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**Conference Paper**

## Suburban collective transit and land use: a methodological approach

52nd Congress of the European Regional Science Association: "Regions in Motion - Breaking the Path", 21-25 August 2012, Bratislava, Slovakia

**Provided in Cooperation with:**

European Regional Science Association (ERSA)

Suggested Citation: Rossetti, Silvia; Tiboni, Michela (2012) : Suburban collective transit and land use: a methodological approach, 52nd Congress of the European Regional Science Association: "Regions in Motion - Breaking the Path", 21-25 August 2012, Bratislava, Slovakia, European Regional Science Association (ERSA), Louvain-la-Neuve

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# *Suburban collective transit and land use: a methodological approach*

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**Keywords:** Suburban mobility, Collective transit, Land Use.

**JEL code:** R41

## **Abstract**

*In the context of sustainable mobility great attention should be paid not only to urban mobility issues but also to suburban and interurban travels: an efficient collective transit service may represent an alternative to cars for these types of movements. Integrated approaches gathering urban planning and transport management can help in lowering individualized traffic volumes and in increasing collective transit usage. An assessment of the existing transit network and of its catchment areas may be a first step to investigate the relationship between the demand and the supply of collective transit facilities: a focus on land uses can help in providing this first assessment.*

*How can accessibility to collective transit be evaluated? Is it possible to link the suburban collective passenger transit network with land uses, in order to analyse the spatial efficiency of bus stops? The present paper aims at linking the location of existing bus stops with the surrounding land uses, with a focus on the case study of the Province of Brescia, which is one of the most dynamic realities of northern Italy. Using a land use geographical database it is possible to select land uses which, more than others, are able to attract or to generate potential transit users: residential units, public (and of public interest) facilities and productive infrastructures. The area served by the transit service can be estimated as the surface that people can reach from each stop by walking. To a first approximation, an influence radius of 450 m, corresponding to a walking distance of about 10 minutes from each stop, may be cho-*

*sen and mapped using a GIS software. Then the assessment can be performed calculating the proportion of different land uses covered by the transit service (and by difference the proportion of land uses that are at the moment not served by transit facilities). Furthermore, through an observation of the less covered catchment areas it is possible to detect the less useful bus stops, which in case of a reorganization of the lines may be taken off without generating disagreements.*

*The paper doesn't represent an exhaustive overview of all the accessibility issues related to collective transit but may be seen as a starting point from which further analysis can be developed.*

## **Introduction**

In European cities, the last years have been characterized by a growth attention on urban mobility issues and by an increasing awareness of the need to move towards more sustainable and climate friendly transportation modes. Nowadays “*in cities, switching to cleaner transport is facilitated by the lower requirements for vehicle range and higher population density. Public transport choices are more widely available, as well as the option of walking and cycling*” (European Commission, 2011).

But what about suburban travels and commuting? How can we encourage collective transit usage for interurban travels, incentivising in this way more sustainable mobility patterns? In Italy interurban and suburban mobility is still highly overbalanced toward the car (with the exception of travels between important cities efficiently connected by train). For this reason an important goal, in terms of transport policies, may be a consistent modal share shift from individual transportation modes towards collective ones also for suburban and interurban travels.

Furthermore “*a higher share of travel by collective transport,..., will allow increasing the density and frequency of service, thereby generating a virtuous circle for public transport modes*” (European Commission, 2011). Demand management and land-use planning can lower individualized traffic volumes and help in increasing collective transit usage. As a first step, it is possible to analyse the spatial efficiency of the collective transit system, focusing on

the land use of the areas that are reached by the service and to potential catchment areas not properly covered. The analysis will highlight important outcomes that should be taken into account while planning.

Collective transit stops, especially on roads, represent the initial and the terminal points of the pedestrian movement and it is around these points that people can verify the quality of pedestrian accessibility to the transit itself. The area served by a transit line can be estimated as the area that people can reach from the stop by walking. Literature values assume 400 m as the influence area of a bus stop and up to 800 m in case of transit services with higher capacities and speeds, like railways (Festa D., 2009). Anyway the maximum distance that people are willing to walk to reach the collective transit highly depends on the urban contexts. An adult usually walks at a 1.2 m/s speed, elderly and children are slower. For interurban busses the present paper considers three different influence radiuses of 450 m, 300 m and 150 m. The radius of 450 m corresponds to a walking distance of about ten minutes and defines the maximum area served by the transit. Lower radiuses represent areas closer to the stops that can be analysed to evaluate how the surroundings of the stop are composed. These radiuses figure a first approximation of served areas since a more detailed representation must take into account also other elements like the real availability of pedestrian paths within the area, possible slopes, barriers...

