Politecnico di Torino

Master's degree programme in

Territorial, Urban, Environmental and Landscape Planning

Curriculum: Planning for the Global Urban Agenda

Master's Thesis

Geospatial analysis for urban cycling planning and design

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La bicicletta è quella cosa che
forse
un giorno ci salverà.

Dario Pegoretti, artigiano telaista

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1. Introduction

At the base of this study is the geospatial analysis of urban cycling mobility understood as a space and policies aimed at promoting and ameliorating the utilization of non-motorized vehicles in the city and over medium distances.
COVID-19 stresses the already-known unsustainability of the private car as the main mean of transport in urban environments giving some help to speed up the transition process from a car-oriented way of thinking the built environment into a more integrated and multimodal approach of moving. Active-mobility such as cycling has recorded strong increased rates due also to distrust on the safety-from-contagious in public transportation where ventilation is limited, and users cannot perfectly respect distances especially during rush hour.
The reasons that led me to deepen this theme are first personal interest in this form of mobility. The passion for urban cycling has been with me for some time and the experience created the conditions that led me to wonder what problems were related to moving around the city without a car. While pedalling in urban and extra-urban environments, it is almost natural to notice what put cyclists in most difficulty. So, I wondered if in the Italian context of knowledge of a cycling infrastructure the features taken into consideration could be more than paved or unpaved path and its mileage. Reality is undoubtedly more complex with material and immaterial aspects that influence the experience of cycling and cannot be so simplified.
The objective of this master's thesis is to provide an accurate geospatial analysis of the cycle ways data collected on-site, highlighting further aspects of the cycling infrastructures. The work aims to propose a new interpretation of the cycling infrastructure that goes beyond the simple knowledge of its extension.
The municipality of Mappano is intended to augment the attention, and so finances, to cycling mobility demonstrating the growing importance of a good cycling network to give alternative solutions to move inside the municipality and outside its boundaries. Hence, the town has been chosen as the case study of this final project.
The methodology consists of a first phase of analysis to collect spatial data about the municipal cycling infrastructure network: a cargo bike was used for on-site analysis, equipped with a GNSS RTK system to trace the path, a Garmin action Cam for video recording of the pavement condition and a 360° Go Pro camera to observe the surrounding environment for understanding the safety perception of the rider on each link. The acquired data are then extracted and processed in the second phase

in which the prototype of spatial data infrastructure model is applied. The GeoDB is obtained by the combination of existing OpenStreetMap and BDTRE Regione Piemonte attributes, but an additional new section of attributes is created, giving them hierarchical and non-hierarchical numeric coded values (1-5), to have further details such as maintenance status, type of cycle way, presence of impedance, road light condition, presence of dedicated road signs, safety perception, path dangerousness. A paragraph is dedicated to local businesses and how positively might be impacted if scenarios of growing levels of walking and cycling are applied. Finally, a review of future intervention is presented focusing on the relevance that urban design has in cycling infrastructures and more in general in the built environment. Indeed, pleasant, well-design, inclusive and connected networks for non-motorized vehicles can strongly attract new users and reduce car-dependency.

This work is divided in seven chapters. Chapters 2 and 3 are the theory on which this final work is based on, useful to understand the real potential of cycling by historical notes on the development and diffusion of the bicycle (2) and Italian legislation on cycle mobility (3). Concomitantly Chapter 4 is the basis of the data infrastructure project for the creation of the GeoDB explaining the logic of the model and how it is possible to use a combination of OpenStreetMap, BDTRE Regione Piemonte and new additional data section to broaden the point of view on the cycling infrastructure. Data analysis and results are presented in Chapter 5. Finally, Chapter 6 presents an intervention review related to urban design questioning the traditional approach of building cycle paths in response to the demand for non-motorized mobility.

This research led me to understand how the factor of speed is deeply influential in the experience of cycling. The results will be detailed in the final conclusions of this thesis.

2. The culture of cycling

2.1. The bicycle

The beginning of the history of the bicycle, summarized in Figure 7, can be assumed to be the year 1817, in which the Baden forestry official Karl von Drais presented his Laufmaschine or running machine (Wikipedia, 2021 c), also known as "Draisine" (or Draisienne) after its inventor. This ancestor of the bicycle was a single-track, human-powered vehicle without pedals (Wikipedia, 2021 b) and Drais' merit was to have added a steering device to the non-steerable impellers already known in the previous century (Wikipedia, 2021 c). Alleged predecessor - the "Célérifère"- from the 18th century was a French priority fairy tale from 1791 (Wikipedia, 2021 b). Its existence is controversial but cannot be ruled out. As a matter of fact this invention refers to a French express car and not a non-steerable man-power-powered two-wheeler (Wikipedia, 2021 d) developed by the Count de Sivrac (Delore, 1977) and presented to the Paris public in June 1791 (Wikipedia, 2021 d). The confusion derived from the Célérifère has been considered a fake since Jacques Seray in 1977 (Delore, 1977). Indeed, Drais' invention is well-documented with patent (*Figure 1*) specifications and other materials which suggest that it was unprecedented (Lessing, 1997).

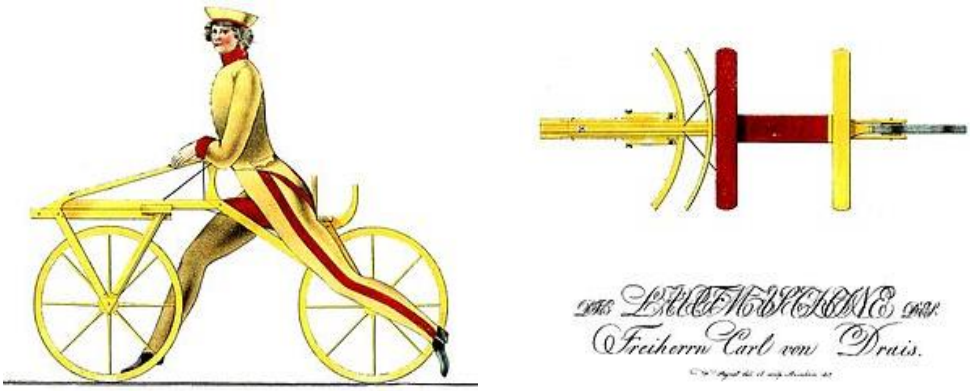


Figure 1. Illustration of the Drais'patent specification of 1817 about the Draisine [Source: Wikipedia https://rb.gy/mqvzqr]

Figure 2. Ride on a Draisine. Extract from the film "Our Hospitality" directed by and starring Buster Keaton, 1923. Click or scan to watch. [Source: Wikimedia Commons]

The draisine consisted in two consecutive wagon wheels among which a saddle as a seat and a padded board for balancing and supporting the forearms was attached. A travel bag could be attached with straps behind the saddle (Wikipedia, 2021 b). The hands stayed on the handlebars of the front wheel. By alternating repulsion of the feet on the ground, the vehicle
was moved (Ibid.). The rear wheel was firmly mounted in the frame, while the front wheel can be rotated around its vertical axle with the steering axle located about fifteen centimetres ahead of the front wheel axle *(Figure 1)*. The rear wheel could be braked with a grinding brake (Ibid.). These machines were popular with wealthy young gentlemen for park riding and (Hanlon, Bicycle Fashion Files Part One: Early Inventions 1790-1860s, 2016) in London took the nickname of "dandy horse" due to the type of customers it had stereotyped as dandies (Ibid.) The term "vélocipède"(from Latin *velox -ocis «veloce»,*fast, and *pes pedis «piede»*,foot, Treccani, 2017) was instead probably first coined as a French translation from the German "*Laufmaschine*" by Karl von Drais for its importation into France (Wikipedia, 2021 g). Alternately, "Bone-shaker" was another adopted word as the effect produced by the stiffness of the material (wood and iron) and rough roads (mainly cobblestones) (Frittoli, 2017).
Few years later a draisine for women *(Figure 3)* was developed (Wikipedia, 2021 b) creating a drop frame compatible with conventional skirts and dresses (Hanlon, Bicycle Fashion Files Part One: Early Inventions 1790-1860s, 2016). That was one of the options to adapt women's costumes for cycling, which was recognised at a very early stage in the development of bicycle technology. The other option was a new style of dress with shorter modest skirts or gymnastic outfits. Most women who cycled in those years were wealthy or aristocratic (Ibid.).
The most important steps in the further development to today's bicycle were (see also *Figure 7*):

- 1861/63 | addition of pedal crank to a draisine by French Pierre Michaux and his son Ernest. The Michaux's pedal crank bicycle *(Figure 4)* or "Michauline" was the direct predecessor of the high wheel bicycle (Wikipedia, 2021 c). Three German men might have been invented it even forty years before but since the dates are controversial the Michauline is the one considered (Ibid.).
- 1885 | design of the Rover safety bicycle by English designer John Kemp Starley (Ibid.). The Rover was a rear-wheel-drive, chain-driven cycle with two similar-

Figure 3. Women on a female type of draisienne, 1819. [Source: https://www.sheilahanlon.com/?p=2069]

sized wheels, making it more stable than the previous high wheeler designs (Wikipedia, 2021 e) also known as "Biciclo[1]" *(Figure 5).* The high wheel, which was stimulated by the pedal crank drive and used for two decades mostly as sports equipment, was replaced by the safer low wheel, which could finally be used for general purposes (Wikipedia, 2021 c).

A ladies' drop bicycle frame was devised by lowering or removing the crossbar to left room for full skirt (Hanlon, 2017). Skirt guards were added to moving parts to prevent loose fabric from snagging (Ibid.).

- 1888 | the invention of the pneumatic tyre by British veterinarian John Boyd Dunlop (Wikipedia, 2021 c) who actually re-invented without knowing pneumatic tyres for his child's tricycle and developed them for use in cycle racing (Wikipedia, 2021 f). This was an important contribution to increase riding comfort.

[1] Biciclo, or penny-farthing, enabled higher speeds on bicycles limited to direct drive. Depending on the rider's leg length, the front wheel could have had a diameter up to 1.5 m.

Figure 4. Preserved Michaux' type draisienne [Source: Traore, 2021 Picture taken at AcdB museum, , Alessandria]

Figure 5. "Biciclo" dated 1880 and restored in 2015 by G. Meazzo exposed at AcdB museum [Source: Traore, 2021]

Parallel to the "biciclo" there was another option for women who wanted to ride: the "tricycle" (*Figure 7* under "Everyday life" category) (Hanlon, 2016 a) which allowed them to follow the dress code of the epoque *(Figure 6)*.

Figure 6. Women on a tricycle. [Source: Hanlon, 2016a urly.it/3dxtn]

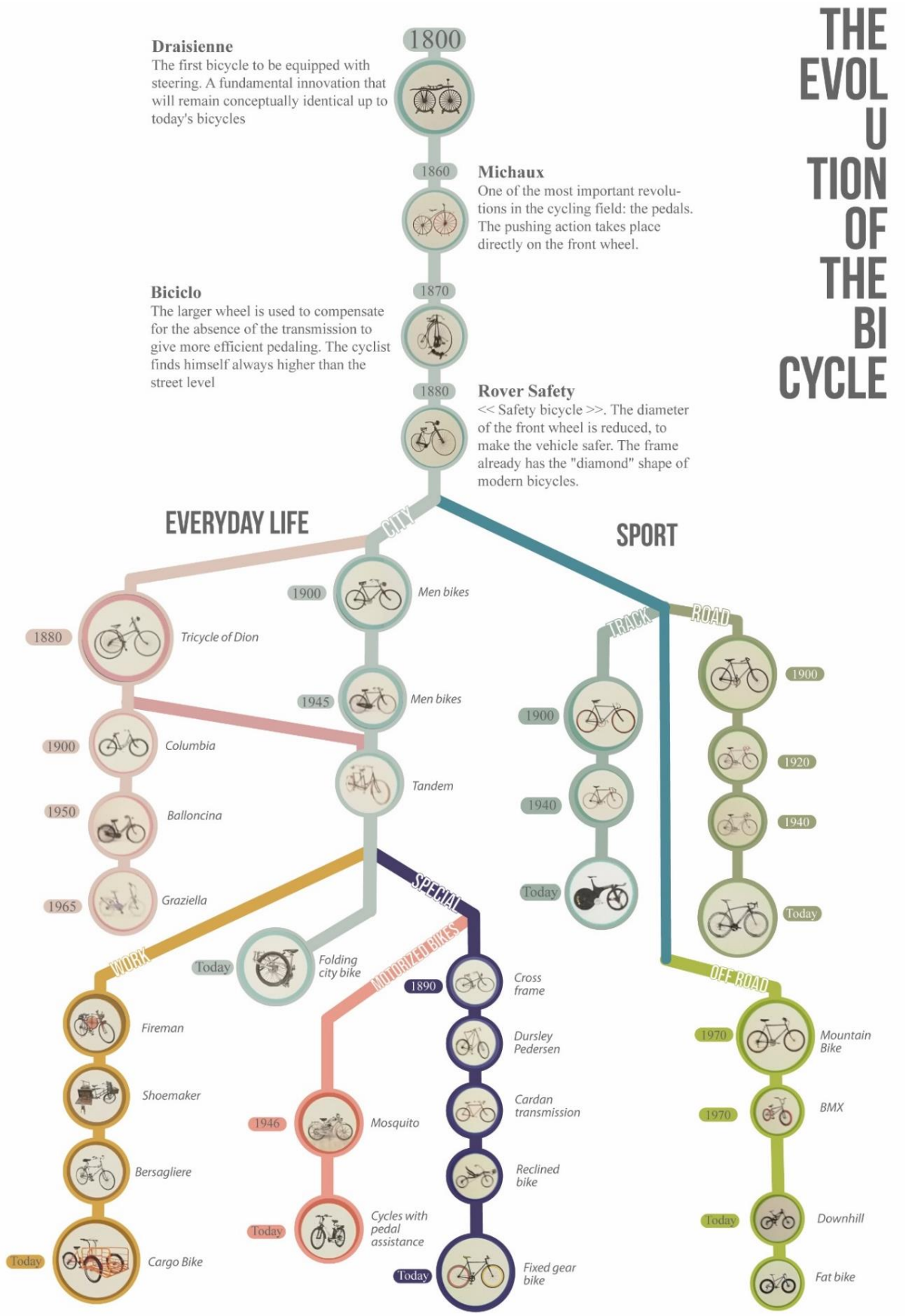


Figure 7. Evolution of the bicycle's technology from 19th century till today. [Source: Traore, 2021 through "Alessandria città delle Biciclette" (AcdB) museum's infographic and pictures]

Tricycling was considered a respectable pastime suitable for aristocratic ladies. Thus, cycling fashion took off to meet the demand for elegant riding gear in the 1880s. Freedom of movement and mobility, coupled with dress decorum and full coverage while in motion, were key to these designs (Ibid.). Reality was that despite the best-efforts tricycle costumes were not quite fit for purpose. Adaptations of women's dress for cycling reflected the new place women were beginning to occupy in society and in public spaces (Hanlon, 2017). Sadly, this new type of woman was publicly insulted and attacked, in particularly when wearing rational cycling dress as the women in *Figure 8,* a satirical cartoon in Punch magazine (Ibid.). As the cycling historian Sheila Hanlon wrote in her web documents dated 2017:

> [...] the cycling new woman was seen as stepping beyond accepted gender barriers and abandoning her role as wife and mother in favour of politics, education, and independence. Outrage at rationals was a direct attack on women's mobility and an attempt to curtail the freedom and escape from the domestic sphere that the bicycle represented.

Figure 8. Lady Cyclists in Punch satirical magazine cartoons, 1890s [Source: https://www.sheilahanlon.com/wp-content/uploads/2017/03/Puck-The-New-Woman-and-her-Bicycle2.jpg]

The development of the modern bicycle could be considered complete at the end of 1880s with the transition from cross frames (*Figure 9* and "Special" bikes of *Figure 7*), which already resembled a diamond, to the diamond ones *(Figure 10 and Figure 11)* starting from 1890s (Wikipedia, 2021 c).

Gradually the bicycle, increasingly mass-produced at lower prices, left the status of elegant leisure to become a sport, touring and even transport machine (Wikipedia, 2021 g). As a result of constant technology evolutions such as the introduction of derailleur by Tullio Campagnolo (Italy) in 1946, with gear ring packages (cassette) and thus different ratios for different routes (Wikipedia, 2021 c), this vehicle become a mass mode of transport (Ibid.) in a world of few cars.

Figure 7 – category "Work", bike type *Bersagliere* - shows how the bicycle was also used for working and during the two World Wars by soldiers. The formation of the first Bersaglieri cycling department dates back to 1899 The metamorphosis of those work-type bicycles is the Cargo Bike ("Work" in *Figure 7*), which is used for moving bulky material but even for commercial purposes (such as food/goods delivery) and find its application also to transport people, mainly children but initiatives like "Cycling Without Age"[2] is pushing the limit forward <<with an electric rickshaw bike providing older adults with an opportunity to remain an active part of society and the local community.>> (Team of "Cycling without Age", 2012). "Special" category groups less popular bicycles such as Scandinavian Pedersen-type frame, an example of unique craftsmanship, which did not find popularity over the first decade of 1900 (pedersenbicycles.com, 2012).

Sport became one of the most associated purposes of the bicycle since the first velocipedes and it covers a parallel evolution path next to "Everyday life" cycles (*Figure 7*). Until the 1880s most of the races were organized in velodromes (Mignot, 2016). From the 1890s, races started to be organized on public roads by newspapers, mainly to boost their sales and their advertisement revenue but also to show bicycles enabled to cover great distances - from 250 to 400 km - meaning that the best riders of French, Belgian and Italian annual races, from one city to another, had to race for more than ten hours to complete the race (Ibid.).

