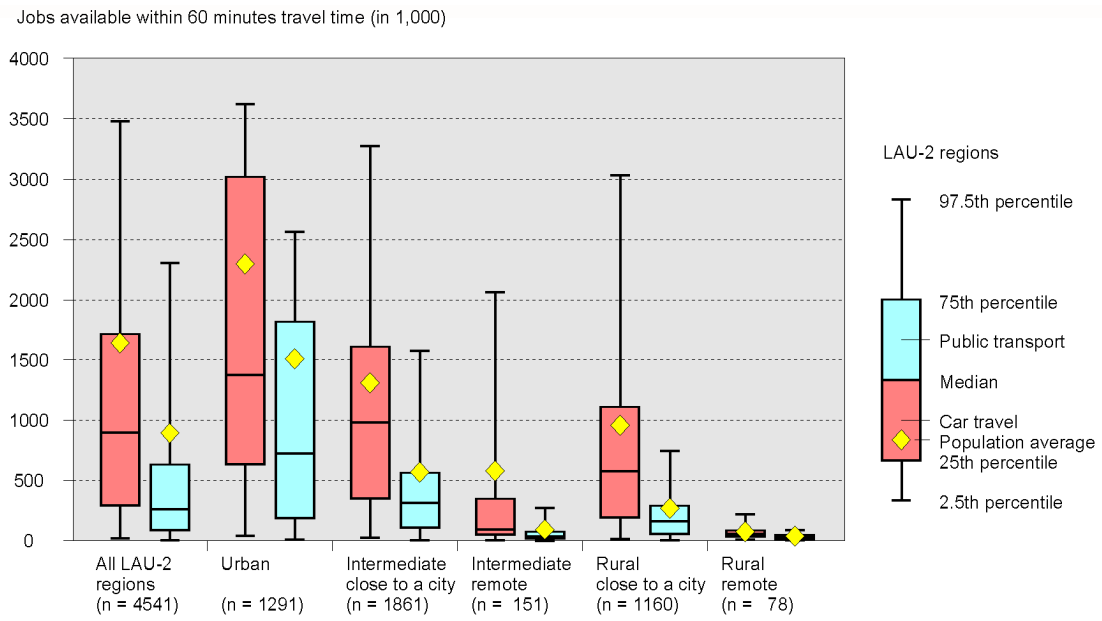


Figure 12. Jobs accessible within 60 minutes, by urban-rural typology

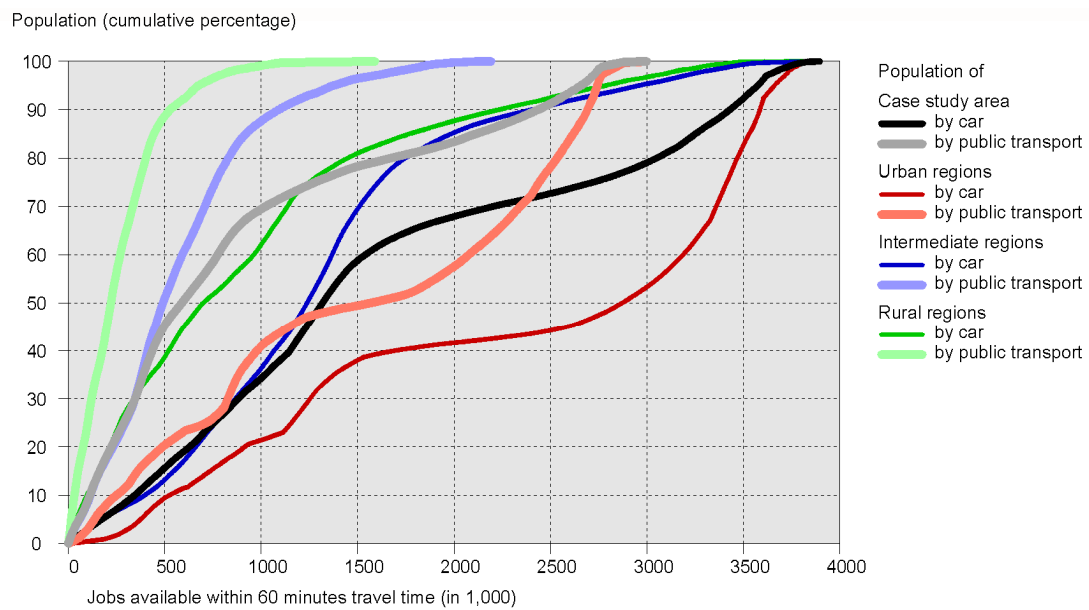


Figure 13. Jobs accessible within 60 minutes, cumulative distributions

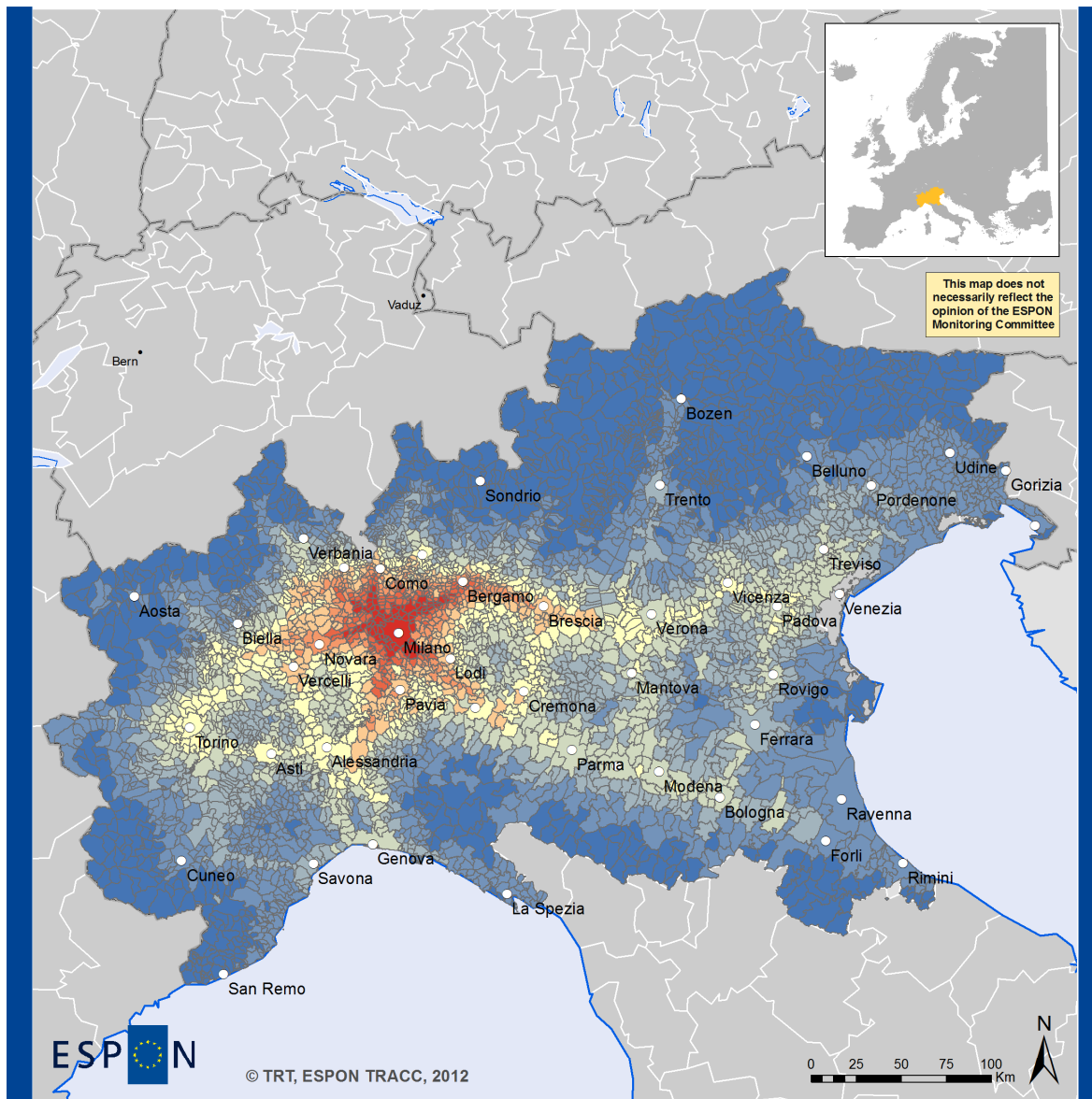
3.3 Regional accessibility potential

The map of the potential accessibility by car to population makes quite visible the “enlarged city” which characterise the territory of the study area. There is an apparent continuity in the (above the average) level of potential accessibility throughout the Padan region and in the northern part of the corridor between Turin and Bologna (figure 14). The average potential accessibility in the area does not result from very high values for a few zones and a large number of lower values. 20% of zones (accounting for more than one third of population) are over the average. This means that despite some polarisation there is a relatively even distribution of potential accessibility in the core of the area. Of course, potential accessibility of very peripheral LAU2 is well below the average, but they account for only 6% of population.

Also for potential accessibility, on average public transport performs worse than car. Taking the (weighted) average of potential accessibility by car as term of reference, most of the LAU2s are ranked below this value (figure 15a). Nevertheless there are a few zones (where about 10% of population lives) whose potential accessibility by public transport is above the average potential accessibility by car. These zones are basically those which are very well connected by train to Milan and its metropolitan area. Outside this area, the potential accessibility by public transport is generally lower than the average accessibility by car. Namely, in two thirds of the zones (accounting for nearly 40% of the population) the level of potential accessibility by public transport is less than 25% of the average level of car accessibility.

Considering the public transport in itself, i.e. ranking the LAU2s with respect to the weighted average of public transport potential accessibility (figure 15b), the picture is not very different from that of car accessibility, however with a smaller number of zones above the average, located along the main rail corridors.

Comparing the distribution of zones, the lower accessibility by public transport emerges clearly (figure 16). As expected, the gap is lower for urban areas and larger for remote and rural areas. The advantage for population living in urban areas is also visible in the cumulated distributions (figure 17): the share of population living in urban zones and enjoying a given level of potential accessibility using public transport is nearly the same or higher than that enjoying the same level of accessibility by car in intermediate or rural areas.



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Northern Italy Case Study (2011)

Regional potential accessibility to population by road ($\beta=0.034657$) (standardised on road average)

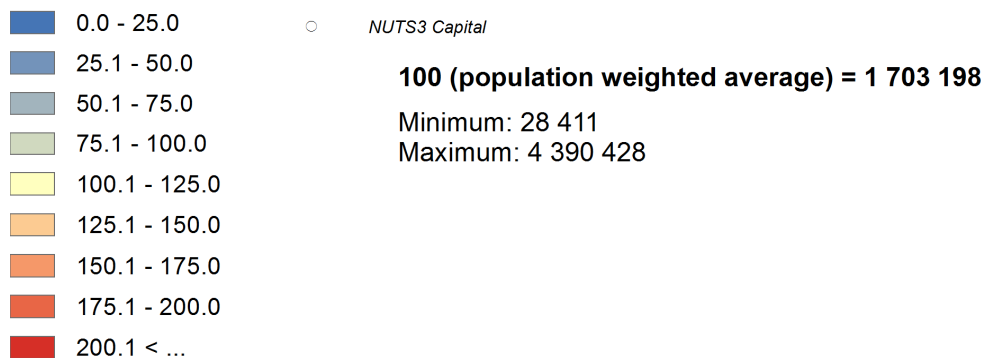
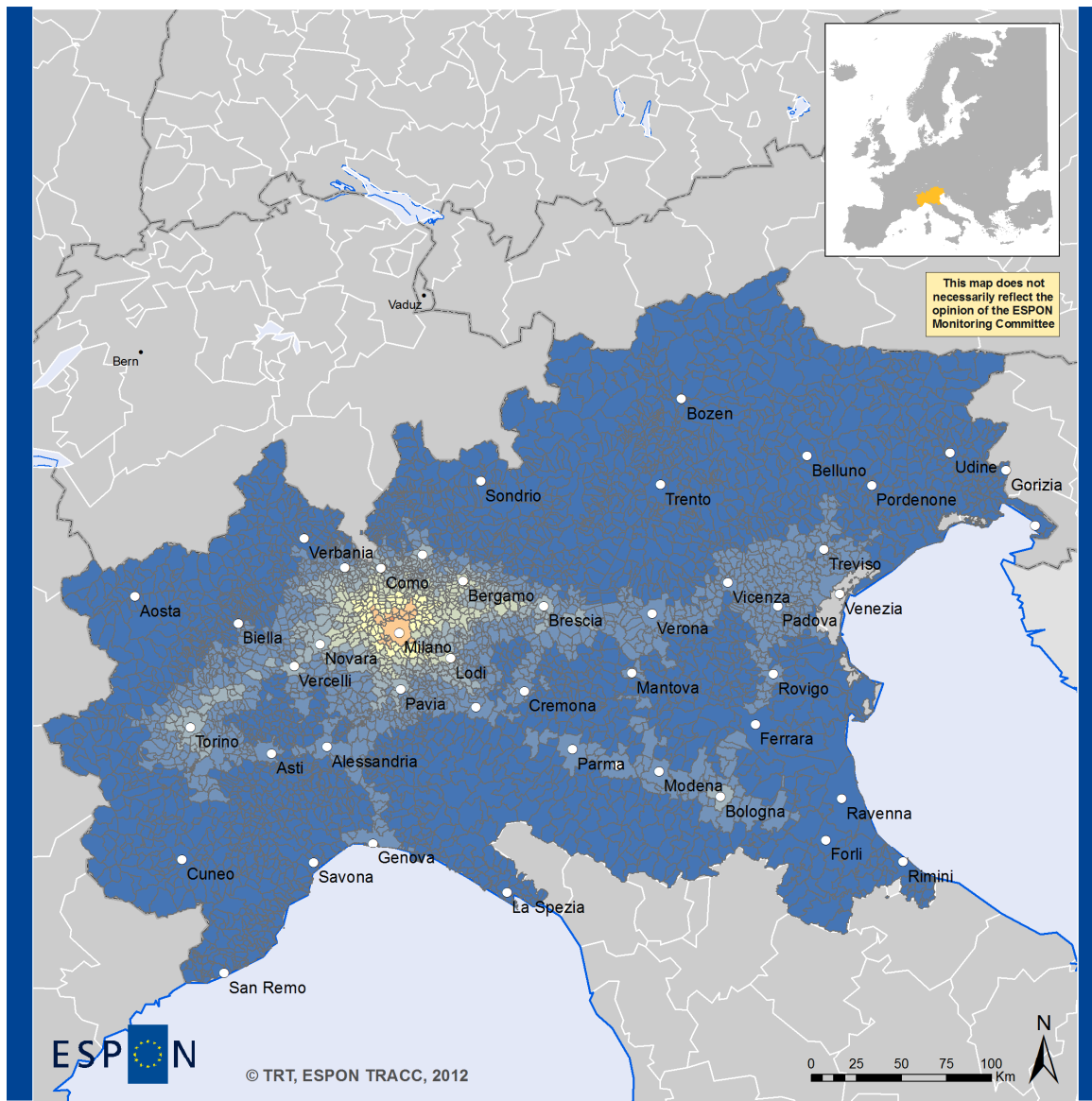


Figure 14. Potential accessibility to population by car



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Regional potential accessibility to population by public transport ($\beta=0.034657$) (standardised on road average)

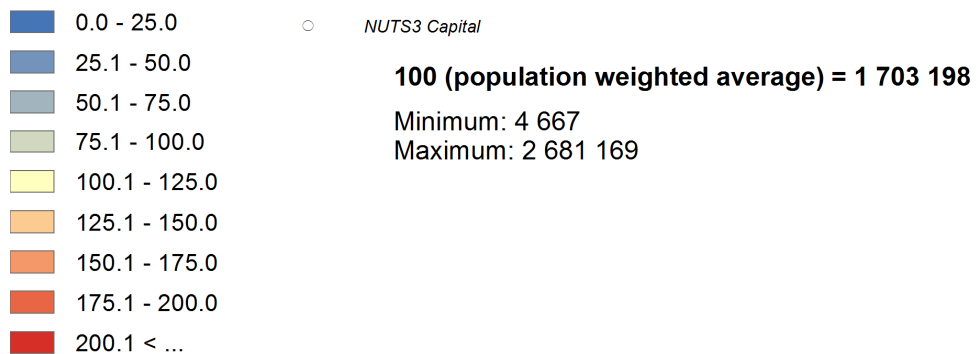
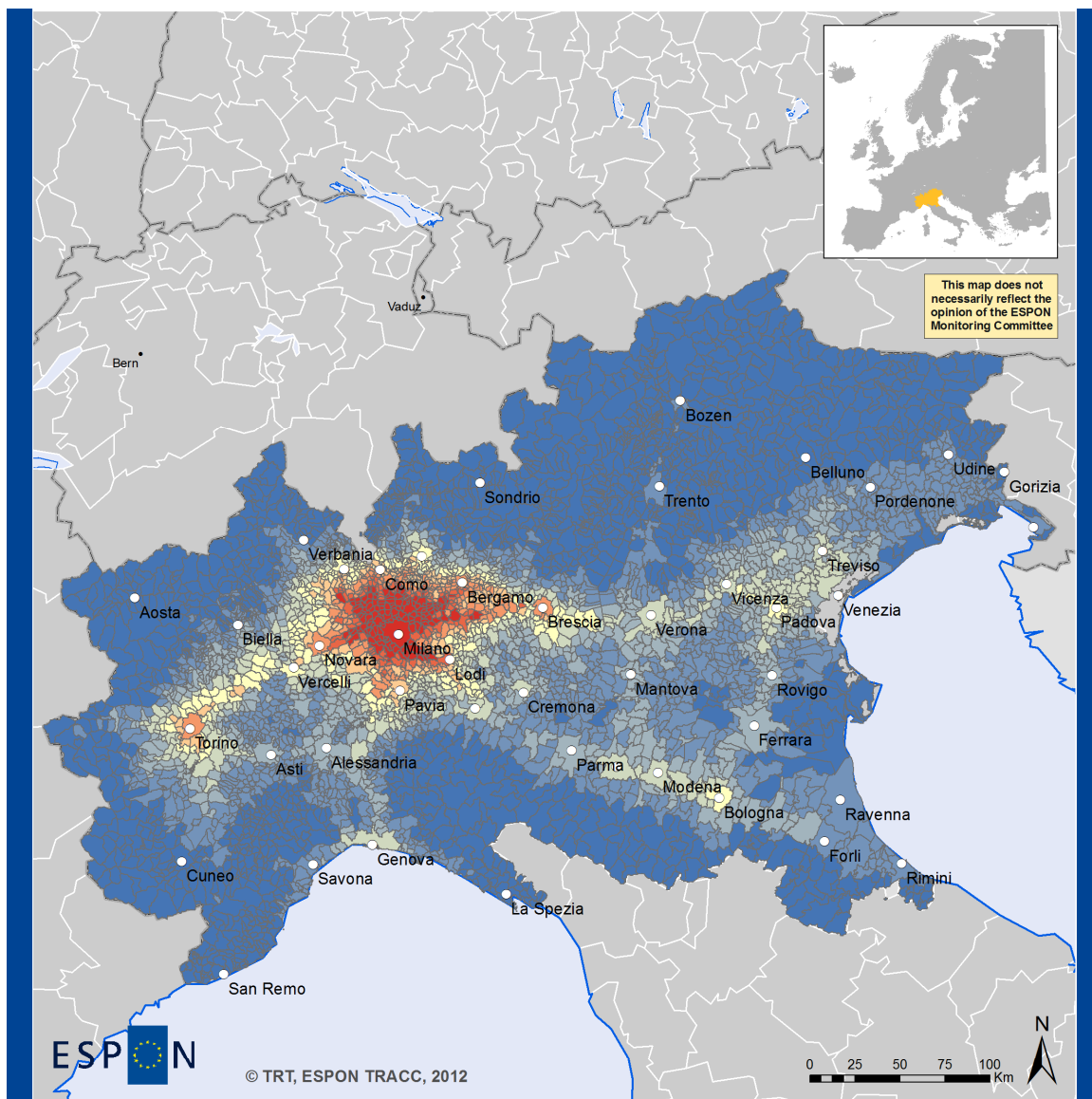


