

An assessment framework for city logistics in mid-sized towns

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Abstract

In this paper, we propose a framework aiming to provide a preliminary assessment and comparison of cities on the most important dimensions related to city logistics, thus preparing the ground for stakeholder engagement and solution design. The framework is also designed to overcome some of most relevant issues in city logistics research, such as lack of data and stakeholder engagement. First of all, the framework takes into account the different characteristics of a city: physical, infrastructural, social and economical features. Next, the framework analyses the state of city logistic features, such as: access conditions, parcel solutions, low impact vehicles adoption, land use, and infrastructures. The dimensions considered in the framework are drawn from the literature. The framework has been tested on two European cities representatives of mid-sized towns that have initiated to redesign their urban logistics systems: Bergamo (north of Italy) and the city of Luxembourg. Despite of the similarities in the two cities, the results indicate also significant differences in the city logistics situation, thus leading to different priorities of discussion and intervention.

Keywords City logistics, comparison framework, sustainability, last-mile distribution, GIS

1. Introduction and literature review

City Logistics is one of the major research topics in the field of freight transportation (ETRAC, 2014) and it is also one of the ways indicated by the European Union to increase the sustainability and liveability in urban areas (European Commission, 2011).

Despite the existence of consolidated solutions that can theoretically fit any city with an adaptation to the context (Dablanc, 2007), still many city logistics projects fail (Quak, 2011).

The main reasons for these failures have been related to difficulties in retrieving data (Cherrett et al., 2012), lack of stakeholder involvement (Lindholm, 2014), uneven regulations, lack of enforcement, obsolete policies (Muñuzuri et al., 2012) and lack of harmonization between the regulations of the neighbouring cities (Quak & de Koster, 2007).

Because of this, several researchers provided in-depth case studies performed on single cities, thus generating a useful library of experiences (e.g., Álvarez, 2011; Hesse, 2007). Nevertheless, these case studies are difficult to compare, as the time-frame, data collection methods and context of the cities are often very different.

As a consequence, in this paper we propose a framework aiming to provide a preliminary assessment and comparison of cities on the most important dimensions affecting city logistics,

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thus preparing the ground for stakeholder engagement and solution design. The framework is also designed to overcome the most relevant issues in city logistics research. First of all, the framework takes into account the different characteristics of a city: physical, infrastructural, social and economical. Stakeholder analysis is not within the scope of this framework, as it comes at a further stage of the research. The framework is also designed to exploit publicly available information to the maximum possible extent (to overcome lack of data). Because of the larger availability of data, the focus is on deliveries of goods to shops and people (thus excluding construction materials, supermarkets, offices, banks).

The dimensions considered in the framework are drawn from the literature. The framework has been tested on two European cities representatives of mid-sized towns that have initiated to redesign their urban logistics systems: Bergamo (north of Italy) and the city of Luxembourg.

The first set of dimensions (*general features*) in our framework is related to the characteristics of the city that can affect the distribution of goods in the city. Among all the possible dimensions, we selected those that were highlighted in the literature as the most relevant in previous case studies, namely:

- Size (Tsekeris & Geroliminis, 2013; Anas & Pines, 2013)
- Morphology, such as presence of hills and slopes
- Land use (Alho and Silva, 2015)
- Presence and extent of the historical centre (Pulawska & Starowicz, 2014)
- Infrastructures: roads types, number of roads, roads dimensions (Mohajeri et al., 2015), road tolls (Lian, 2008)
- Typology and distribution of commercial activities with different requirements (food, non-food small items, non-food bulky items, HORECA, high-value) (Kittelson, 1987; Joubert et al., 2010)
- Transportation companies and logistics activities location (Allen et al., 2012; Luer-Villagra & Marianov, 2013)

While there are several articles in literature that have considered these different characteristics of the city to make valuations on transportation, these have rarely been rarely considered together. The reason is that these dimensions are employed in different disciplines (i.e. urban planning considers shape and size, geography considers land use, logistics considers transportation companies and logistics activities). However, since transportation is a sub-system in the broader city system, our framework proposes to consider these dimensions jointly.

The second set of dimensions (*city logistics features*) is directly related to city logistics infrastructures and solutions. The main solutions identified in the literature (Benjelloun et al., 2010) and included in our framework are the following:

- Access conditions: delivery time windows (Deflorio et al., 2012), overnight deliveries, size and weight restrictions for the access to limited traffic zones (LTZ) and road pricing (Holguín-Veras, 2008).
- Parcel solutions: pick-up points and pack-stations (Morganti et al., 2014).
- Low impact vehicles: bike delivery (Gruber et al., 2014), alternative fuel vehicles (Schneider et al., 2014).
- Land use: loading/unloading bays (McLeod & Cherrett, 2011), hub areas, mini-warehouses
- Infrastructures: urban consolidation centres, urban distribution centres, city terminals (Olsson & Woxenius, 2014)

In our framework, each of these solutions can be existing or not and, if existing, they can be sized according to different parameters (for instance, the extent of limited traffic zones).

2. Objectives and methodology

As mentioned earlier in the paper, we propose a framework to provide a preliminary assessment and comparison of cities on the most important dimensions affecting city logistics, thus preparing the ground for stakeholder engagement and solution design. Our aim is not to provide a framework to identify the solutions to be adopted: rather, the goal is to assess the situation of a specific city in a way that makes it comparable with other cities and that can foster stakeholder engagement.

After the identification of the most relevant variables on a literature basis, we tested our framework on two case studies. Following the guidelines provided by the literature (e.g. Yin, 2009), we selected two cases that have some characteristics in common while some others are different. This gives us the ability to interpret convergent and contrasting results between cases according to the principles of both *literal replication* (where the cases are expected to provide similar results given their similar characteristics) and *theoretical replication* (where the cases are expected to provide contrasting results, given their differences).

As a consequence, we considered two European mid-sized cities (even though the framework can be applied as well to larger cities): Bergamo (north of Italy) and the city of Luxembourg. Moreover, we decided to take two cities with similar geographical, demographic and infrastructural characteristics (Table 1 and Figure A1 – in the appendix). Both the selected cities have shown increasing interest for city logistics issues, and have undergone a process of stakeholder involvement on city logistics issues.

Table 1: Size, morphology, land use and historical centre characteristics in the two cities

Feature	Measure	Bergamo	Luxembourg
Size	Population	121,316	107,340
	Area	39.6 km ²	51.73 km ²
Morphology	Hills	Hilly landscape (min elevation: 211 m; max elevation: 645 m)	Hilly landscape (min elevation: 232 m; max elevation: 408 m)
	Rivers, canals	No	Yes, but not navigable waters
Land use	Population density	3,063/km ²	2,100/km ²
Historical centre	City centre of historical importance	Yes	Yes

In the years 2013-2014, in both cities meetings with the stakeholders to discuss the main issues were organized, involving several classes of stakeholders such as transportation companies, express couriers, municipality, Region (Bergamo) / State (Luxembourg), shop keepers.

The two cities were also mapped using the Smart City Logistics platform (<http://smartcitylogistics.org/>), a geographic information system (GIS) developed by the Luxembourg Institute of Science and Technology (LIST). The mapping of both cities relies on the same sources of information, data collection and mapping methods (described extensively in the results section). Smart City Logistics represents a decision support platform for urban logistics for European cities, providing decision makers with a wide range of easy to understand information to support the development of urban freight transportation plans. The Smart City Logistics platform maps information on transportation networks, access restrictions, traffic measures,

delivery and transport facilities, administrative units, population, land use and emission situations (Figure 1).

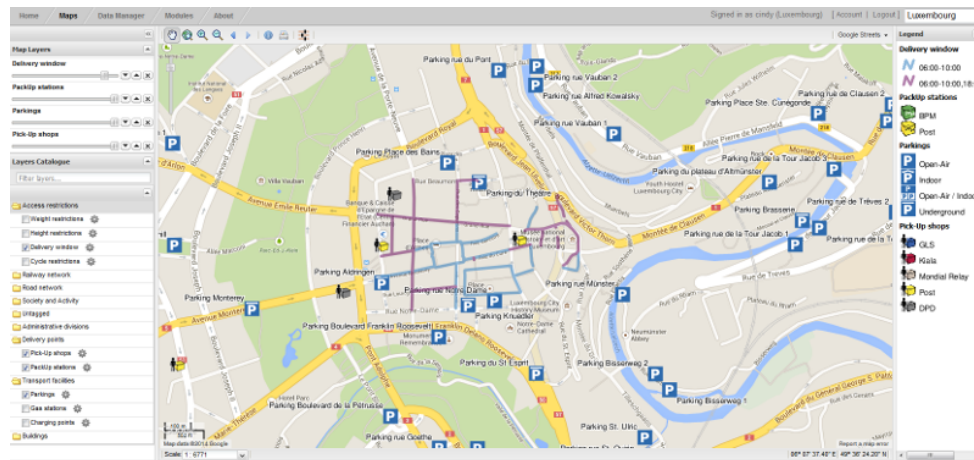


Figure 1: Screenshot from the Smart City Logistics platform

For each city, about 30 layers of different information were collected. In this paper, we present a comparison of the two cities according to a set of contextual variables and solutions as defined in the literature. The solutions that are not existing (e.g., urban distribution centres) in these cities could not be compared and this can be considered in a future development.