[2] Cycling Without Age is a movement started in 2012 by Ole Kassow to help the elders get back on their bicycles, but he had to find a solution to their limited mobility. The answer was a trishaw and he started offering free bike rides to the local nursing home residents. Website: https://cyclingwithoutage.org/about/

Figure 9.Preserved Peugeot cross frame bicycle, 1890 at AcdB museum Alessandria [Source: Traore, 2021]

Figure 10. Preserved Peugeot diamond frame, 1892, AcdB museum Alessandria [Traore, 2021]

Figure 11. Preserved Peerless racing bicycle, 1902, AcdB museum Alessandria [Source: Traore, 2021]

Therefore, newspapers organized cycling such as the Italian newspaper La Gazzetta dello Sport, which had followed some of the early editions of the Tour de France and it pre-empted the Corriere della Sera's decision to organize a stage race: the "*Giro d'Italia*". The success converted, in 1913, the Gazzetta from a thrice monthly to a daily newspaper (Ibid.). Track and Road bicycles, which at first could have had similarities (*Figure 7*), evolved in two very different types of vehicles in terms of components, bike gear changes handlebar, wheels and other details for instance athletes' accessories and clothing.

Without counting the improvised stuff around before the 1970s in 1977 the first with-that-purpose mountain bike (*Figure 7*) – "Breezer number 1"- was built in California by frame builder Joe Breeze (from which the prototype took the name) and another early pioneer in the development of modern mountain bicycles, Charlie Kelly (Sawa, 2020). Kelly was the founder of "Repack" downhill, the first timed mountain bike race. Before MTBs races were held riding clunkers[3] down the track (Ibid.). While Breeze and Kelly created the first purpose-built bikes, the first ever off-road bicycles made to be ridden over on wild terrains have their origins in the eighteenth century. In 1891, the Swiss Army Bikes were the very first recorded examples of hill climbing bicycles. Then the Buffalo soldiers of the US Army were the next to see the use of a bicycle similar in nature and purpose (Sawa, 2020).

The 1970s is considered the period from which mass production of mountain bikes started but off-road riding was practices already with non-specialized cycles. Rough Stuff Fellowship[4], established in 1955 in UK, is the oldest off-road cycling club in the world and Rough Stuff Fellowship Archive is the memory of this period due to several picture which have been taken.

Today, mountain biking is a discipline with several categories that make it a complex sport and pursuit: Trial biking, Downhill, Dirt jumping, Slopestyle, Freeride. Although the list is not exhaustive it shows how it has changed from what it was in the 70s (Sawa, 2020).

The bicycle had a wonderful and romantic past but also a glorious future. They are becoming even more accessible to all generations in all conditions because of electric bikes that have recently come into play, and they are causing a revolution.

[3] Clunker definition: an old or badly working piece of machinery. From Merriam-webster since 1828 (https://www.merriam-webster.com/dictionary/clunker#examples)

[4] See their website for further info and history https://www.rsf.org.uk/about-us/history-and-beginnings.html

Italy could greatly benefit from the widespread diffusion of a vehicle such as the pedal assisted bicycle, since it is a predominantly collinear and mountainous area and only 20% of the Country is flat lands.

2.2. Evolution in the use of bicycles

The history of the bicycle in Italy started early in 1867 when Carlo Michel came back home with a Michaux-type draisine acquired at the Paris World's fair of the same year. Carlo Michel was an eccentric Italian entrepreneur born in the province of Alessandria (Piedmont) already known for his beer production ("Birra Michel" then "Birra Alessandria") in Monferrato, one of the most important wine districts of Italy. The arrival of his velocipede prototype was a remarkable success of curiosity and admiration, so much that his example was soon followed by friends and the first group of cyclists was born shortly after. This news was confirmed, as early as 1869, by the publication of a Regulations on the circulation of velocipedes that the municipality of Alessandria found itself the need. The laws on city traffic of the second half of the nineteenth century had to consider the urban planning and means of transport of the time. Thus, the municipal regulations relating to the circulation of velocipedes, dated respectively 1869 and 1887 (*Figure 12* and *Figure 13*), curiously pointed out also the speed limits. For example, Velocipedes could not be pushed into the raceways faster than a person at a brisk pace and had to be stopped whenever any horse got scared.

The *Alessandrina Velocipedisti* Society carried out a propaganda activity through the organization of trips and social races. Affiliates soon became very numerous. In 1882, however, the Society broke up. The *Circolo Velocipedistico Alessandrino*, C.V.A., was then founded in 1886 by Carlo Cavanenghi and it was promoter, like the previous company, of numerous cycling tours and sports races. In 1896 the First National Cycling Conference was held which brought together numerous cyclists from all over Italy. It is important to underline how the passion for sport cycling found great participation from all social classes.

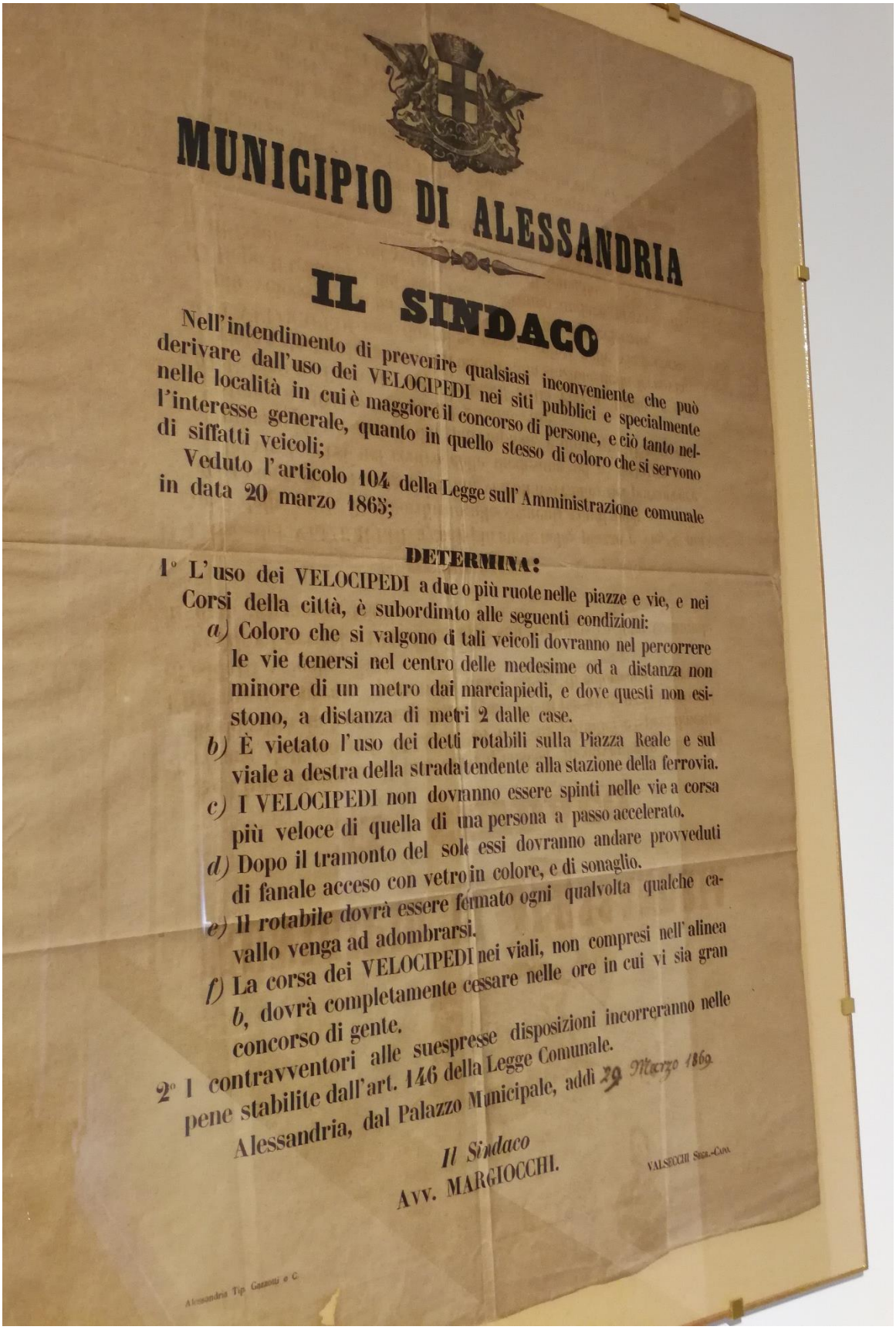
The bicycle become a mass mode of transport until slightly after the first half of the XX century[5] with the economic boom, hence when the car, especially subcompact cars, become affordable enough also for worker classes.

Thus, car supplanted its unmotorized ancestor. From mass motorization urban environment progressively become more dangerous for velocipedes, declaring the end of the bicycle craze. What seemed like a no-appeal sentence experienced its first questioning during the 1970s when, in the wake of the global energy crisis (*Figure 14*) and in conjunction with the first flourishing of an environmentalist awareness, the two-wheeled vehicle returned to the centre of the world in public debate, transport policies and, in some cases, even the actual movement habits of the population (Belloni, 2019).

At the beginning of the XXI century there was a new wave of "*ciclofilia*" which saw in Europe also the Community institutions truly intervene for the first time on the issue of cycling promotion policies in the context of a more general rethinking of European transport and mobility policy (Ibid.).

Nonetheless, the urban environment in which generations after 1960s were born and raised is characterised by the effects of the economic boom started after WWII.

[5] In 1946 there were 150,000 cars in Italy against 3 million bicycles. In 1955 the bicycle was the most popular means of transport in many Italian provinces based on traffic censuses. Cars' overtaking will occur in 1975 (Belloni, 2019).



MUNICIPIO DI ALESSANDRIA

IL SINDACO

Nell'intendimento di prevenire qualsiasi inconveniente che può derivare dall'uso dei VELOCIPEDI nei siti pubblici e specialmente nelle località in cui è maggiore il concorso di persone, e ciò tanto nell'interesse generale, quanto in quello stesso di coloro che si servono di siffatti veicoli;

Veduto l'articolo 104 della Legge sull'Amministrazione comunale in data 20 marzo 1865;

DETERMINA:

1° L'uso dei VELOCIPEDI a due o più ruote nelle piazze e vie, e nei Corsi della città, è subordinato alle seguenti condizioni:

a) Coloro che si valgono di tali veicoli dovranno nel percorrere le vie tenersi nel centro delle medesime od a distanza non minore di un metro dai marciapiedi, e dove questi non esistono, a distanza di metri 2 dalle case.

b) È vietato l'uso dei detti rotabili sulla Piazza Reale e sul viale a destra della strada tendente alla stazione della ferrovia.

c) I VELOCIPEDI non dovranno essere spinti nelle vie a corsa più veloce di quella di una persona a passo accelerato.

d) Dopo il tramonto del sole essi dovranno andare provveduti di fanale acceso con vetro in colore, e di sonaglio.

e) Il rotabile dovrà essere fermato ogni qualvolta qualche cavallo venga ad adombrarsi.

f) La corsa dei VELOCIPEDI nei viali, non compresi nell'alinea *b*, dovrà completamente cessare nelle ore in cui vi sia gran concorso di gente.

2° I contravventori alle suespresse disposizioni incorreranno nelle pene stabilite dall'art. 146 della Legge Comunale.

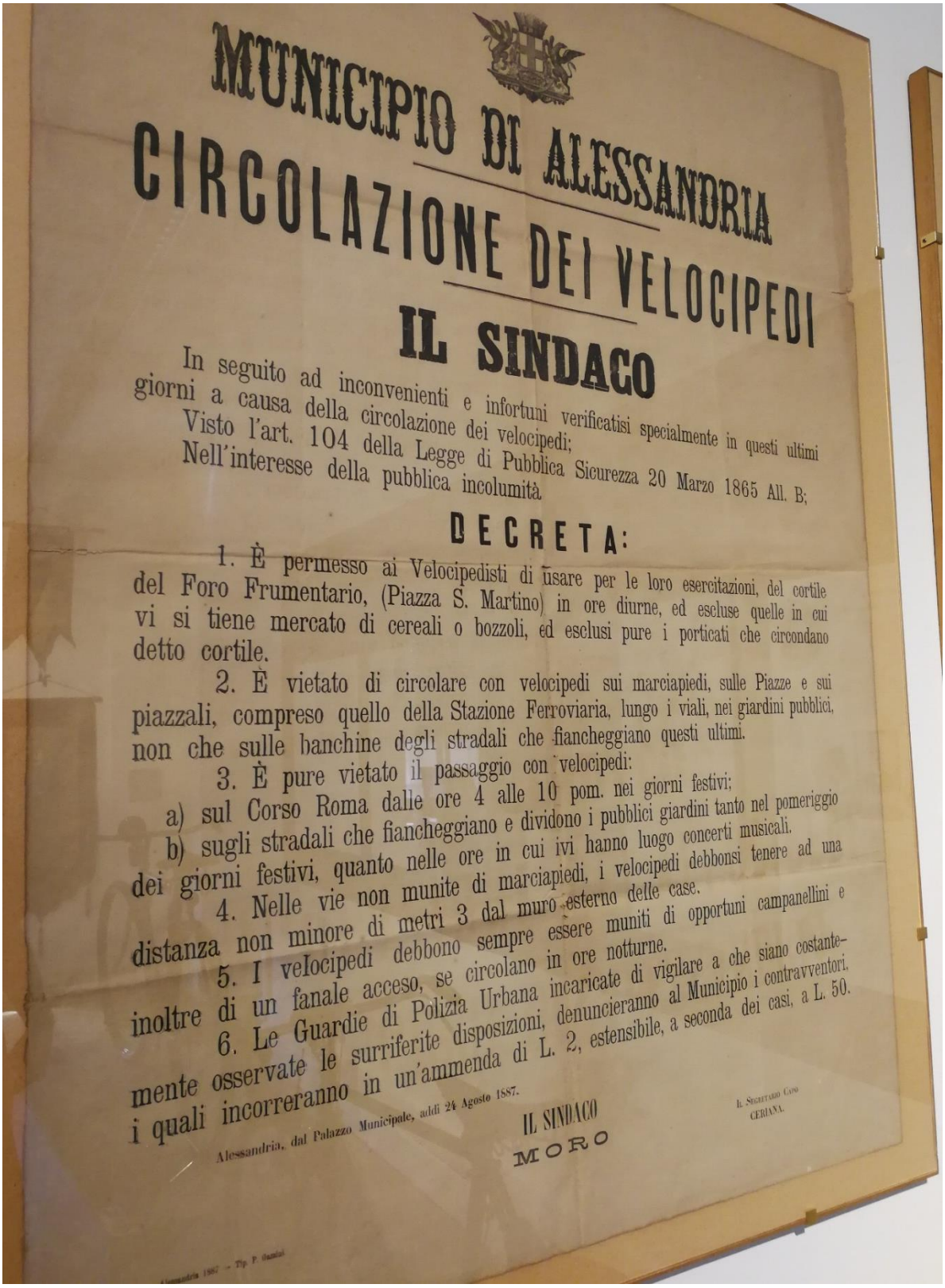
Alessandria, dal Palazzo Municipale, addì 29 Marzo 1869.

Il Sindaco
Avv. MARGIOCCHI.

VALSECCHI Segr.-Can.

Alessandria Tip. Gazzotti e C.

Figure 12. 1869 municipal regulation on the circulation of velocipedes obliges cyclists to equip their vehicles with lights and bells. [Source: Museo AcdB Alessandria]



MUNICIPIO DI ALESSANDRIA

CIRCOLAZIONE DEI VELOCIPEDI

IL SINDACO

In seguito ad inconvenienti e infortuni verificatisi specialmente in questi ultimi giorni a causa della circolazione dei velocipedi;
Visto l'art. 104 della Legge di Pubblica Sicurezza 20 Marzo 1865 All. B;
Nell'interesse della pubblica incolumità

DECRETA:

1. È permesso ai Velocipedisti di usare per le loro esercitazioni, del cortile del Foro Frumentario, (Piazza S. Martino) in ore diurne, ed escluse quelle in cui vi si tiene mercato di cereali o bozzoli, ed esclusi pure i porticati che circondano detto cortile.

2. È vietato di circolare con velocipedi sui marciapiedi, sulle Piazze e sui piazzali, compreso quello della Stazione Ferroviaria, lungo i viali, nei giardini pubblici, non che sulle banchine degli stradali che fiancheggiano questi ultimi.

3. È pure vietato il passaggio con velocipedi:
a) sul Corso Roma dalle ore 4 alle 10 pom. nei giorni festivi;
b) sugli stradali che fiancheggiano e dividono i pubblici giardini tanto nel pomeriggio dei giorni festivi, quanto nelle ore in cui ivi hanno luogo concerti musicali.

4. Nelle vie non munite di marciapiedi, i velocipedi debbonsi tenere ad una distanza non minore di metri 3 dal muro esterno delle case.

5. I velocipedi debbono sempre essere muniti di opportuni campanellini e inoltre di un fanale acceso, se circolano in ore notturne.

6. Le Guardie di Polizia Urbana incaricate di vigilare a che siano costantemente osservate le surriferite disposizioni, denuncieranno al Municipio i contravventori, i quali incorreranno in un'ammenda di L. 2, estensibile, a seconda dei casi, a L. 50.

Alessandria, dal Palazzo Municipale, addì 24 Agosto 1887.

IL SINDACO
MORO

Il Segretario Capo
CERIANA.

Figure 13. 1887 municipal regulation on the circulation of velocipedes continue stressing on compulsory light and bells while riding especially after sunset and it indicate in detailed which are the place where the use of velocipedes is prohibited, mostly square, sidewalks and arcades. [Source: Museo AcdB Alessandria]

L'ITALIA A PIEDI, SENZA DRAMMI

Nei grandi centri la novità delle strade libere e silenziose ha dato un senso di allegria: molte passeggiate, gente in bicicletta, a cavallo, su calessi - In campagna e nei sobborghi isolati una rassegnata disciplina - Gli stadi sono stati affollati dai tifosi locali, pochi sono giunti da fuori - I trasgressori sono forse un migliaio: oggi si dovrebbero conoscere nomi e multe - Rumor ha parlato di "esemplare compostezza"

Tessera per la benzina Sarebbe utile?