Figure 15a. Potential accessibility to population by public transport (standardised on road average)




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Regional potential accessibility to population by public transport ($\beta=0.034657$) (standardised on public transport average)

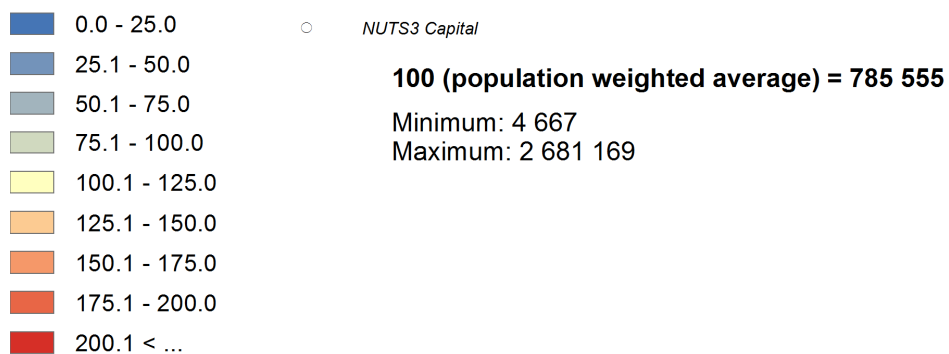


Figure 15b. Potential accessibility to population by public transport (standardised on public transport average)

Potential accessibility to population (car average = 100)

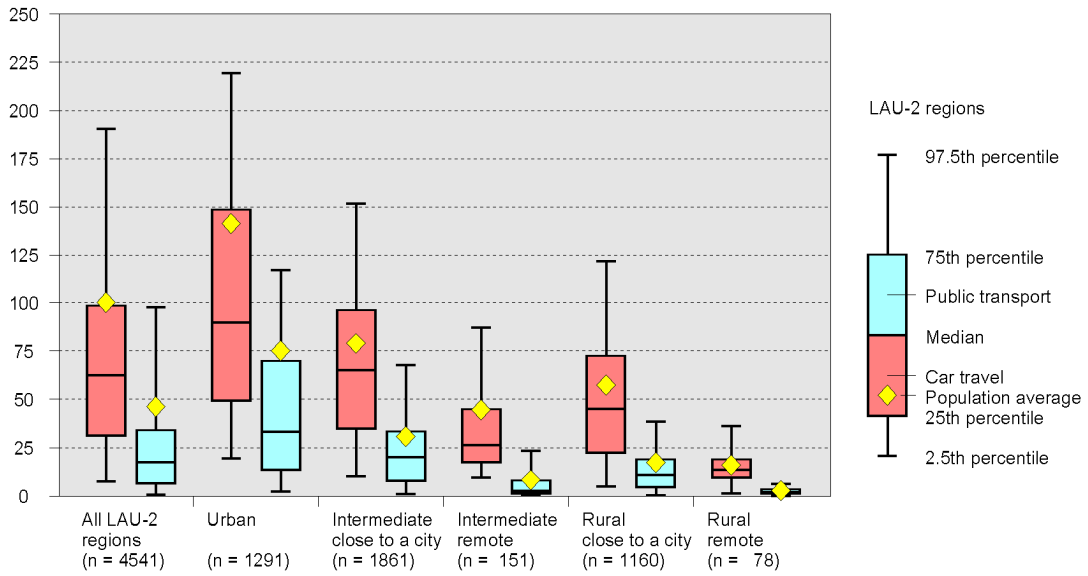


Figure 16. Potential accessibility to population, by urban-rural typology

Population (cumulative percentage)

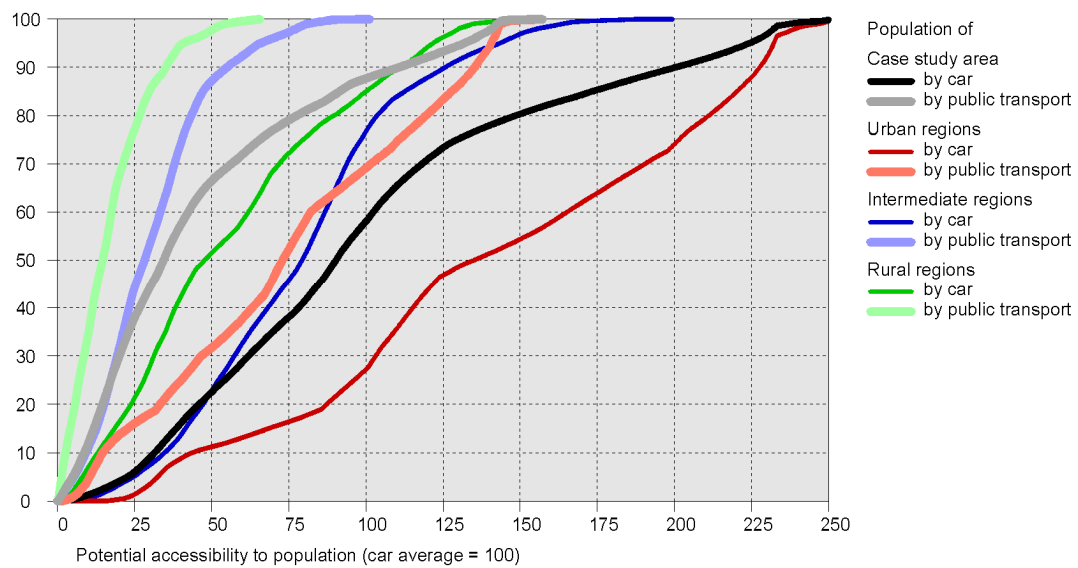


Figure 17. Potential accessibility to population, cumulative distributions

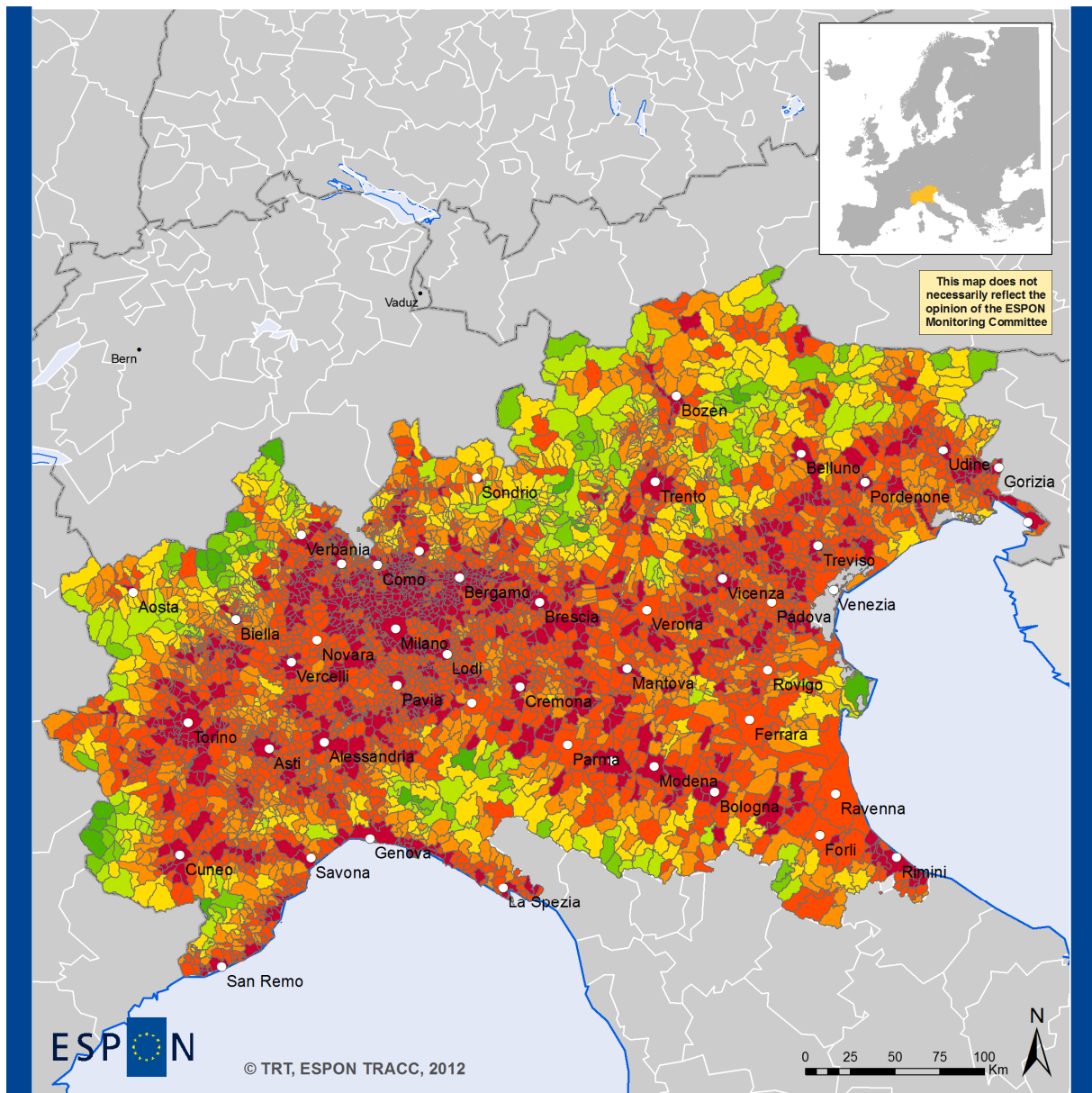
3.4 Access to health care facilities

In Italy, public health system has been dominant for the last decades. A dense network of public hospitals providing a wide range of therapies (including emergency therapies) has been one result of this model. Therefore, accessibility to hospitals by car in Northern Italy is rather good (figure 18). 62% of zones and 89% of the population can reach the closest hospital in less than 20 minutes, while 82% of zones and 97% of population need no more than 30 minutes. Only for 6% of zones, where less than 1% of the population lives, car travel time to the nearest hospital is larger than 40 minutes.

The accessibility to hospitals by public transport is different from car accessibility especially because there are much less zones for which the time required to reach a hospital is below 10 or 20 minutes (figure 19). However the difference is much smaller if a time threshold of 30 minutes is considered. 24% of zones and 62% of the population can reach the closest hospital in less than 20 minutes by bus or train, while 63% of zones and 88% of population need up to 30 minutes. In 17% of zones, where only 4% of the population lives, travel time by public transport to the nearest hospital is larger than 40 minutes.

The quite even distribution of accessibility to hospitals is witnessed also by the similar distributions of different types of zones (figure 20). Yet urban areas are mostly distributed below (i.e. better than) the average, the difference is much more limited than for other indicators of accessibility shown above. The same conclusions can be drawn looking at the cumulate distributions of population (figure 21): the better performance of urban zones in comparison to intermediate and rural zones is confirmed, but the gap between different zones type is small.

It could be noted that in recent years some forms of privatisation have been introduced in the health system and that plans for closing smaller hospitals have been periodically presented (the latest one is a recent government project issued in early July 2012). In case such plans were put into practice the accessibility analysis made here could change significantly.




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Northern Italy Case Study (2011)

Access to health care facilities: Travel time (min) to nearest hospital by road

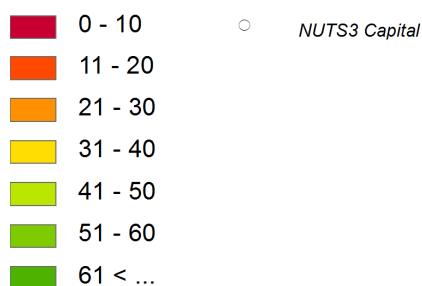
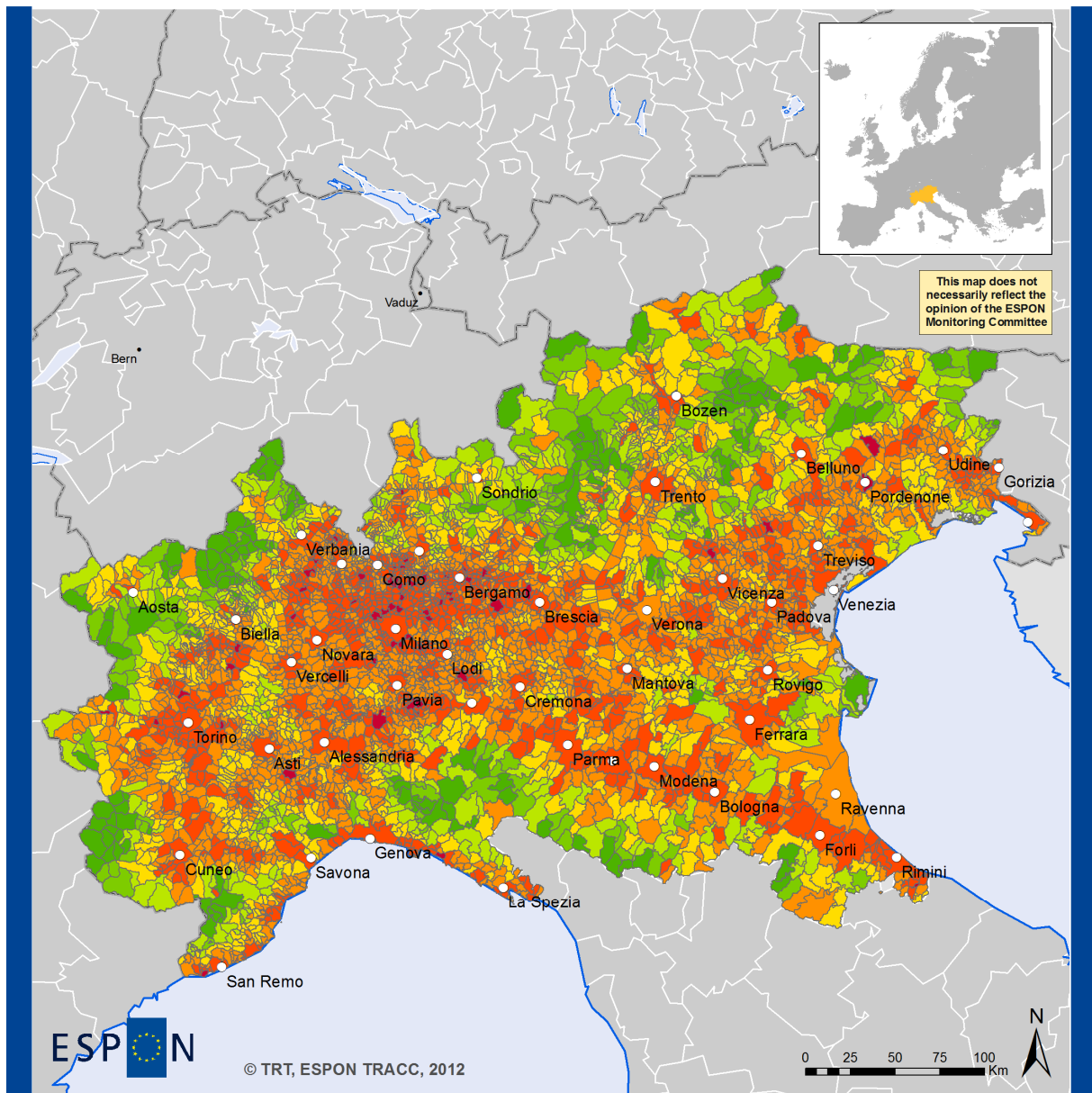


Figure 18. Car travel time to next hospital




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Northern Italy Case Study (2011)

Access to health care facilities: Travel time (min) to nearest hospital by public transport