For all the remaining dimensions, we provide information on the data source and quality of the information to enable replication of the methodology also in other cities. Moreover, for each dimension we highlight the key comparison indicators and key questions that should be discussed with the stakeholders.

3. General features

3.1 Size, morphology, land use and historical centre

Previous Table 1 and Figures A1-A2 in the Appendix summarize the characteristics of the two cities with respect to the first set of general features (size, morphology, land use and historical centre). Bergamo, the seat of the province of Bergamo, has a surface area of 39.6 km² and a population of 121,316 (3,063 inhabitants per km²). As of 2014, the city of Luxembourg, capital of the Grand Duchy of Luxembourg, featured a similar number of residents (107,340) on a larger area (51.73 km²), thus has a lower density (2,100 inhabitants per km²). Compared to larger European cities (e.g., Paris has more than 21,000 inhabitants per km²), both cities have a relatively low population density. Both cities are set up in a hilly landscape: città alta “upper city” and città bassa “lower city” in Bergamo and Ville-haute “upper city” and Grund “lower city” in the Luxemburgish city compose the historical part of the cities.

3.2 Infrastructures

Bergamo and Luxembourg are both served by an international airport located close to the city centre (respectively 6.5 and 4 km away). The Luxembourg Findel Airport is ranked as Europe's 5th busiest in terms of cargo tonnage in 2010, while Bergamo Orio al Serio is the Italian north-east hub for DHL and north-west hub for UPS. As displayed in Figure A3, both cities are well connected to the national railway and highway systems. The city of Luxembourg displays many access points through primary roads from all the directions, while Bergamo, having the hills on north, is mainly accessible from the south, thus creating potential bottlenecks. The source for the

road network is Open Street Map. However both cities lack of specific infrastructures for city logistics such as urban distribution centres.

3.3 Commercial activities

Figure 2 shows the density of commercial activities based on Open Street Map (OSM) data and on official 2008 document of the municipality for Bergamo. While OSM data for Bergamo were found to identify about 15% of the actual activities in the centre (323 vs 2732), still these data can provide a good overview of the density of the commercial activities. In Luxembourg the coverage of OSM is instead much better. In conclusion, we used actual commercial activities for Bergamo and OSM for Luxembourg to produce Figure A4.

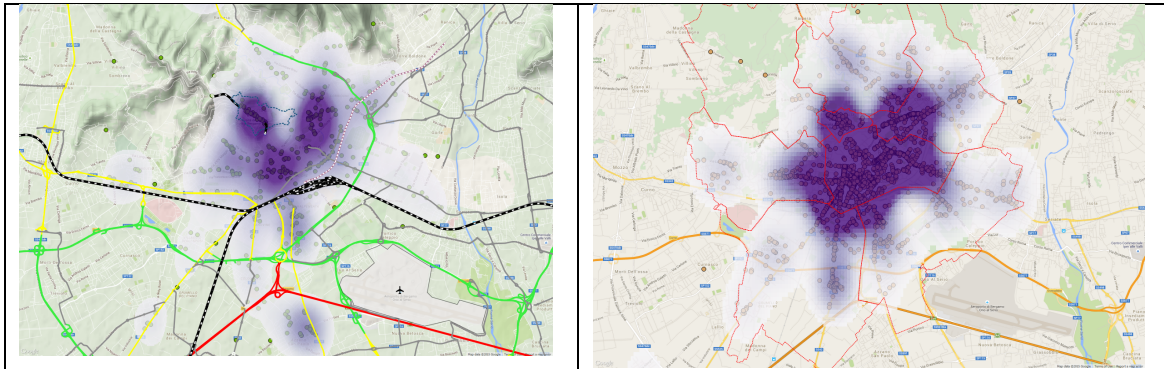


Figure 2: Open Street Map OSM activities on the left. Actual commercial activities (2008) on the right (city of Bergamo)

We divided the commercial activities into different categories according to the nature and/or volume of the goods and related transport. Thus, a furniture store is tagged as a building dealing with bulky and non-food items, whereas a clothing shop is tagged as a building dealing with small and non-food items. This classification allows the user to better identify potential customer of a logistic initiative. We did exclude supermarkets from the analysis as they have their own distribution systems in place.

In Bergamo, we found three highly concentrated areas: the first one in the Città Alta, and other two in the lower part of the city. Similarly, in Luxembourg the highest concentration of shops is found in the city centre and in the station area.

This map can help to identify the main attractors of business-to-business shipments and the areas that are very likely to be affected by freight transportation.

In Bergamo, the large presence of small items shops (51% of the total commercial activities), opens to the possibility for innovative solutions as this typology of goods is suitable to different type of vehicles (even bicycles) and does require very high frequency. All the other categories have minor relevance. For this analysis, we simply counted the number of shops (Table 2): however, further measures could be evaluated, for example weighting the number of shops with the size of the shops, the number of employees or the delivery frequency, and the like. The availability of relevant data plays a key role in the selection of the most reliable measures.

Table 2: Distribution of the commercial activities

Type of shop	Characteristics of the transport	Bergamo		Luxembourg	
		Tot	%	Tot	%
Commerce bulky items (furniture, sport equipment, car, household appliances)	Low frequency, require special larger vehicles	137	5%	453	10%
Commerce small items (apparel, accessories, kiosks, excluding supermarkets)	Medium frequency, suitable to smaller vehicles	1393	51%	717	16%
Food	High frequency, can require refrigerated vehicles	407	15%	789	18%
HORECA (Hotel, bar, restaurant...)	Medium/high frequency, can require refrigerated vehicles	721	26%	1869	43%
Health (Pharmacies...)	Very high frequency, can require refrigerated vehicles	35	1%	214	5%
High value (Optician, Jewelleries, excluding banks)	Low frequency, subject to robberies	39	1%	359	8%
Total		2732	100%	4401	100%

3.4 Location of transportation companies

So far we have focused on the destination of the goods (commercial activities and delivery points), but it is also important to analyze the origin of the flows. As a consequence, we collected data on the location of the main transportation companies (express couriers and 3PLs) that regularly deliver the goods in the city. This stage was quite labor-intensive, as for Luxembourg the market turned out to be very fragmented, while for Bergamo some interviews have been needed to understand which companies actually deliver in the city of Bergamo. The resulting picture is reported in Figure A5. Interestingly, in Bergamo we found about five express couriers and only five third-party carriers, of which one is specialized on fresh products (with refrigerated warehouses and trucks). In Luxembourg, on the contrary, we identified a comparable number of express couriers but almost 25 third-party carriers.

Of course, in both cities own-account transportation (e.g., the shop keeper or the supplier delivering by its own) makes a large share, but it is very difficult to track. However, the difference on third-party transportation is quite evident. Probably, as a consequence of the restrictive measures in Bergamo, the market reacted by aggregating the flows and deliver by means of these local companies.

4. City logistics features

4.1 Restriction measures

As a second level of analysis, we compared the restriction measures.

As a first policy measure, we located the delivery windows (Figure A6). We can notice how in Bergamo there are five main areas, three of which are open “7-10 and 15-16” (Città Alta is in one of these) while two “19-7 and 10-16”.

In Luxembourg city, the delivery windows are limited to the inner part of the centre. Half of the streets have a “6-10” time windows, while the other half are open to deliveries also “18-22”. In both cases, these areas are overlapped with the densest areas in terms of commercial activities, but to a smaller extent.

After that, we compared the weight restrictions (Figure A7). While in Luxembourg city these are very limited and mainly due to the characteristics of some streets (bridge or street next to an industrial area), in Bergamo these are overlapped with the delivery window areas. This means that in those areas, only vehicles that are smaller than 3.5 tons can enter only in the specific times.