La regione più disciplinata: Trentino - Alto Adige

Il Verona demolito: 5-1

Una Juventus che entusiasma

Un'agitazione molto grave che blocca mezzo Paese

Autotrasportatori in sciopero

E' cominciato a mezzanotte - Gli autotrasportatori hanno respinto l'invito del governo - Non partecipano gli iscritti a Cgil, Cisl, Uil (30 mila su circa 170 mila) - Gli scioperanti: "Nessuna suggestione di tipo cileno"

subito calore col gas

Si riunisce oggi a Bruxelles il Consiglio della Cee

Solidarietà e crisi del petrolio

Figure 14. Front page of La Stampa newspaper on 3rd Dec 1973 during the Oil Crisis and Austerity Decree. Quote: << Italy on foot without drama >> [Source: (La Torre, 2020) from Archivio Storico La Stampa]

Thus, Millennials and Generation Z[6] experience the city at its highest level of motorisation rates per inhabitant (Eurostat, 2019) (Figure 15*)*

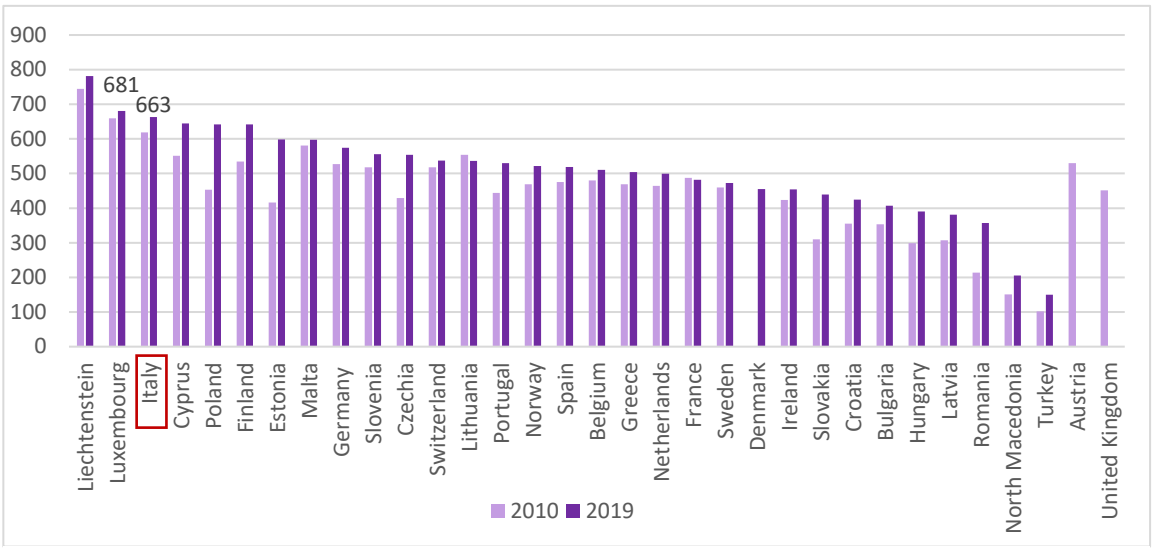


Figure 15. Passenger cars per 1 000 inhabitants [Source : Eurostat]

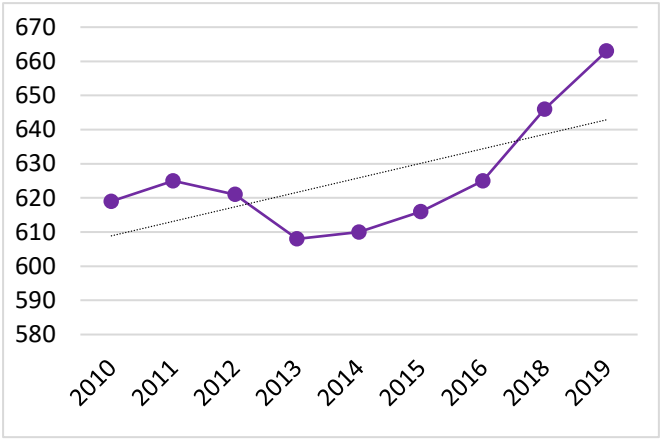


Figure 16. Italy's growth of cars every 1000 inhabitant. [Source: author with ISTAT data]

Data collected by ISTAT *(Figure 16)* highlight the growing trend of this rate in Italy particularly starting from 2014 when motorisation rate registered no degrowing values until 2019 - end of the analysed period. 2017 data of this trend were not available in ISTAT database. Due to these numbers Italy is one of the countries with the highest motorization rates counting 663 cars every 1000 inhabitants *(Figure 15)* and ranking second only to Luxembourg (Schepisi & Romio, 2021). Nevertheless the 16th Report Isfort[7] 2019 shows (*Table 1*), how, in 2018, 76.5% of Italian trips were lower or equal to 10 kilometres and 33.2% were even lower than 2 kilometres, (Schepisi & Romio, 2021), representing 3 out of 4 of the trips, compared

[6] Anyone born between 1981 and 1996 (ages 23 to 38 in 2019) is considered a Millennial, and anyone born from 1997 onward is part of a new generation, Generation Z (Dimock, 2019).
[7] I*stituto Superiore di Formazione e Ricerca per i Trasporti*, Higher Education and Research Institute for Transport

to less than 3 out of 100 over 50 km (ISFORT, 2019). Hence, short-range mobility has a dominant position in the Italian demand model (ISFORT, 2019), distances which could be easily covered by bicycle (Schepisi & Romio, 2021). "Very short distance" trips (≤ 2 km) have lost points, from 38.6% in 2001 to 33.2% in 2018, in favour of "Short distance" trips (2-10 km) while "Long distance" (> 50km) trips have gained half a point at the expense of "Medium distance" ones (10-50km) (ISFORT, 2019). Measuring the historical evolution of road space distribution within a city might provide an interesting form of visualizing and assessing changes in urban form, transport networks and the usage of public space (Nello-Deakin, 2019).
Renzo Piano talks about this disorganized building growth, which has therefore a strong dependence on cars, in an article dated 26 January 2014 published on ilSole24Ore:

> The suburbs need to become cities but without spreading like wildfire, they need to be sewn and fertilized with public structures. We must put a limit to growth also because it becomes economically unsustainable to take public transport and collect rubbish further and further away. Today growth must be implosive instead of explosive, former industrial, military or railway areas must be completed, there is a lot of space available. I speak of flourishing city complexity, of building on the built. In this sense, a Green Belt as the British call it is important, a green belt that clearly defines the impassable border between the city and the countryside. [...] The right city is one where you sleep, you work, study, have fun, you shop. [...]Let's go to fertilize this great emotional desert with catalytic functions. Building places for people, meeting points, where values are shared, where a ritual called urbanity is celebrated.
>
> [...] if there are functions, restaurants, and theatres there must also be public transport. We need to stop digging parking lots. I think the cities of the future need to free themselves from gigantic silos and tunnels carrying cars and try to focus on public transport. I have nothing against the car but there are already ideas, such as car sharing, to decline the concept of the car in a different and shared way. I believe it is the right way for a more rational and enjoyable use of the car.

He is referring specifically to the suburbs, but the discourse could also be applied to the small municipalities of the hinterland, which have undergone a strong building growth often not associated with the adequate provision of services.
Table 2 describes how traditional motivations linked to work and study (32.9%) represent only one third of the reasons for Italian mobility.

% distribution of trips and passengers*km by length classes						
	Trips			Passengers * km		
	2001	2017	2018	2001	2017	2018
Very short distance (≤ 2 km)	38,6	34,7	33,2	5,7	4,2	4,2
Short distance (2-10km)	42,5	41,8	43,3	27,5	23,1	23,8
Medium distance (10-50km)	17,1	21,3	19,8	42,1	43,3	37,9
Long distance (> 50km)	1,8	2,3	2,8	24,7	29,4	34,9
Total	100	100	100	100	100	100

Table 1. Distance ranges of Italian trips. [Source: ISFORT 16th Report 2019]

% distribution of trips by motivation			
	2001	2008	2018
Work	34,5	30,8	29,0
Study	5,5	5,1	3,9
Total work and study (a)	40,0	36,9	32,9
Family management dedicated to services	19,5	19,5	22,0
Family management dedicated to people	9,2	11,9	11,0
Total family management (b)	28,7	31,4	33,0
Free time (c)	31,2	32,7	34,2
Total (a+b+c)	100	100	100

Table 2. Reasons behind people's weekly journeys [Source: (ISFORT, 2019)]

The most significant weight is instead to be assigned to "Free time" (34.2%) and "Family management" (28.5%, 2/3 for services and 1/3 for people) showing a significant process of redistribution of demand: these trend in citizens' mobility reflects the process of differentiation of lifestyles (ISFORT, 2019). The traditional systemic flows of mobility, and above all the commuting components remain in the majority but do not explain the entire volume of demand. Indeed, about 40% of the trips made by Italians on weekdays are occasional or repeated less than 3 or 4 times in a week (*Figure 17)* "Soft hours" absorb 65% of journeys, 10% more than ten years ago *(Figure 17).* Again, these trends confirm the evolution of mobility styles towards a more fragmented, differentiated and more spatially and temporally distributed model (ISFORT, 2019).

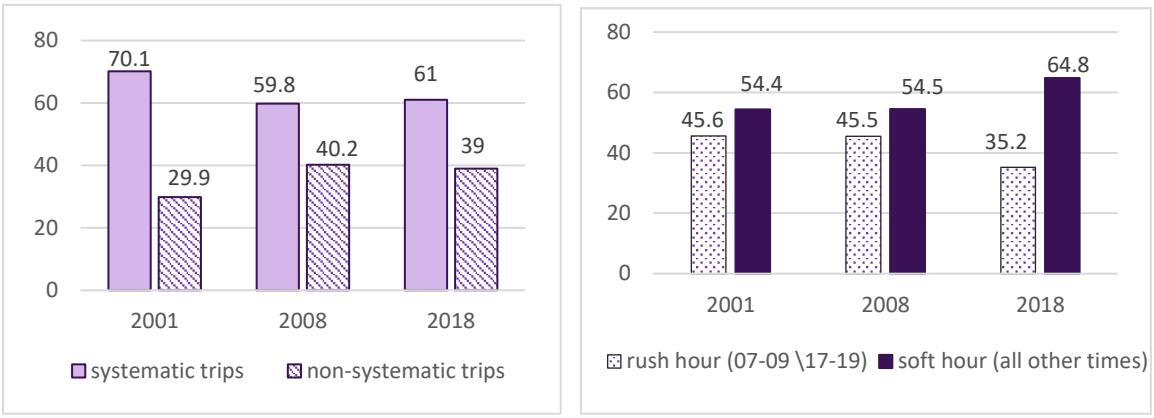


Figure 17. Frequency and time of trips [Source: ISFORT data]

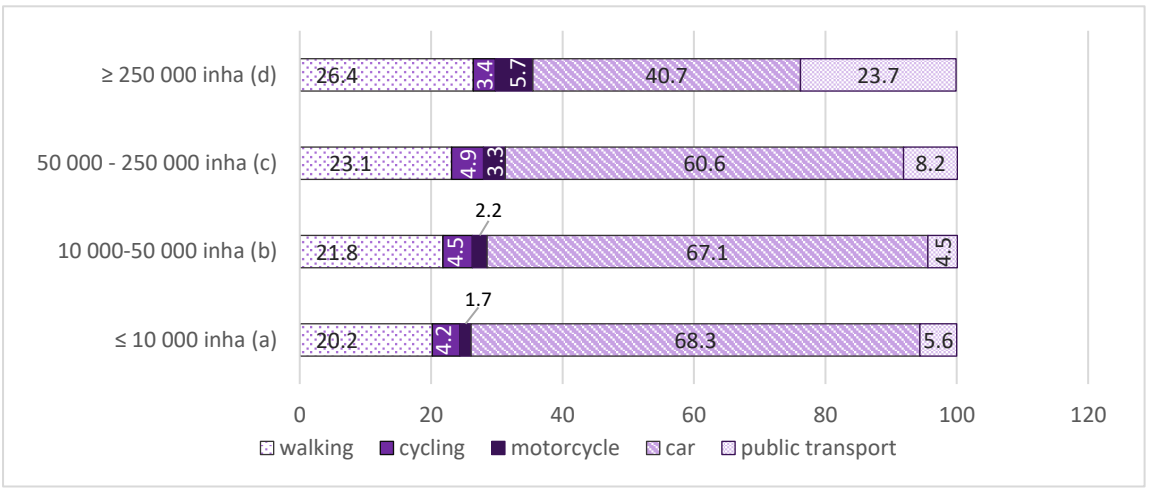


Figure 18. Percentage of trips by mode of transport and size of the municipality. [Source: ISFORT data]

A more detailed explanation of Italian mobility could be done through the segmentation of the modal distribution of transport modes (modal share) by size of municipalities *(Figure 18)*. The result is an evident difference in the use of public transport between the largest municipalities (d), where the share approaches 25%, recording a decrease in that of the car at 40%. On the other hand, in small (a) and small-medium (b) sized municipalities the share of collective mobility is completely marginal, with only 4-5%, compared to the dominant presence of cars, which satisfies about 2/3 of the demand. Active mobility records higher share of walking (26.4%) in large cities compared to small municipalities (20.2%), while the highest share of cycling (4.9%) is in medium-sized centres (c) and the lowest in the largest urban areas, albeit the value 3.4% is affected by the modest level of bicycle use in some metropolitan areas of the Centre and South & Islands regions *(Figure 19).* 5.7%

of motorcycle trips take place in large cities (d), which is more than three times that of smaller towns.

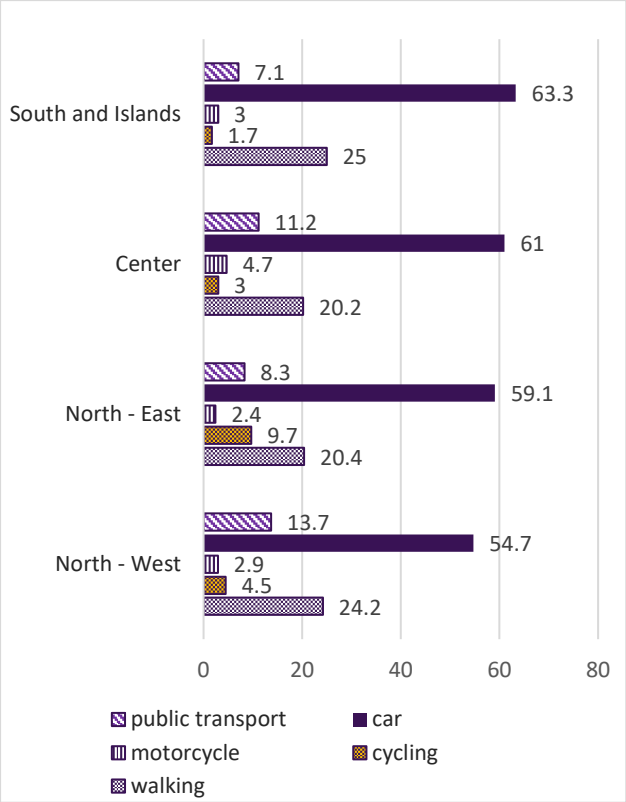


Figure 19. Percentage distribution of journeys by mode of transport and territorial district 2018. [Source: ISFORT data, 2019]

Hence, the rate of sustainable mobility, which is considered as the sum of the shares of walking, cycling and public transport journeys is, according to 2018 data of ISFORT Report 2019, at 37.1%, slightly down compared to 2017 (37, 9%) (ISFORT, 2019). Looking at the long-term data, between 2002 (37.2%) and 2016 (31.1%) the index fell by six points (in 2015 the reduction was almost ten points, 27.6%), and then recovered in the two following years. However, the rate of sustainable mobility is practically at the same level as at the beginning of the millennium, testifying to the inefficiency of policies, at various levels, applied in past years in favour of sustainable mobility. Differences between sustainable mobility rate *(Figure 19)* in the Italian South and Islands (33.8% in 2018) and North-West Italy (42.4% in the same year) are significant with the latter showing almost ten points more than the first. The false freedom to choose the most suitable mean of transportation is one of the many aspects characterizing the North-South Italy issue. Indeed, Italian South and Island local public transport (*Trasporto Pubblico Locale T.P.L.)* is lower in quality service and so the demand decreases creating a situation in which financial

investments in this sector is not seen as convenient. Poor public transport service and inefficient incentive policies on non-motorised mobility induced a higher demand for private car, which it concretely becomes the only mean of transport to reach places.