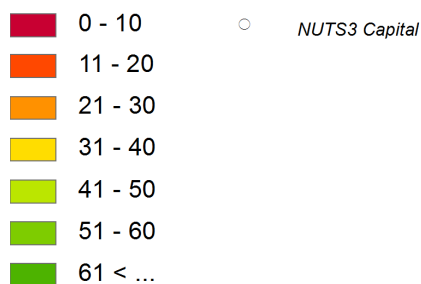


Figure 19. Public transport travel time to next hospital

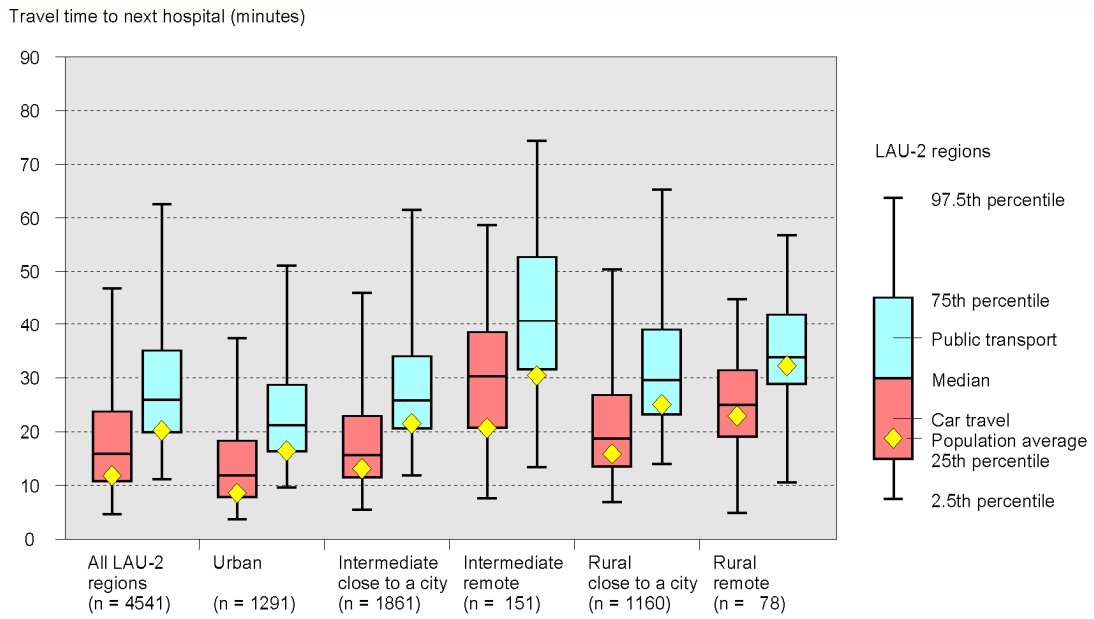


Figure 20. Travel time to next hospital, by urban-rural typology

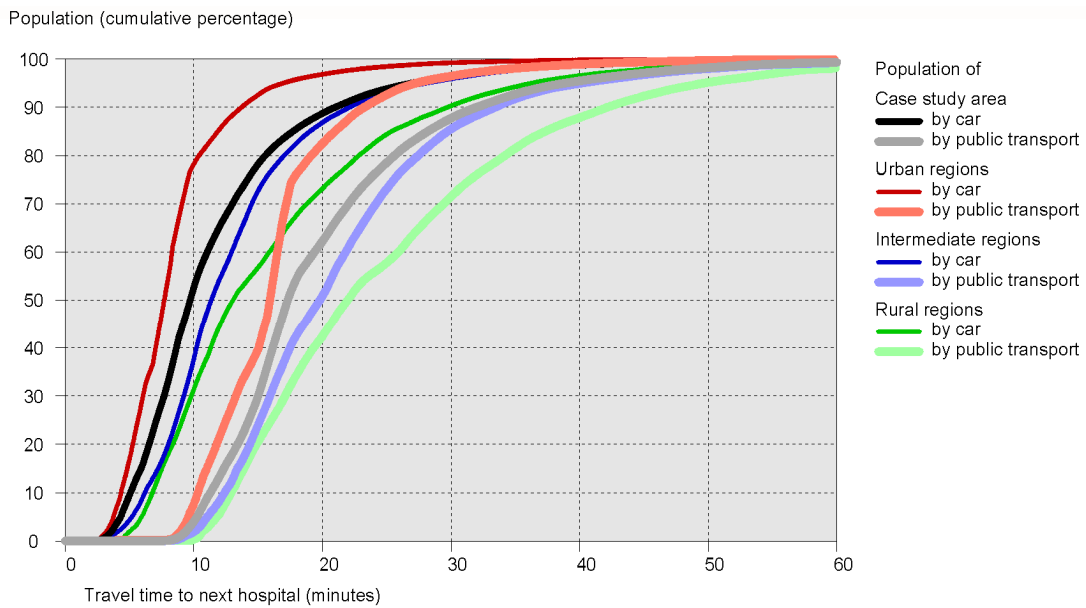


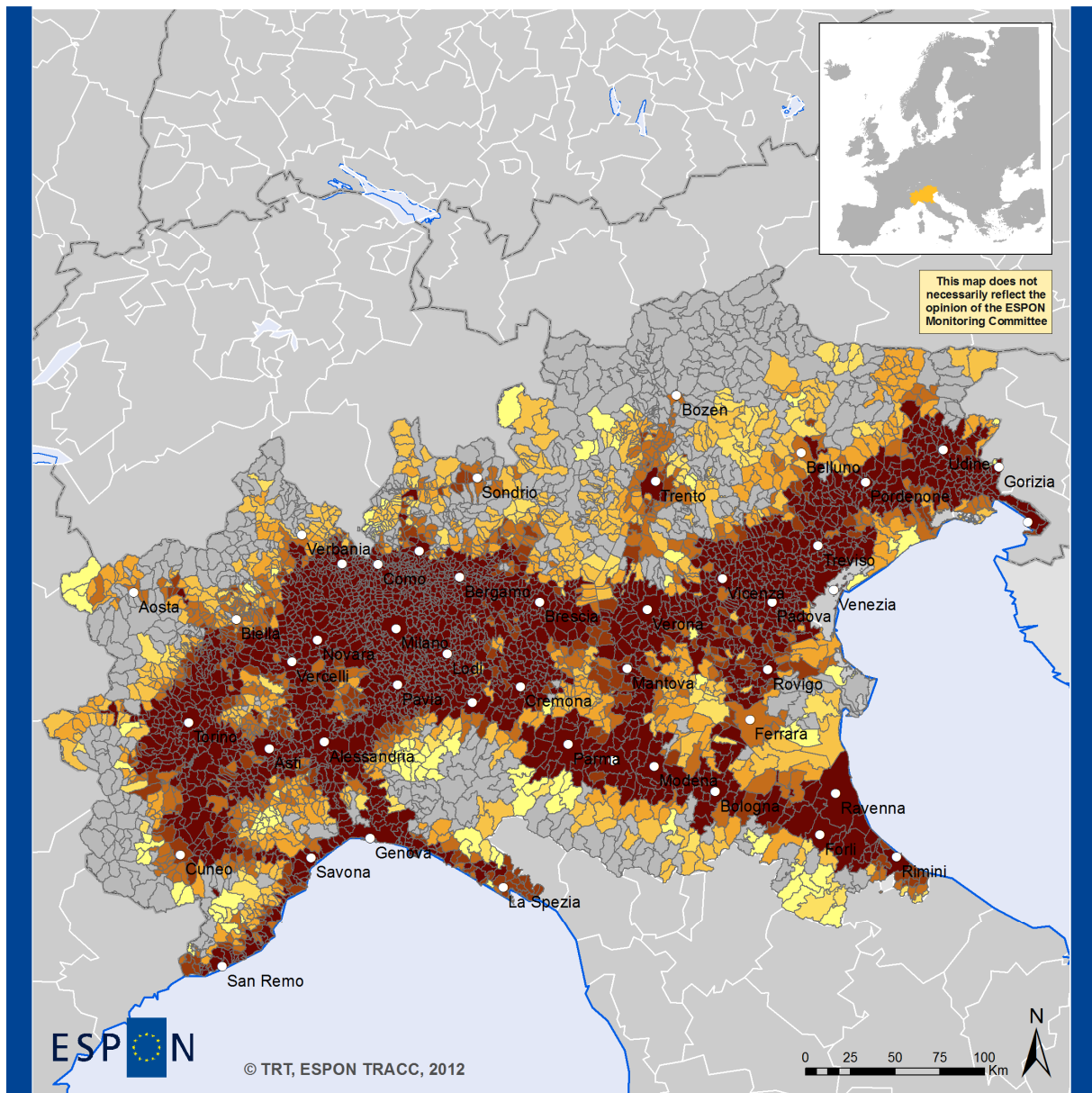
Figure 21. Travel time to next hospital, cumulative distributions

3.5 Availability of higher secondary schools

In the Northern Italy region, secondary schools exist not only in the bigger cities, but also in most of the medium centres. Also considering the “enlarged city” type of urbanisation, many alternatives are available for the large part of the population. Therefore car accessibility is quite high in most of the zones (figure 22). Only 4% of the population, living in 12% of zones has no schools available within 30 minutes and just a little more can reach only one school in less than 30 minutes). Instead 87% of the population can reach 11 secondary schools or more in half an hour by car. One qualitative aspect to be considered is that secondary schools are of different kinds, offering (in part) different courses. Therefore, availability of more schools do not necessarily means availability of more schools of the same kind.

Since public transport is slower, the accessibility to secondary schools within 30 minutes is more limited than by car (figure 23). In one zone out of three, where 11% of the population live, no secondary schools can be reached in less than half an hour using train or bus. 38% of the zones and 13% of the population has just one schools available. Since in Northern Italy public transport is a major mode of transport for students of secondary schools, this measure of accessibility is probably more representative than car accessibility. Anyway 60% of the population can access at least 11 secondary schools within 30 minutes travelling by public transport.

Considering the accessibility to higher secondary schools it is worth to note that urban zones are less homogenous than they are for other accessibility indicators. Especially looking at car accessibility, the distribution of urban zones spreads over a large interval of values (figure 24). In other words, while for other indicators the equivalence “living in an urban area = accessibility much better than the average) is very robust, in this case the situation is different. It depends on the specific urban zone. However, if we look at the amount of population living in the urban zones, the picture is different. The cumulated distribution of population of urban areas according to the public transport accessibility to higher secondary school looks more or less the same as cumulated distribution of overall population according to car accessibility (figure 25), i.e. inhabitants of urban areas are much better positioned.



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Northern Italy Case Study (2011) Availability of secondary schools: Number of secondary schools within 30 minutes of road travel time

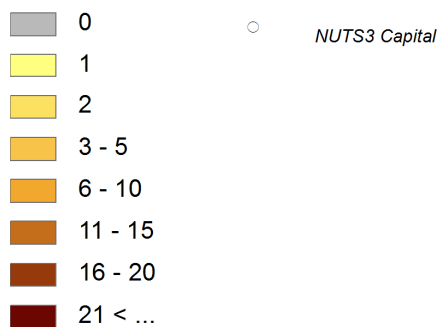
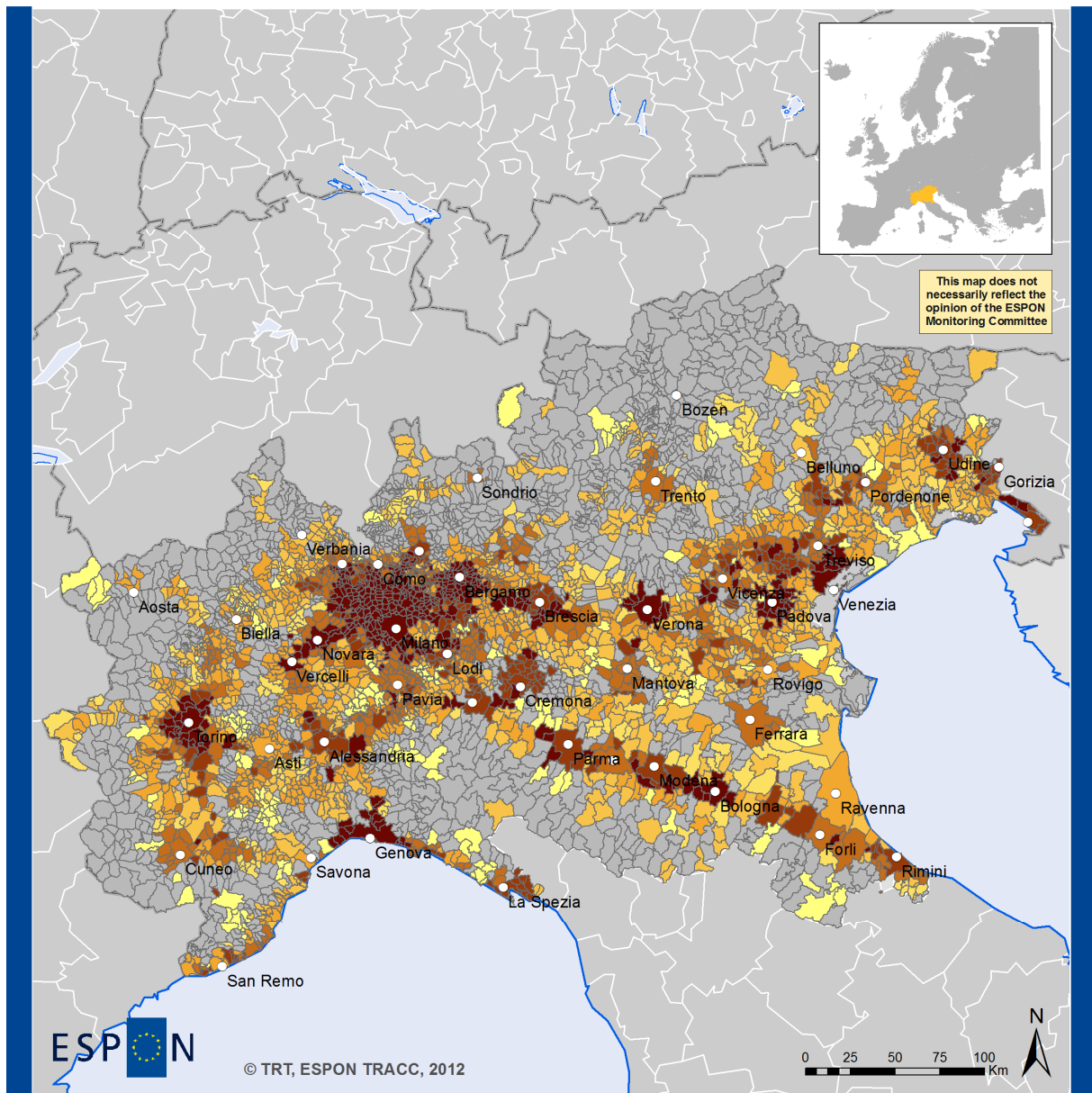


Figure 22. Higher secondary schools within 30 minutes travel time by car



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Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011), Road Network: OSM (2011), Italian Ministry of Education (2010/2011)
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Northern Italy Case Study (2011) Availability of secondary schools: Number of secondary schools within 30 minutes of public transport travel time

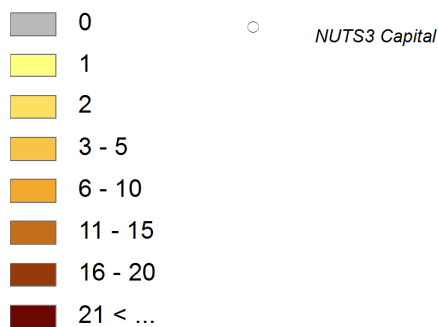


Figure 23. Higher secondary schools within 30 minutes travel time by public transport

Higher secondary schools available within 30 minutes travel time

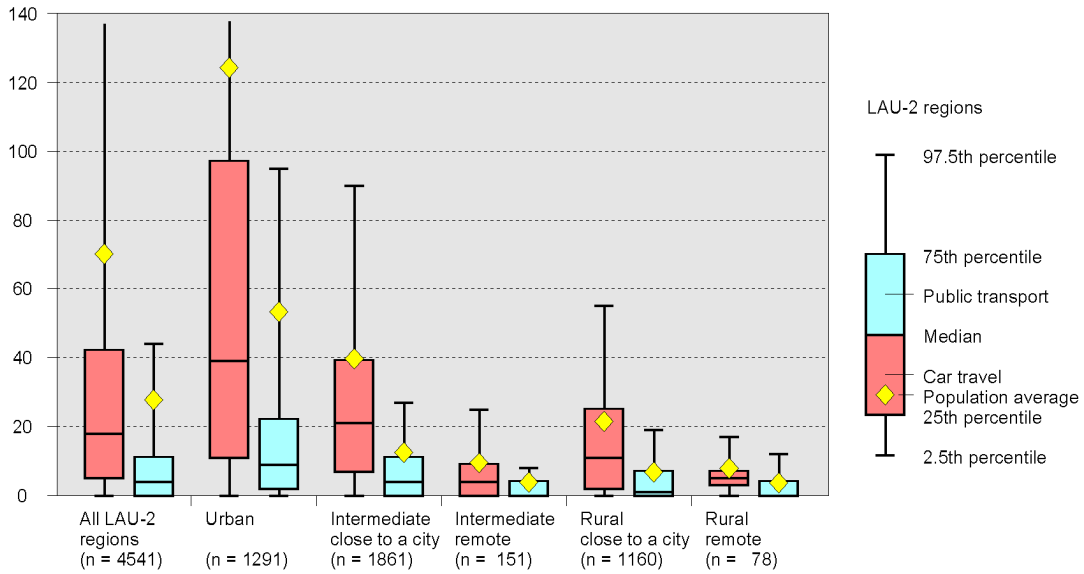


Figure 24. Higher secondary schools within 30 minutes travel time, by urban-rural typology

Population (cumulative percentage)

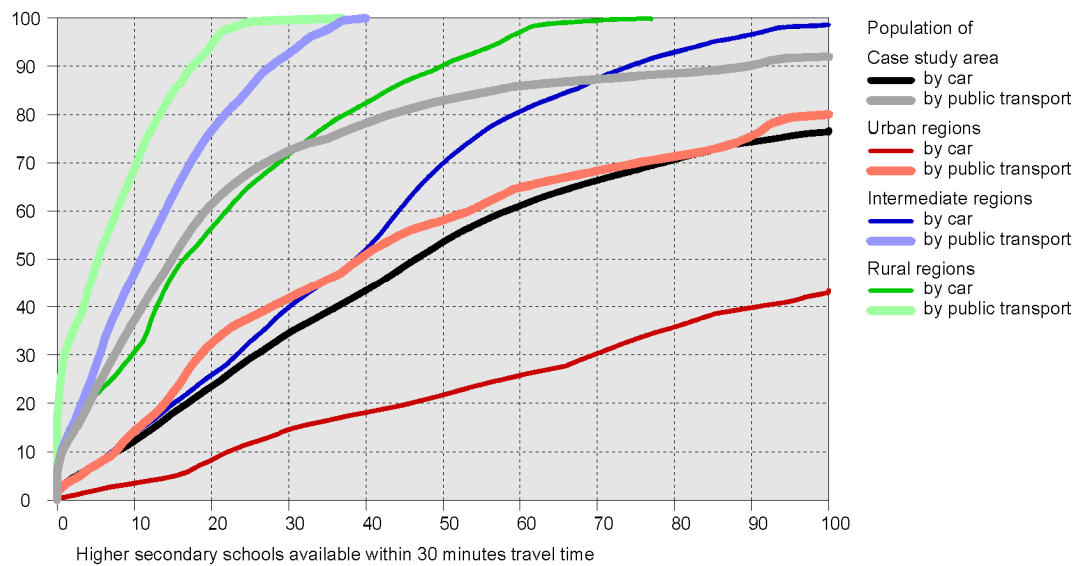


Figure 25. Higher secondary schools within 30 minutes travel time, cumulative distributions

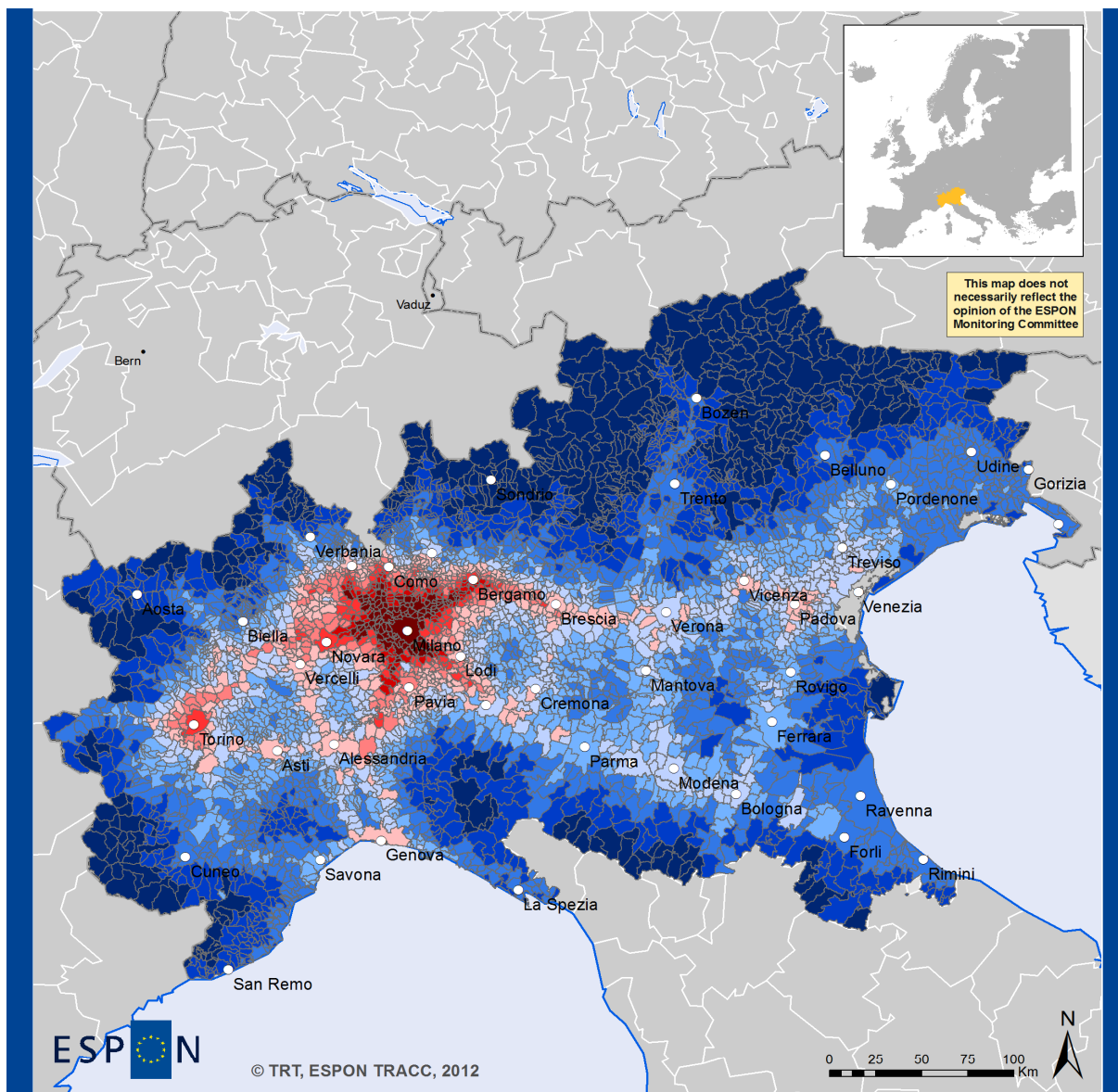
3.6 Accessibility potential to basic health care

The pattern of potential accessibility to basic health care (doctors) by car is somewhat similar to the pattern of potential accessibility to population (figure 26). The relevance of the metropolitan area of Milan and of the “enlarged city” connecting Turin to Venice is even more apparent as doctors are slightly more concentrated than population. Sparsely populated regions in the mountain areas are those where potential accessibility to basic health care is significantly lower than the average. These areas include some not so remote regions in South Tyrol valleys. Given the relevance of these zones for tourism, it is however most likely that the number of doctors is more than proportional to population (at least in the tourism seasons).