Finally, if the limited traffic zones do not affect only the commercial vehicles, they can provide useful information about the interference with non-commercial traffic. While in Luxembourg city there are no limited traffic zones, in Bergamo they are overlapped with the delivery windows (and, by consequence, to the weight restriction areas). In particular, in the three areas with the shortest delivery windows (7-10 and 15-16) there is a permanent limited traffic zone (i.e., only residents can access). This can help commercial vehicles to be more efficient in the delivery windows, thanks to reduced flows of non-commercial traffic. On the other hand, the two zones with delivery window 10-16 face the same limitation of the non-commercial traffic (that is allowed 10-16). While this measure helps residents or workers to move in these areas during peak hours, it creates an overlap between commercial and non-commercial traffic.

We also considered height restrictions: however, these are very few and they might have an effect to slightly deviate the traffic flows.

In conclusion, we can highlight that Bergamo appears much more restrictive in terms of policy than Luxembourg city, where the main constraints are due to the characteristics of the roads.

4.2 Delivery points for parcels

Shifting our focus on B2C deliveries, we took in consideration the existence and location of delivery points (Figure A8). Beside the classic post offices, we also included in the analysis pick-up points and pack-stations (i.e., parcel lockers). We also crossed this information with population density.

The results are consistent between the two cities and show that post offices are quite spread over the territory, while pick-up points are located in high dense areas and concentrated in few neighborhoods. Interestingly, in both cities, there are exclusive partnerships of pick-up points with online retailers (e.g. Amazon-Post offices, Mondial Relay) or Express Courier (TNT, Kiala, DPD, DHL, UPS). However, in Bergamo there are two independent networks of pick-up points (Fermo!Point and Indabox) that aim to create a link between online retailers and final consumer. While this creates the opportunity to have more delivery points, on the other hand it can confuse the consumer that according to the chosen online retailer may have its product delivered in one or another point. Pack-stations were found only in Luxembourg as in Italy they are not yet largely diffused. In Luxembourg there are two operators at the national level, (one private and one public), but only one is active in Luxembourg city, the other ones are located on the main roads (five in total).

4.3 Availability of alternatives to conventional fuels for urban logistics operations

Figure A9 displays the location of gas station providing LPG, CNG and electric columns for vehicles recharge. The information was retrieved from publicly available sources (e.g., mylpg.eu, cngeurope.com, openchargemap.org, plugsurfing.com). In Luxembourg city we found only one CNG (Aral) and one LPG (Shell) station, but several charging columns (13). In Bergamo, we found nine gas stations close to the centre, and seven charging columns (even if some of these are privately owned by hotels). While in Luxembourg city charging columns are quite evenly distributed along primary roads, in Bergamo, the distribution seems more random and less suitable to support electric vehicles distribution. On the other side, Bergamo offers more LPG and CNG gas stations in the surroundings of the centre along the primary roads.

4.4 Distribution of loading and unloading bays and their compliance with regards to the number of retailers and companies

The information about loading and unloading bays is unfortunately not publicly available. For Bergamo, the information was provided by the public administration while for Luxembourg city was necessary to manually retrieve the information from a specific area of the city near the train station. Because of this, for both cities we focused on a specific area near the train station. Following the guidelines of the literature (Certu, 2013), the loading-unloading bays should be positioned at maximum 50 meters from the shops. As it can be seen in Figure A10, in Luxembourg the coverage is very good, while in Bergamo there is an evident mismatch. For Bergamo, we could extend the analysis to all the shops and bays, finding that the mismatch is a problem extended to the entire city, thus requiring a re-design. For Luxembourg, even if the spatial coverage seems adequate, the time of usage for these parking in shared use is too restrictive.

4.5 Existence and location of green/innovative solutions for city logistics

In both cities, we found only few initiatives related to green or innovative solutions. In Bergamo, a small company (Orobici) provides bike deliveries in the entire city center. Their customers are mainly shops that need to send parcels to their customers (e.g., flowers), but the company is extending its business through agreements with express couriers.

In Luxembourg, one pack-station operator proposes to be delivered from e-shops which do not deliver in Luxembourg in indicating one of the operator delivery addresses in US, UK, France, Belgium or Germany. The delivery is then redirected to Luxembourg via this operator. The service works independently to the logistics operator dealing with the e-shop.

5. Discussion and conclusions

In conclusion, in this paper we present a framework to provide a preliminary assessment and comparison of cities on the most important dimensions affecting city logistics, thus preparing the ground for stakeholder engagement and solution design. The framework is designed to exploit at maximum publicly available information, such as Open Street Map for infrastructures and commercial activities. Beside the speed in collecting the data, the advantage is also in the ease to maintain the information up to date.

The framework was tested on two cities (Bergamo and Luxembourg) and, despite the similarities in the two cities, the results indicate also significant differences in the city logistics situation.

Among the general features, the existence of an historic centre and the hilly morphology seem to be two very relevant factors affecting the city logistic features. In fact, to preserve historical centres, policy makers defined areas with specific delivery windows and the hilly landscapes further limits the accessibility to delivery vehicles. While restrictions can be good in principle, in practice, they often bring to a fragmentation of the consignments. This problem is particularly evident in Bergamo, where the areas subject to restrictions are many, discontinuous and not homogeneous.

In terms of transportation infrastructures, the two cities appear quite similar but significant differences emerge in terms of typologies of shops: Bergamo has a relevant share of shops in the “commerce small items” and Luxembourg in the “HORECA” category. Moreover, Luxembourg features a very fragmented market of the transportation companies.

Looking at the city logistics features, and in particular the access regulations, we have already pointed out for Bergamo the extended and limited traffic zones, featuring also different delivery windows and weight restrictions. However, also in Luxembourg there are different delivery windows in the streets in the same area, thus leading to potential confusion for transportation companies not accustomed to.

In terms of delivery points for parcels, it emerged the lack in using pack-stations in Bergamo. Next, when looking at the alternatives to conventional fuels, we found few LPG/CNG gas stations in Luxembourg, while in Bergamo the electric charge columns are unevenly positioned. Furthermore, in Bergamo there seems to be a mismatch between the location of loading and unloading bays and the shops. Finally, both cities have very limited adoption of green and innovative solutions and not specific infrastructure for urban logistics as urban distribution centres. This solution can be particularly effective in Luxembourg city given the fragmentation of the transportation companies. In Bergamo, where there are already few companies operating, a micro urban distribution centre could be designed for the parts of the city more difficult to reach and with higher historical values (i.e., Città Alta).

These results highlights the need to develop ad-hoc solutions, rather than relying on one-size-fits-all approaches. In particular, for Bergamo, the priorities of intervention that emerge are related to:

- Harmonization of the limited traffic zones and delivery windows
- Develop a specific analysis for shops in the “commerce small items” category
- Review the location of loading and unloading bays
- Develop a consistent strategy for the location of charging points
- Evaluate the possibility to install pack-stations
- Evaluate the possibility to develop a micro urban distribution centre for Città Alta in combination with bike delivery

On the other side, for Luxembourg city, the focus should be:

- Harmonization of the delivery windows
- Review the time of usage of the loading and unloading bays in shared use
- Enhance the LPG/CNG gas station network
- Evaluate the possibility to develop urban consolidation centres

Our paper also presents a framework of analysis that could be easily replicated in other cities, thus enabling a broader comparison with other cities in the future. Our framework is still under development, and the future development include an analysis of the traffic, provide a set of indicators for the different features, enrich the list of general and city logistic features, provide clearer connections between the features.