This paper will present a methodology to analyse the spatial efficiency of bus stops coverage over a given territory by linking the stops location with the surrounding land uses. The methodology will be applied to the case study of the Province of Brescia, located in northern Italy between the more famous cities of Milan and Venice. According to the Province of Brescia, the distance between new interventions of urban transformations and collective transit stops must be evaluated during the ex-ante environmental assessment process of new urban plans, required by law. This specific requirement may help in understanding if foreseen urban development is sustainable from a transportation point of view. The Province of Brescia, in Lombardy Region, with its 1,261,605 inhabitants and an area of 4785.52 km<sup>2</sup> is one of the largest in Italy. It takes its name from its biggest and most important city, Brescia, and it is composed by 206 local municipalities.

## **Land Uses that attract transit users**

The knowledge of land use dynamics plays an important role for territorial planning practices (and for transport planning too). Since the '90s, within the European CORINE Land Cover Programme, Lombardy Region set up a geographical database, called DUSAF, to collect land use information. DUSAF is an informative layer, homogeneous on the whole regional territory, that Lombardy Region makes available for download on its *GeoPortale* website<sup>1</sup>. The first version of the DUSAF geographical database has been built through the reading of aerials images of the years 1998-1999. The most recent version is updated at 2009 shots.

DUSAF uses a legend divided into three main levels, which is coherent with the technical specifications of the CORINE European Programme. The first level consists of five main land cover categories: artificial surfaces, agricultural areas, forests and semi natural areas, wetlands, water bodies. The legend becomes more detailed on its second and then on the third hierarchical level.

Since our objective is to link land use with the location of bus stops, only land uses that are able to generate or to attract potential transit users have been chosen. For this reason the present paper focuses only on the first category of the DUSAF legend (artificial surfaces), which is mainly composed by built-up areas. Within this category only land uses which can highly affect the necessity of a bus stop have been taken into account. Looking at the DUSAF legend, an effort has been done to select and collect the different uses that should be covered by the transit service. These uses have been then grouped into three main classes which are residential units, productive units and services. All considered land uses are listed in the following table.

<sup>1</sup> "Geoportale" is the Lombardy Region GIS website, where DUSAF and many other geographical informative layers can be downloaded for free ([www.cartografia.regione.lombardia.it](http://www.cartografia.regione.lombardia.it)).

Residential units (divided by the urban structure density)		Productive infrastructures		Public services, facilities and attractions	
Dense	1111	Industrial or commercial units	12111	Hospitals	12121
Average dense	1112	Agricultural units	12112	Public services (others)	12122
Discontinuous	1121			Graveyards	12124
Sparse and core-shaped	1122			Urban parks and gardens	1411
Scattered	1123			Sport facilities	1421
Farms	11231			Camping and accommodation facilities	1422
				Fun parks	1423
				Archaeological sites	1424

*Table 1 – Land uses considered and grouped as in the stops spatial covering analysis with the related DUSAF code*

Obviously not all detected land uses affect the necessity of a walking-distance located bus stop in the same way: e.g. looking at residential units, denser is the structure, more potential transit users are supposed to live there and more useful may be the presence of a bus stop within walking distance. Similarly, there are services that are able to attract more potential users than others (e.g. hospitals and sport facilities attract more than urban parks or graveyards) and in industrial and commercial units are supposed to work more people than in agricultural units. Anyway the collective transit is a service of public interest and, from a social point of view, all the inhabitants should have the opportunity to access and to use the service easily. For this reason, while performing a spatial covering analysis of the stops, also more scattered residential units and less important services have to be considered.

### **The Province of Brescia and its collective transit system**

The Province of Brescia, with a population of 1,1261,605 inhabitants, 206 local municipalities and six mountain communities is one of the largest in Italy. It is characterized by an impressive number of small and medium enterprises, which produces a great amount of goods,

to be sold at a national and transnational level. The Province of Brescia is also a renowned zone for tourism, especially in the many beautiful places around the Garda Lake, the Sebino Lake and on the surrounding mountains. From a geographical point of view Camonica, Trompia and Sabbia valleys are the main built-up territories of the northern mountainous part of the Province. Trompia Valley is characterized by high densities and many productive plants, while Camonica and Sabbia valley are less industrialized. On the two lateral borders of the Province it is possible to find the two lakes, Garda on the east and Sebino on the west, with their surroundings that attract tourism. In the middle of the Province the main city, Brescia, takes place with its high density conurbation, where many facilities are located. Last, the "Bassa Pianura" represents the southern part of the Province, characterized by an historical agricultural vocation.