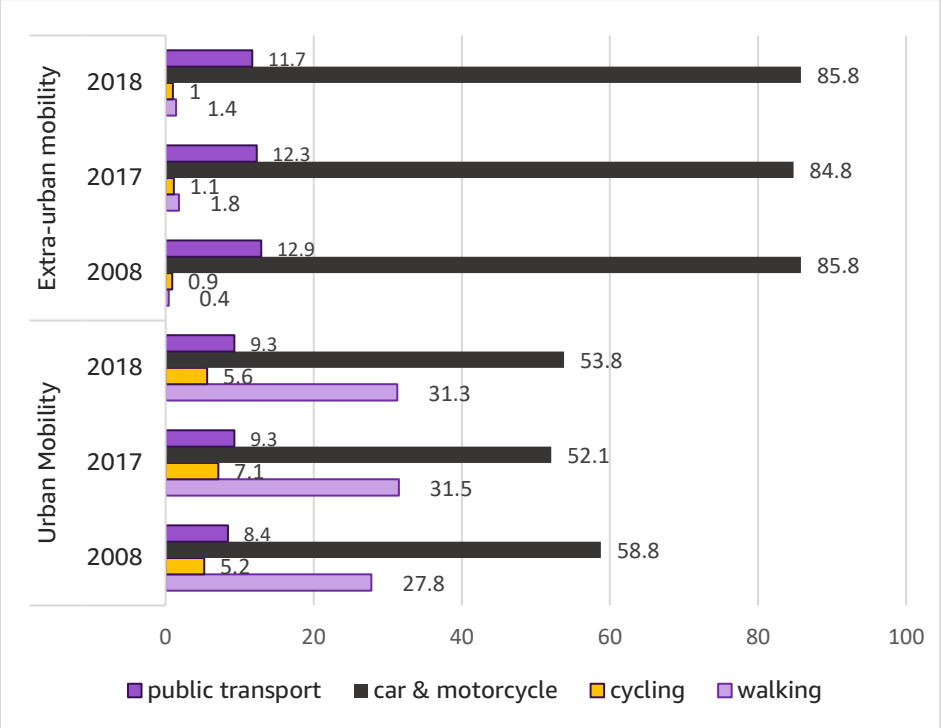


Figure 20. Extra-urban and urban mobility 10 years evolution [Source: 16th ISFORT Report data, 2019]

Car plays an essential role in urban environments, but its supremacy is recorded in extra-urban mobility approaching 90% of mode share as data in *Figure 20* show. Walking and cycling became totally marginal perhaps telling a territory that should invest more in the neighbouring connection.

The average filling coefficient of the car in 2018 is estimated by Audimob at 1.36 passengers per vehicle which is a slight decrease compared to the previous year (ISFORT, 2019). This information is particularly relevant since it calls attention to how car traffic would be positively affected, and so reduced, if the people chose to switch from car to micro mobility as the main mean of transport. Naturally cars need a minimum space to move around

The ongoing transition towards higher cycling and walking mode share levels, has been boosted up by the spread of SARS-CoV-2 which caused the COVID-19 pandemic at the beginning of 2020. This global pandemic has changed the way in which urban mobility was conceptualised. In year 2020 the COVID-19 pandemic has been omnipresent in Europe and globally, European cities, regions and countries have

gone from lockdown to recovery, and they headed back towards lockdown in many places. Italy was the first country to impose a COVID-19 lockdown. The pandemic has impacted everything and has prompted people across world to view many aspects of their daily lives through a different lens and one of the aspects was, in fact, mobility. For quite some weeks during lockdown motorized mobility came to a near standstill, quiet and empty streets ruled the day and gave a new perspective as well as attracted old and new cyclists. When lockdown eased, cities had to ensure that people could move about safely and respect social distancing and that they did not go from lockdown to traffic gridlock if more people turn to their cars to achieve social distancing. That has not been an easy challenge for the cities to face. It is interesting to focus on how the pandemic influenced mobility and how it has been influencing the demand form more cycling. Paragraph 2.5 goes into detail about the relationship between COVID-19 global pandemic and the growth of people who chose to ride a cycle in urban environments.

2.3. City of cars: Are cycle infrastructures elements of segregation or road safety?

> The segregation of cyclists is at best a very controversial subject, disliked by many existing cyclists and giving little real assistance to newcomers. It may well be that they do as much to put people off cycling, by reinforcing the falsehood that cycling with traffic is a "dangerous" activity *(Franklin, 2001)*.

Today most cities emphasize the construction of separate bicycle lanes as a sure path toward sustainable urban mobility. Nonetheless, bicycle lanes were never neutral but contested from the start (Oldenziel & de la Bruhèze, 2011). Indeed, following a comparative research of cycling history covering nine European cities in four countries, urban-planning professionals projected separate lanes to control rather than to facilitate working class, mass-scale bicycling. The reason behind was that they framed automobility as the inevitable modern future, while cycling organizations were those opposing the lanes. It was in the 1970s that bicycle lanes enter the debate as safe and sustainable solutions, nonetheless, cycling activists point out that their construction should never be the sole focus, but always be combined with policies such as special road junctions, limited vehicles' speed, calming residential neighbourhood traffic, bike parking facilities, and traffic training

for both cyclists and motorists. Still some scholars claimed bicycle lanes serve to maintain rather than challenge existing motorized travel and traffic planning norms (Oldenziel & de la Bruhèze, 2011). The urban environment has the advantage that the promiscuity between motor vehicles and bicycles is generally less dangerous, as the speeds of motor vehicles are, or should be, lower than in an extra-urban environment. The disadvantage of urban planning is the great difficulty in identifying suitable protected itineraries due to lack of space. For these reasons, interventions for traffic moderation should be privileged in the urban environment and only in the most dangerous roads should integration interventions be carried out, such as cycle lanes, or separation solutions, such as off-road cycle paths (Deromedis, 2019).

Yet the general perception is that bicycle paths increased traffic safety. A large-scale study (Agerholm, Caspersen, & Lahrmann, 2008) in medium and large town in the western part of Denmark considered 40 km of road distributed on 46 road segments to analyse traffic safety effect from implementing one-way bicycle paths in build-up areas. Results from previous studies they mentioned showed an increased risk for cyclists when bicycle paths were implemented. For example, a study from the Netherlands in 1988, showed that the number of cyclist accidents decreased by 25% on road sections while it increases with 32% in intersections when implement bicycle paths, another one from USA in 1994 showed that the accident frequency rate for cyclists increases by 1.8 while riding on a bicycle path (Agerholm, Caspersen, & Lahrmann, 2008). Traffic safety problem is related to intersections since it is where most of bicycle accidents involving cars happen (Ibid.). Finally, they focused on the lack of improvement in the design of new bicycle paths (2000s) compared to the older ones (1980s).

In addition to traffic safety of bicycle paths, critiques could be moved when refer to distribution of road space. Indeed, dividing road space into a series of distinct functions replicates a car-centric imaginary which forces to see road space as exclusive to a single mode of transport. Road space is just as much about public space as about mobility. The will to divide road space areas among transport modes assume that streets are little more than the physical stage for transportation (Nello-Deakin, 2019).

Focus should be on “speed”, which is the real critical factor in urban transportation by being socially destructive (Ibid.). Greater traffic speeds lead to a form of spatial development which forces people to depend on motorized transport. One of the

problems is that in some cases, there might be a discrepancy between nominal speed limits and observed traffic speeds. (Ibid.).

2.4. Comparing cycling culture between European cities: Amsterdam and Turin

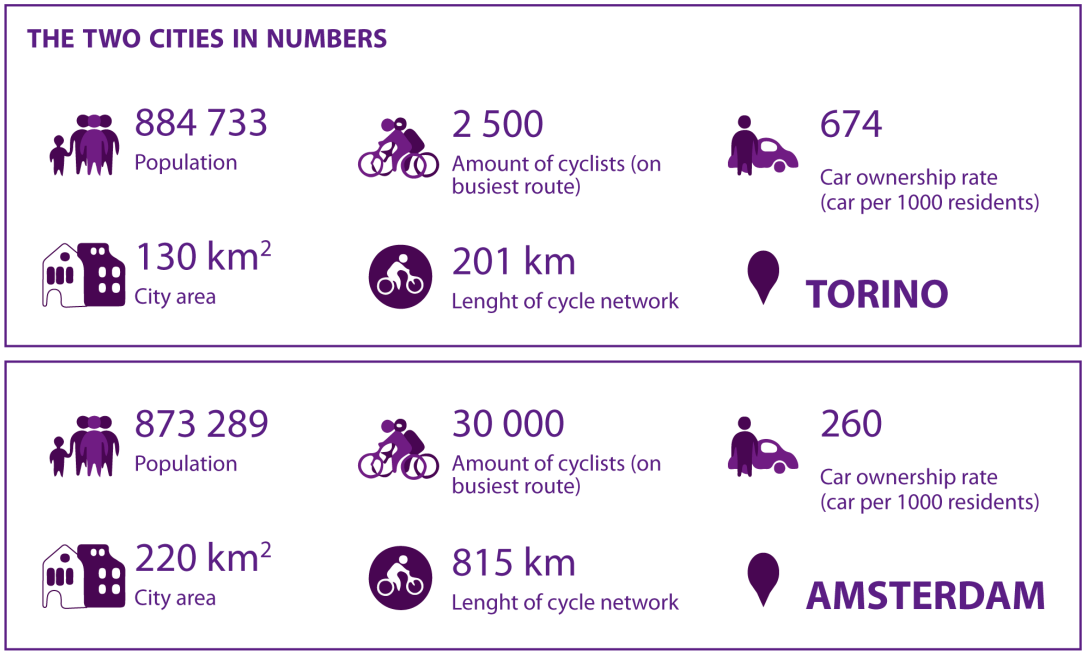


Figure 21. Statistics on the city of Turin and Amsterdam. Since the latter is the mentor of Turin inside the EU CIVTAS Handshake project is useful doing a comparison of the actual cycling situation. [data from Handshake project]

The Turin municipal administration increasingly recognizes the potential of the bicycle within the transport system, identifying it as a valid alternative to private motorized traffic, as well as being the solution to citizens' health concerns and local environmental problems (La Torre, 2020). Thus, Turin promptly applied the new 2020 regulations on cycle lanes and advanced bike boxes at traffic lights. The city also knew how to innovate and create new models, such as the 20 km/h crossroads. New "Zone 30" routes must be added to this list of actions, together with the opening of the two one-way cycle paths along the entire Via Nizza (Comune di Torino , 2021). If a car-centric perspective is applied at the observation of urban cycling phenomenon certain logics are difficult to understand. Great attention is given to the quantity, but few to the quality, of cycle paths which have been built during these years and those of the emergency COVID-19 period in 2020. To have a better view of the actual condition of the city of Turin it might be interesting to compare it to another EU city

similar in population: Amsterdam, The Netherlands, since the latter is the actual mentor of Turin by being part of the EU project "Handshake"[8] inside the CIVITAS[9] initiative. The Netherlands in general and Amsterdam, in particular, are seen worldwide as the epicentre of the bicycle and the city is one of the few EU and non-EU cities with such a maturity in its cycling culture to be chosen as one of the three city leaders in the Handshake project. By being part of this initiative, Amsterdam is mentoring several EU cities providing knowledge and good practices for others to follow.

Looking at a glance at the comparison made in *Figure 21*, the difference between the two cities is clear: with forth times the length of cycle network in its municipality and twelve times more cyclists per day along the busiest route than Turin, Amsterdam is definitely a city to learn from when referring to successful measures in favour of cycling. It might be more precise to talk about cycling culture of the whole country since the approach Dutch population has with cycling worth a mention. Cycling in The Netherlands appeals to everyone and at the same time is not appealing; it is not strongly associated with a group, a subculture, or an identity (te Brömmelstroet, 2014). It is not associated with a particular social class or region. It is neither conscious lifestyle nor political statement (Kuipers, 2012). The fact that cycling is so common is therefore precisely the exception and perhaps the resounding success (te Brömmelstroet, 2014). In short, cycling is part of the Dutch national habitus (Kuipers, 2012). All associations and backgrounds to understand why Dutch ride bicycle so much are largely irrelevant to Dutch cyclists. Kuipers (2012) wrote:

> If you want to go somewhere, you just take the bike. Everybody cycles. You wouldn't know any better. In Dutch cities the unit of distance is the cycling minute, even in real estate brochures. The history has been forgotten – because cycling has become a second nature.

Marco te Brömmelstroet is assistant professor in Urban Planning and member of the Centre for Urban Studies at the University of Amsterdam. He specialized in

[8] See paragraph 2.6 for further details

[9] CIVITAS is one of the flagship programmes helping the European Commission achieve its ambitious mobility and transport goals, and in turn those in the European Green Deal. It does this by acting as a network of cities, for cities, dedicated to sustainable urban mobility. Through peer exchange, networking, and training, CIVITAS fosters political commitment and boosts collective expertise, equipping cities to put mobility at the centre of decarbonisation. Since its launch in 2002, CIVITAS has advanced research and innovation in sustainable urban mobility and enabled local authorities to develop, test and roll out measures via a range of projects. A series of ten thematic areas underpin these. Website: https://civitas.eu/about

metropolitan transport planning, with a specific research focus on urban cycling and cycling behaviour. He made, in 2014, an analysis about the design of Dutch traffic space using two metaphors, geese for cars and a flock of starlings for cycle traffic at intersections:

> Geese are graceful, large, and unwieldy. They are difficult to manoeuvre, therefore do not cope well with mutual interaction while flying and usually travel long distances. There is a clear and common goal here: to travel large distances with as little energy loss as possible (to The North or South). Because of these characteristics, they especially need clarity and clear rules (e.g., about distances between them, passing, paying off). Just think about what the consequences would be if one of the geese ... would make an unexpected turn.
> This is very similar to the characteristics of the car.
> That logic governs the design of our traffic space.
> [...]I see how beautiful and complex the cycling phenomenon in Amsterdam actually is. It immediately reminded me of the fantastic choreography of a flock of starlings [*Figure 22* n/a] [...] For everyone who cycles a lot in the city: just think for yourself what your brain and body are capable of. Imagine, you're approaching a crossroads [*Figure 23* n/a]:
>
> - You know in a fraction of a second the position, direction, and speed of a large number of other cyclists, pedestrians, scooters, cars etc (from 5 to 70 kilometres per hour).
> - You have also recorded and processed a lot of other information: cyclists body position, types of bicycles, types of cyclists, colours of bicycles (red = tourist), colour car (white vans), colour of traffic light, colour license plate car (blue = taxi).
> - Your brain translates this in a fraction of a second into clues to your body that directly converts this into often very delicate manoeuvres. A tap to the left to give that inserting cyclist space, just off the pedals to pass just behind a pedestrian, HO STOP! A taxi driver!!
>
> [...] The complex pattern that we see is a result of the interaction of those individual rules. So, it is not directed from above, but a resultant of individual rules of conduct. Or as it is called: the emergence of a self-organizing system. Let's look at the Amsterdam cycling swarm in that way.

What is evident from te Brömmelstroet's article (2014) is how the Dutch need to be working on the next step already. Promotion of bicycle use is being a policy goal of the Dutch Government for a long time and so is the construction and improvement of the bicycle infrastructure. A complex interplay of infrastructure, policies and culture underlies the vibrant Amsterdam. Dutch system is so mature that the issue

is how to manage such a cycling modal share and alleviate pressure on bicycle networks.

Figure 22. A flock of starlings taken from Martijn Ipema and published on his YouTube channel [Source: te Brömmelstroet, 2014]

Figure 23. A bicycle swarm published by Marco te Brömmelstroet on his YouTube channel. [Source: te Brömmelstroet, 2014]

The question is if those guidelines in the Dutch design manuals were sufficient to respond at such a high, and increasing, number of people riding bicycles. Sociological research provided many examples of the impact of nationality: even suicide, the most individual and solitary choice a human being can make, varies greatly across countries (Kuipers, 2012). Again, nationality even impinges upon people bodies as obesity levels vary greatly across countries with similar income levels and social organization (Ibid.). Cycling behaviour also varies cross-nationally. The fact that in the Netherlands a larger share of movements is undertaken by bicycle than in neighbouring countries are of course averages: within the country, people from Protestant areas cycle more than people from Catholic areas; people of Dutch descent cycle more than descendants of immigrants -although many of them have adopted the bike - educated people cycle more than less educated people. Still, Dutch people in all categories cycle more than people in other countries (Kuipers, 2012). The Netherlands is one of the oldest, most stable, and homogeneous nation-states in the world. However, today the nation-state seems less potent in its role as producer of national similarities (Ivi, p. 3). Interpretation of the cycling phenomenon might rely in the "national habitus[10]". The concept of national habitus allows

[10] It was first coined by Norbert Elias. Giselinde Kuipers author of the article "Dutch cycling culture and the shaping of national similarity" refers to it as the learned practices and standards that have become so much part of an individual that they feel self-evident and natural. Habitus is the self culturally and socially shaped "second nature". What people learn as members of a society, in a specific social position, is literarily incorporated, absorbed, and becomes personality.

investigation of the processes contributing to the development of national similarities within countries, not only in institutions and physical surroundings, but also in people's behaviour (Ivi, p. 5). The increasing interdependence and the density of this network connected more people and in more ways. National institutions influenced people's lives such as education which is central to the formation of national habitus. It contributes to vertical diffusion of standards, tastes and practices which happens from upper social strata moving down through emulation. This is not a necessarily enforced or imposed process; yet vertical adaptation does not always occur spontaneously. However, vertical diffusion of standards starting from the 1970s has slowed down. Observing upper social classes in the Netherlands, Kuipers (2012) wrote about how «the Dutch royals are still characterised by an informal, bourgeois, and rather unglamorous style. Their habit of publicly riding a bicycle – a tradition upheld already by five generations of the House of Orange – underscores their lack of pretentiousness.» This introduces the fourth process identified by Kuipers (2012) which led to national similarity: the concept of nationalism. In the Netherlands, royals with their bikes and unpretentious manners were instrumental in the development of a national we-feeling (Velde & Verhage 1996 in Kuipers, 2012). Great power has been in the hands of media when shaping "imaged communities" (Kuipers, 2012). Mass media provide the symbols, stories, and rituals to bind large groups of people who can never all know each other personally (Ibid.). The images of the "informal" Royal Dutch family on their bikes have acquired strong symbolic significance. Hence, the bicycle became a potent Dutch national symbol.

> So how do these four processes explain the Dutch fondness of the bicycle – and its ending at the national border? The wide adoption of the bicycle in the Netherlands can be understood from the country's homogeneity and high level of integration; the traditional dominance of the upper middle classes; and the small power distance between classes (cf. Ebert 2004).
>
> [...]Of course, there were facilitating conditions: compact cities, flat land, suitable climate. But most importantly: over the years more conditions supporting cycling came into existence. An increasingly dense network of institutions and conventions developed around the bicycle, from city planning regulations and cycling legislation to a nightlife organised around bikeable distances. (Kuipers, 2012)

Increasing globalisation entails growing interdependence on a transnational level, and growing awareness of, and mutual adaptation to, people across the border. From 1970s a process of democratisation of tastes and styles started due to growing

people mobility. Informality and individualism spread around western societies (Kuipers, 2012). People increasingly find their standards and role models abroad from a much wider variety. Hence, it would be useful to find research on new forms of socialization and cultural transfer.