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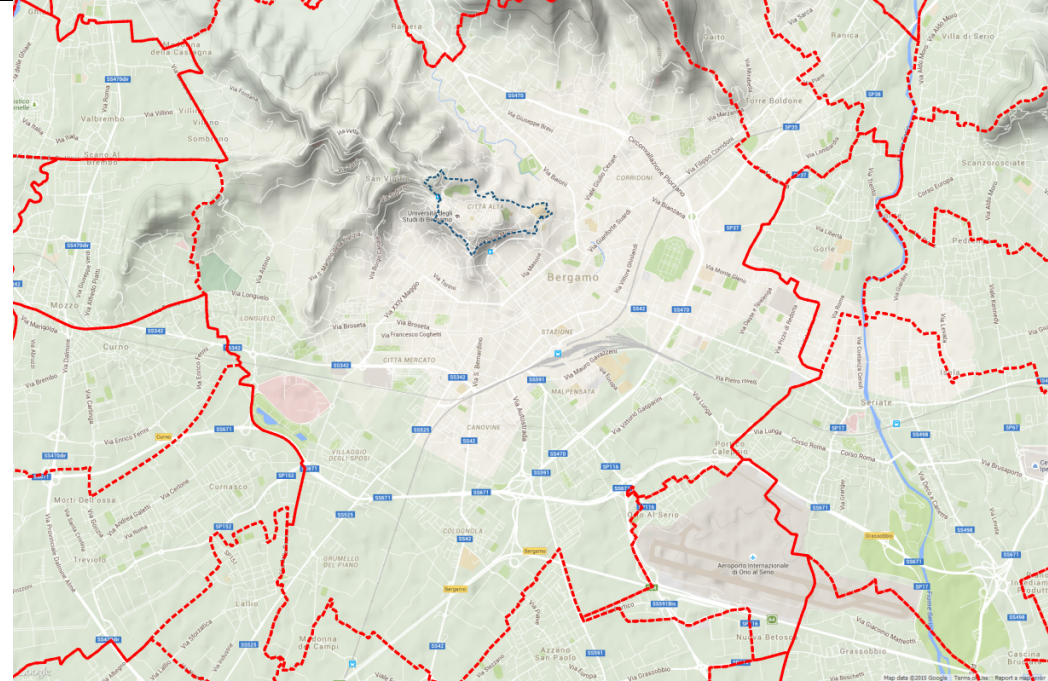
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Appendixes

Bergamo



Luxembourg

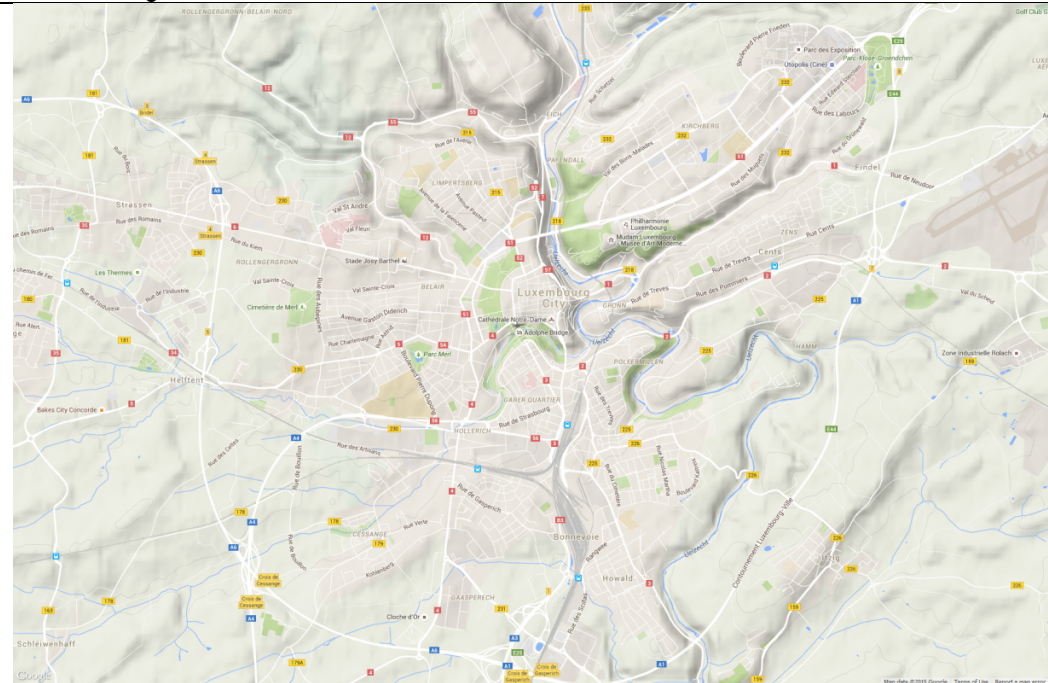


Figure A1: Morphology (1:65,741). Source: Google Map Terrain

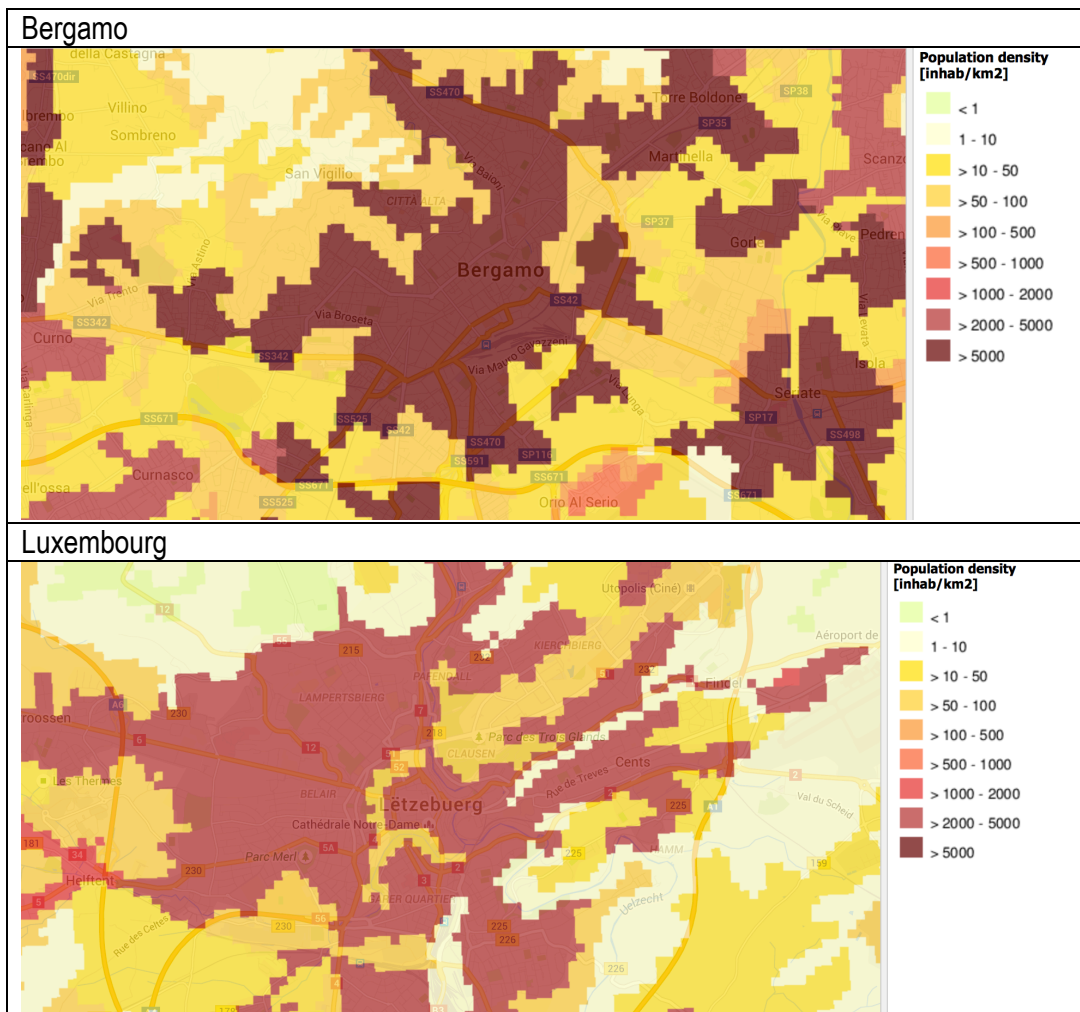
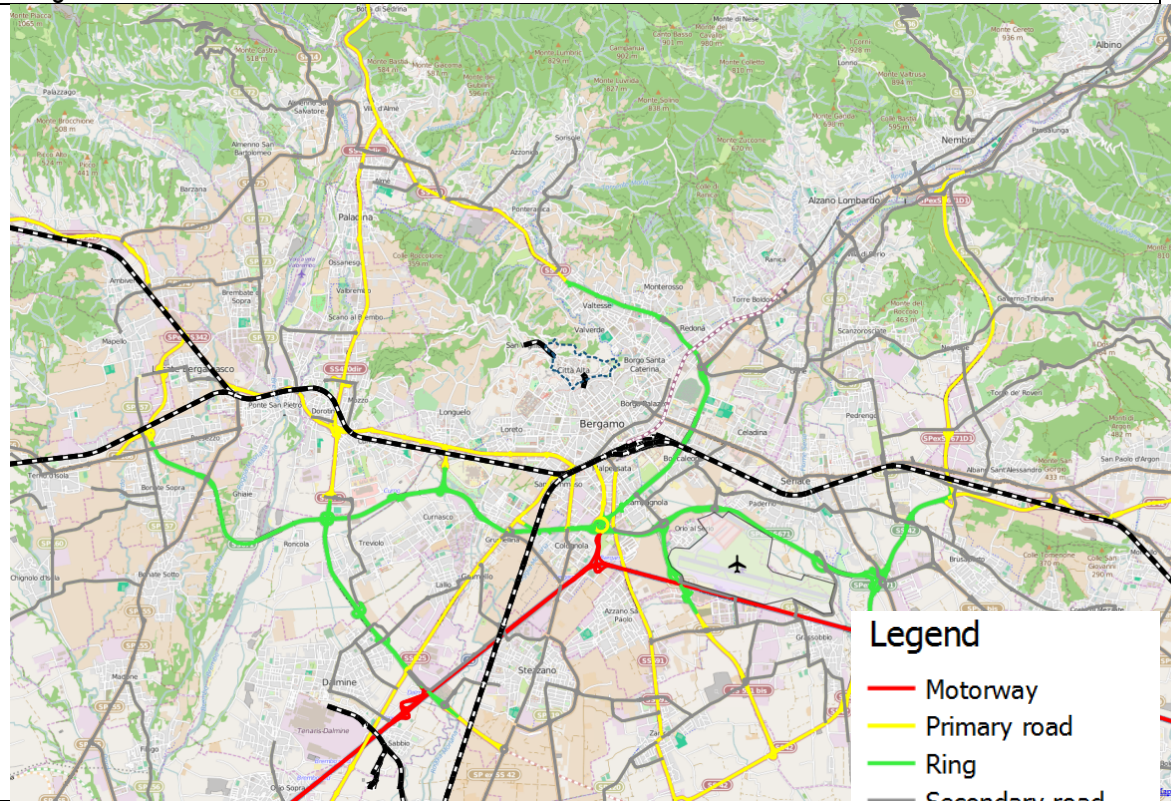