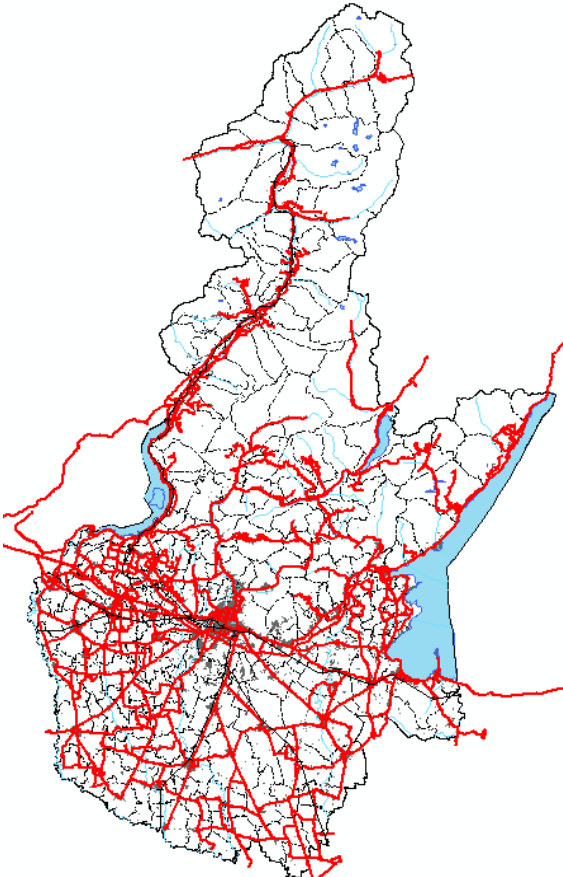


*Figure 1 - The province of Brescia in the north of Italy  
Source: GIS website, Province of Brescia*

The Province of Brescia is one of the twelve provinces that constitute the Lombardy Region (according to the Italian constitutional system Regions are the bricks of administrative organisation and Italy is divided into twenty Regions). In Italy, the Province is responsible for many administrative tasks, attributed by the State or the corresponding Region. The most important are the following: protection of the environment, regulation of the use of waters and

natural energies, transports and ways of communication, health services, secondary education, data processing and technical assistance to the local authorities. According to these tasks, the Province of Brescia is the administrative body that manages interurban collective transit within the province itself. The Province plans, authorises and controls on roads collective transit, including stops and timetables of the bus lines. Local transports companies, after having won competitive bids published by the Province, provide the service.

The interurban collective transit network within the Province of Brescia consists of 93 bus lines and of 1,750 stops spread over the territory. The total length of the lines (within the Province, since there are few lines that link also locations outside the province) is of 4,862 km and the commercial speed settles around 30 km/h. In addition there is an urban transit service that operates in the main city, Brescia, and in 13 surrounding municipalities. Since this analysis focuses on suburban and interurban transit, only interurban lines managed by the Provincia have been considered. These lines are shown in the following map.



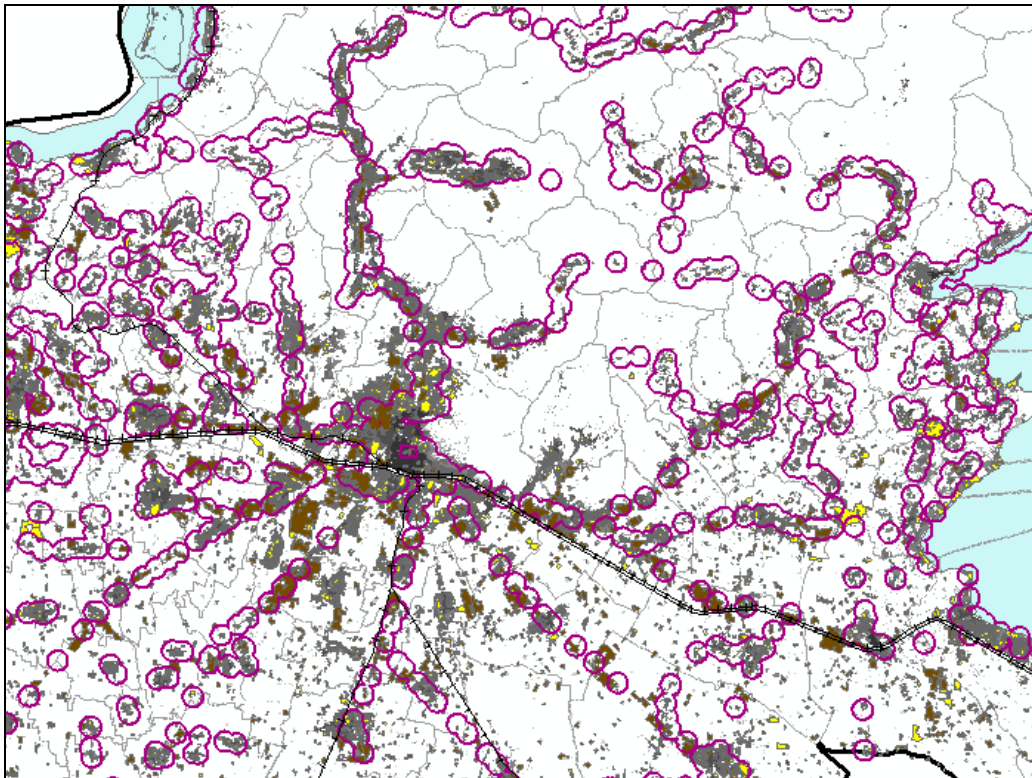
*Figure 2 – Province of Brescia, map of the suburban collective transit lines*