Potential accessibility to doctors by public transport is generally well below the average accessibility to doctors by car (figure 27a). Only in Milan and its surroundings, there are zones whose public transport potential accessibility is higher than the average car accessibility. Also, the profile of the “Padan megalopolis” is clearly recognisable. Outside of it, only the Genoa metropolitan area is not too far away the reference level of average accessibility. For all other zones the public transport accessibility is less than 25% or even less than 10% of the average car value.

Taking the average accessibility of public transport as reference (figure 27b), the profile of the enlarged cities remains clear whereas differences in peripheral areas emerge more evidently. While as far as car accessibility is concerned critical situations are basically confined to the most peripheral areas on mountains, the zones where public transport accessibility is below 10% of the average are more numerous, include also some municipalities not very distant from major centres and even a couple of these centres in the northern part of the area.

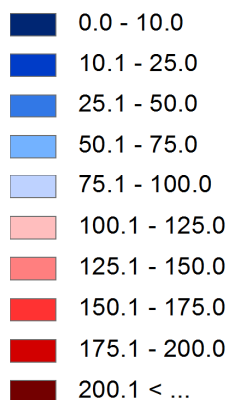
The similarity between potential accessibility to population and potential accessibility to doctors is also visible in the distribution by different zone type (figures 28 and 29). The same degree of difference between urban, intermediate and rural areas can be observed in this case.



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Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011), Road Network: OSM (2011), Italian Statistical Office (ISTAT)- Doctors (2008)
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Northern Italy Case Study (2011) Potential accessibility to basic health care for road ($\beta=0.046210$) (standardised on road average)



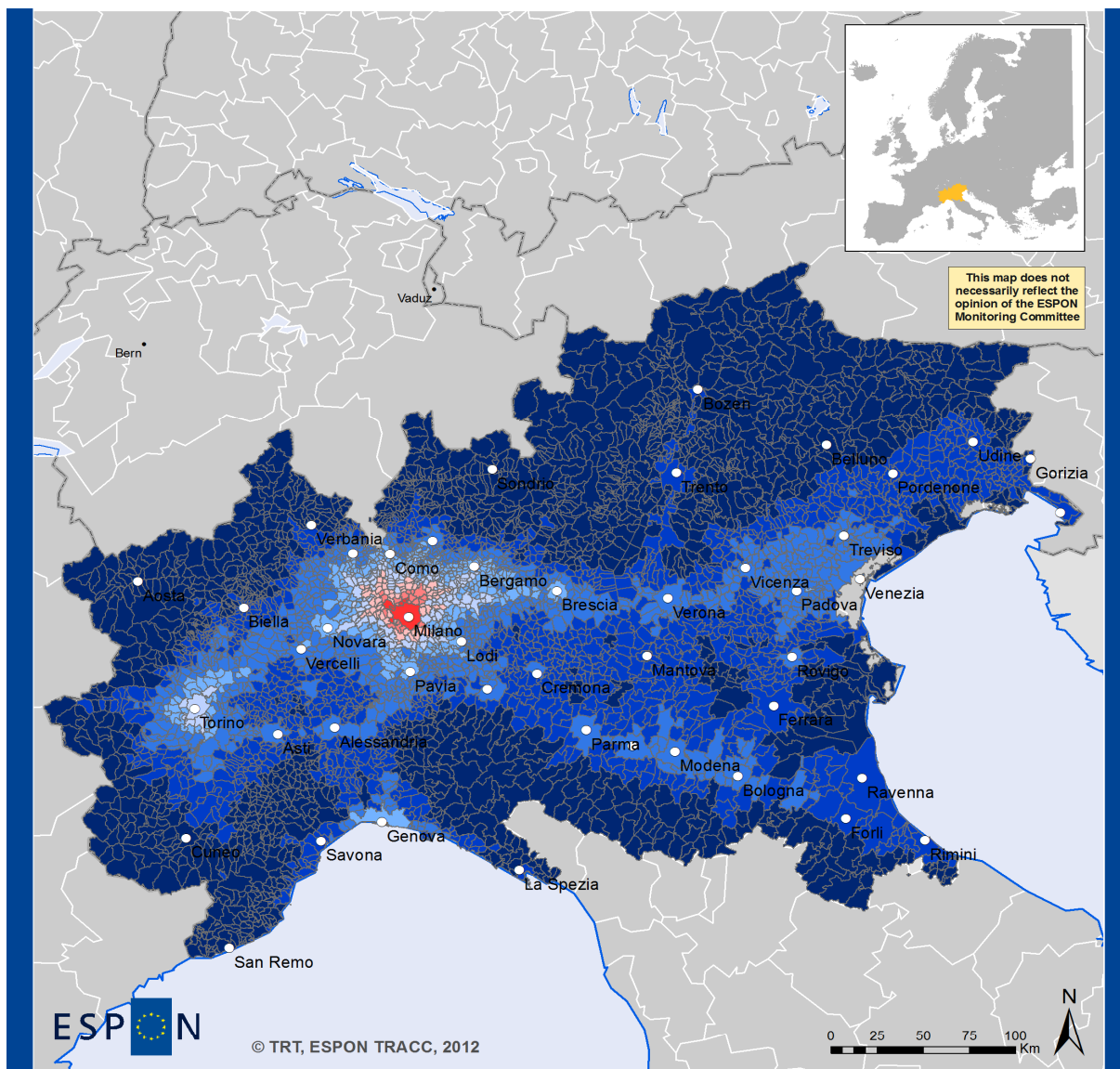
○ NUTS3 Capital

100 (population weighted average) = 787

Minimum: 5

Maximum: 2 374

Figure 26. Potential accessibility to medical doctors by car



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Northern Italy Case Study (2011) Potential accessibility to basic health care for public transport ($\beta=0.046210$) (standardised on road average)

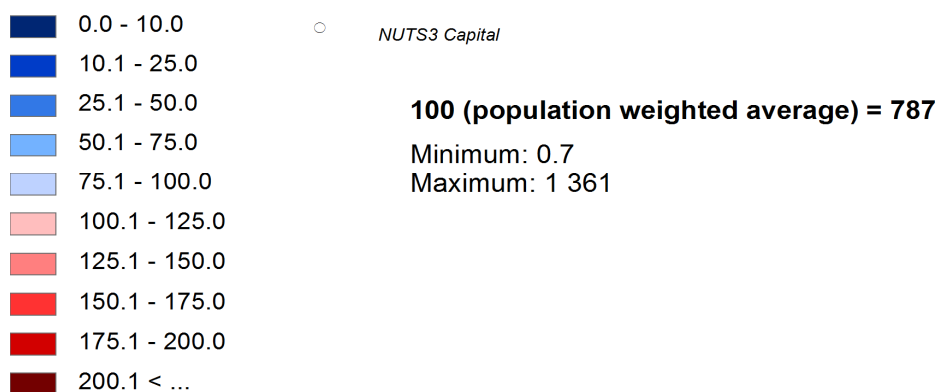
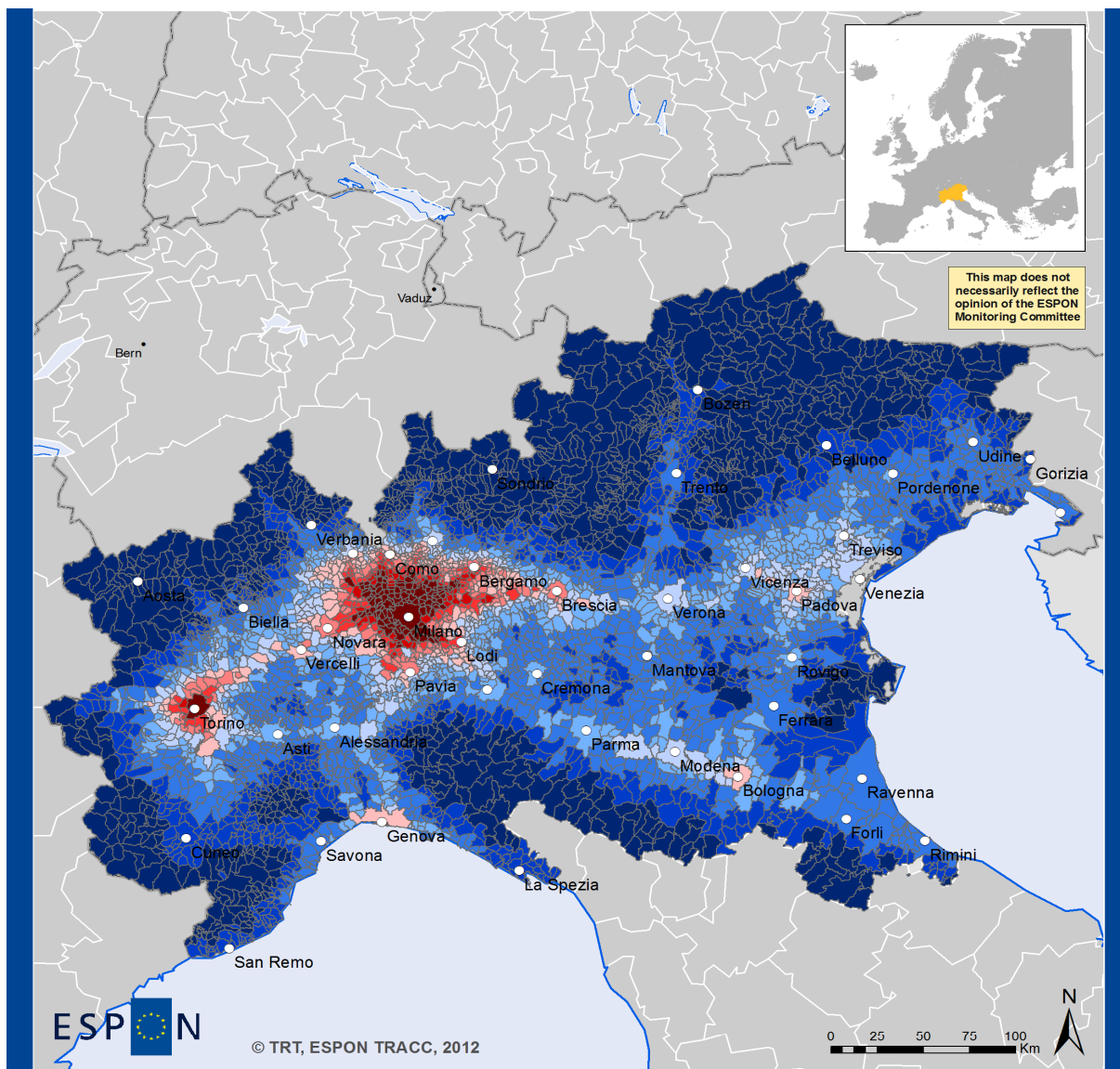


Figure 27a. Potential accessibility to medical doctors by public transport (standardised on road average)



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Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011), Road Network: OSM (2011), Italian Statistical Office (ISTAT)- Doctors (2008)
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Northern Italy Case Study (2011) Potential accessibility to basic health care for public transport ($\beta=0.046210$) (standardised on public transport average)

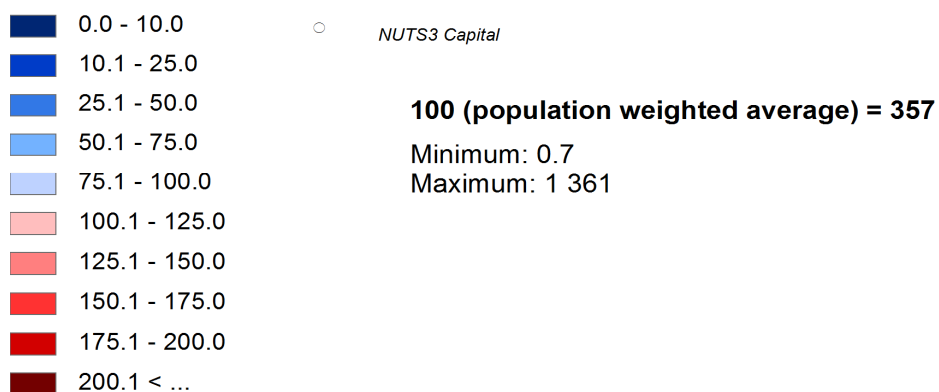


Figure 27b. Potential accessibility to medical doctors by public transport (standardised on public transport average)

Potential accessibility to medical doctors (car average = 100)

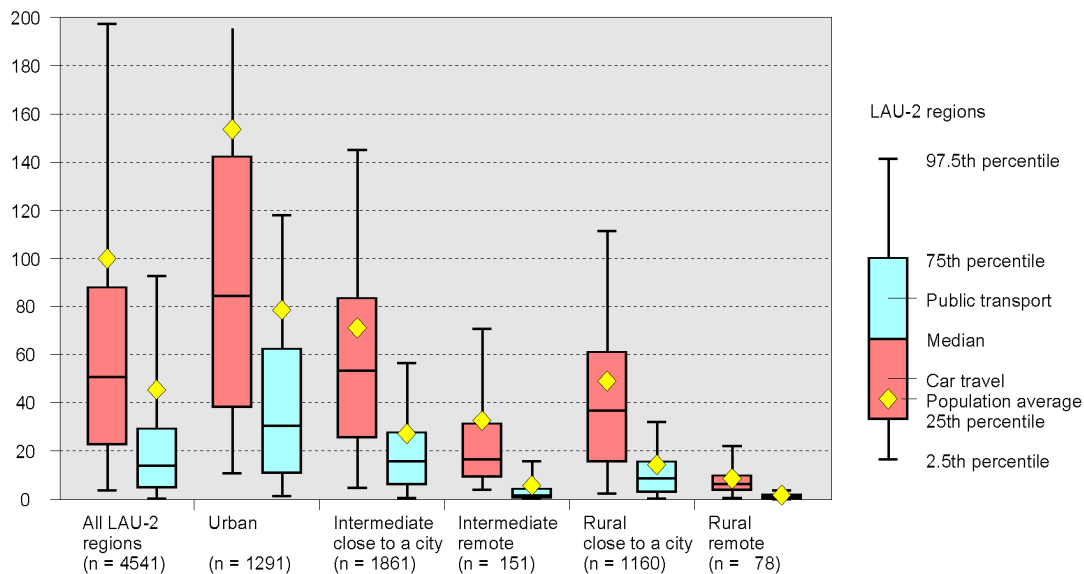


Figure 28. Potential accessibility to medical doctors, by urban-rural typology

Population (cumulative percentage)

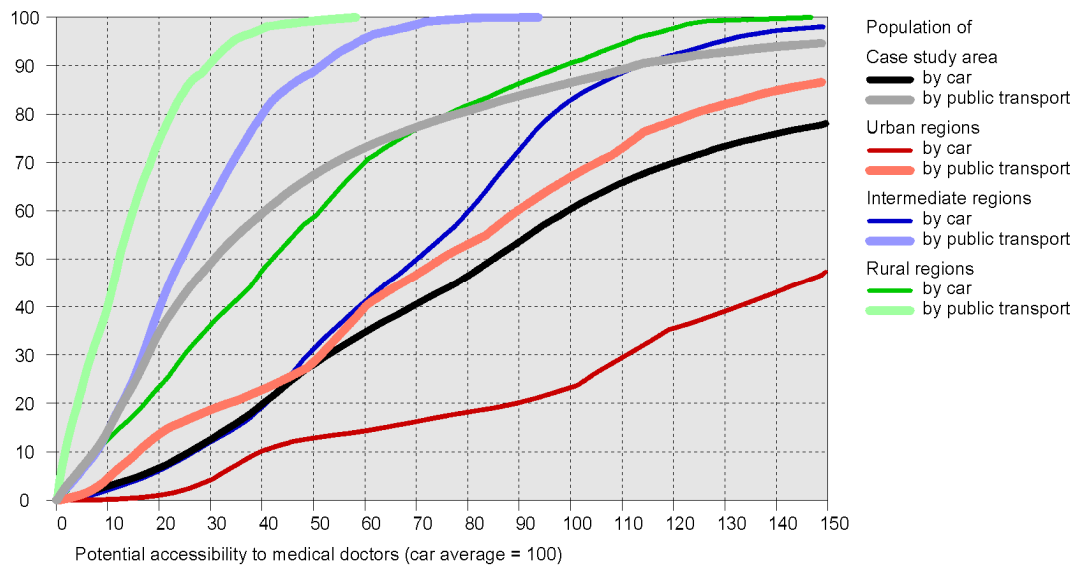


Figure 29. Potential accessibility to medical doctors, cumulative distributions

4 Accessibility situation at different regional subtypes

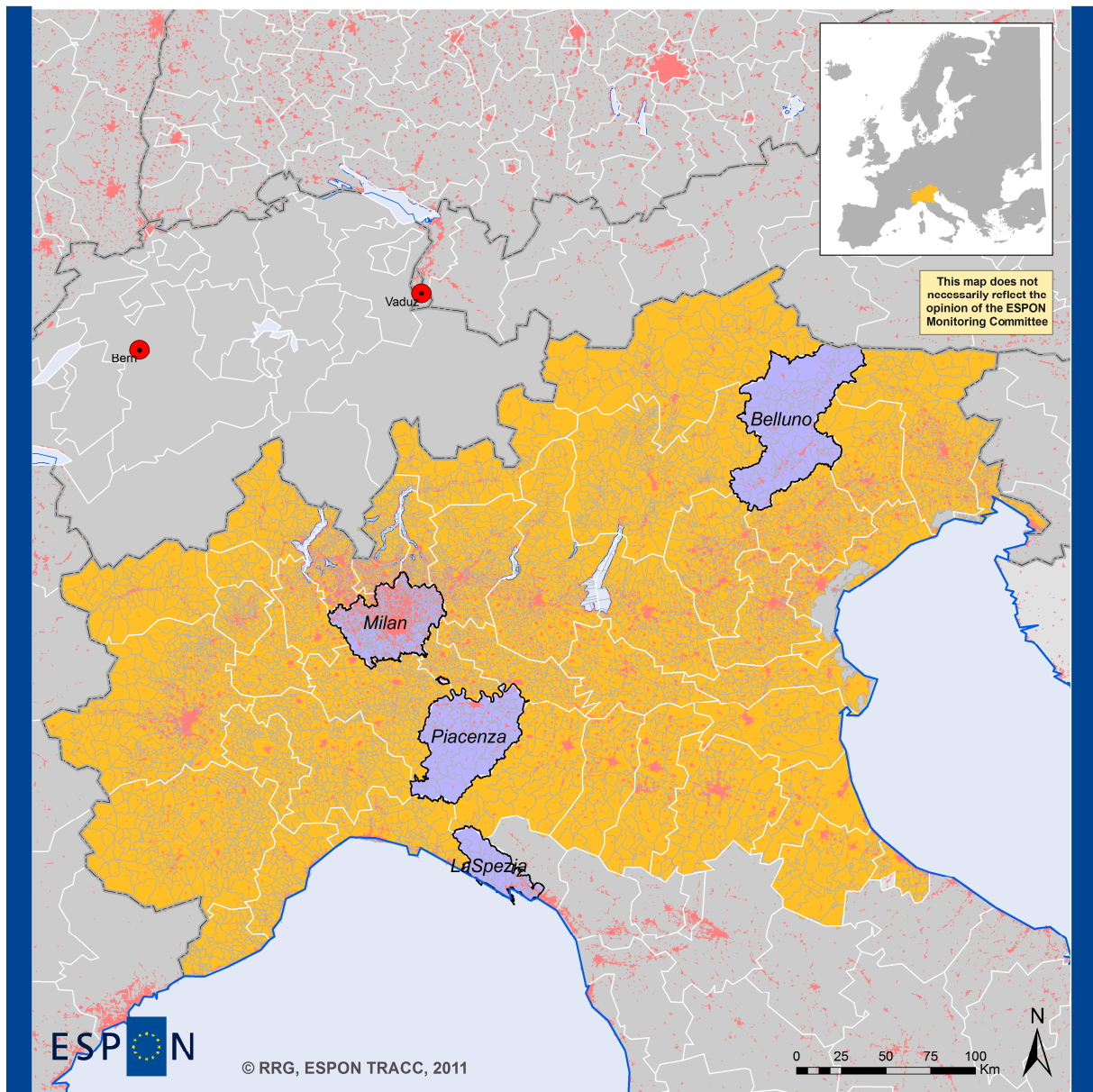
Within the macro region, four areas have been identified as relevant examples of different zone types and will receive special attention in the analysis:

The Milan metropolitan area is the major centre of the macro-region, covering a surface of about 2,000 km², with a population of about 3,900,000 inhabitants. Milan is in middle of the macro region and it is the hub of regional rail services as well as of motorways, national and regional roads. Its accessibility is therefore very high if not for problems of congestion.