Figure A2: Population density (1:54,168)

Bergamo



Luxembourg

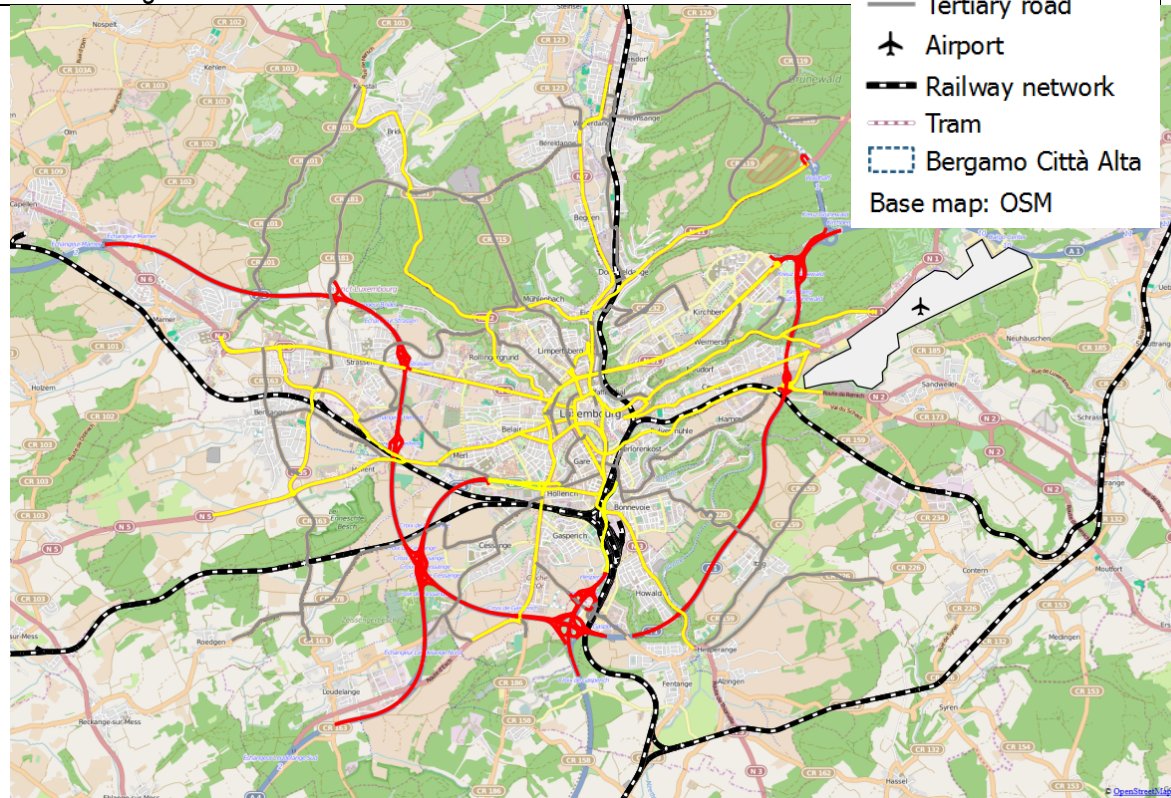
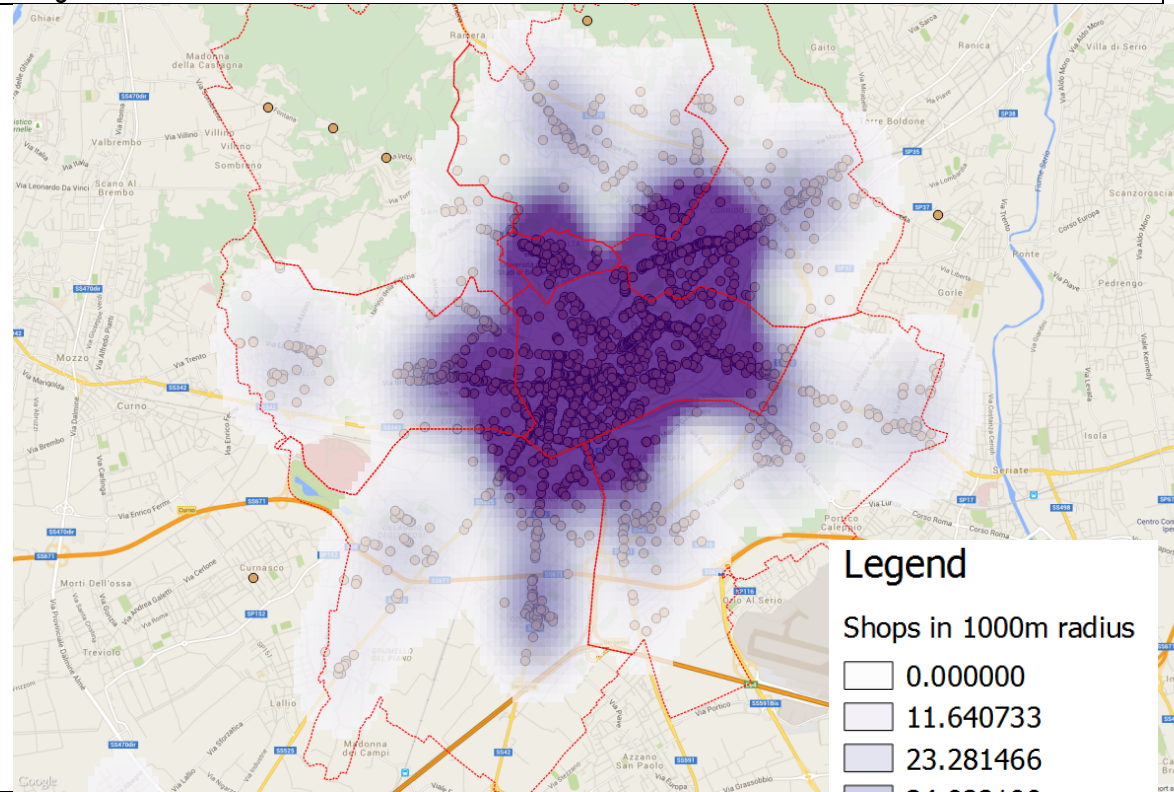