## Linking stop location with land uses

As already said in the introduction, it is possible to estimate the area served by a transit network looking at the area that a pedestrian can walk to from every stop. While performing the present analysis three different radiuses have been used: a 450 m radius represents the maximum distance that a pedestrian is disposed to walk to reach the bus transit service, 300 m may be considered as a sort of optimal walking distance and finally a 150 m radius correspond to the land use area located very close to the stop.

In the Province of Brescia, which is 4,785.52 km<sup>2</sup> large, the 17% of the surface (815.73 km<sup>2</sup>) and the 56% of built-up areas (270.50 km<sup>2</sup>) are located within 450 m from an interurban line bus stop.



*Figure 3 – Portion of the provincial territory, with detected land uses and a 450 m radius of influence from each bus stop*

After having mapped the surfaces covered from the interurban bus stops, from the DUSAF layer it is possible, using a GIS software, to select all the land uses that are located within the

agreed influence radiuses and to calculate their geometry. In this way the surface and the percentage of each kind of land use covered within walking distance by the collective transit can be estimated and, on the difference, the surfaces not covered can be highlighted. The following table shows the results in terms of surface [km<sup>2</sup>] and percentage of surface covered within the three different radiuses and divided by land use.

Land Uses	Whole province [km <sup>2</sup> ]	Within 450 m from a stop [km <sup>2</sup> ]	% of surface covered	Within 350 m from a stop [km <sup>2</sup> ]	% of surface covered	Within 150 m from a stop [km <sup>2</sup> ]	% of surface covered
<b>Province of Brescia</b>	<b>4785,52</b>	<b>815,73</b>	<b>17%</b>	<b>432,11</b>	<b>9%</b>	<b>125,08</b>	<b>3%</b>
<b>Residential units</b>							
Dense	3,76	3,36	89%	2,57	68%	1,06	28%
Average dense	30,20	26,01	86%	21,79	72%	10,82	36%
Discontinuous	155,04	106,18	68%	75,78	49%	29,69	19%
Sparse and core-shaped	51,68	31,62	61%	21,02	41%	7,97	15%
Scattered	21,78	7,87	36%	4,52	21%	1,53	7%
Farms	23,07	3,71	16%	1,87	8%	0,67	3%
	<b>285,54</b>	<b>178,75</b>	<b>63%</b>	<b>127,55</b>	<b>45%</b>	<b>51,74</b>	<b>18%</b>
<b>Productive infrastructures</b>							
Industrial or commercial units	102,63	56,69	55%	35,15	34%	11,14	11%
Agricultural units	41,20	7,57	18%	3,80	9%	0,95	2%
	<b>143,83</b>	<b>64,27</b>	<b>45%</b>	<b>38,94</b>	<b>27%</b>	<b>12,09</b>	<b>8%</b>
<b>Public services, facilities and attractions</b>							
Hospitals	0,99	0,91	92%	0,83	91%	0,34	34%
Public services (others)	7,60	5,62	74%	4,32	77%	2,02	27%
Graveyards	2,82	1,66	59%	0,99	60%	0,27	10%
Urban parks and gardens	15,96	9,17	57%	6,24	68%	1,91	12%
Sport facilities	17,93	8,40	47%	4,86	58%	1,61	9%
Camping and accommodation facilities	3,57	1,58	44%	0,86	54%	0,26	7%
Fun parks	0,52	0,16	30%	0,13	83%	0,05	10%
Archaeological sites	0,09	0,00	0%	0,00	0%	0,00	0%
	<b>49,48</b>	<b>27,49</b>	<b>56%</b>	<b>18,23</b>	<b>37%</b>	<b>6,45</b>	<b>13%</b>

Table 2 – Land uses covered within walking distances from the stops

First of all it is important to point the attention on residential areas, where most of the people live and that often represent the starting point of daily movements. In the Province of Brescia, 178.75 km<sup>2</sup> of residential units are located within a radius of 450 m from a bus stop. This corresponds to the 63% of the residential units located in the whole province. Looking at the 300 m radius it is possible to find that 127.55 km<sup>2</sup> of residential units are covered by the stops while they are 51.74 km<sup>2</sup> if we consider the 150 m radius (respectively 45% and 18% of the provincial residential units). The most covered areas are dense and average dense residential areas. More than an half of discontinuous and sparse core-shaped territories are reached by the transit within 450 m, while only few scattered houses and farms can benefit from the transit service.