It is though-provoking to read how much consolidated is the Dutch cycling system compared to the rest of the world, especially when considering that in the past century Italy, and Turin in particular, did not differ much from the cycling modal share of the Netherlands. In Turin, the bicycle became accessible to the working classes from the early years of the twentieth century, well ahead of the Dutch capital, which had to wait for the end of the First World War. Nevertheless, both in Turin and in Amsterdam the velocipedes, highly elitist goods, established themselves in the same period. The technological improvement that followed this two-wheels mean of locomotion, was due to the presence of a niche in which new solutions and improvements could be experimented. When the price of bicycle decreased and before car mass-production, workers from the two countries shared the same everyday mean of transport (La Torre, 2020). Indeed, the autonomous developments that influenced both municipalities were, up to the 1970s, essentially the same. Then, technological innovation generated the automobile. As in the case of the bicycle, initially this new mean of locomotion was not well received. However, the desired-by-all spirit of progress, allowed to go further to the point that the automobile industry gradually began to assert itself: Turin developed following the model of the "*ville industrielle*", characterized by the presence of wide avenues and dispersed industrial sites, which implied a first increase in distances, which put the bicycle in an unfavourable position. Amsterdam had a different destiny since its automotive sector never achieved industrial solidity, thus it failed to influence the urban transformations of the city, as in the case of FIAT for Turin.

The following different political views of the administrations considerably increased the time gap between the two cities. In Turin, a bike-oriented niche was formed only during the 1980s, made up of exponents from the world of environmentalism. A fundamental aspect is the different approach adopted by the two Municipalities in removing space to cars: Amsterdam proceeded with the removal of surface parking spaces, redesigning streets to allocate space to cycle paths, on the other hand, Turin opted for a policy of pedestrianization and weak circulation and parking regulations, limiting motorized traffic rather than taking away space (La Torre, 2020). Results are

that in Amsterdam, in 2019, bicycles covered 36% share in the modal split of journeys, and if limited to the city centre, it reaches 87% for journeys of less than 4 km (Ivi, p. 140). Currently, the city is in the position of having to manage the great use of the bicycles rather than encourage it.

2.5. Is cycling popular?

Answers to the question if cycling is a popular mean of transport in the Italian context can be found in further analyses made by the observatory Audimob of ISFORT which collected data related to motorised and non-motorised mode of transport *(Figure 24.* It considered walking and cycling as non-motorised mobility (ISFORT, 2019), so without counting the current phenomena of electric scooters which is being particularly relevant during this COVID-19 pandemic (Il Sole 24ORE, 2020). In 2018, active (non-motorized) mobility absorbed 27.1% of trips, almost seven points more than in 2016 (with a modest retreat between 2017 and 2018). Symmetrically, motorized mobility satisfies 72.9% of the demand compared to the 80% recorded in 2016. Considering only motorized journeys, more than 80% are carried out with the car *(Figure 25)* while the set of all collective vehicles has a modal share of weight less than 15%. The residual 4.3% is the modal split of the motorcycle. The profile of the motorized modal split has not changed significantly in the last ten years; however, the modest consolidation of the public transport market share should be noted. Yet the car held its ground despite the prolonged economic crisis (ISFORT, 2019).

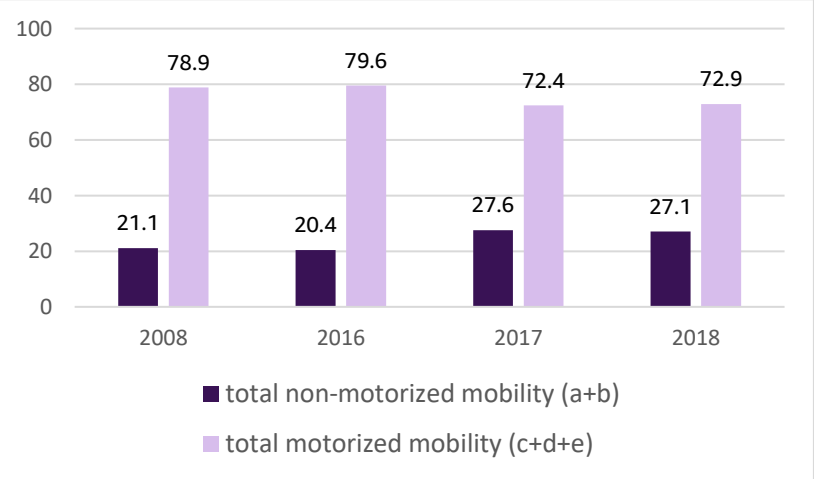


Figure 24. Evolution of motorised and non-motorised mobility in Italy. [Source: ISFORT, 2019]

Overall, almost six out of ten trips are made by car, five of which are drivers not passengers. Thus, the car is by far the most used mode of transport in Italy. In 2017 *(Figure 26)* it lost seven points (from 65.3% to 58.6%) in favour of non-motorized

vehicles as The use of other forms of electric micro-mobility is also increasing for example, about 100 thousand scooters -monopattini - are in use in Italy and they have been equated with bicycles in the Highway Code by "*Legge di Bilancio"* No. 160 of December 27th, 2019 - paragraph 75 . shows. In 2018, the reversal trend suffered a setback and the car rose at 59.1%, but also pedestrian mobility (now at 22.9%), gained points, while cycling mobility lost one (from 5.2% to 4.2%); public mobility remained stable around 10%. Two further negative signs in the perspective of more innovative and sustainable mobility behaviours: percentage of "car as passengers" lost points after the significant increase in 2017 (from 12.3% to 9.9%), and "combinations of means of transport" confirm a negative trend already started in 2016 (from 4.6% to 3.7%), which leaves behind the growth observed between 2001 and 2008 (from 2.3% to 4.5%) (ISFORT, 2019).

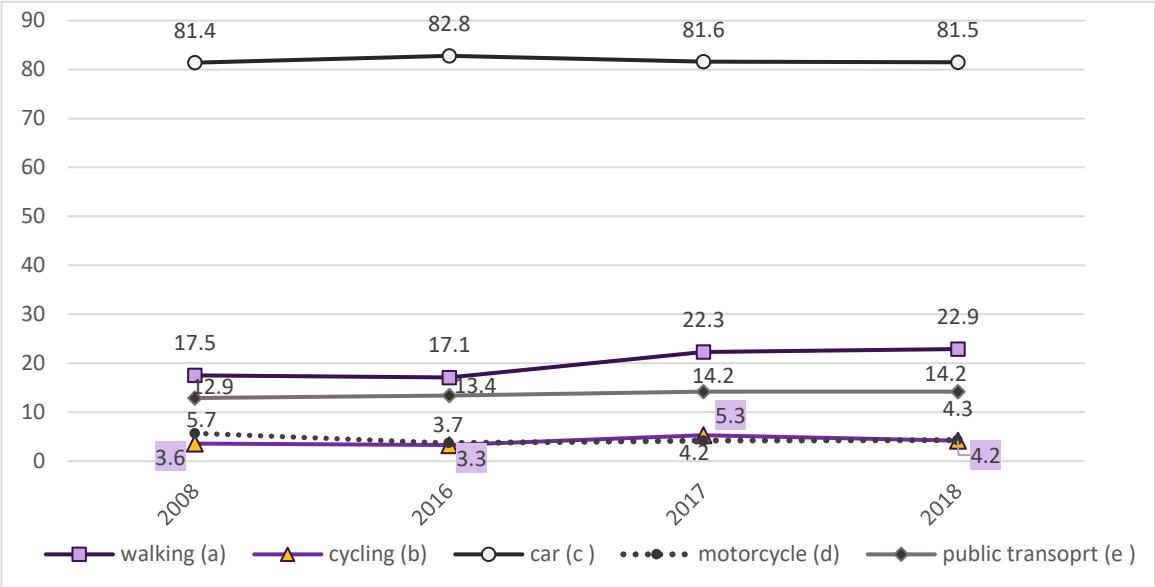


Figure 25. Active mobility in detail compared to motorised modes of transport in detail too. [Source: ISFORT, 2019]

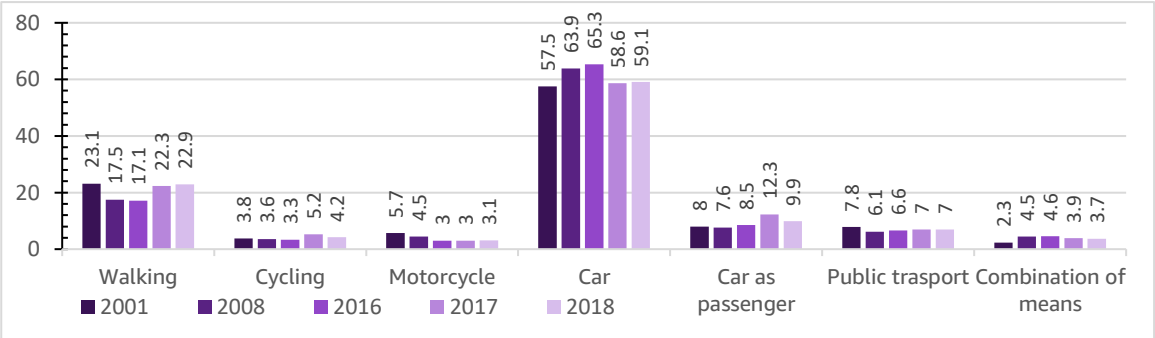


Figure 26. Percentage distribution of journeys by mode of transport. The car is nothing new, it is the most used mode of transport of the Italians [Source: ISFORT, 2019].

Italy is characterized by a predominantly hilly area (41.6% of the total surface), followed by that of mountains (35 %) and flat lands (23.2%). Its orographic conformation could be misleading into thinking that the non-diffusion of the bicycle could be related also to the morphology of its territory, and probably it is, but the reasons behind the low level of active mobility in urban environments can also find explanation in the Eurostat data results delivered in 2014 which put Italy in the last positions for minutes spent each week in physical activity. Thus, statistically speaking Italians are a quite inactive population. Indeed, those who responded "Never" as answer to the question "How often do you exercise or play sport?" were 62%. (*Figure 27*). A study (2018) conducted by a team of scientists and published on *TheLancet*[11] in 2018 revealed how physical inactivity can led to higher risk factors for non-communicable diseases and has a negative effect on mental health and quality of life. The health benefits of physical activity include a lower risk of cardiovascular disease, hypertension, diabetes, and breast and colon cancer. Additionally, physical activity has positive effects on mental health, delays the onset of dementia, and can help the maintenance of a healthy weight (Guthold, Stevens, Riley, & Bull, 2018).

Women are the ones to move less following the study published by the journal "The Lancet" (*Figure 28*) and Italy is in line with this trend, with 40% to 49.9% of women who suffer of insufficient activity against men who cover 30% to 39.9%. These data could be interpreted as the expression of the past, but evolving, man-at-work and woman-at-home relationship of Italian and other societies as well as the prevalence of men in sport disciplines.

Thus, with this additional data it might be simpler understanding the little bicycle mode share and why the growth of this sector of transportation is taking a large amount of time. Furthermore, social, and cultural arguments should find a place in the conversation, particularly the important position that car represent in the Italian imagination and status quo.

Despite the slow transition toward decarbonisation of transport sector, there is still a chance for a different outcome. In 2019, the sale of bicycles and electric bicycles, in fact, increased by 7% compared to the previous year mainly due to the diffusion

[11] *The Lancet* began as an independent, international weekly general medical journal founded in 1823 by Thomas Wakley. It has evolved as a family of journals, but retains at its core the belief that medicine must serve society, that knowledge must transform society, that the best science must lead to better lives (website: https://www.thelancet.com/about-us)

of e-bikes, which grew by 13% (from 173 thousand to 195 thousand pieces sold) for a total of 1 million 713 thousand units.

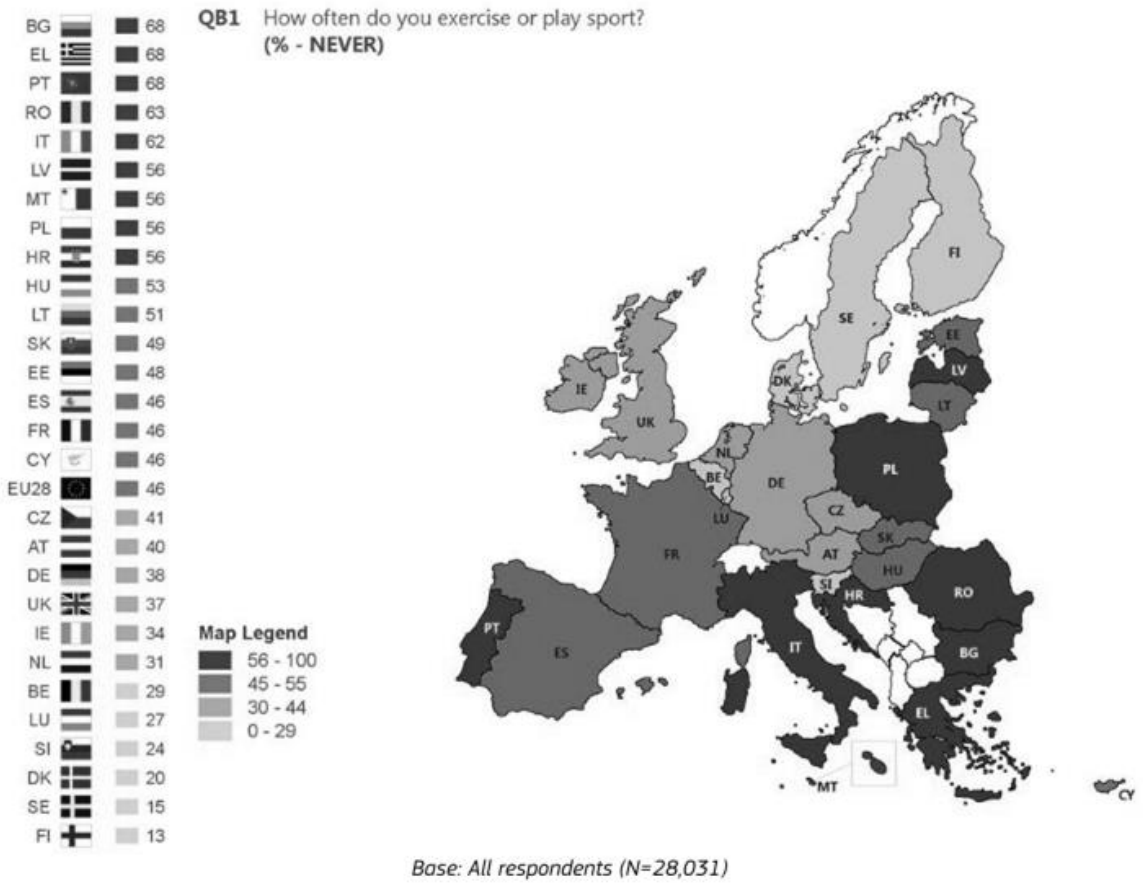


Figure 27. Eurostat data results on questionnaire related to time spent in exercise or play sport. Italy has one of the higher percentage of "Never" as answer.

The use of other forms of electric micro-mobility is also increasing for example, about 100 thousand scooters -*monopattini* - are in use in Italy and they have been equated with bicycles in the Highway Code by "*Legge di Bilancio"* No. 160 of December 27th, 2019 - paragraph 75 (Istat, 2020) .

Now something has brought active mobility into more prominence. That something is the COVID-19 pandemic. Soon after the COVID-19 began sweeping apparently slower across the countries in the spring of 2020, busy streets in many cities were declared car-free zones geared to pedestrian recreation increasing open-air spaces to contrast the diffusion of the virus. The pandemic influenced mobility and how it has changed the demand for more cycling since it has been perceived as a safer alternative to public transport.

Figure 4: Country prevalence of insufficient physical activity in men in 2016

Figure 5: Country prevalence of insufficient physical activity in women in 2016

Figure 28. Insufficient physical activity in men and women, 2016. The maps show a clear negative difference in physical inactivity of women who registered higher levels of insufficient activity. Italy is in line with this division. [Source: The Lancet, 2018]

Temporary pop-up bike lanes appeared globally almost overnight; Italy included. As many as a third of Europe's capitals, including Brussels, Rome, and Berlin, decided to close road sections to car traffic or reallocate road space to create temporary bicycle paths instead (Küster & Kolczyńska, 2020). Since the beginning of the pandemic in March 2020 more than 2300 km of new pop-up bike lines and other pro-cycling measures have been announced across Europe, committing new investments of more than one billion euro (Ibid.).

Italy introduced also an important measure investing in an incentive that led to record sales, helping to bring a higher part of the Italian population closer to non-motorised mobility. The mobility bonus – "*Bonus mobilità*"- is one of the many

measures launched in the Relaunch Decree – "*Decreto Rilancio*"[12] - which reserves an incentive of five hundred euros to cover up to 60% of the cost of a sustainable vehicle such as a traditional or electric bicycle but also electric propulsion vehicles such as scooters, hoverboards and Segway. (Di Stefano, Bonus mobilità: cosa si sa finora dell'incentivo da 500 euro?, 2020a) Adults with residence in the regional capitals (even under fifty thousand inhabitants), in the provincial capitals (even under fifty thousand inhabitants), in municipalities with a population greater than fifty thousand inhabitants and in municipalities with Metropolitan cities (even under fifty inhabitants) had the right to use that bonus (Di Stefano, Bonus mobilità: cosa si sa finora dell'incentivo da 500 euro?, 2020a). The former Minister of the Environment Sergio Costa announced during 2020:

> We want to move from the purchase incentive to the bicycle use incentive: therefore, our plan provides resources for the municipalities, aimed at creating 20 000 km of cycle lanes. The plan we are implementing will help individual citizens change the way they travel for the benefit of the environment and their health.