Figure A3: Infrastructures (1:131,481). Base Map: Open Street Map

Bergamo



Luxembourg

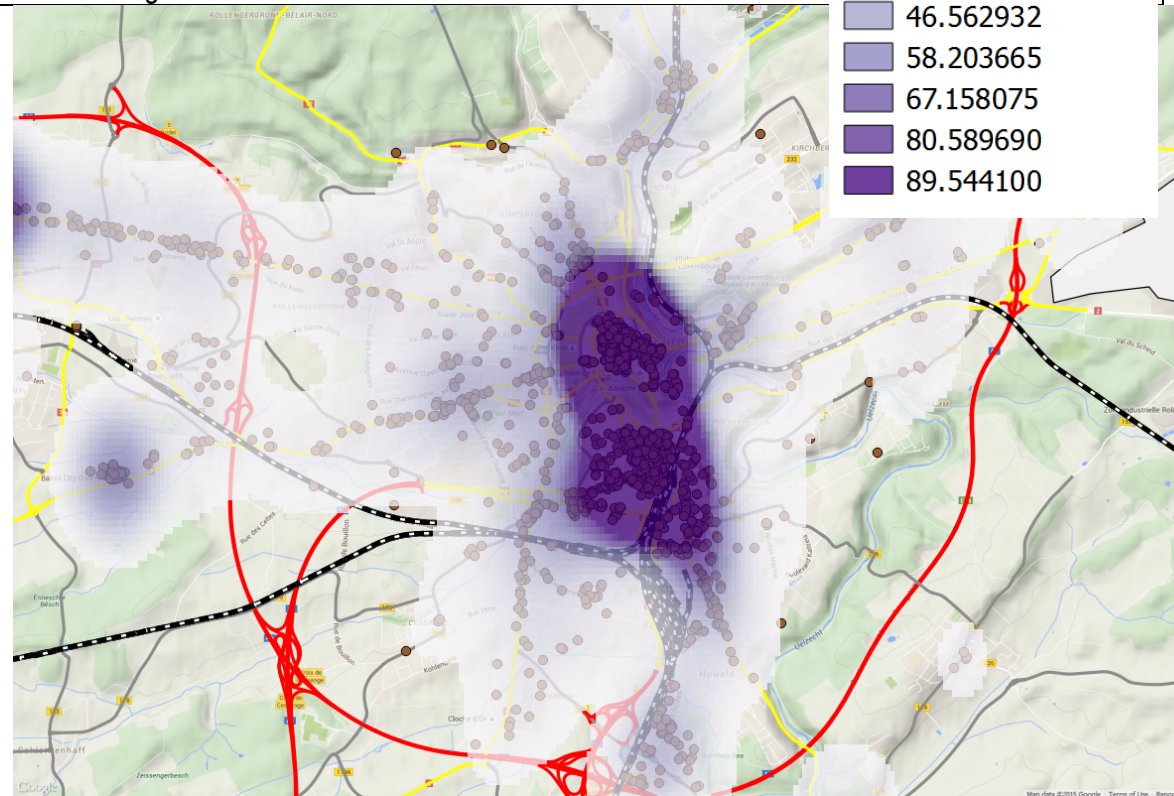
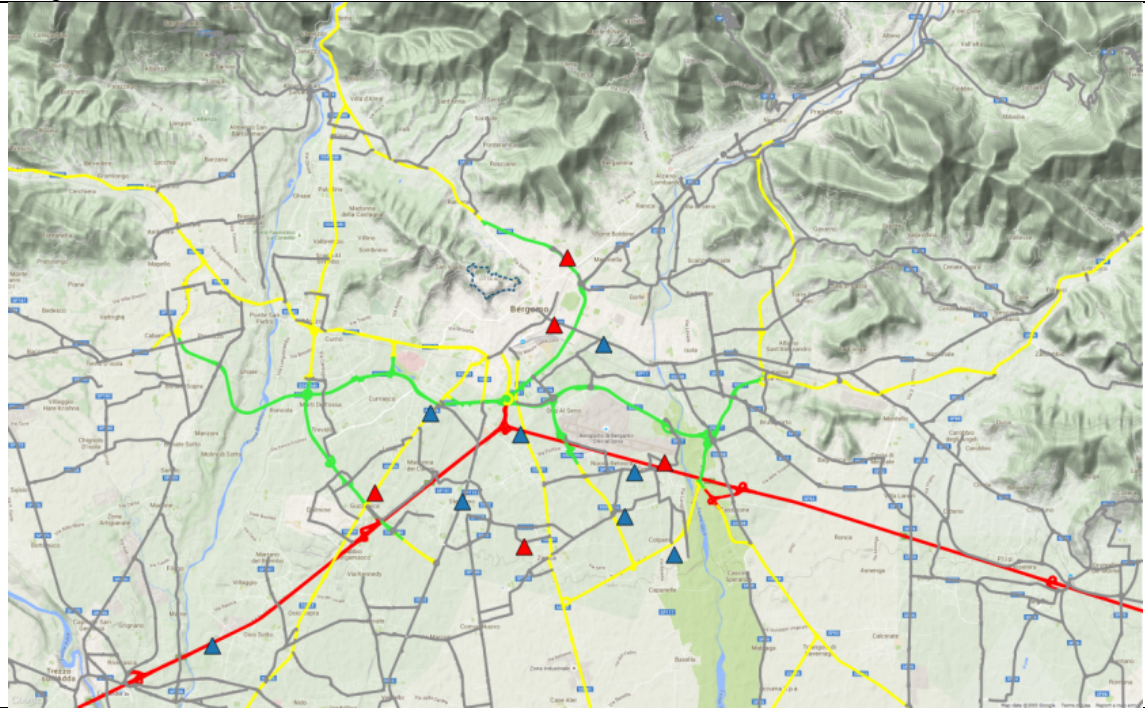


Figure A4: Density of commercial activities (1:65,741)

Bergamo



Luxembourg

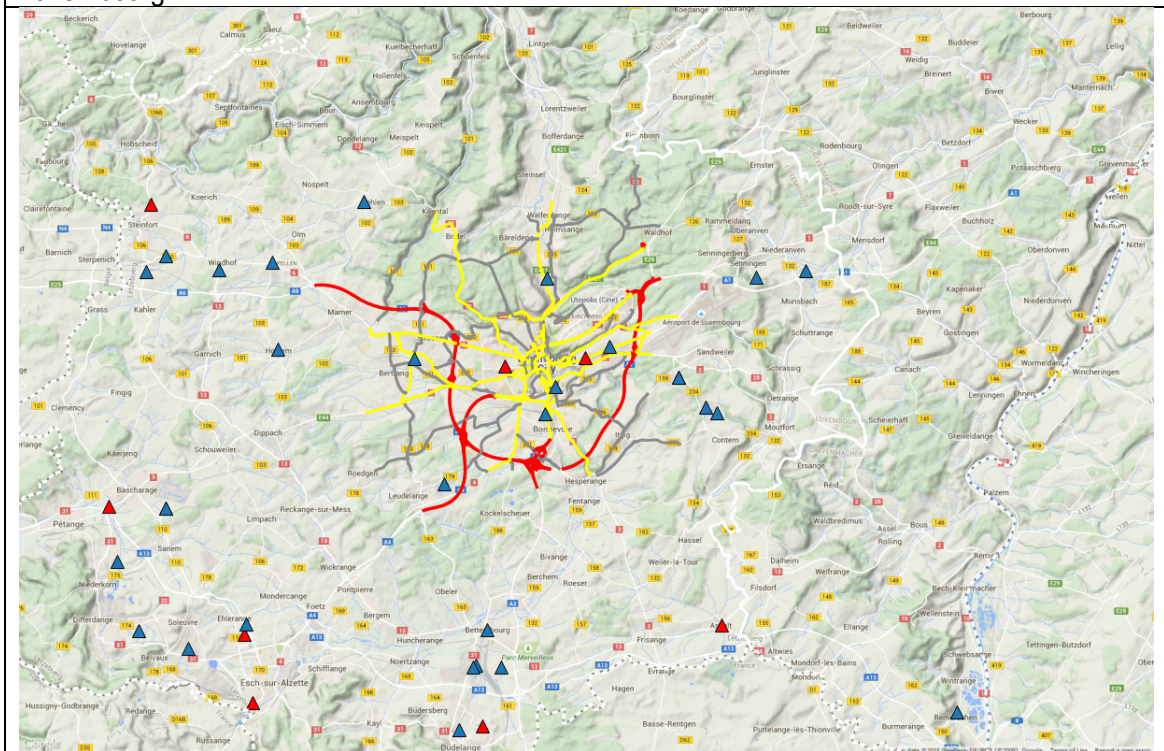
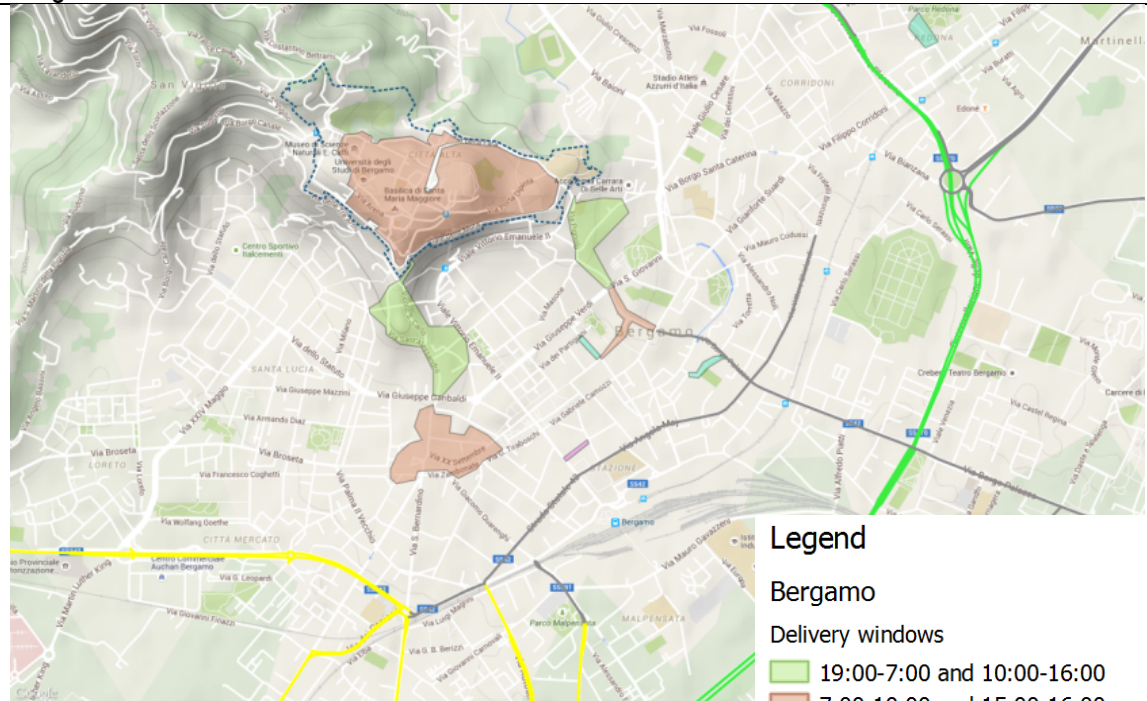