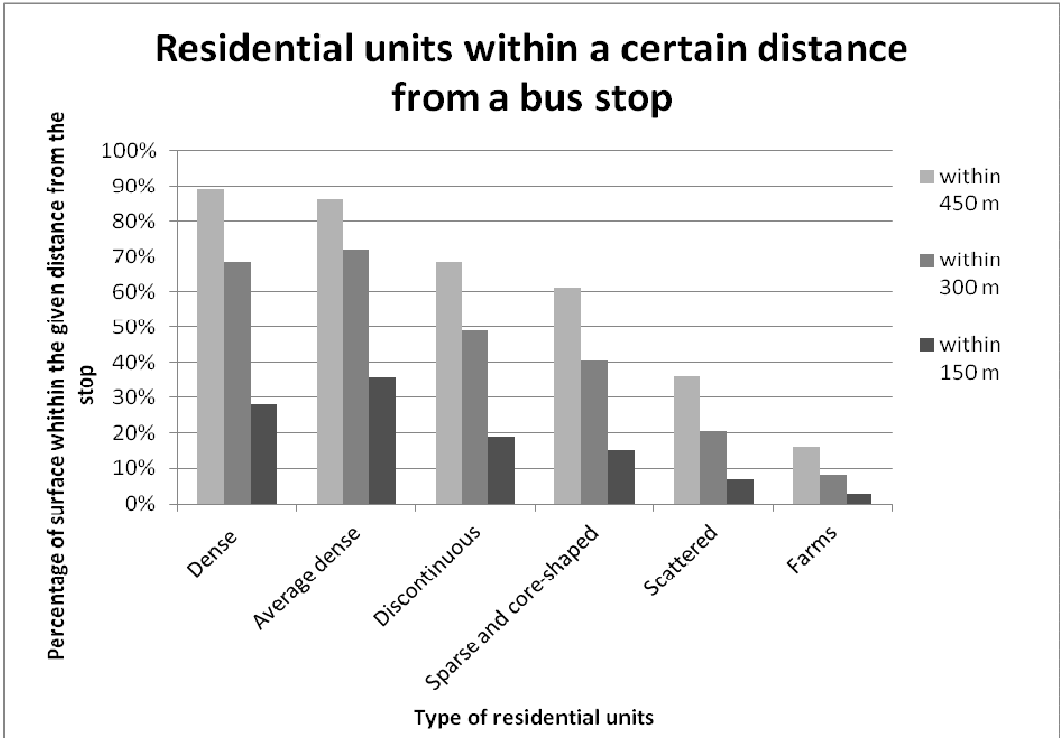


Figure 4 – Province of Brescia, % of residential units located within 450 m, 300 m and 150 m from a bus stop

Looking at home to work mobility, it is also important to consider productive (industrial, commercial and agricultural) units, where many potential transit users are employed: produc-

tive units are often the final destination of systematic movements. Within the radius of 450 m from the bus stops 64.27 km<sup>2</sup> of productive units are located, (which correspond to the 45% of the productive units located in the whole province). More than half (55%) of the industrial and commercial units are covered by the service, while only the 18% of the agricultural units are inside the 450 m buffer. The productive units area covered linearly decreases considering lower influence radiuses.