The Piacenza Province is placed on the North-south corridor linking the city of Milan with the rest of the Peninsula (Florence, Rome, Naples, etc.). It has about 288,000 inhabitants living on a total area of 2,589 km². Most of the area is flat, but its south-west part include some mountains, Piacenza Province is an example of an area with good transport infrastructures (and other planned) with an internal mobility but also generating mobility towards main centres like Milan and Bologna.

The Province of La Spezia is one of the four provinces of Liguria Region, with an area of about 881 km², and a total population of 223,503 inhabitants. Given its position, with sea on the one side and mountains on the other, La Spezia connections are channelled through the coast and a limited number of passes. Thus its level of accessibility is low if compared to other provinces. A new rail track for national services could make available capacity for local rail services in the future.

Belluno province is a mountain area of 3.700 km², populated by 214,000 inhabitants but attracting thousands of tourist especially in the winter season. This area is not crossed by any motorway or trunk rail line. Motorway A27 and a local railway provides connections to south, while most direct links to north, east and west are provided by national roads crossing mountain passes allowing only limited speeds and capacity.




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Origin of data: ESPON Databank Project, 2010/2011
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Northern Italy Case Study Macro region and zoom-in regions

- Macro-region: municipalities
- Zoom-in regions
- Capital city
- Settlement area
- NUTS-3 region boundary

Figure 30. Zoom-in regions

Since all the zoom-in regions include at least one regional centre, the differences among them in terms of travel time to the next regional centres are not huge (figure 31). Of course the metropolitan area of Milan is much more homogeneously distributed than other zoom-in regions, while the wider distribution belongs to Belluno. Looking at the cumulated distribution of population (figure 32) the lower level of accessibility in Belluno is more evident as a significant share of population in this area is more distant to the next regional centre using car than the average inhabitant of the whole study area moving by public transport. It can also be noted that the distribution of population living in La Spezia is not so different from that of the population living in the Milan metropolitan area.

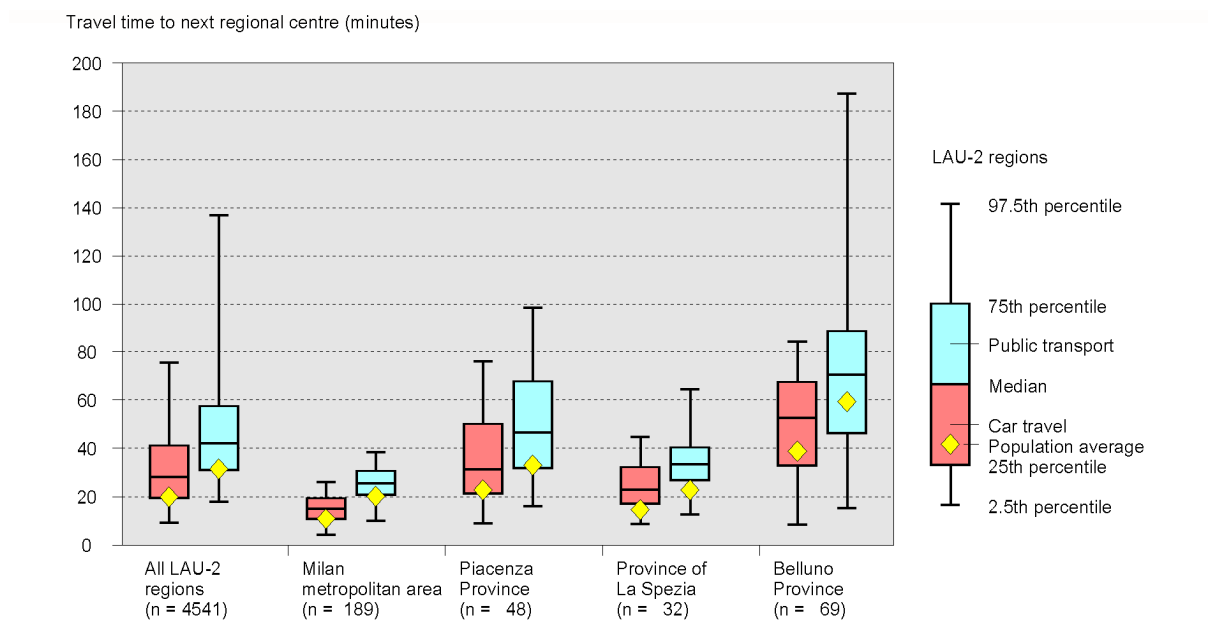


Figure 31. Travel time to next regional centre, by zoom-in region

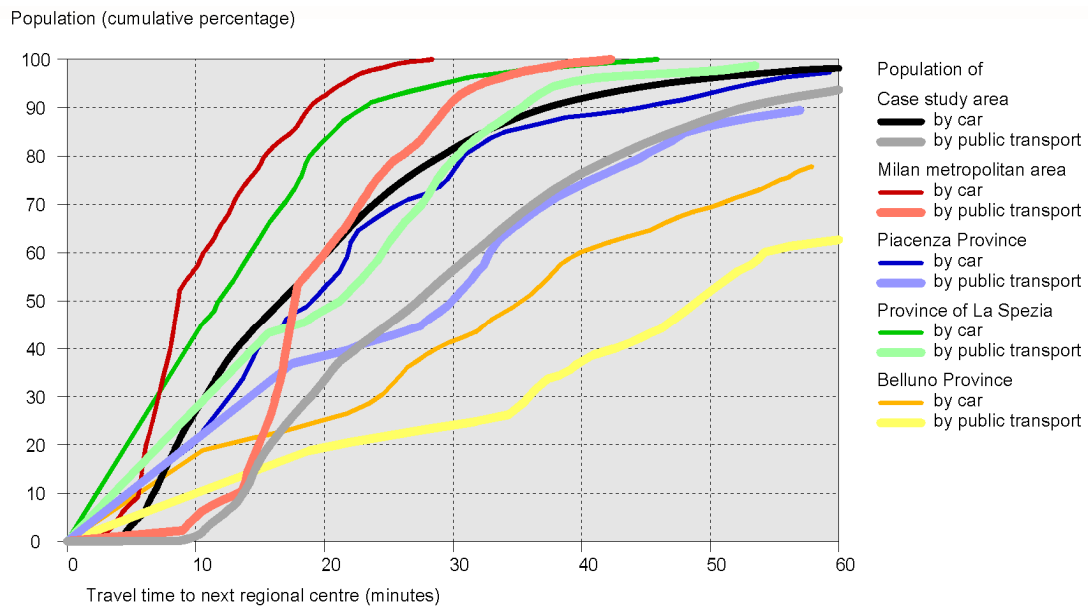


Figure 32. Travel time to next regional centre, cumulative distributions by zoom-in region

If in terms of closeness to regional centres the zoom-in regions are not so diverse to each other, when looking at availability of jobs the story is different. The Milan metropolitan area is basically incomparable to the other zones (figure 33). Remarkably, the La Spezia zone, which was considered comparable to Milan for its distance to the next regional centre is much more similar to Belluno regarding accessibility to jobs. This circumstance suggests that the regional centres, which have especially an administrative role, do not necessarily offer many jobs opportunities. In other words, regional centres are different to each other and being close to one does not imply being close to many economic activities. Piacenza is also remarkable, especially looking at the cumulated population distributions (figure 34). While in terms of car accessibility the profile of distribution is more similar to Milan's one, in terms of public transport accessibility the profile looks like that of Belluno and La Spezia.

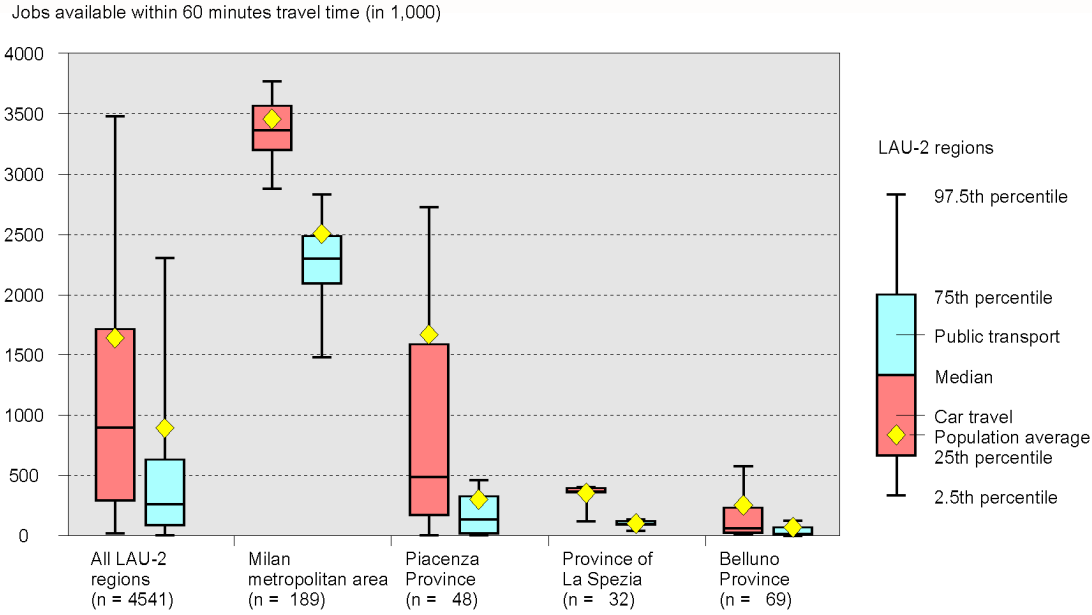


Figure 33. Jobs accessible within 60 minutes, by zoom-in region

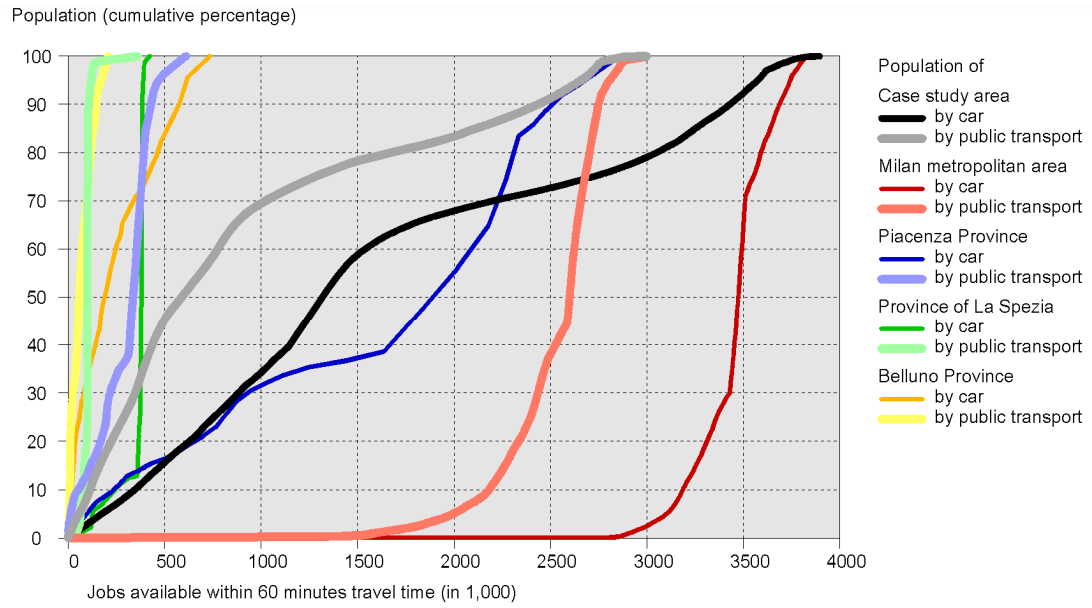


Figure 34. Jobs accessible within 60 minutes, cumulative distributions by zoom-in region

The comments made above about jobs accessibility holds also for potential accessibility to population even if differences are lower (figures 35 and 36). Milan metropolitan area is still much better than the average and La Spezia and Belluno are worse, with Piacenza somewhat comparable to Milan if car accessibility is considered but definitely not comparable in terms of public transport accessibility. It seems therefore confirmed that, among the zoom-in regions, Piacenza shows the largest gap between car and public transport performance.

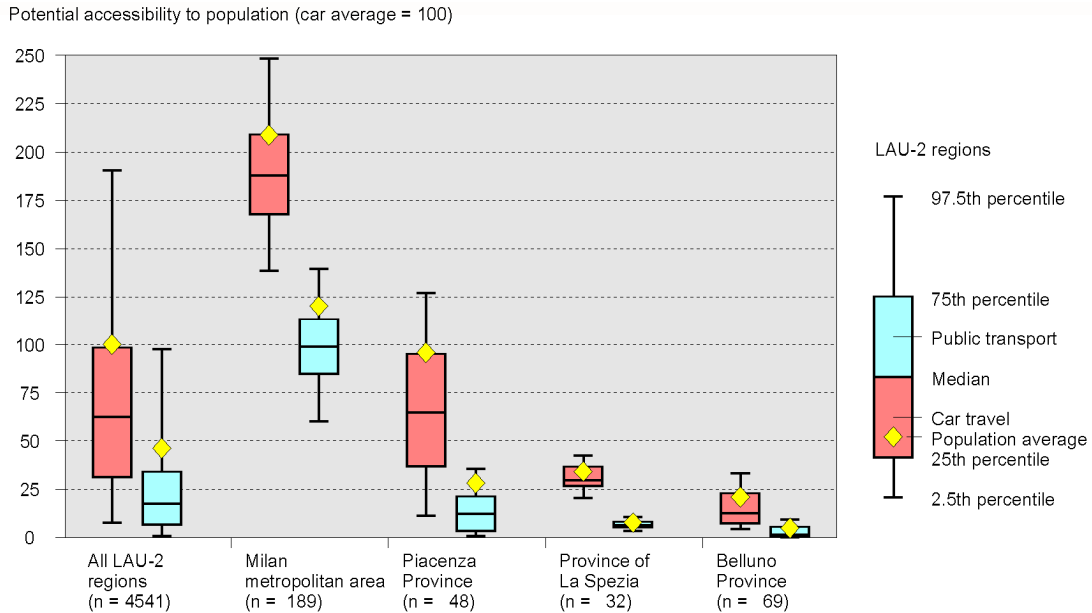


Figure 35. Potential accessibility to population, by zoom-in region

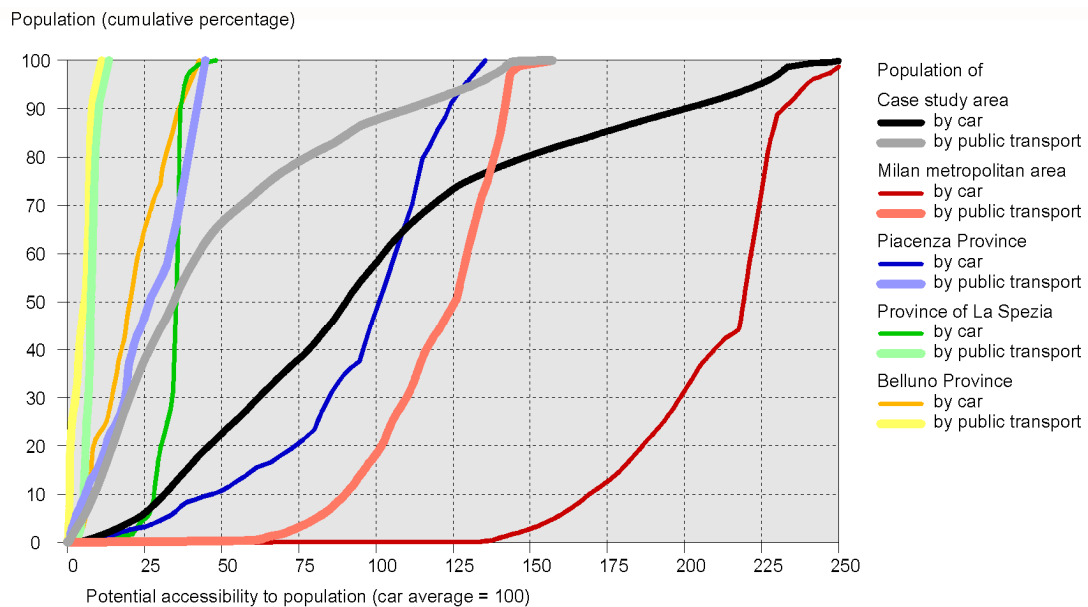


Figure 36. Potential accessibility to population, cumulative distributions by zoom-in region

Since we observed above that accessibility to hospitals is relatively even across the whole study area, it is not surprising that also the differences between the zoom-in regions are limited (figures 37 and 38). According to this indicator La Spezia is again close to Milan, like for accessibility to the next regional centre. This coincidence is by no means accidental of course. Both indicators are based on the closest destination (regional centre or hospital). When we looked to other indicators based on accessibility to a wider range of destinations, the picture was radically different. This suggests a stylized interpretation like this: until La Spezia province inhabitants can cater for their needs within the province itself they enjoy a good level of accessibility, but as soon as they need to move farther they run across accessibility problems.