Because of this measure, the National Association of Cycle Motorcycle Accessories (Ancma) within Confindustria recorded a plus 60% in bicycle sales in May 2020 compared to the same period in 2019. Piero Nigrelli, cycle sector manager of Ancma said when he was interviewed by journalist Alessandra Schepisi in the episode of March 28th, 2021, during "A Ruota Libera" podcast on Radio24 published by IlSole24Ore:

> We must go back to 1995, the years of MTB to have sales figures exceeding two million sales. The sector that drives the market the most are pedal assisted bicycles, a new bicycle that was not there before, like the MTB of the 90s. Like other means of transport, cycling has always guaranteed social distancing, but also doing good for health by increasing metabolism which improves the immune system. The increase in traditional ones recorded a plus 14% in sales. For 2021, demand is expected to hold on to last year's levels, which would mean increasing awareness of a new way to move more efficiently.

Therefore, the pandemic has put many sectors in crisis but has instead brought luck to the bicycle by accelerating many processes and many policies on urban cycling. In Italy, many changes have been introduced to the Highway Code which, however,

[12] It is a Law Decree to contain the economic crisis caused by the COVID-19 pandemic, which has allocated 55 billion euros in aid to workers, families, and businesses. The decree contains new measures on layoffs, aid for self-employed workers and for business support, including non-repayable payments. (Il Post, 2020)

still struggle to be translated into practice by some municipalities. These are changes that can also be achieved at very low costs if not at no cost. FIAB has presented a manual to help administrations into this process (Schepisi, 2020). Alessandro Tursi, FIAB (*Federazione Italiana Ambiente e Bicicletta*) president and vice president of the European Cycling Federation (ECF) spoke about it during the March 28 episode of "A Ruota Libera"podcast:

> There has been a lot of talk about the Bike Bonus (Mobility Bonus a/n), that's fine, the increase in the use of the bike, but there was also one more important innovation of all: the structural modification to the Highway Code, which creates the conditions for a real bike revolution, especially in the urban space. About fifteen articles of the Highway Code have changed, almost all relating to cycling. We took a leap of twenty years with two decrees:
>
> - "Relaunch Decree" of May 2020
> - "Simplification decree" of July converted into law in September 2020
>
> The most important municipalities have begun to apply them to experiment, also interpreting the norm.
>
> [...] These rules are immediately applicable, created in an emergency to avoid the disastrous transition from public transport to private cars. Immediate and extremely economical changes, such as cycle lanes, when there is no space for the reserved cycle path.
>
> The most virtuous municipalities were:
>
> - Larger municipalities such as Bologna, which started from a good base and completes an already decent level cycling network
> - Milan's "open roads" plan, the most famous being the Corso Buenos Aires cycle path which brought about a cultural revolution, counting ten thousand cyclists a day. Let's imagine what a disaster it would be for the city if these people were to converge to the subway or take a private car
> - Turin, by limiting the crossroads to 20 km/h, creates cycle roads where the bike at that speed has priority. They also did the classic cycle paths
> - Naples and especially Bari are making progress starting from worse situations

Results from this financial aid and the realisation of pop-up cycle lanes have been observed by French company "Eco-counter ", specialized in pedestrian and bicycle counting solutions, which installed counting sensors also in many Italian cities. IlSole24Ore daily journal published their data and Enrico Durbano CEO of Eco-counter has been interviewed by journalist Alessandra Schepisi in the episode of April 18th, 2021 of "A Ruota Libera"podcast. He declared:

> We have installed counters in the major cities of eleven European countries. Comparing the data of the last two months with those of 2019 we have a 4% increase in passes during the week and 45% during the weekend.
> In Italy, the data increased more generally, specifically the trips during the week had an increase of 70% compared to March 2019 while the weekend recorded an increase of 20%.

It is necessary to highlight the nature of these data since most of them come from Northern Italy[13]. The extremely increase they recorded is unquestionably a positive sign of change, but it is unrealistic to talk about Italian bike revolution along the whole territory when the counters were applied in those regions where bicycle tradition was more mature. It would be interesting to analyse Centre and South and Islands performances to truly have a clearer view in bicycle use growth.

2.5.1. About Sharing mobility

Italian North South gap is strengthened also when observing distribution of shared vehicles fleets data. The sharing economy sector has recorded, particularly in bike sharing and recently in scooter (*monopattini elettrici*) sharing, numbers that need to be highlighted. In fact, sharing mobility services in Italy have been growing since 2015. The analysis by type distribution carried out by the National Observatory on sharing mobility underlines how the services currently active on the national territory are, in 2018, 40% more than in 2015. Services are mainly in the Northern Italy, recording about half of the total. In 2018, shared mobility trips were estimated between thirty and thirty-five million per year. Bike sharing services with fleets of less than 100 bikes are excluded. It can therefore be deduced that approximately daily 100 000 are shared trips, or approximately 0.1% of the approximately 100 million trips per day. These are therefore modal solutions able to satisfy a still limited slice of the market also due to a territorially very concentrated presence of this sector, but its growth potential is relevant. Still, municipalities reached by the sharing services are 271, approximately 3% of the total, mainly in Northern Italy (57% of the total) (ISFORT, 2019). For what concerns the type of vehicles, about three out of four vehicles are bicycles (Ibid.). The bike sharing service allows the short rental of

[13] The author called, June 2021, the Italian office of Eco-counter to have a specific answer to this topic.

bicycles, which are distributed on the network within a territory, and can be picked up automatically without the need for assistance from staff.

Bike sharing services are characterized by two operating models: station based and free-floating (free-floating). In the first case, the bicycles are picked up and released at specific stations either by making a one-way or round-trip rental (from station to station or return trip from the same station). In the case of free-floating bike sharing services, however, bicycles, within a predefined area, can be released anywhere. The most widely used bike sharing systems today are of two types, depending on whether the stations (and the relative bike racks) or the bicycles are georeferenced (MIT, 2020).

The arrival of free-floating bicycles in 2016 led micro-mobility to exceed the 80% share of the total shared vehicle fleet, then exceeding 90% in September 2020 after the spread of scooter-sharing services in many Italian cities (Osservatorio Nazionale

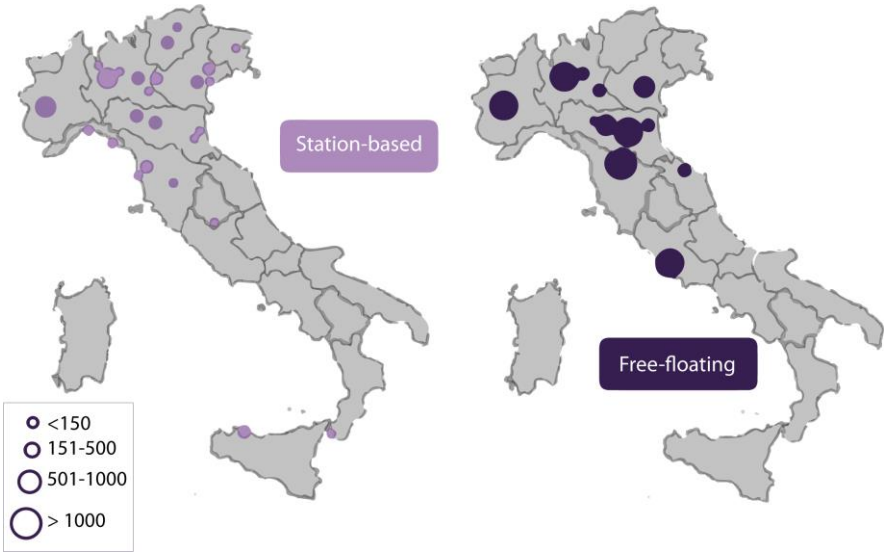


Figure 29. Italian bike sharing availability in 2019 according to IV Report published by Osservatorio Nazionale sharing mobility

Sharing Mobility, 2020). And 43% of the car and scooter fleet is zero-emission, meaning electric vehicles represent a quadrupled percentage from 2015 to 2018 (ISFORT, 2019). The offer of sharing vehicles therefore tends to be characterized using increasingly less bulky, less powerful, and lighter vehicles (Osservatorio Nazionale Sharing Mobility, 2020) but also zero emissions when referring to car-sharing and moped-sharing.

However, half of the bike fleets are in just four cities: Milan 22.3%, Florence 11.2%, Turin 8.4%, and Bologna 6.3% (ISFORT, 2019).

The fourth national report on sharing Mobility focuses on Italian bike sharing with a different more detailed approach from those carried out in previous editions. Criteria

to be followed for the selection of the sample are that the city is a provincial capital and that the fleet has at least eighty bikes. As already pointed out, with the entry into the market of free-floating services, the numbers of micro-mobility have continued to grow.

Seven cities coexist with the two types of station based and free-floating services. Subscriptions to the first typology service observe a loss of 30%, while subscriptions to free floating services doubled between 2017 and 2019 (*Figure 30)* passing from 5.6 million to 12.5 million rentals between 2015 and 2019, thus observing a growth of over 150% in two years. In 2019, free floating bike rentals were 55% of the total *(Figure 29)* in cities where both the services coexist, hence, when the two services coexist in the same city one prevails over the other. Turin is one of the cities where a free-floating bike sharing service and a station based one coexist.

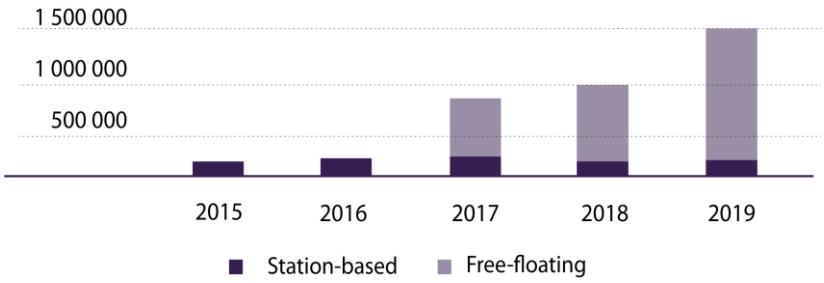


Figure 30. Subscriptions to bike sharing services by Station-based and free floating [source: IV Report, Osservatorio Nazionale Sharing Mobility]

Comparing how the two types of services are used, results show that free floating is characterized by short rentals with a duration of no more than five minutes, actually 73% is less than 500 m. The station-based service, on the other hand, has routes of one or two kilometres and 80% of journeys take less than 20 minutes, the time limit included in the subscription price. There are no large variations in the use between the two services during the working week, while during the weekend free-floating bike sharing is the one that is used the most. Going into detail, it is noted that the latter is also the most widely used service during the night-time hours. Turin, Pisa, Brescia recorded the highest percentages of use of each bicycle over 24 hours. On average, each city offers 1.4 per thousand inhabitants while for free floating services the capacity is of four vehicles per thousand inhabitants. Turin records 1.9 for free floating and 1.5 for station-based bikes respectively.

Attention should be also paid to the presence of 5413 electric shared bicycles in 2019 because it means that availability of vehicle fleet, between 2015 and 2019, has more than tripled. The potential of the electric bike is therefore confirmed by comparing

the duration and distance of the rentals of traditional bicycles and pedal-assisted ones. Over half of electric bike rentals last more than ten minutes. Therefore, by increasing the fleet of pedal assisted bikes, travelled distances increases so it might do the number of potential users.

At the end of lockdown period, between June and September 2020, a large part of scooter sharing services were launched, thus increasing their presence in Italian cities by more than five times within a few months (Figure 32). In 2019 three provincial capital cities were covered by the service while in 2020 they were eighteen *(Table 3)*. Active operators in September 2020 were eight reaching from one to eleven cities, Milan has all of them. Still, the presence of most of these services in Northern Italy (Figure 31). Even bike sharing service, the most nationally widespread, is still mainly active in the North (Osservatorio Nazionale Sharing Mobility, 2020).

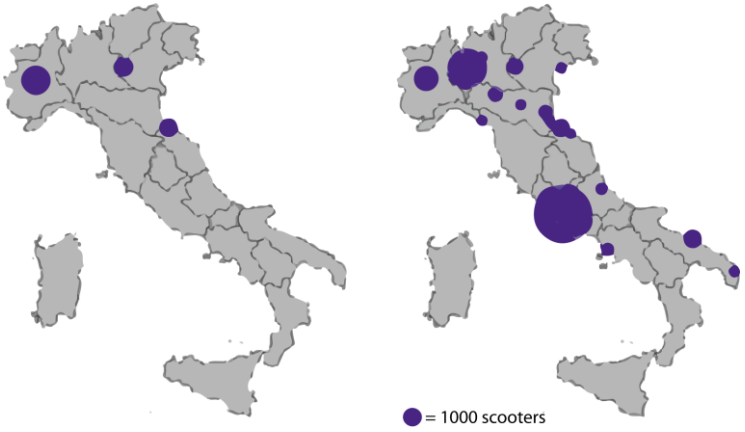


Figure 31. spatial distribution of scooter fleets from 2019(left) to 2020 (right). Most of these services are in Northern Italy [source: (Osservatorio Nazionale Sharing Mobility, 2020)]

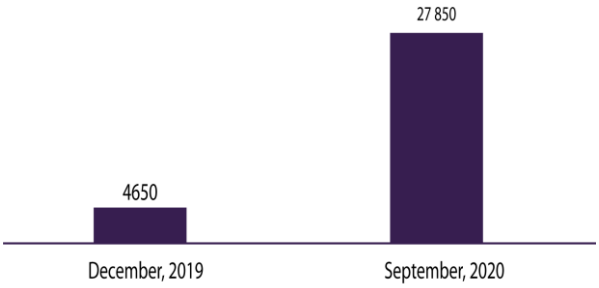


Figure 32. Sharing scooter fleet evolution from December 2019 to September 2020 has increased more than five times in few months [source: (Osservatorio Nazionale Sharing Mobility, 2020)]

	December 2019	September 2020
Bari	-	1000
Bergamo	-	300
Cesena	-	200
La Spezia	-	300
Lecce	-	250
Milano	-	6000
Modena	-	200
Monza	-	400
Napoli	-	900
Parma	-	900
Pesaro	-	250
Pescara	-	500
Ravenna	-	350
Rimini	1000	1000
Roma	-	11000
Torino	2650	3000
Venezia	-	300
Verona	1000	1000
Total	4650	27850

Table 3. The provincial capital cities covered at the end of 2019 are only three while reaching eighteen in 2020 [source: Osservatorio Nazionale Sharing Mobility, 2020]

2.5.2. On the popularity of cycling mobility

There is not much to prove in the scientific literature about how advantageous the use of bicycle is compared to car when it comes to urban journeys. In fact, numerous studies have already been published, showing how active-mobility particularly the bicycle has numerous findings on the psycho-physical health of those who ride it. Having a bicycle modal share of about 5%, Italy could only gain if it were able to change its habits even to a small part of its citizens and city users. Specific studies should be carried out on the characteristic of a country's population in which policies of cycling promotion will be introduced, since the cultural sphere plays an important role for the success. It has been written that statistically the Italians are a population with low attitude for physical activity (*Figure 28*) and it is perhaps unthinkable to look for examples in countries such as those of northern Europe which instead occupy the first positions for the amount of time spent in physical activity during the year. TV and advertising are powerful means that should and could be better exploited for the promotion of cycling as well. Thinking about how many TV commercials are dedicated to two wheels, it is difficult to identify it even just one. As TV may be criticized as a means of information and propaganda, it remains an extremely widespread medium. The fact that at each advertising period, between a program or a movie, has at least two advertising slots dedicated to car brands promotion appear to have an influence on people's willingness to decide. It is

impressive how in every accident involving a scooter or a bicycle there is so much media coverage with mayors who spend words on the importance of the helmet on a scooter, but little is said about the danger of the car when it exceeds 30 km/h. In Italy, electric bicycles as well as scooters has a huge potential market, and they should not be hindered but rather a safe environment should be created where they could easily move. Proposals with no fortune have been made to make helmets mandatory even for those who travel by bicycle. There are various studies that explain the negative effects that would follow a law imposing helmets, effects on health and therefore on the economy of the country (ECF, 2014). Limiting to cycle paths kilometres calculation in a municipality, without thinking about the most important intervention, traffic moderation, is irrelevant. Knowing which city has the most kilometres of cycle paths without knowing whether these tracks are in good condition on a smoothly constructed surface is useless. Until 2019, the Highway Code provided that urban roads and local urban roads would allow speeds of up to 70 km/h if permitted by conditions. From 2020, art. 49 L. 120/2020 "*Semplificazioni*" decree introduced the definition of "urban cycle road" applied to certain roads to reduce their speed at 30 km/h thus allowing bicycles and other means of micro-mobility to move in a mixed manner together with cars. This is a very interesting update of the Highway Code which must however find a way to communicate it quickly to the rest of the population, like all those people who cannot afford to check the Official Gazette as well as update and raise awareness of the technical offices. More successful examples of participatory mobility plans should be studied, such as that of the city of Brera, in which citizens could promptly report and geo-reference their observations through a WebGIS (Deromedis, 2019). It is true that the modal share of the bicycles in Italy is on the rise, and it is true that sales have skyrocketed following lockdowns due to the COVID-19 pandemic. But it is also true that the types of bicycles purchased should be checked to really understand if those huge sales also correspond to a slice of the population that moves around the city on two wheels. Furthermore, the amount of people who travel by bicycle in Southern Italy and the Islands should be further investigated because if it is true that Il Sole24Ore daily journal has published data from the Eco Counter company, telling how much Italy has experienced a boom in urban cycling journeys, it is also true that bicycle counters have been installed mainly in the regions of Northern Italy as Piedmont, Lombardy, Veneto, and Emilia-Romagna. Those extremely positive and encouraging data have rightly generated a lot of enthusiasm but reality is that mobility progresses

are taking place mainly in the North. Apparently, it is of little use to demonstrate how much it can be saved by using the bicycle for urban daily journeys and the urban fabric of our suburbs and all those dormitory villages that surround the major centres is perhaps also an accomplice. The urban sprawl has created an addiction to the car that has almost become necessary to be able to carry out an everyday life. This because <<in small towns, the most common type of residence is the single-family home that continues to survive because of its perverse symbiosis with the private car, which in turn paradoxically survives only by consuming non-renewable energy resources such as petrol and diesel.>> (Pileri & Scalenghe, 2016)

2.6. European bodies and policies

Reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels is the goal behind policies published by the European Commission. To make Europe the world's first climate-neutral continent by 2050 EU's climate, energy, transport, and taxation policies must fit for reducing the impacts Europe has on the environment. The European Green Deal set the blueprint for this transformational change. Cycling is of substantial added value to EU policy goals considering it is a low emission mobility, a source of growth and jobs in a thriving bicycle manufacturing and cycling tourism industry, multimodality. By lowering barriers to cooperation, reducing coordination costs and increase information-exchange between Member States, the Commission can unlock cycling's socio-economic and environmental potential in areas where local, regional, and national authorities are currently lacking behind (European Cyclists' Federation, 2017). Indeed, while in a small number of places cycling is already a dominant way of life, most places in Europe have a much longer way to go and much to learn to become cycling countries.