Figure A5: Transportation companies (1:262,963)

Bergamo



Luxembourg

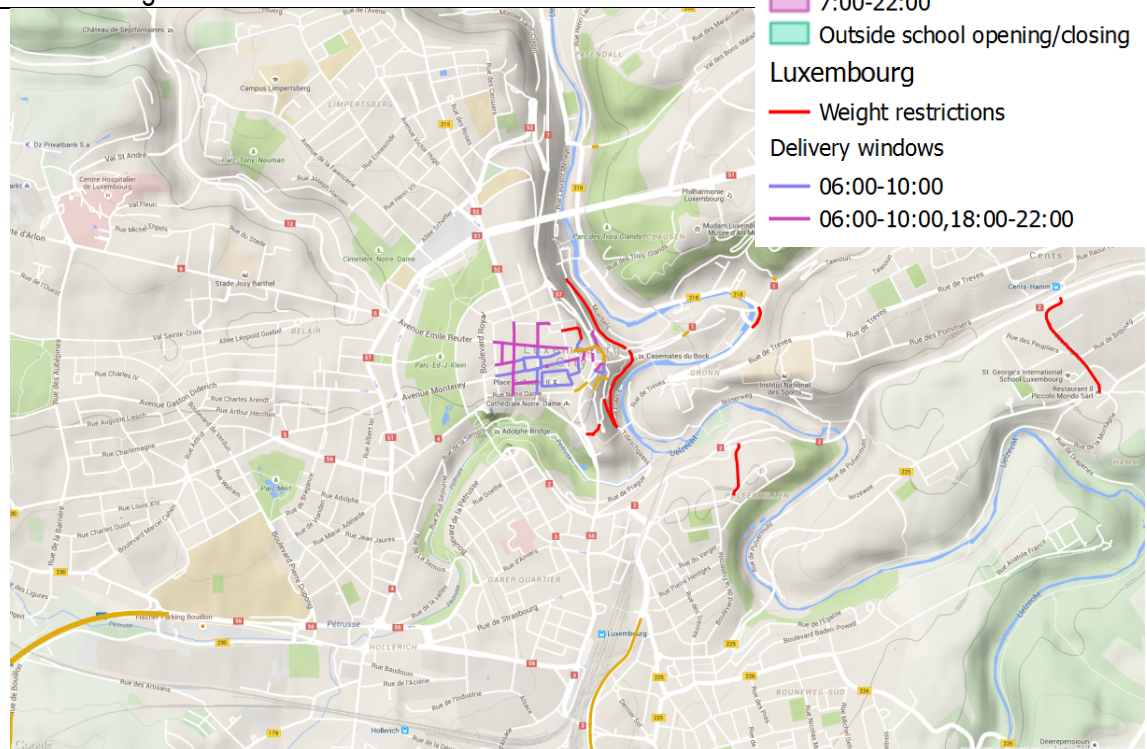
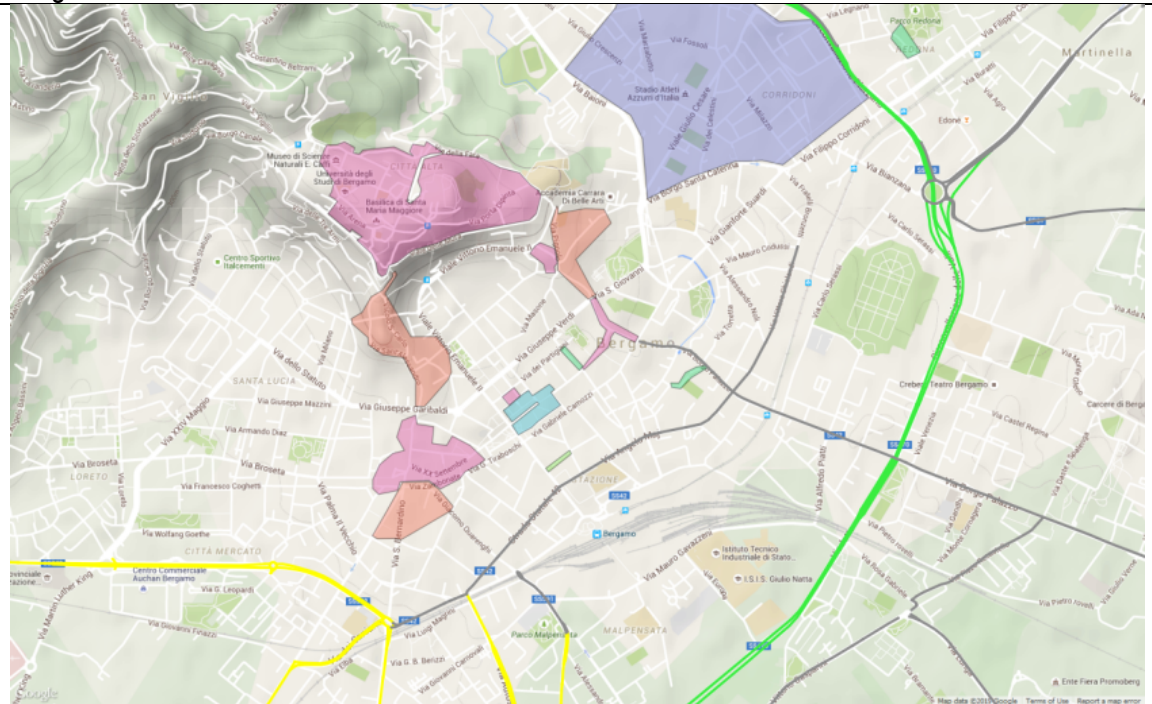


Figure A6: Delivery windows and weight restrictions (1:32,870)