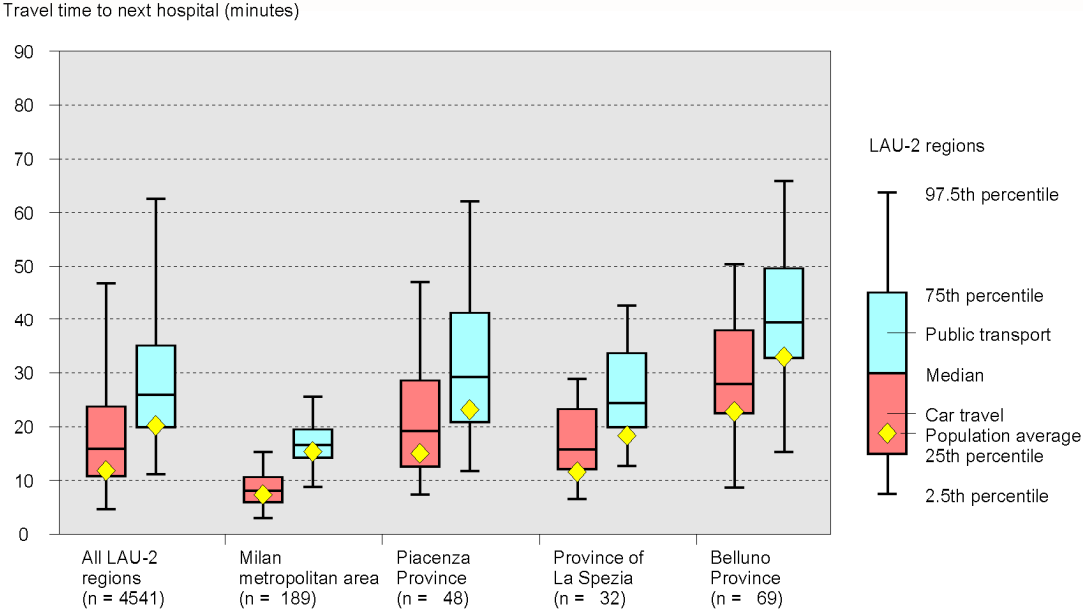


Figure 37. Travel time to next hospital, by zoom-in region

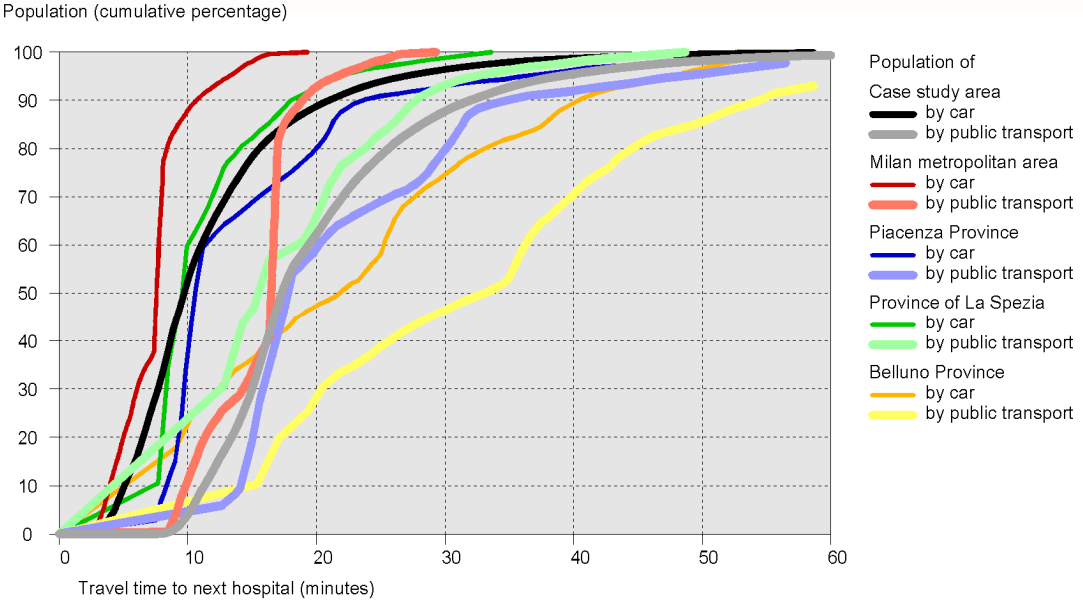


Figure 38. Travel time to next hospital, cumulative distributions by zoom-in region

It is remarkable that even in Milan, the number of secondary schools available within 30 minutes using public transport is drastically lower than the number of secondary schools available within 30 minutes using car (figure 39). The former is still quite high, so it is fair to say that in the metropolitan area of Milan there is a large choice of secondary schools also using public transport (as many students do in Northern Italy). However, the availability of a lift by car (or, often more realistically, the availability of motorcycles) drastically increases the possibility to choose. In the other zoom-in regions, while Belluno confirms to be comparatively disadvantaged, the situation of La Spezia observed through the cumulated distribution of population (figure 40) confirms what has been already observed. The distribution for La Spezia is initially quite flat, to show, then it becomes very steep. La Spezia is like and “isle”: when the resources in it are finished, reaching other facilities is complex.

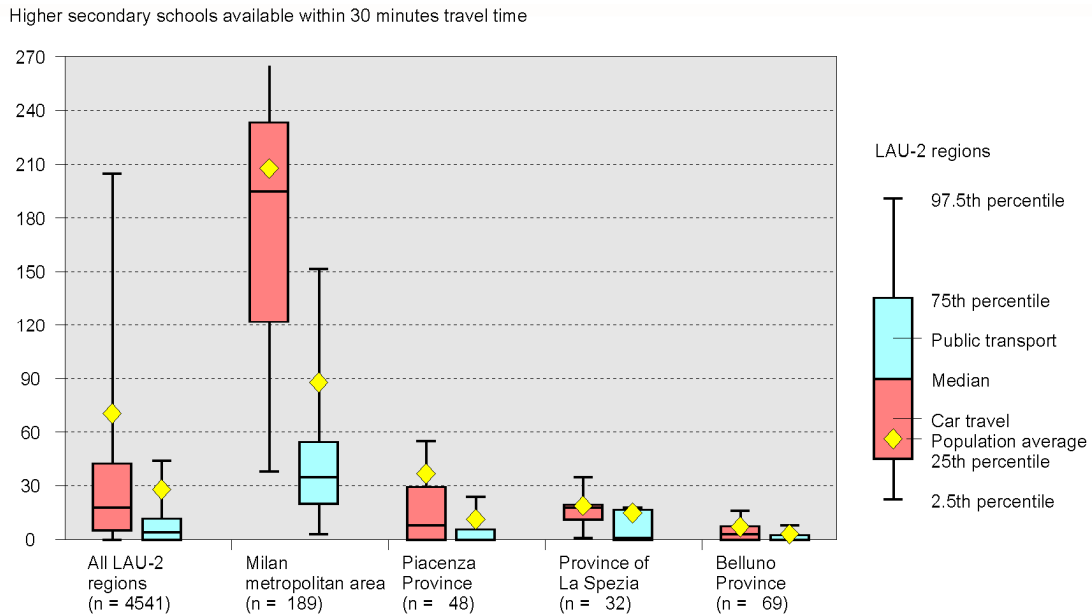


Figure 39. Higher secondary schools within 30 minutes travel time, by zoom-in region

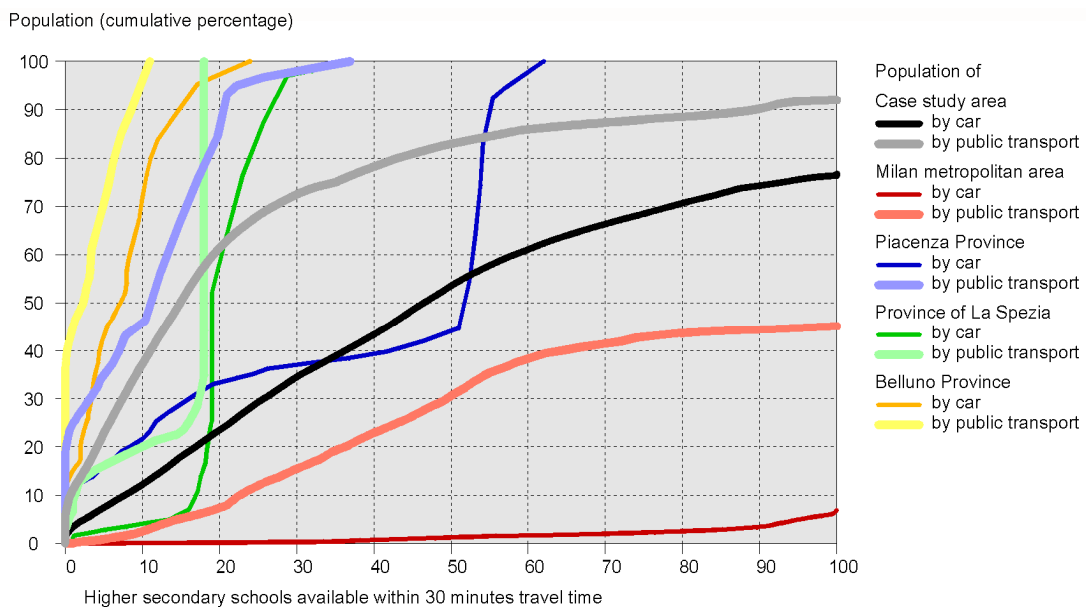


Figure 40. Higher secondary schools within 30 minutes travel time, cumulative distributions by zoom-in region

The potential accessibility to medical doctors is once more incomparably better in the Milan metropolitan area than in the other zoom-in regions (and in the whole study area). It is interesting that the median of the distribution of LAU-2s in the Milan zone according to public transport accessibility is higher than the 75th percentile of the distribution of all LAU-2 regions according to car accessibility (figure 41). It is also confirmed that Piacenza shows the largest difference between accessibility by car and by public transport (figure 42).

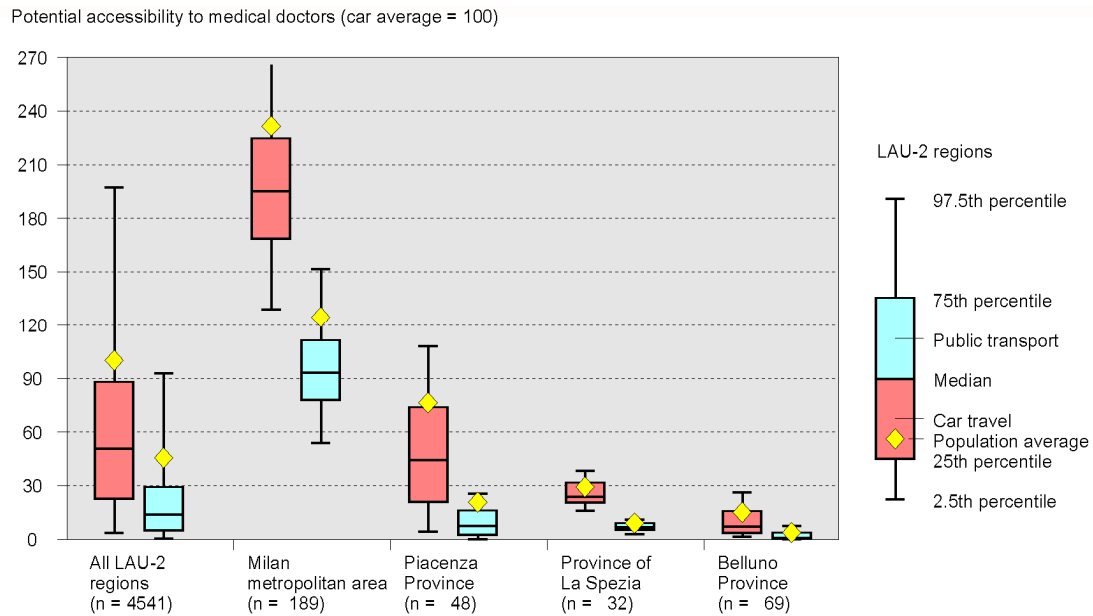


Figure 41. Potential accessibility to medical doctors, by zoom-in region

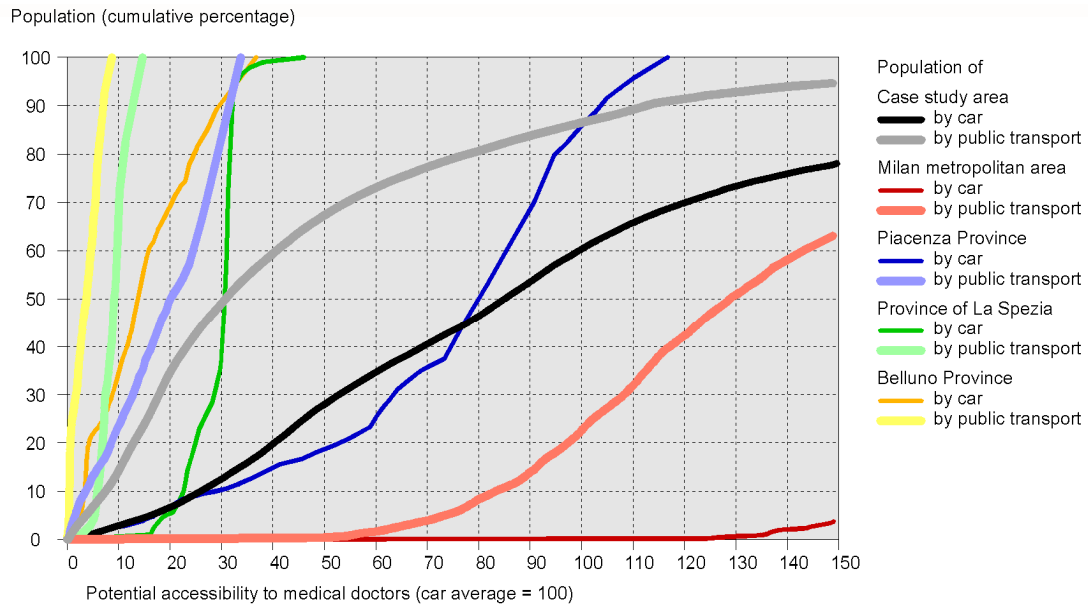


Figure 42. Potential accessibility to medical doctors, cumulative distributions by zoom-in region

To make a summary, compared to the average values of the accessibility indicators for the whole case study, the zoom-in regions present different conditions (tables 1 and 2). The Milan province is always much better than the average. Its ratio with respect to the study area average is significantly below 100 for those indicators - Accessibility to regional centres and Accessibility to hospitals – whose low values correspond to a good accessibility and it is well above 100 for those indicators whose value is larger as the accessibility is better. As discussed also in the comments to the maps, Milan and its province is at the top of the accessibility level in the study area.

Piacenza province is a good embodiment of the average accessibility conditions, especially concerning car accessibility. The exception is the accessibility to secondary school: here Piacenza is not as good as the average. It is remarkable the drop in the relative level of accessibility to jobs when public transport is considered instead of car. This drop is much larger than for the other two peripheral zoom-in regions (La Spezia e Belluno). Looking at this indicator, the accessibility of the Piacenza province to the economic activity of Northern Italy is better than other zoom-in regions but is particularly dependent on car.

La Spezia is a good example of a peripheral area which has a reasonable local connectivity, but rather poor accessibility to functions which are more widespread. Despite below the average, the indicators of accessibility to regional centres, hospitals and medical doctors are good (only accessibility to secondary schools is low especially by car). Instead accessibility to jobs and population is quite limited. Therefore, La Spezia is much more dependent on the local conditions than e.g. Piacenza. A worsening of the economic performance or of the level of services provided would affect population significantly more, because alternatives would be difficult to reach.

Finally, Belluno is fully a peripheral area with limited accessibility from any point of view. For all indicators it scores well below the average values. There is basically no difference if car accessibility or public transport accessibility is considered. This does not mean that accessibility by public transport is as good as car accessibility in this province (the former is worse than the latter as in all other provinces) but that car accessibility is already quite limited.

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

Area	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
	Minutes	Index	In 1,000	Index	Index	Minutes	Index	Number	Index	Index
Milano	10.9	55	3,456	211	209	7.4	62	208	295	232
Piacenza	22.8	114	1,666	102	96	15.0	127	37	52	76
La Spezia	14.7	74	351	21	34	11.6	98	19	27	29
Belluno	38.8	195	252	15	21	22.8	193	7	10	15
Case study region	19.9	100	1,637	100	100	11.8	100	70	100	100

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

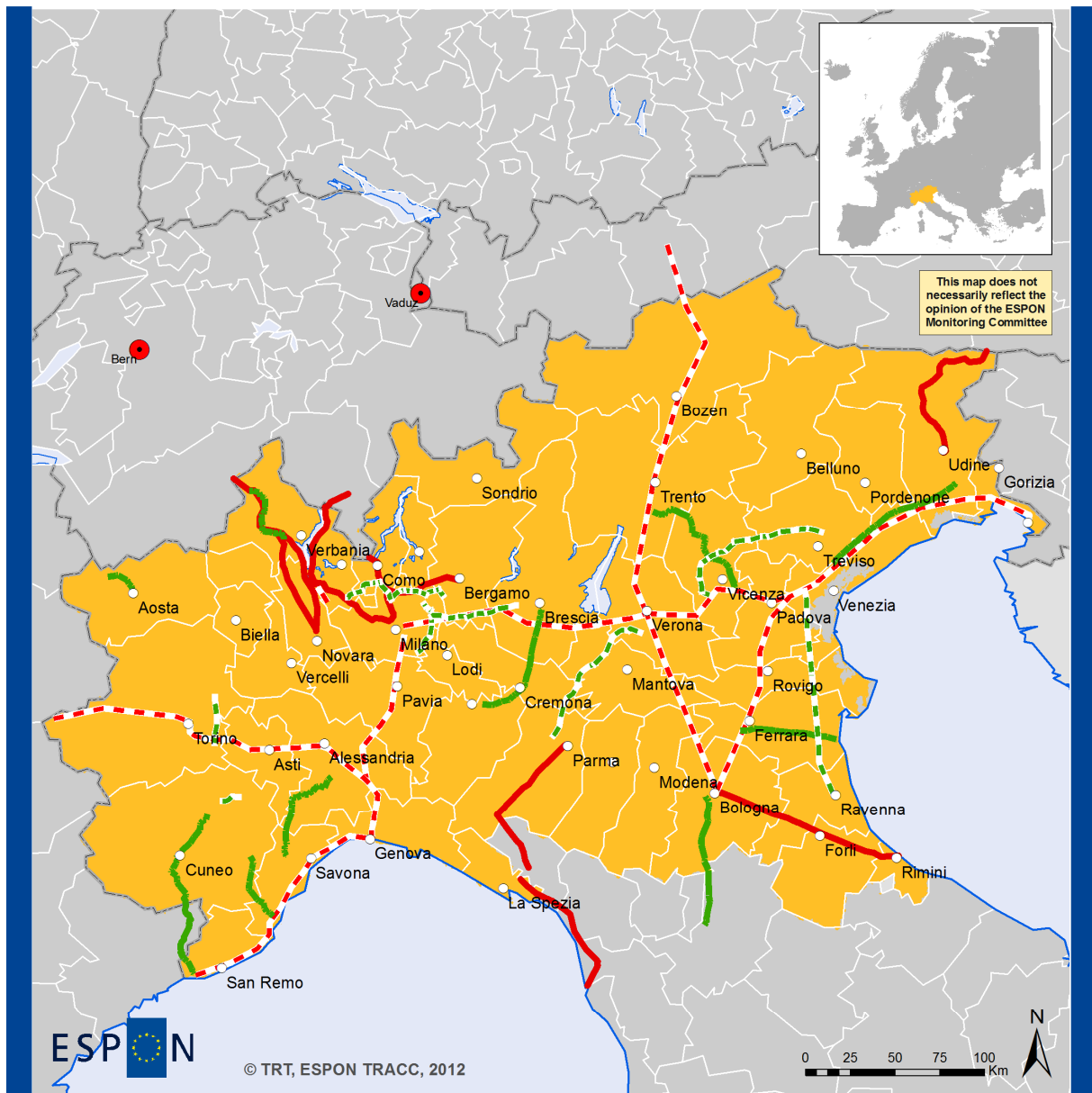
Area	Travel time to next regional centre		Jobs accessible within 60 minutes		Potential accessibility to population (on PT average)	Travel time to next hospital		Higher secondary schools within 60 minutes		Potential accessibility to medical doctors (on PT average)
	Minutes	Index	In 1,000	Index	Index	Minutes	Index	Number	Index	Index
Milano	20.1	64	2,507	282	261	15.4	76	88	314	274
Piacenza	33.0	105	297	33	61	23.1	115	11	39	46
La Spezia	22.7	72	100	11	17	18.3	91	15	54	20
Belluno	59.3	189	67	8	11	33.0	164	3	11	8
Case study region	31.4	100	890	100	100	20.2	100	28	100	100

5 Accessibility effects of future TEN-T developments

The major TEN-T project envisaged in the case study area are rail projects (figure 43). Namely, the new connection between Turin and Lyon, including the new Frejus tunnel, and the new Brenner tunnel are both large rail projects aimed at significantly increase the capacity of rail transport. In both cases, however, the projects are more relevant for long distance international traffic (and especially freight traffic) than for mobility within the Northern-Italy region. The completion of the high speed rail connections on the west-east axis, from Milan to Trieste – also part of the Lisbon-Kiev corridor – is instead expected to improve rail connections also for regional demand (also making available more capacity for local trains on the current tracks). The same holds for the high speed rail connection between Milan and Genoa and especially for the upgrades of existing links.