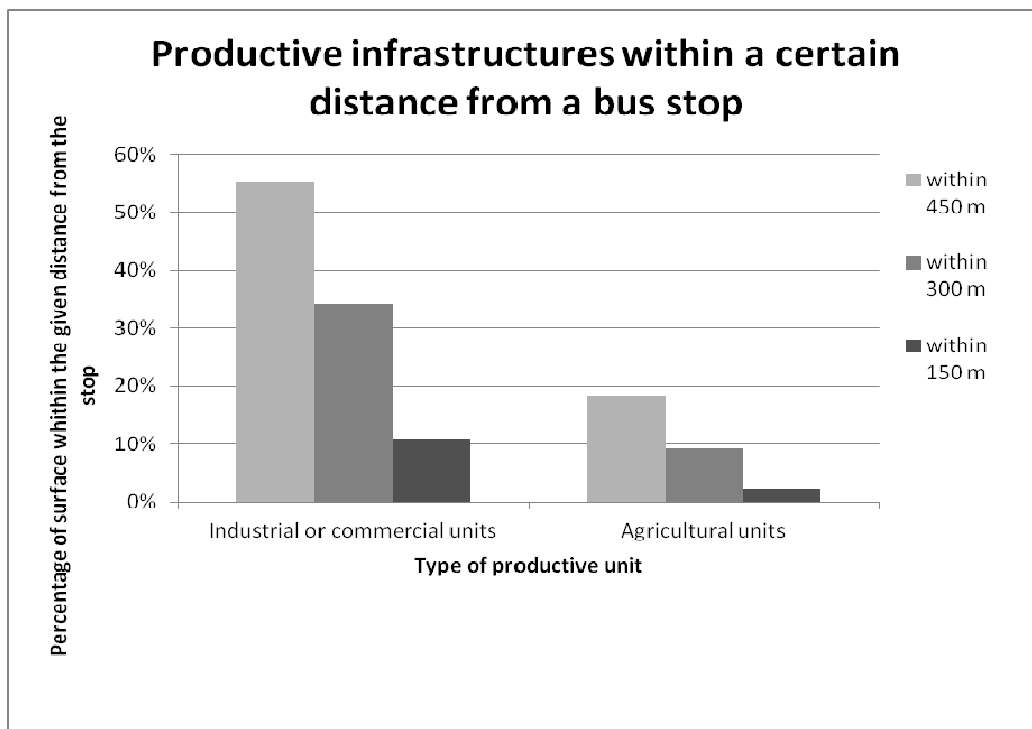


Figure 5 – Province of Brescia, % of productive units located within 450 m, 300 m and 150 m from a bus stop

Public (or of public interest) services are fundamental functions in the urban system and are the final destination of a large amount of movements. For this reason high collective transit accessibility levels to the services may consistently help in reducing car usage.

In the province of Brescia only the 56% of areas dedicated to public (and of public interest) services is placed within 450 m from a bus stop. Hospitals are very well covered by the transit service (more than 90%) while fun parks, sport, camping and accommodation facilities are covered for less than 50%. No archeological site can be reached using collective transit.

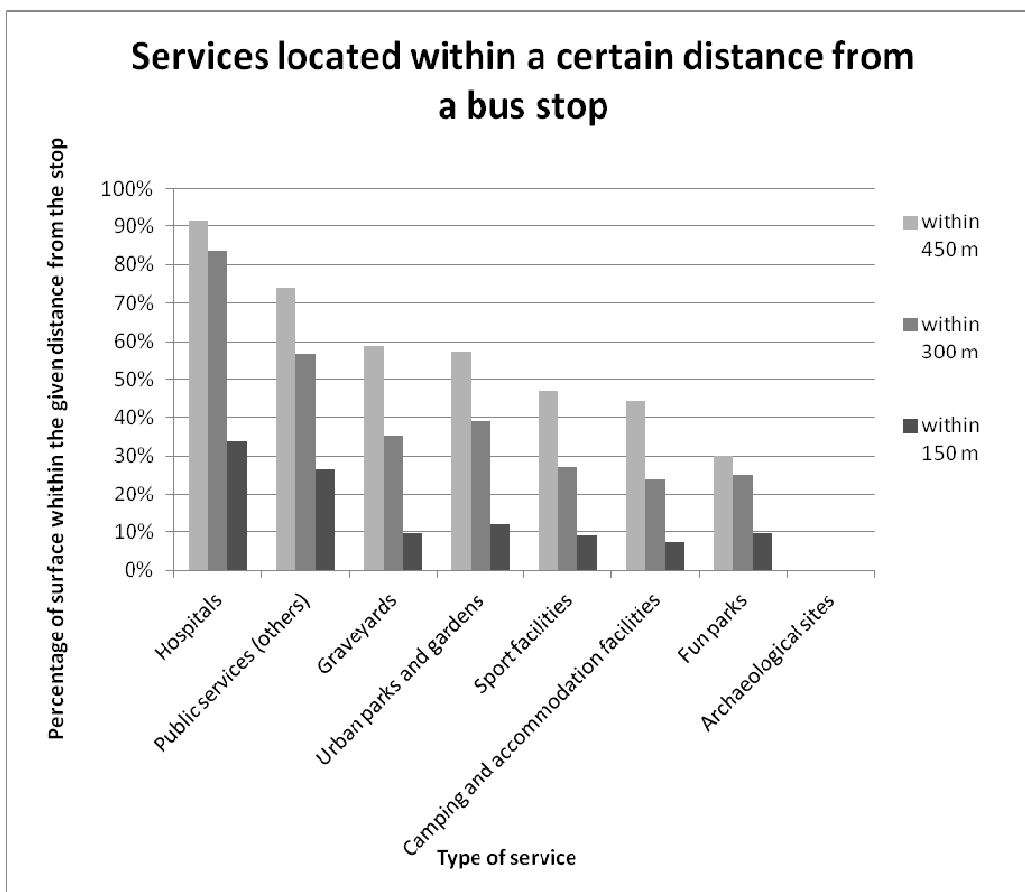


Figure 6 – Province of Brescia, % of services located within 450 m, 300 m and 150 m from a bus stop