2.6.1. European Cyclists' Federation

Among European essential bodies in the promotion of cycling, the European Cyclists' Federation (ECF), founded in 1983, is a Brussels-based independent non-profit association dedicated to achieving more and better cycling for all in Europe. They unite the European cycling movements as the only civil society voice at the pan-European level, and as the world's largest and best-known cyclists' advocacy organisation. ECF spends itself into reviewing EU documents and data to check the impact cycling has at European and single EU member state. It has published a clear set of goals which are those in the European Cyclists' Federation 2030 strategy showed in *Figure 33*: public investment for better and safer cycling infrastructures, policies and laws that enable and boost active mobility, but also a strong civil society movement that advocates for change and a shift in culture. ECF plays a key role in driving, influencing, and facilitating this change across Europe. It obtained several achievements. The Federation oversees developing and managing EuroVelo, the pan-European cycle route network.

Figure 33. European Cyclists' Federation 2030 Strategy summarised. [ECF.com\about-us]

2.6.2. Eurovelo

The European cycle route network Eurovelo[14] is a project of the European Cyclists' Federation ECF. The network had grown to 90 000 km (ECF, Discover Europe by bike!, 2020). The aim is to dedicate these infrastructures to free-time journeys for cycle tourism but also daily-trips for the local population. The EuroVelo network consists of seventeen long distance cycle routes around the whole European continent carrying the best European practice across borders and harmonising standards. However, the routes are in different stages of expansion. The development and operation of the EuroVelo routes is carried out by national, regional, and local governments, commercial service providers and NGOs (Ibid.).

Three routes cover Italy: "EuroVelo 5" Via Romea Francigena, from London to Rome till Brindisi (3900km) but it still needs to be realised; "EuroVelo 7" Sun Route from Cape North – Norway – to Malta (7700 km) crossing Italy from Trentino Alto Adige – Südtirol to sicilian Pozzallo; "EuroVelo 8" Mediterranean Route from Cadiz to Athens, Cyprus, and recently till Izmir – Turkey – for 7,500 km total. Italy is part of this route from Ventimiglia to Trieste.

2.6.3. European Green Deal

The "European Green Deal" should be mentioned among the relevant European set of policy initiatives which facilitated cycling growth between EU member States. The European Commission proposes ambitious targets for reducing the CO2 emissions

[14] https://en.eurovelo.com/

promoting the growth of the market for zero- and low- emissions vehicles. Since transport accounts for a quarter of the EU's greenhouse gas emissions a 90% reduction is needed (European Commission, A European Green Deal, 2019). Achieving sustainable transport means providing users with more affordable, accessible, healthier, and cleaner alternatives to their current mobility habits. For this reason, the document stresses the necessity of a strong boost in multimodal transport. The Commission will adopt a strategy for sustainable and smart mobility in 2020 that will address this challenge and tackle all emission sources (European Commission, A European Green Deal, 2019). The Green new Deal recognises how the EU transport system and infrastructure must fit to support new sustainable mobility services to reduce congestion and pollution, especially in urban areas.

2.6.4. New European Bauhaus

The "New European Bauhaus" (*Figure 34*) initiative connects the European Green Deal to EU citizens to reimagine sustainable living in Europe and beyond. It is defined

Figure 34. #neweuropeanbauhaus is a creative and interdisciplinary initiative, convening a space of encounter to design future ways of living, situated at the crossroads between art, culture, social inclusion, science and technology. [Source:The New European Bauhaus]

as a bridge between the world of science and technology and the world of art and culture. It is an invitation to see green and digital challenges as opportunities to finding innovative solutions through co-creation. It is a design lab, accelerator, and network at the same time; indeed, it unfolds in three phases (*Figure 35*): Design, Delivery and Dissemination.

The goal of the design phase is to accelerate, concretise and materialise good ideas providing special facilitation methods and harvesting tools. Summer 2021 saw the design phase (from October 2020 to June 2021) coming to an end. The outcome should be five pilots distributed in different EU Member States. Delivery phase (from

September 2021 onward) needs to complement the pilots to structure and spread the movement.

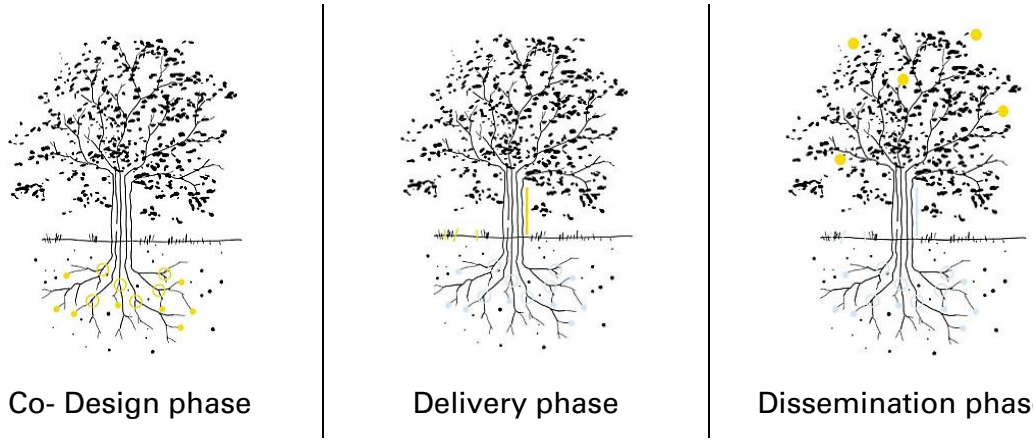


Figure 35. Three New European Bauhaus phases in an iconography released for the presentation of the NEB [Source: https://europa.eu/new-european-bauhaus/about/about-initiative_en]

Finally, Dissemination phase (from January 2023 onward) will focus on diffusing good ideas and concepts to a broader audience (New European Bauhaus, 2021). Cycling is a field that could earn from the New European Bauhaus since it would share faster knowledge and best practices of different EU countries.

2.6.5. CIVITAS Handshake

CIVITAS Handshake, a European Union's Horizon Research and Innovation programme 2020-funded project under the CIVITAS Initiative, aims to support cities to make the transition to two wheels. The Handshake project is running from September 2018 to February 2022 (Handshake Team, 2018). Its aim is to help cities of all types becoming more liveable places, improving conditions for cycling as an everyday mode of transport *(Figure 36)*. Because cities are facing alarming levels of congestion and air pollution and a scarcity of public space, whilst urban environments remain dangerous for vulnerable road users Handshake wants to help finding solutions to these issues through share of know-how and best practices. Since cycling is a powerful way to address these challenges, the project selected three "Handshake Cycling Capitals" based on the level of development and their holistic approach to cycling (Ibid.). These three pioneers are Copenhagen (Denmark), Amsterdam (the Netherlands), and Munich (Germany). Under Handshake, cycling knowledge and expertise is being shared through transfer processes and mentoring programmes between cities. The Cycling Capitals have been assigned to ten future

Cycling Capitals to work on different measures to becoming Cycling Capitals themselves. Turin and Rome are the only Italian cities which are taking part to this project, Amsterdam is mentor of both. This project represents for the city of Turin an important possibility to learn from the Country with the most mature cycling culture. Turin will focus on the fundamental development of its cycling infrastructure, which will be aided by learning more advanced assessment and monitoring techniques (Del Carlo, 2019).

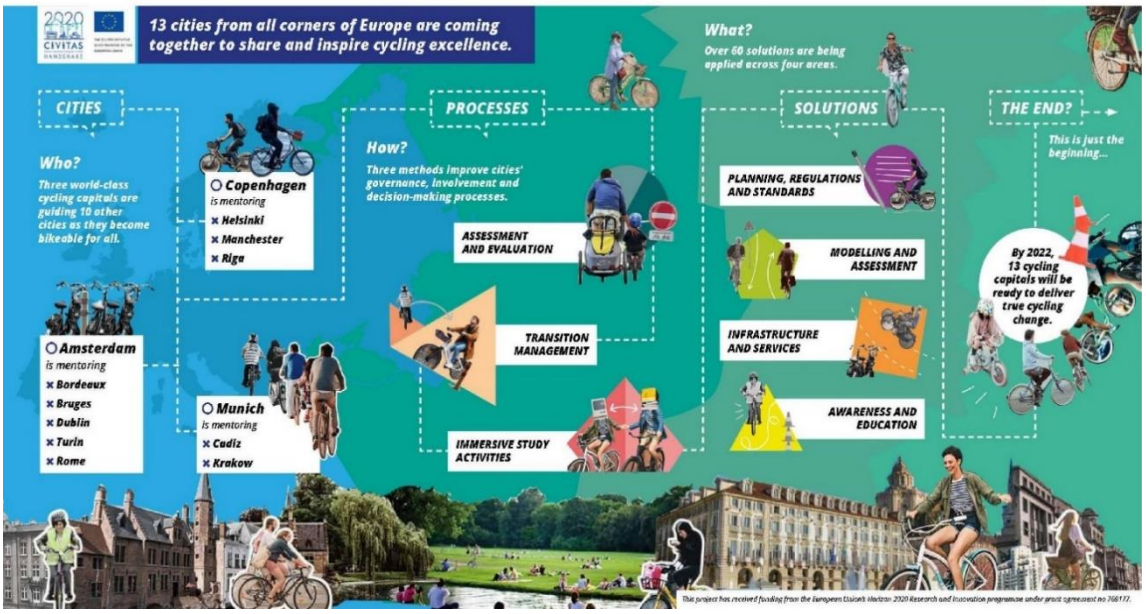


Figure 36. 13 cities from all corners of Europe are coming together to share and inspire cycling excellence [Source: Handshake Infographic https://handshakecycling.eu/infographic]

2.7. NRRP *(PNRR)*. National Recovery and Resilience Plan

750 billion euros will be allocated to EU member States through grants and loans in the Next Generation EU (NGEU) to address the economic crisis caused by the COVID-19 crisis. The largest single fund is the Recovery and Resilience Fund (RRF) with a budget of 672.5 billion (*Figure 37*). At least 37% of these investments must be used to support climate action (Küster & Kolczyńska, 2020).

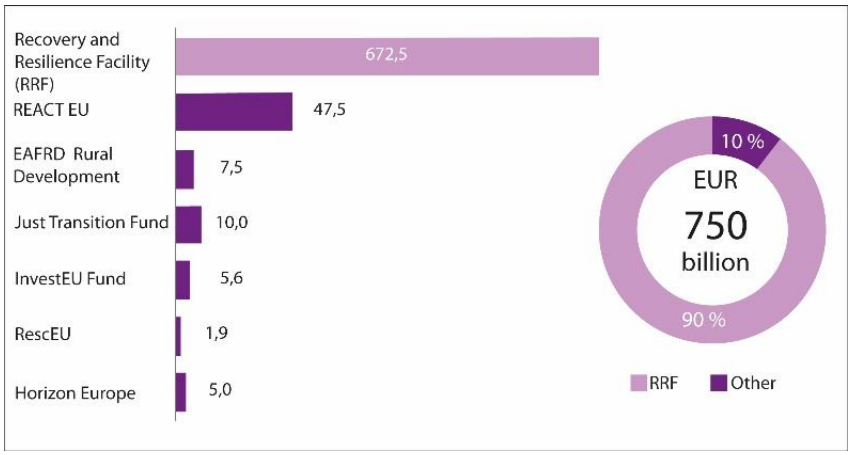


Figure 37. Next Generation EU - available devices and resources, billions of euros. [Source: official PNRR Italia]

The RRF has a duration of six years, from 2021 to 2026. Its total size is 672.5 billion euros, of which 312.5 billion are grants and 360 billion low-interest loans. Italy is the first beneficiary, in absolute value, of the two main instruments of the NGEU. The RRF alone guarantees to Italy resources of 191.5 billion euros (*Figure 38*), to be used in the period 2021-2026. The RRF mechanism requires member States to present an investment and reform package: the National Recovery and Resilience Plan (PNRR). The Italian Plan, which is divided into six Missions, listed in *Figure 38*, and sixteen Components, benefits from the close dialogue that has taken place in recent months with the Parliament and the European Commission, based on the RRF Regulation. To RRF's resources are added those made available by REACT-EU, conceived in a shorter-term perspective (2021-2022) to help countries in the initial phase of relaunching their economies as well as those deriving from the additional national programming.

Sectors touched by the Missions are many: Mission no. 2 "Green revolution and ecological transition" – *Rivoluzione verde e transizione ecologica* - is where cycling has been analysed. *Figure 39* indicates where cycling sector find implementation and how many funds will be the destinated. 600 million euro will be used for the construction of approximately 570 km urban cycle paths and over 1200 km tourist

cycle paths. *Table 4* shows the paragraph entirely dedicated to cycling sector in the official Italian PNRR.

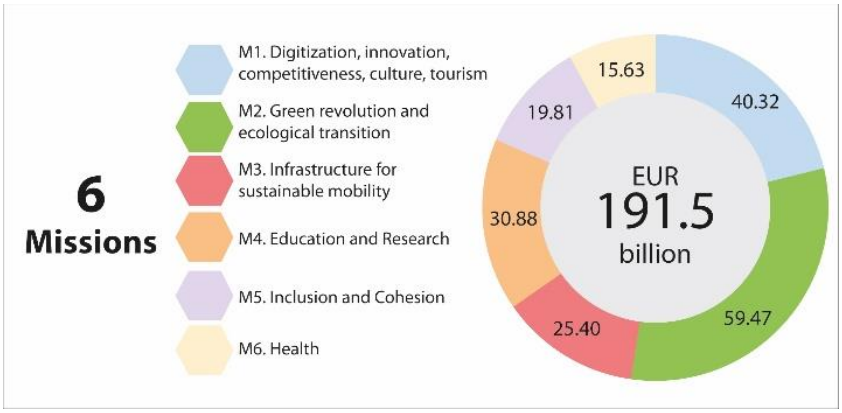


Figure 38. Allocation of RRF resources to Missions. [Source: official PNRR Italy]

M2 - GREEN REVOLUTION AND ECOLOGICAL TRANSITION	PNRR (a)	React EU (b)	Fondo complementare (c)	Total (d)= (a)+(b)+(c)
M2C1 - Sustainable agriculture and circular economy	5,27	0,50	1,20	6,97
M2C2 - Ecological transition and sustainable mobility	23,78	0,18	1,40	25,36
M2C3 - Energy efficiency and building renovation	15,36	0,32	6,56	22,24
M2C4 - Protection of the territory and of the water resource	15,06	0,31	0,00	15,37
Total Mission 2	**59,47**	**1,31**	**9,16**	**69,94**

Figure 39. Composition of the PNRR Mission No.2. M2C2 section four "Development of a more sustainable local transport system" is where investments for a stronger cycling mobility are allocated.

The fourth objective within the component No. 2 of Mission No.2, they wrote in the document:

> is to develop [...] also as a lever for the overall improvement of the quality of life (reduction of air and noise pollution, reduction of congestion and integration of new services): 1) by investing in "soft" mobility, favouring intermodality and the use of bicycles[...].

The fact that cycling is defined as "soft" is a sign of the lower relevance it is given to this mean of transport which could, instead, find definition using different adjectives such as "active" or "alternative" mobility, and even "non-motorised" mobility. It is important to stress how cycling and other non-motorised means of transport should find a same-level-spot inside mobility conversation instead of being marginalised as weaker component with several benefits but lower priority. As the public awareness campaigns also pass from consciousness in the use of words higher attention should

be given to definitions. Cycling should be an equal partner in the mobility system (ECF, 2017)

M2C2.4 SVILUPPARE UN TRASPORTO LOCALE PIÙ SOSTENIBILE Investimento 4.1: Rafforzamento mobilità ciclistica "Il numero di ciclisti è in costante crescita dal 2013 (con crescita di oltre il 40 per cento nel 2018) e, oltre alla diffusione di un mezzo di trasporto non inquinante rappresenta una fonte di indotto economico dal valore di 7,6 €Mld ogni anno. A causa dell'emergenza Covid-19, si prevede una crescita ancora più pronunciata del settore, con numero di ciclisti nel 2020 aumentato del 20 per cento rispetto al 2019. L'intervento si pone l'obiettivo di facilitare e promuovere ulteriormente la crescita del settore tramite realizzazione e manutenzione di reti ciclabili in ambito urbano, metropolitano, regionale e nazionale, sia con scopi turistici o ricreativi, sia per favorire gli spostamenti quotidiani e l'intermodalità, garantendo la sicurezza. La misura ha anche l'obiettivo di migliorare la coesione sociale a livello nazionale, con il 50 per cento delle risorse destinate alla Regioni del Sud. Nello specifico, la misura prevede la realizzazione di circa 570 km di piste ciclabili urbane e metropolitane e di circa 1.250 km di piste ciclabili turistiche."	**M2C2.4 DEVELOP A MORE SUSTAINABLE LOCAL TRANSPORT** **Investment 4.1: Strengthening cycling mobility** The number of cyclists has been growing steadily since 2013 (in 2018 there was over 40 percent of growth). Velocipedes represent a non-polluting mean of transport, but also source of induced economic value of 7.6 billion euro every year. Due to the COVID-19 emergency, an even more pronounced growth in this sector is expected, with increasing number of cyclists, in 2020, by 20 percent compared to 2019. The aim of the intervention is to facilitate and further promote this growth by creating and maintaining cycle networks in urban, metropolitan, regional, and national contexts. The purposes are both tourist or recreational, in favour of daily travel, and intramodality. 50% of the resources of the measure will be allocated to the Southern Regions. In fact, the investments also have the objective of improving social cohesion at national level. Specifically, the measure provides for the construction of approximately 570 km of urban and metropolitan cycle paths, and approximately 1,250 km of tourist cycle paths.