Comparatively, TEN-T road projects are more limited. The main project is probably the “New Romea” crossing Romagna in the southern-east part of the study area. This project is aimed at alleviating the significant congestion affecting the current state road “Romea”, also because of the freight traffic generated by the Ravenna and Ferrara ports. Other two significant projects are the “Pedemontana Lombarda” and the “Pedemontana Veneta” motorways providing alternative west-east connections for the densely populated areas north of Milan and north of Venice. Since many years the availability of a fast connection to move from east to west and vice-versa has been a request of local communities as well as economic activities.

The main impacts expected as result of the implementation of the TENs on the accessibility in the Northern Italy study area are shown in the following figures using the potential accessibility to population as reference indicator. The overall picture of car potential accessibility is not significantly changed (compare figure 44 to figure 14). This means that new road projects are not expected to alter the potential accessibility pattern in the study area. Despite they can improve accessibility locally (see figures 46 and 48), the benefits are either not as large as required to reduce the accessibility gap with respect to the most accessible zones or go to zones which are already above the average. The former case applies for instance to the impact of “new Romea”, in the south-east side of the study area, while the latter circumstance holds for the “Pedemontana Veneta”.



Northern Italy Case Study Road and rail infrastructure projects

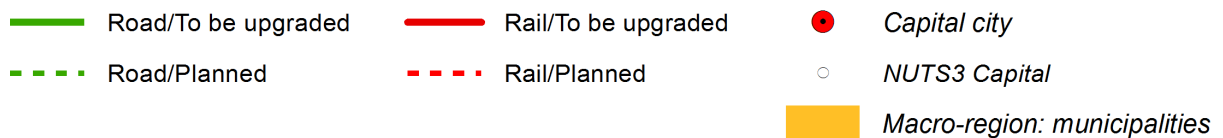
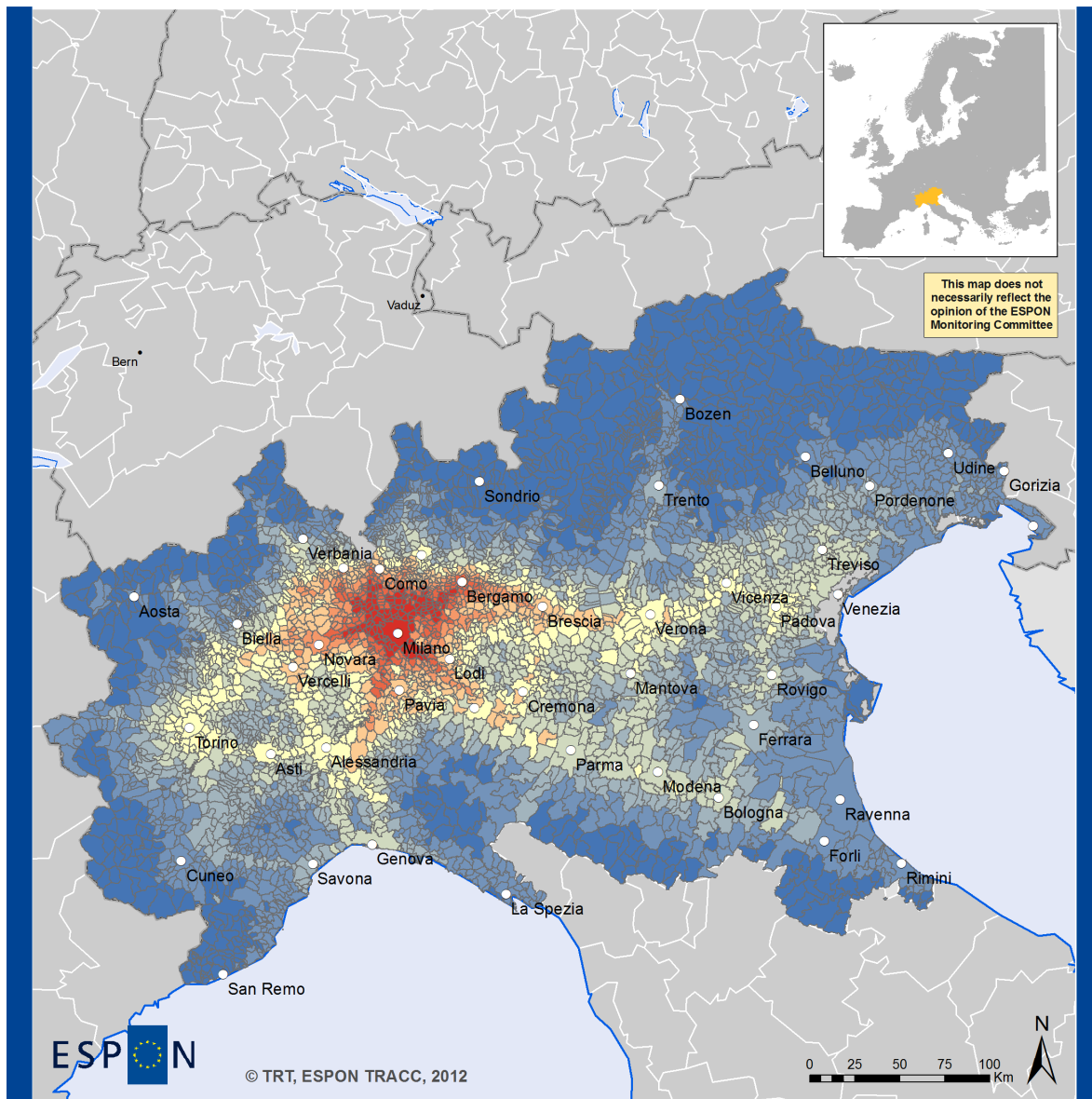


Figure 43. TEN-T road and rail infrastructure projects

Also looking at the map of potential accessibility by public transport after the implementation of TENs differences with respect to the base year are not easy to detect (compare figure 45 to figure 15b). Improvements can be noted in some spots like Bologna or Genoa, but in general the pattern is unchanged. Looking especially at relative differences (figure 47) one can see clear advantages for the Brenner axis, for the Liguria region and for other zones in the north-west and south-east of the study area, where rail improvements are concentrated (instead the new Frejus tunnel towards Lyon is basically irrelevant for the regional accessibility). Increased potential accessibility in the same areas are also visible in absolute terms (figure 49) but the increments do not bring the benefited zones up to the same level of core zones.

In summary, the modelling exercise suggest that the planned TENs in the Northern Italy area will provide local benefit but will not change the current accessibility pattern with reference to regional mobility. A major reason for this outcome is that the potential accessibility pattern is tightly related to population distribution. New infrastructures in peripheral areas do not have a large impact, while improved connections in the core of the region which are already at the top of the accessibility rank simply do not change such a rank. Notwithstanding, two relevant specifications to this conclusions should be made. First, improved connectivity can induce some re-localisation of population and jobs, so that an indirect impact on potential accessibility could emerge in the longer run. Second, the analysis carried out in the exercise is focused on potential accessibility to the population of the area, i.e. local or regional passenger demand is concerned. If national and international demand for passenger and freight was taken into account, the outcome could be different, especially as far as high-speed rail connections are concerned.

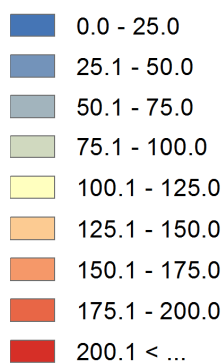


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Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011),
Road Network: OSM (2011), Italian Statistical Office (ISTAT)- Population (2006),
TEN-T outline plans (October 2011)
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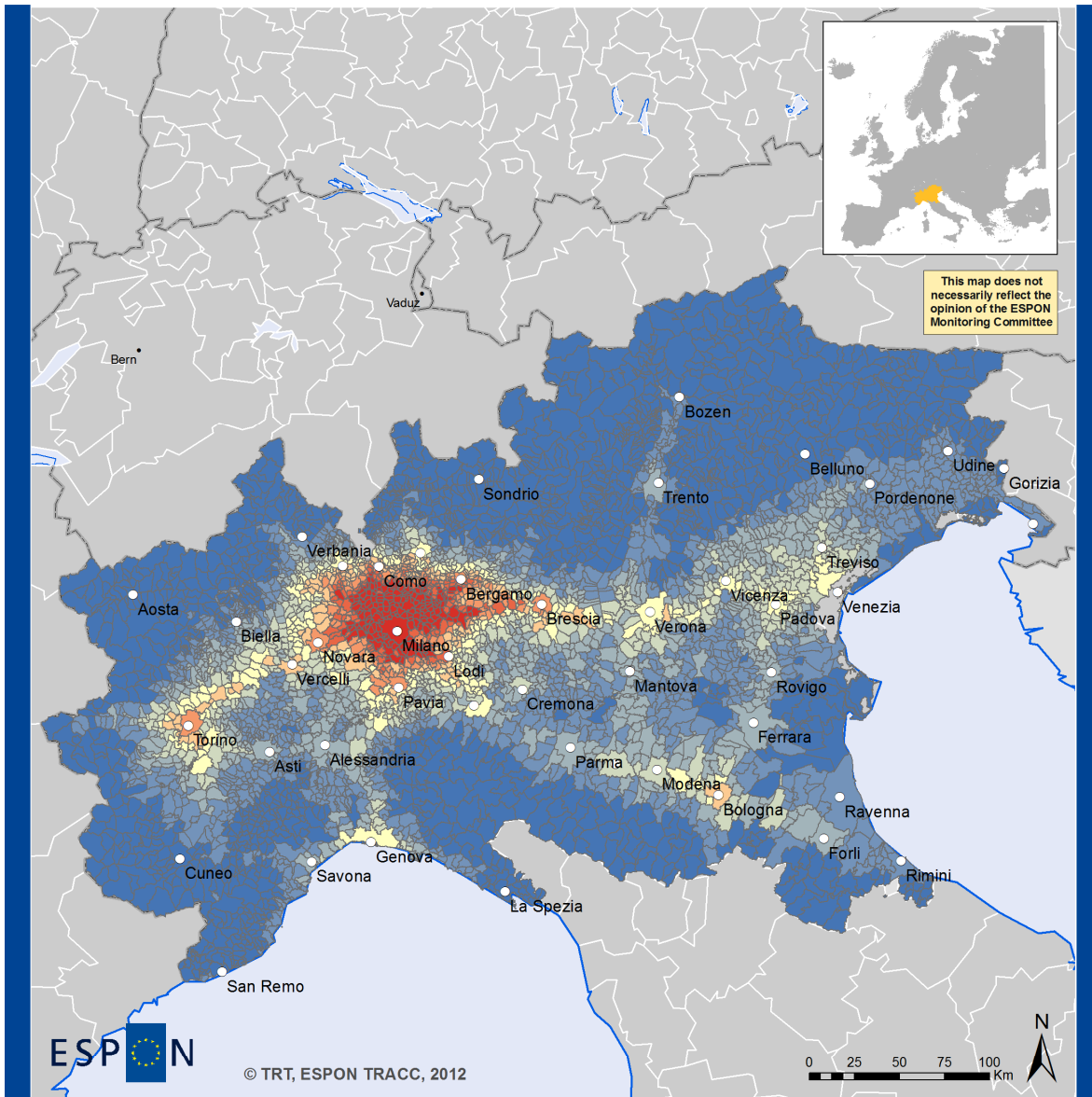
Future situation after implementation of TEN-T outline plans (2020)
Regional potential accessibility to population by road ($\beta=0.034657$)
(standardised on road average)



100 (population weighted average) = 1 703 198

Minimum: 28 881
Maximum: 4 450 869

Figure 44. Potential accessibility to population by car with TEN-T projects



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Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011),
Road Network: OSM (2011), Italian Statistical Office (ISTAT)- Population (2006),
TEN-T outline plans (October 2011)
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Future situation after implementation of TEN-T outline plans (2020)

Regional potential accessibility to population by public transport ($\beta=0.034657$) (standardised on public transport average)

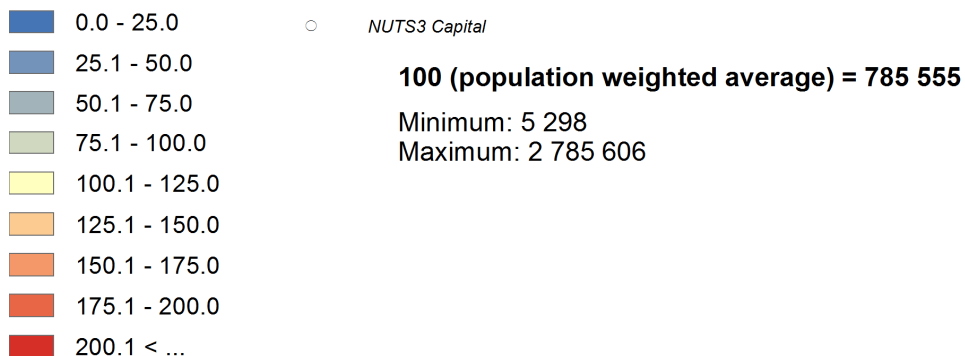
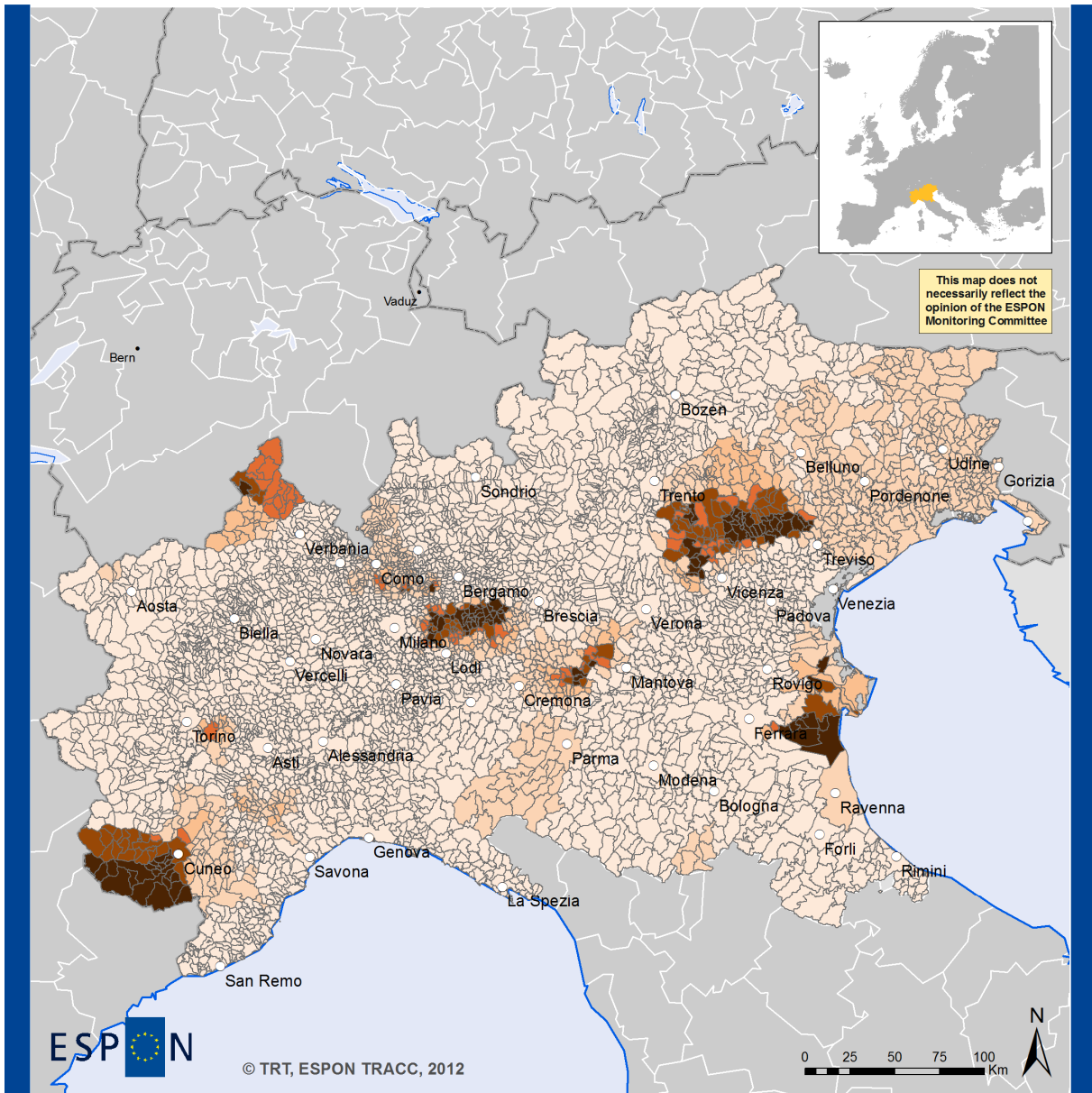


Figure 45. Potential accessibility to population by public transport with TEN-T projects