The shown figures (4-5-6) may be observed, on the difference, also looking at the residential, productive and service units that are not covered by the transit service. E.g. it is positive to note that only the 8% of the areas occupied by hospitals is not located within the 450 m radiuses. It is less positive that the 56% of the camping and accommodation facilities surfaces aren't covered by the transit service: this means that collective transit is often not suitable for tourists needs. Dense and average dense residential units are well served by the transit, while the 64% of scattered houses, corresponding to 13.91 km<sup>2</sup> don't have a walking access to it.

## **How to detect the less useful bus stops**

This chapter tries to provide new elements to the issue already described, focusing on the bus stops that serve residential, productive and service units less than others. This analysis has been performed on a pilot bus line, the Slink202 Brescia-Salò-Gargnano-Arco line, which links the main city of the Province, Brescia, with the northern part of the lake of Garda passing through important municipalities of the eastern part of the Province like Salò, Gargnano and Vestone. The line has a total length of 104.52 km. It reaches 17 municipalities of the Province and in its final section also two municipalities, Riva del Garda and Arco, which belong to the neighboring Province of Trento. Within the Province of Brescia the line counts 94 stops. The area served by each stop, considering the walking distance radius of 450 m, has been analysed, with a focus on the surfaces that don't belong to the categories that potentially generate or attract transit users (the same categories that have been listed in the previous chapters and grouped into residential, productive and service units). Along the line there are four stops that have more than the 95% of the served area not covered by these categories of land uses. All these four stops are located in the northern municipalities that overlook the lake of Garda, along the main street that borders the lake. Looking at the DUSAF layer that surrounds these 4 stops it is possible to note that it is mainly composed by greenery (bushes and olive groves) and by the lake itself. This is possibly due to geo-morphological reasons: in that part of the lake mountains arrive very close to the lake so on that areas it is not easy to build up and settle. Anyway these stops may be considered less useful than others and, in case of a re-organization of the lines, it would be possible to take them off without generating disagreements.

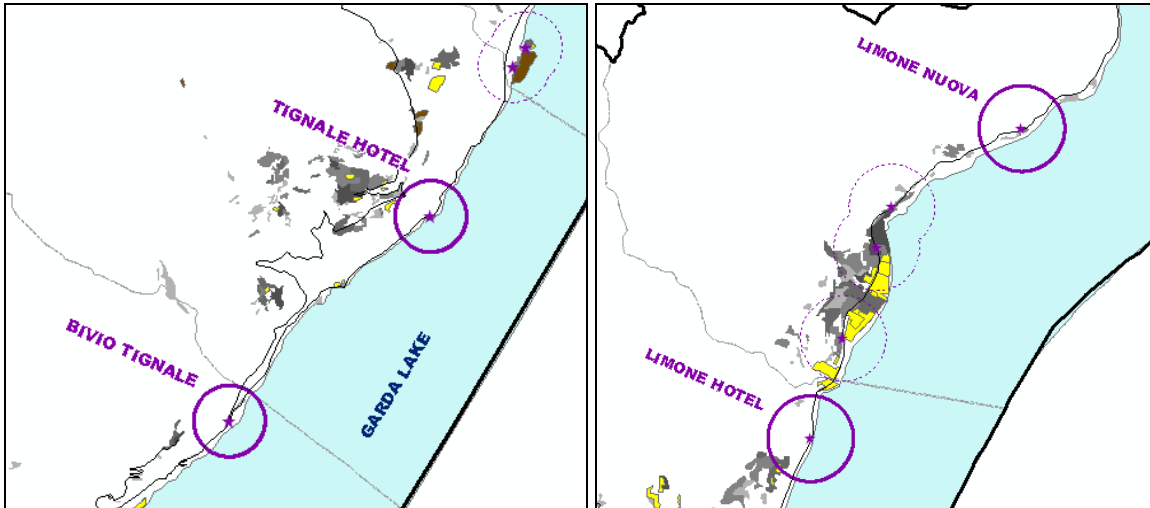


Figure 7 – The four stops that have more than 95% of served area not covered by residential, productive or services units

On the contrary, using this methodology it emerges clearly that there are also stops that have a large part of the served area covered by land uses that are able to generate and attract transit users (e.g. 19 stops of the Slink202 line have a served area that is not covered by residential, productive or service units for less than the 20% of the surface). These stops play an important role in the transit system and have to be maintained.