Bergamo



Legend

Bergamo

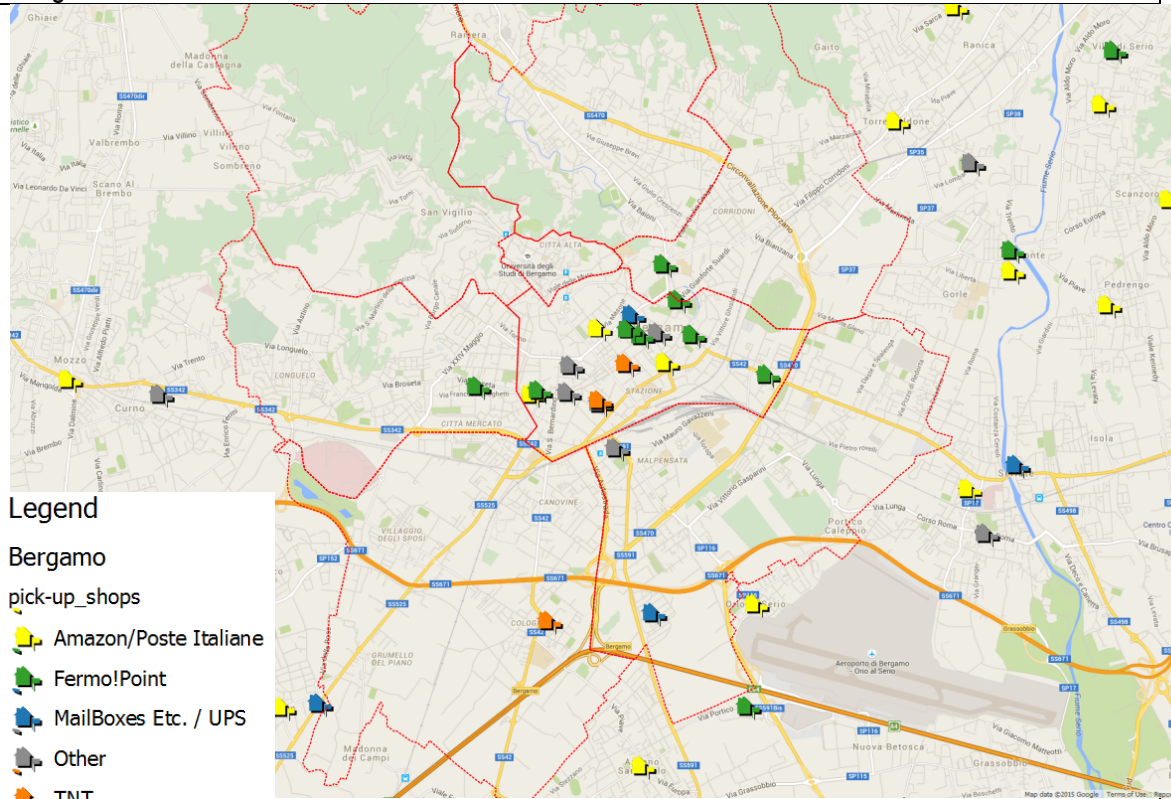
Limited Traffic Zones

- 22:00-7:00
- 7:00-10:00 and 16:00-19:00
- 8:00-19:00
- Other
- Permanent
- School
- Sport events

Base map: Google Physical

Figure A7: Limited traffic zones and weight restrictions (Bergamo only). Note: all the limited traffic zones are accessible only to vehicles < 3.5 tons

Bergamo



Luxembourg

Pick-up shops

- Post
- Kiala
- Mondial Relay
- GLS
- DPD
- Other
- Pack-stations

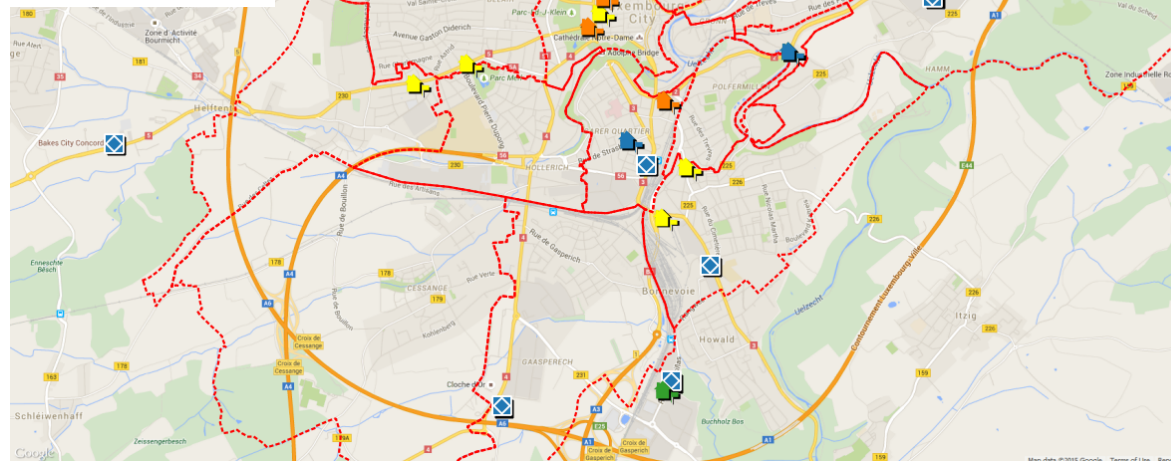
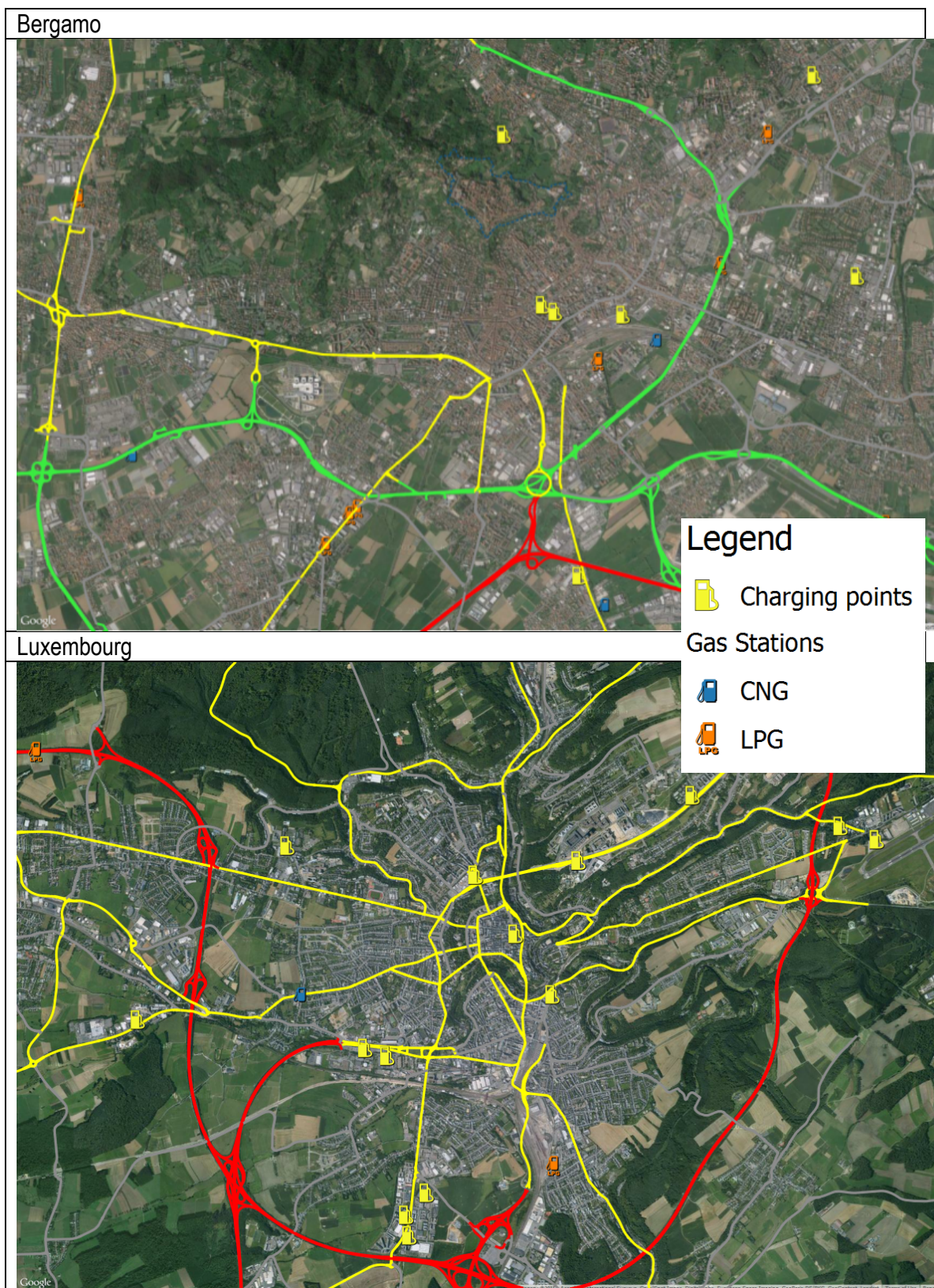


Figure A8: Pick-up shops (1:65,741)



Bergamo



Luxembourg



Figure A10: Loading-unloading bays (50m radius)