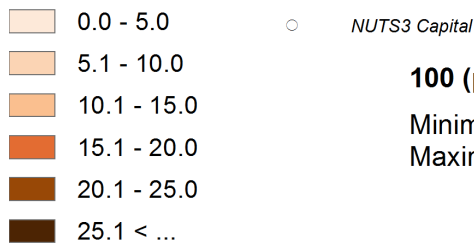


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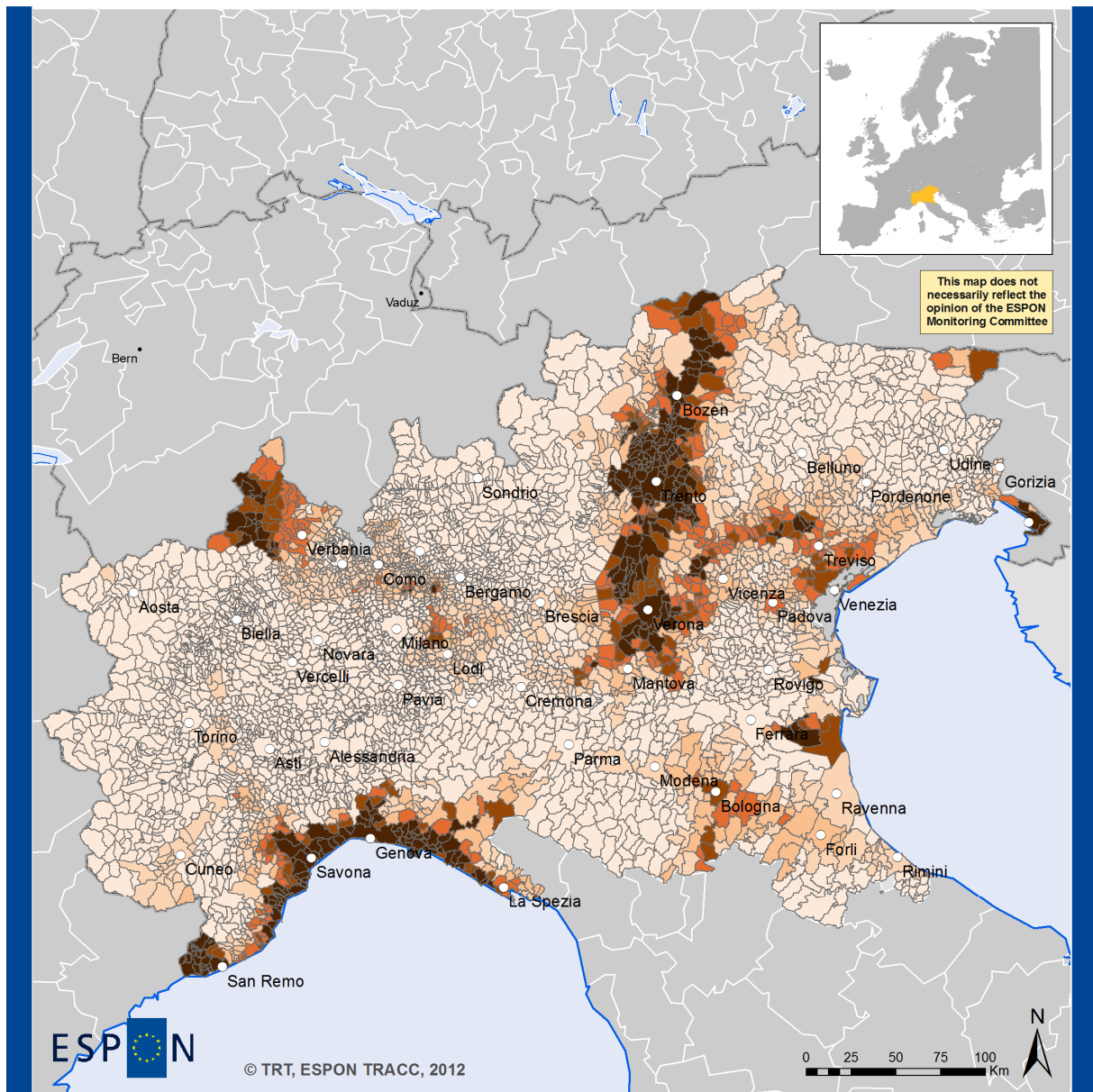
Northern Italy Case Study

Future situation after implementation of TEN-T outline plans (2020)
Regional potential accessibility to population by road ($\beta=0.034657$);
relative change (%) (standardised on road average)



100 (population weighted average) =
 Minimum:
 Maximum:

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



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Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011), Road Network: OSM (2011), Italian Statistical Office (ISTAT)- Population (2006), TEN-T outline plans (October 2011)
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Northern Italy Case Study

Future situation after implementation of TEN-T outline plans (2020)

Regional potential accessibility to population by public transport ($\beta=0.034657$); relative change (%) (standardised on public transport average)

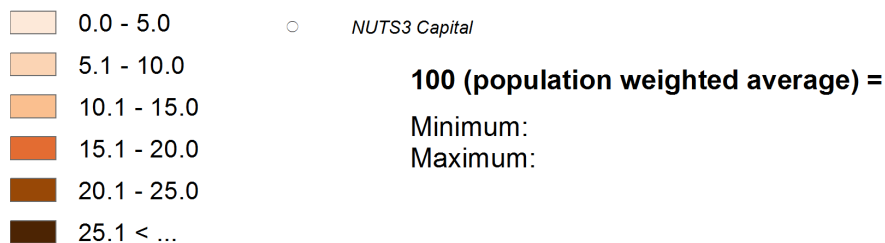
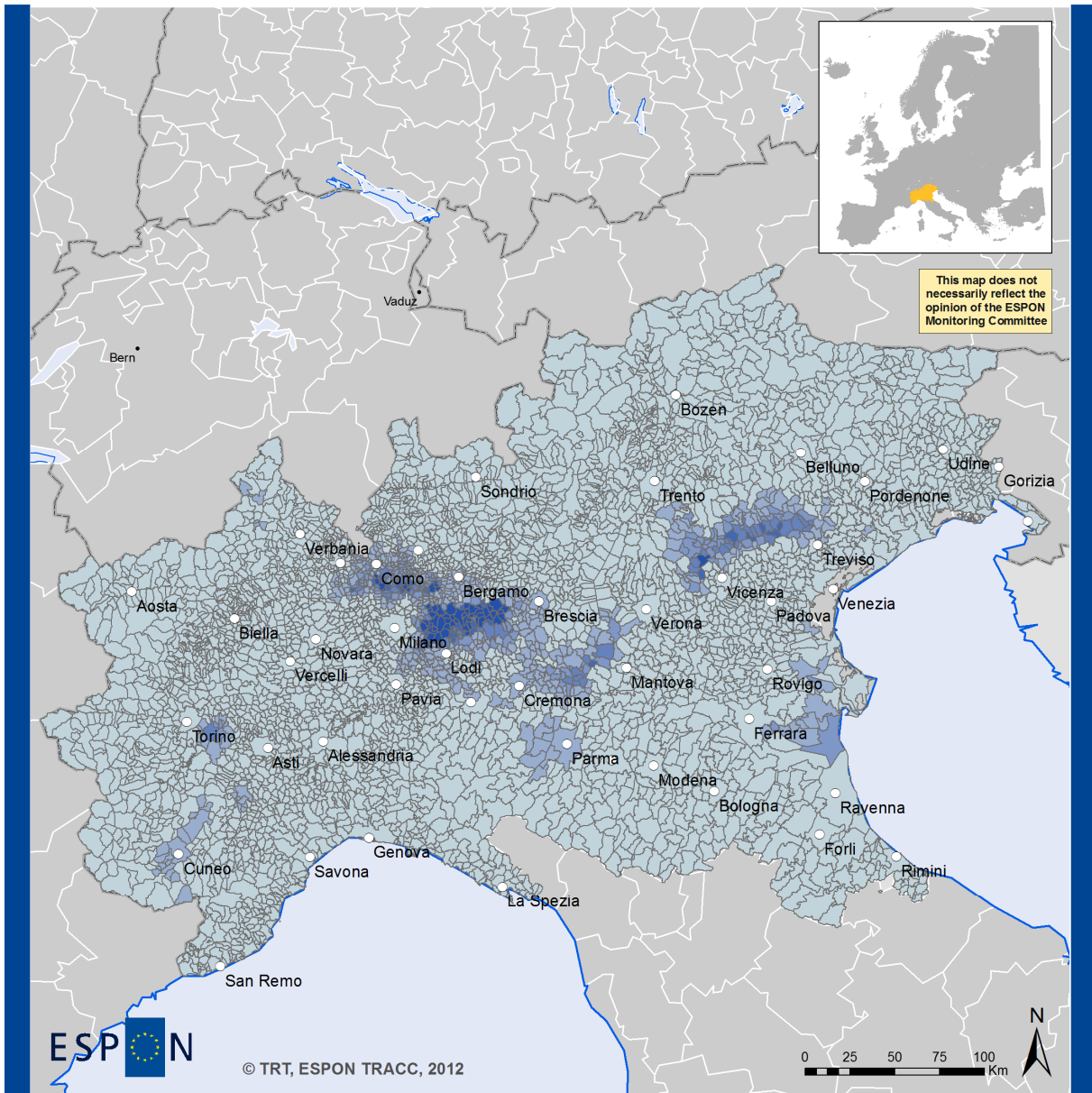


Figure 47. Relative increase of potential accessibility to population by public transport with TEN-T projects



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Future situation after implementation of TEN-T outline plans (2020)
Regional potential accessibility to population by road ($\beta=0.034657$);
absolute change (standardised on road average)

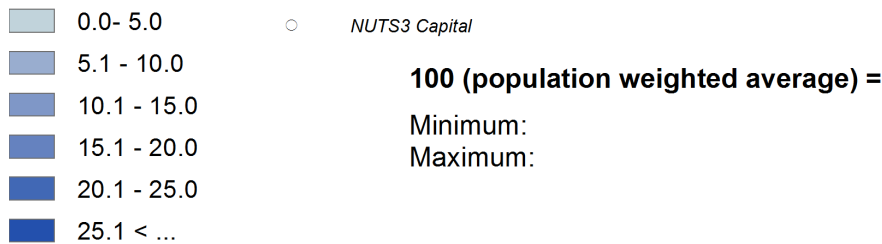
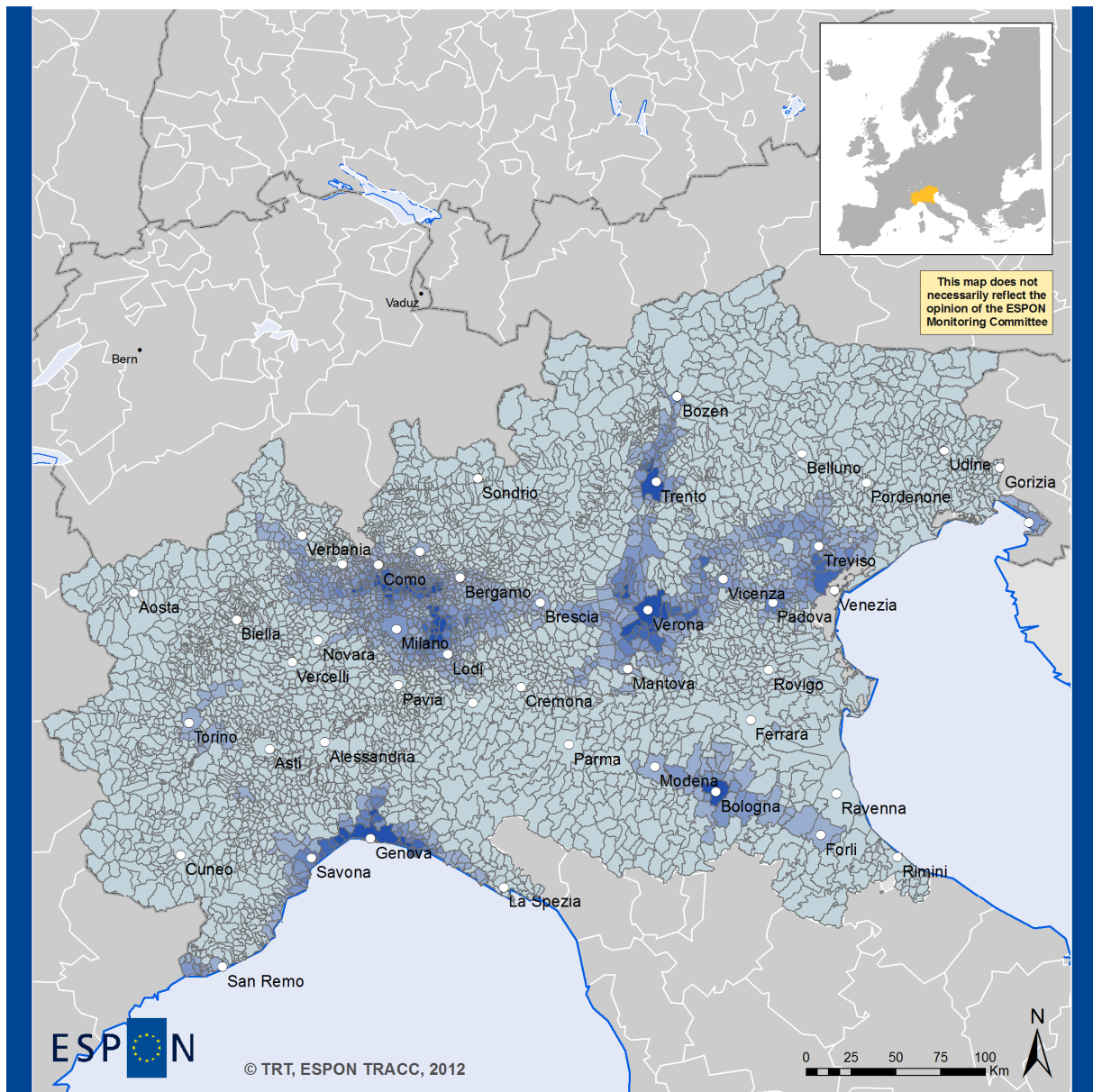


Figure 48. Absolute increase of potential accessibility to population by car with TEN-T projects



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Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011), Road Network: OSM (2011), Italian Statistical Office (ISTAT)- Population (2006), TEN-T outline plans (October 2011)
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Northern Italy Case Study

Future situation after implementation of TEN-T outline plans (2020)

Regional potential accessibility to population by public transport ($\beta=0.034657$);
absolute change (standardised on public transport average)

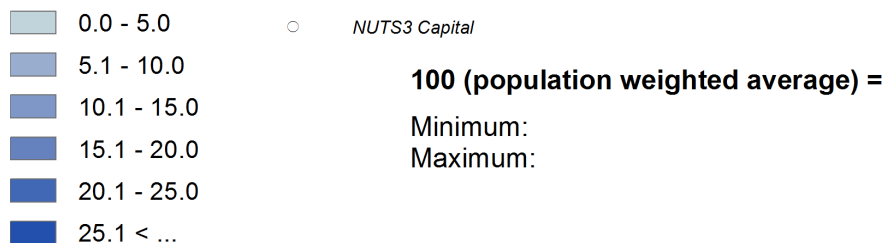


Figure 49. Absolute increase of potential accessibility to population by public transport with TEN-T projects

6 Conclusions

Looking at the various index computed, the Northern Italy region can be described as an area with four main subzones; within the subzones accessibility is quite homogeneous while between the subzones the accessibility changes significantly. The first subzone is the metropolitan area of Milan and its surroundings. This subzone is significantly at the top of accessibility values thanks to the structure of the transport networks (and of the transport services) as well as to the concentration of activities. The second subzone is made of the subalpine area extending east and west of Milan (from Turin to Venice) and of the corridor from Turin to Rimini (at the south-east corner of the study area. This second subzone, broadly corresponding to the “Padan megalopolis”, also shows high level of accessibility, sometimes even as large as those of the metropolitan area of Milan. The third subzone includes the mountain part of the study area at its northern and southern borders. This subzone has generally quite a poor accessibility, but it is also very sparsely populated. Finally the fourth subzone is made of the remaining zones, which are located in between the other ones and present a medium level of accessibility. Zoom-in regions are significant samples of the four subzones.

There is a clear difference in terms of accessibility between private car and public transport in the Northern Italy region, the latter performing worse than the former. However, at least in the core subzones, also public transport allows for good levels of accessibility.

The analysis of zoom-in regions allowed to highlight different patterns of accessibility existing within the study area: the privileged situation of the metropolitan area of Milan, the peripheral position of Belluno, the high dependency on local destinations for La Spezia and the gap between car and public transport accessibility for Piacenza.

The impact of new road and rail infrastructures on potential accessibility to population is significant at the local level, but it is not so large to change the current accessibility pattern, which is significantly driven by the distribution of population in the area.

Annexes

Annex 1 References

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Annex 2 Database

The network data comes from different sources. The rail layer is taken from the RRG GIS Database whereas the road layer is the one of OpenStreetMap. While all railway links under operation today for passenger transport in the macro region are included (pure freight lines are excluded), a subset of the entire road network as provided by OpenStreetMap (OSM) has been selected. Namely, the subset covers all motorways and expressroads, as well as dual-carriageway roads, plus other trunk roads, secondary roads or tertiary roads to guarantee connectivity of all municipalities.

The various elements of activity data at the LAU2 level are taken from different sources:

- The population is provided by data published by ISTAT (the Italian national statistical office) yearly (the latest available dataset is for the year 2006)
- The number of jobs is taken from the activity census data 2001 issued by ISTAT.
- The number of hospitals comes from the Italian Ministry of Health data for the year 2010.
- The number of secondary schools is extracted from Italian Ministry of Education data for the year 2010/11

Doctors are used as destination data to compute the accessibility to base health service. A database providing the number of doctors for each LAU2 is not available for Northern Italy, therefore an estimation has been made using the number of general practitioners (excluding those working in hospitals) operating in each NUTS2 region provided by ISTAT. First, the number of doctors has been used to compute the average doctors/inhabitants ratio in the regions. Second, such ratios have been applied to the number of inhabitants of each LAU2 zone to produce a first estimate of the number of doctors in each zone. Third, this first estimate has been rounded down to the closest integer number (i.e. to zero for those zones where the first estimate resulted in a number below 1). Fourth, the difference between the total number of general practitioners resulting from ISTAT and the sum of the rounded values has been redistributed to the LAU2 zones proportionally to their size. The outcome is the final number of doctors for each zone.

Annex 3 Accessibility model used

The accessibility model used to compute travel times and costs for the accessibility indicators is a network model developed by TRT in the MEPLAN software environment. The model allows for the assignment of Origin-Destination matrices at the LAU2 level of detail for both road and rail.

Transport supply is modelled by means of the road and rail networks introduced in Annex 2. The key attributes of network links are speed and cost.

In the road network, when a representative origin-destination matrix is assigned, base speeds are endogenously changed as effect of congestions. For the purposes of TRACC a virtual matrix including all OD pairs has been assigned, rather than a matrix with just the relationships where some traffic exists. This way, the ingredients to compute the accessibility indicators for one given origin are available for all destinations, as required, but the amount of traffic on the network links is not representative. Therefore the speed-flow curves have not been activated and the link speed is not endogenously adapted. Instead, speed has been exogenously reduced to take average congestion levels into account.

For the rail network, speed does not reflect only the physical features of the link but also the commercial speed of services operating (i.e. speed takes into account the trains timetable). However, the travel time between the main centres, which are connected by faster or even high speed services, are integrated with appropriate “discounts” also based on timetables.

Specific link-based costs exist only in the road network and consist of motorways tolls.

Each LAUS2 zone is represented by a centroid connected to the network by means of one or more links. The route between each zone pair is then endogenously estimated by the assignment algorithm, which is a SUE (Stochastic User Equilibrium) one. A SUE algorithm distributes demand among different available alternative routes using a logit algorithm. Each path will be used proportionally to its convenience. The convenience is measured in terms of generalised time (i.e. the sum of travel time and time equivalent of monetary costs) for road and in term of time for rail (as trip cost of rail does not depend on the specific route, also because there is usually one only reasonable route between two stations).

Travel time depends on link features as explained above. Travel cost depends on link-based tolls and on cost parameters representing the variable operating costs, which are those relevant for path choice.

The model is used to estimate accessibility for car and for public transport. The latter includes (interurban) public bus and coach services as well as train services. Public road transport is not simulated based on actual timetables because bus and coach services in Northern Italy are provided by a large number of local operators and collecting and implementing the actual timetables in the network model was unfeasible. Bus travel times on OD pair has been obtained by means of assignment with reduced speed on road links. The level of reduction has been defined by comparing modelling results to actual travel times according to timetables for a sample origin-destination pairs. The use of rail or bus as public transport for a given origin-destination pair is an endogenous modelling result based on their availability and competitiveness in terms of travel time. In particular for O/D pair <70 km minimum time between rail and road has been selected. For O/D pair >70km public transport is basically non existing).

Availability concerns rail as not all regions pairs can be connected by rail. Indeed, even though all zones can access the railway network, some of them share the same node (station) as entrance point. In these cases the model cannot find a valid rail path (which is realistic as nobody could actually use rail for those OD pairs).

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