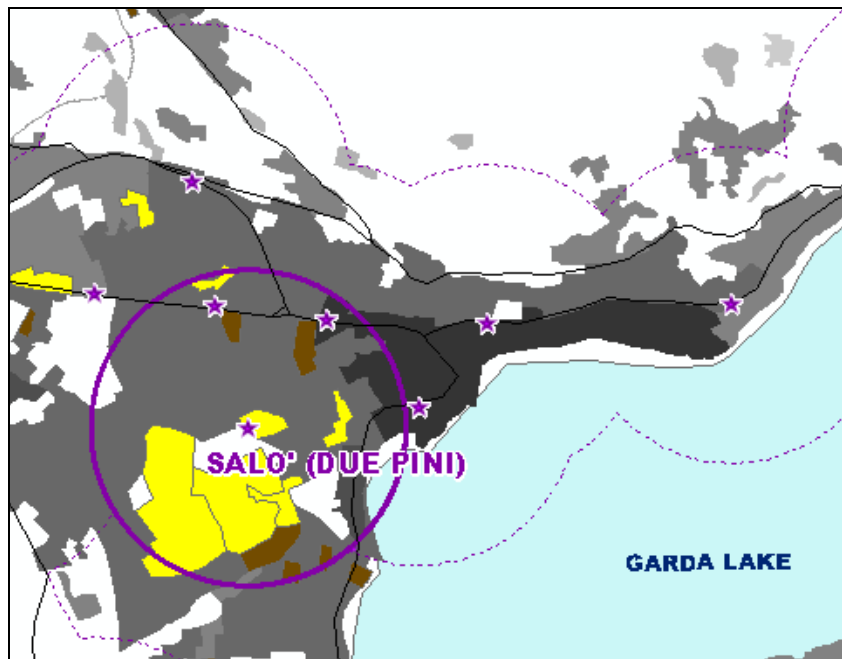


Figure 8 – Example of bus stop which is not covered by residential, productive or services uses land uses for less than 20%. It may be judged as an useful stop.

The distribution of Slink202 stops within different coverage percentage range is shown in the following table.

	Percentage of walking distance surface from the stop not covered by residential, productive or service units	Number of stops of the S-LINK202 line
<p>LESS USEFUL STOPS</p> <p style="text-align: center;">↓</p> <p>MORE USEFUL STOPS</p>	80% - 100%	14
	60% - 80%	16
	40% - 60%	25
	20% - 40%	20
	0% - 20%	19
	total	94

*Table 3 – Distribution of stops according to the served areas covered*

## Conclusions

Urban planning and land use can highly affect the sustainability of transport systems, especially in a long-term vision. Integrated approaches gathering urban planning and transport management can help in reducing car usage and encouraging more climate-friendly mobility patterns (Tiboni M., Rossetti S., 2011).

Starting from the need of moving towards more sustainable transportation modes not only for urban travels but also for suburban and interurban ones, this paper has dealt with the problem of suburban collective transit stops land coverage. It doesn't represent, of course, an exhaustive overview of bus stop location and accessibility issues: a focus on land use can help in providing a first assessment of the transit network but then many other factors should be considered, both from the transportation and from the urban planning point of views. Collective transit necessarily has to be organized with a strong relation to pedestrian facilities (Busi R., Pezzagno M., 2000). Furthermore it is necessary to provide a good balance between proximity and plant logics: stops should be located as close to the users as possible but in the mean-



time, from an operational point of view, they shouldn't be too close each other in order to obtain more efficiency in terms of operational speed, frequencies and costs (Tira M., Lombardi S., 2009). Starting from this assumption in the recent years the Transit Oriented Development (TOD) is born, where high-density settlements with a mix of facilities are located on transit nodes.

It is furthermore necessary to remark that the spatial coverage of the transit service is not enough to describe the effective availability and accessibility to the transit service itself: it is important to evaluate also the temporal issue, in terms of frequencies and working hours of the transit service. In this sense on demand services may play an important role in providing a high-quality level of service in areas that don't have enough demand to be reached by a scheduled transit line.

The methodology proposed in this paper represents a first assessment that can be easily applied to highlight the relationships between built-up settlements and transit efficiency. Further developments of the present research may involve the analysis of previous land use layers in relation to the correspondent collective transit network. The DUSAF project started in the '90s but it is now available also for previous years thanks to continuous updates which involved also older aerial images. At the moment DUSAF land use layers of the years 1950, 1980, 1999, 2007 and 2009 can be downloaded. A chronological analysis of the land use and the transit network could help in understanding how, during the recent history, the interactions between urban development and collective transit have worked. The proposed methodology applied to different years will highlight if urban planning and transit development have proceeded together or not.

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