Table 4. Paragraph 4.1. of Mission No.2, Component No. 2 represents Investment dedicated to cycling mobility. [Source: official PNRR Italy]

According to European Cycling Federation (ECF), which has analysed the Plans of each EU member State to understand the role cycling has played in the Recovery Plan, Italy is among the most virtuous EU countries, due to the high budget it will be dedicated to this sector. If loans could be allocated in cycling it would allow countries and regions to meet 30% minimum spending thresholds in climate protection measures, and the remaining money could be spent for other vital projects outside

these policy areas. Thus, cycling is a perfect solution for both these concerns. It is one of the safest means of transport during the COVID-19 pandemic since it keeps people at the minimum physical distance recommended and it prevents physical and mental illnesses, which have been taking an increasing toll through periods of recurrent lockdowns, social restrictions, and isolation (Küster & Kolczyńska, 2020). The 2021–2027 EU budget has been the subject of heated disputes among European policymakers. Indeed, the new EU financial policy must contribute towards making Europe a pioneer in responsible and sustainable transformation so that it can meet the ambitious goals of the European Green Deal (Küster & Kolczyńska, 2020).
Unfortunately, over half of European Union Member States are neglecting cycling in their post-pandemic recovery plans, missing out on billions of euros in economic and health benefits. The European Cyclists' Federation - ECF - shows that only six countries are properly using their plans to seize upon the enormous recovery potential of cycling. According to a 2014 study, doubling cycling levels could lead to more than one million cycling-related jobs in Europe (ECF) (Küster, 2021).

Jill Warren, CEO of ECF, said:

> Cycling emerged as the most resilient mode of transport during the COVID-19 pandemic, enabling millions of EU citizens to stay active and healthy. More Europeans than ever are cycling because of new bicycle lanes and infrastructure in European cities. EU governments must now step up and sustain this positive momentum by including dedicated budget lines for cycling in their recovery plans. Deciding to allocate few or no funds coming from RRF into the promotion of healthy and active mobility alternatives means missing the opportunity to boost the traditional, full of failures, transport system.

A missed opportunity since it will not happen, or it would be better writing in the hope such a tragedy will not happen again, that such a large amount of non-repayable resources which will overwhelm the EU Countries and in particular Italy, the country that most of all will benefit from these funds. Eight EU Countries are leading the race (Küster, 2021) (*Figure 40*).
Belgium is in the lead in relative numbers, having budgeted 473 million euros, equal to 8% of its Recovery Plan, for cycling investments such as the construction of cycling highways in the northern region of Flanders and around Brussels. As already mentioned, Italy is committing to build 1770 km of cycling paths and will invest 600 million euros in reinforcing cycling mobility.

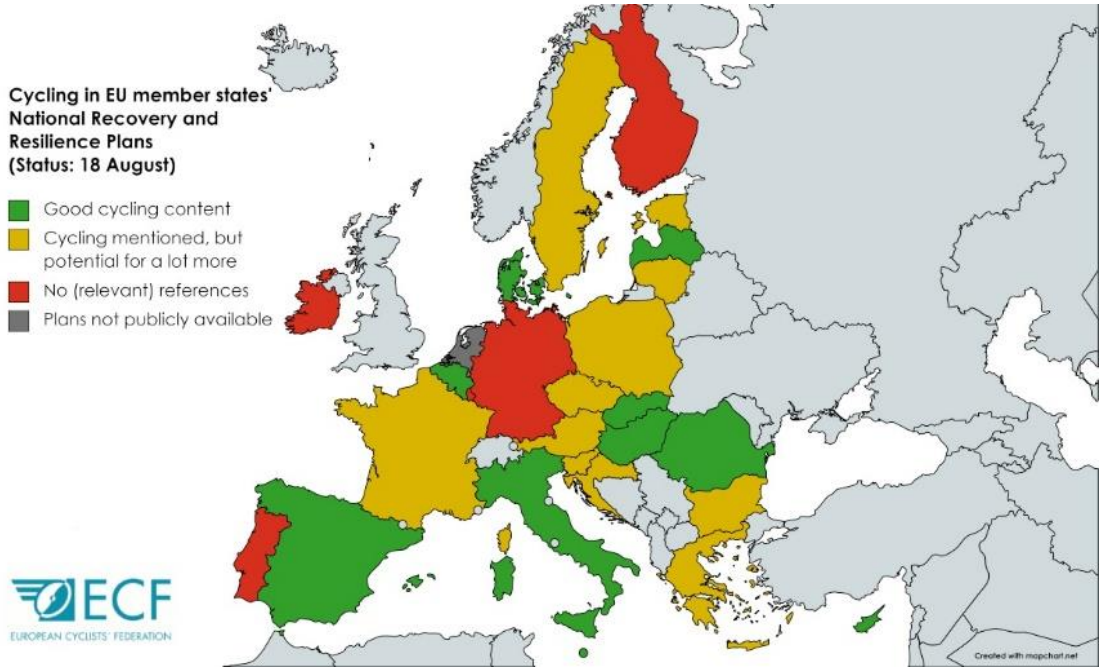


Figure 40. Cycling in National Recovery and Resilience Plans. Final analysis shows how cycling becomes mainstream in EU member states' COVID-19 recovery plans [source: (Colli, 2021)]

Hungary clarified that €120 million will go to cycling infrastructure (Colli, 2021). Slovakia has budgeted one hundred million euros to build two hundred kilometres of high-quality cycling paths. Latvia has included the development of cycling infrastructure for daily mobility in its Recovery Plan. France is earmarking one hundred million euros to finance its national cycling plan and is also set to introduce incentives to those purchasing e-bikes instead of the car. Germany's absence is the most prominent among the EU countries that have yet to include cycling in their post-pandemic NRRPs. It has set aside more than three billion euros in purchasing premiums for electric and hybrid cars but nothing for e-bikes, despite Germany's stated goal of becoming a cycling nation by 2030. Other notable countries that are behind include Spain, whose plan commits to creating sustainable, safe, and connected mobility in urban areas but fails to include any explicit reference to cycling. Finland and Croatia are aiming to boost sustainable tourism in their plans but do not provide any place for cycling tourism (Küster, 2021).

Kevin Mayne, CEO of Cycling Industries Europe, declared:

> A lot of Europeans are purchasing bikes, especially e-bikes. In 2020, more than five million e-bikes were sold, almost four times the number of electric cars. And this is creating more jobs: half of companies surveyed by CIE have more staff today than in 2019, and 94% say they will add staff over the next two years. EU governments can take advantage of this

> massive economic growth potential by earmarking at least 10% of their recovery plan mobility budgets to support cycling. We need to create a level-playing field for cycling and other modes of transport.

Manuel Marsilio, General Manager of the Confederation of the European Bicycle Industry, said:

> A total of almost 1.3 billion euros has been committed so far through the National Recovery and Resilience Plans to improve the cycling experience across the EU. Nevertheless, this is still modest compared to what we could see if more member states committed to cycling in these Recovery Plans. EU countries need to recognise that cycling investments are the best way to structurally improve people's mobility patterns while creating green jobs and boosting the economy.

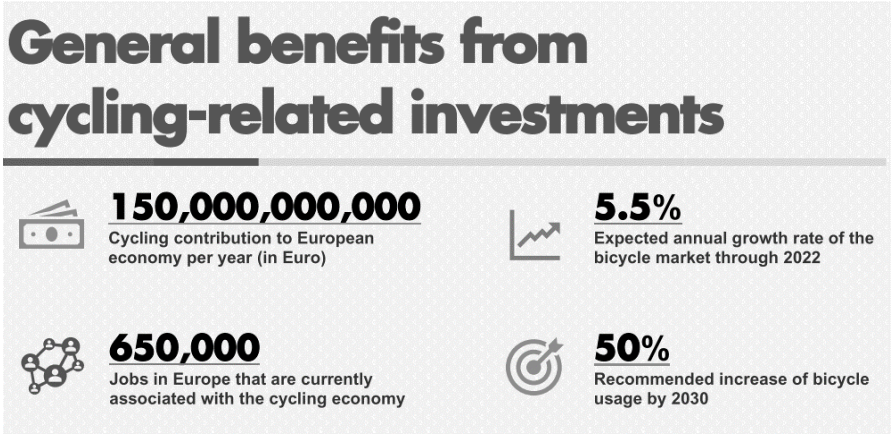


Figure 41. The benefits of cycling are evident, and the European Cycling Federation spends itself strongly to make it clear. [Source: (Küster & Kolczyńska, 2020)]

The list of challenges where cycling can make a cost-efficient impact at city, regional, national, European, and global level is long. The benefits of cycling appear not only in specific, isolated fields like transport or environmental policy, but also in many other areas where the EU has competences. Current levels of cycling produce benefits of 150 billion euros per year for the EU countries. About 650 000 jobs are associated with the cycling economy (*Figure 41*). More than ninety billion euros of these benefits are positive externalities for the environment, public health, and the mobility system. In comparison the negative externalities for those same sectors of motorised road transport are estimated at heigh hundred billion euros per year. Investments in cycle projects have very profitable benefit-cost ratios and are excellent value for money. To increase the number of people cycling and decrease the negative externalities of motorised road transport, it is needed not only integrated policies, but also adequate funding (Küster & Kolczyńska, 2020).

3. Regulations on cycling

3.1. Highway Code and other regulations

The main laws and regulations relating to cycling currently in force in Italy find their origins at the beginning of 1990s and have been updated throughout the years with the growth of interest in alternatives to motorized vehicle mobility, the sharing economy from which scooters are a product. Indeed, the first approved Italian law on cycling mobility (Deromedis, 2019, p. 59) was Law n.366 19/10/1998 "Rules for the financing of cycling" (*Norme per il finanziamento della mobilità ciclistica*).

In Italy, the bicycle is considered a vehicle and for this reason it falls within the category called "velocipedes". The reason behind this choice is the desire to include all vehicles powered by human muscle strength in a single group. Therefore, bicycles are vehicles and cycle paths are roads, in fact, they are subject to the Highway Code (*Cds* [15]) "New Highway Code" Legislative Decree (D.Lgs.) n. 285/1992 together with Presidential Decree n. 496/1992 "Rules for implementing the highway code" and subsequent updates (Deromedis, 2019, pp. 53-54).

Art. 50 of Legislative Decree n. 285/1992 the "New Highway Code" defines *(Table 5)*:

Table 5. Art. 50 D. Lgs. No. 285/1992
continue on next page...

1. I velocipedi sono i veicoli con due ruote o più ruote funzionanti a propulsione esclusivamente muscolare, per mezzo di pedali o di analoghi dispositivi, azionati dalle persone che si trovano sul veicolo; sono altresì considerati velocipedi le biciclette a pedalata assistita, dotate di un motore ausiliario elettrico avente potenza nominale continua massima di 0,25 KW la cui alimentazione è progressivamente ridotta ed infine interrotta quando il veicolo raggiunge i 25 km/h o prima se il ciclista smette di pedalare. (I velocipedi a pedalata assistita possono essere dotati di un pulsante che permetta di attivare il motore anche a pedali fermi, purché' con questa modalità il veicolo non superi i 6 km/h.).	1. Velocipedes are vehicles with two or more wheels operating with exclusively muscular propulsion, by means of pedals or similar devices, operated by the people who are on the vehicle; pedal assisted bicycles are also considered velocipedes, equipped with an electric auxiliary motor having a maximum continuous rated power of 0.25 kW whose power supply is progressively reduced and finally interrupted when the vehicle reaches 25 km/h or earlier if the cyclist stops ride. (Pedal assisted cycles[16] can be equipped

[15] CdS= abbreviation commonly used in Italy which stands for "*Codice della Strada*"
[16] Also "pedelec" (Deromedis, 2019)

Sono considerati velocipedi, ai sensi dell'articolo 50 del codice della strada monopattini a propulsione prevalentemente elettrica non dotati di posti a sedere, aventi motore elettrico di potenza nominale continua non superiore a 0,50 kW, rispondenti agli altri requisiti tecnici e costruttivi indicati nel decreto del Ministro delle infrastrutture e dei trasporti 4 giugno 2019, pubblicato nella Gazzetta Ufficiale n. 162 del 12 luglio 2019.

2. I velocipedi non possono superare 1,30 m di larghezza, 3 m di lunghezza e 2,20 m di altezza.

with a button that allows you to activate the engine even when the pedals are stationary if the vehicle does not exceed 6 km/h in this mode).

Pursuant to Article 50 of the Highway Code, scooters with mainly electric propulsion not equipped with seats, having an electric motor with a continuous nominal power not exceeding 0.50 kW, are considered velocipedes, meeting the other technical and construction requirements indicated in the decree of the Minister of Infrastructure and Transport of 4 June 2019, published in the Official Gazette no. 162 of 12 July 2019.

2. Velocipedes cannot exceed 1.30 m in width, 3 m in length and 2.20 m in height.

Table 5. Art. 50 D. Lgs. No. 285/1992

Art. 69 "Constructive and functional characteristics and equipment devices for velocipedes" of the "New Highway Code" then defines also:

Table 6. Art. 67 D. Lgs No. 285/1992
continue on next page...

1. I velocipedi devono essere muniti di pneumatici, nonché:
   a) per la frenatura: di un dispositivo indipendente per ciascun asse che agisca in maniera pronta ed efficace sulle rispettive ruote;
   b) per le segnalazioni acustiche: di un campanello;
   c) per le segnalazioni visive: anteriormente di luci bianche o gialle, posteriormente di luci rosse e di catadiottri rossi; inoltre, sui pedali devono essere applicati catadiottri gialli ed analoghi dispositivi devono essere applicati sui lati.
2. I dispositivi di segnalazione di cui alla lettera c) del comma 1 devono essere presenti e funzionanti nelle ore

1. The velocipedes must be equipped with tires, as well as:
a) for braking: an independent device for each axle that acts promptly and effectively on the respective wheels,
b) for acoustic signals: a bell,
c) for visual signals: white or yellow lights at the front, red lights, and red retroreflectors at the rear; moreover, yellow reflectors must be applied to the pedals and similar devices must be applied to the sides.

2. Warn devices referred to in letter c) of paragraph 1 must be present and functioning

e nei casi previsti dall'art. 152, comma 1. 3. Le disposizioni previste nelle lettere b) e c) del comma 1 non si applicano ai velocipedi quando sono usati durante competizioni sportive. 4. Con decreto del Ministro delle infrastrutture e dei trasporti sono stabilite le caratteristiche costruttive, funzionali nonché le modalità di omologazione dei velocipedi a più ruote simmetriche che consentono il trasporto di altre persone oltre il conducente. 5. I velocipedi possono essere equipaggiati per il trasporto di un bambino, con idonee attrezzature, le cui caratteristiche sono stabilite dal regolamento. 6. Chiunque circola con un velocipede senza pneumatici o nel quale alcuno dei dispositivi di frenatura o di segnalazione acustica o visiva manchi o non sia conforme alle disposizioni stabilite nel presente articolo e nell'articolo 69, è soggetto alla sanzione amministrativa del pagamento di una somma da € 26 a € 102.	within the hours and in the cases provided for by art. 152, paragraph 1[17]. 3. The provisions set forth in letters b) and c) of paragraph 1 do not apply to velocipedes when they are used during sports competitions. 4. By decree of the Minister of Infrastructure and Transport, the construction, and functional characteristics as well as the methods of homologation of bicycles with several symmetrical wheels that allow the transport of other people besides the driver are established. 5. Velocipedes can be equipped for the transport of a child, with suitable equipment, the characteristics of which are established by the regulations. 6. Anyone traveling with a velocipede without tires or in which any of the braking or acoustic or visual warn devices is missing or does not comply with the provisions established in this article and in article 69, is subject to the administrative sanction of payment of a sum from € 26 to € 102.

Table 6. Art. 67 D. Lgs No. 285/1992.

Velocipedes are not allowed to circulate in all classes of roads *(Figure 42)* of D.M. 5/11/2001 "Functional and geometric standards for roads construction*" (Norme funzionali e geometriche per la costruzione delle strade*) reassumes which are road spaces assigned to each vehicle classifying road construction, technical and functional characteristics. It further displays that velocipede can only travel in the lane on:

- secondary extra-urban roads (type C),
- urban neighbourhood roads (type E),
- local roads (type F) and
- service roads.

[17] outside built-up areas when external lighting is lacking or insufficient and from half an hour after sunset to half an hour before sunrise and also during the day in the tunnels, in case of fog, snowfall, heavy rain and in any other case of poor visibility

Velocipedes are admitted on urban arterial roads (type D) only if in cycle paths. They are not allowed on highway (type A) and main extra-urban roads (type B) (Deromedis, 2019, p. 57).

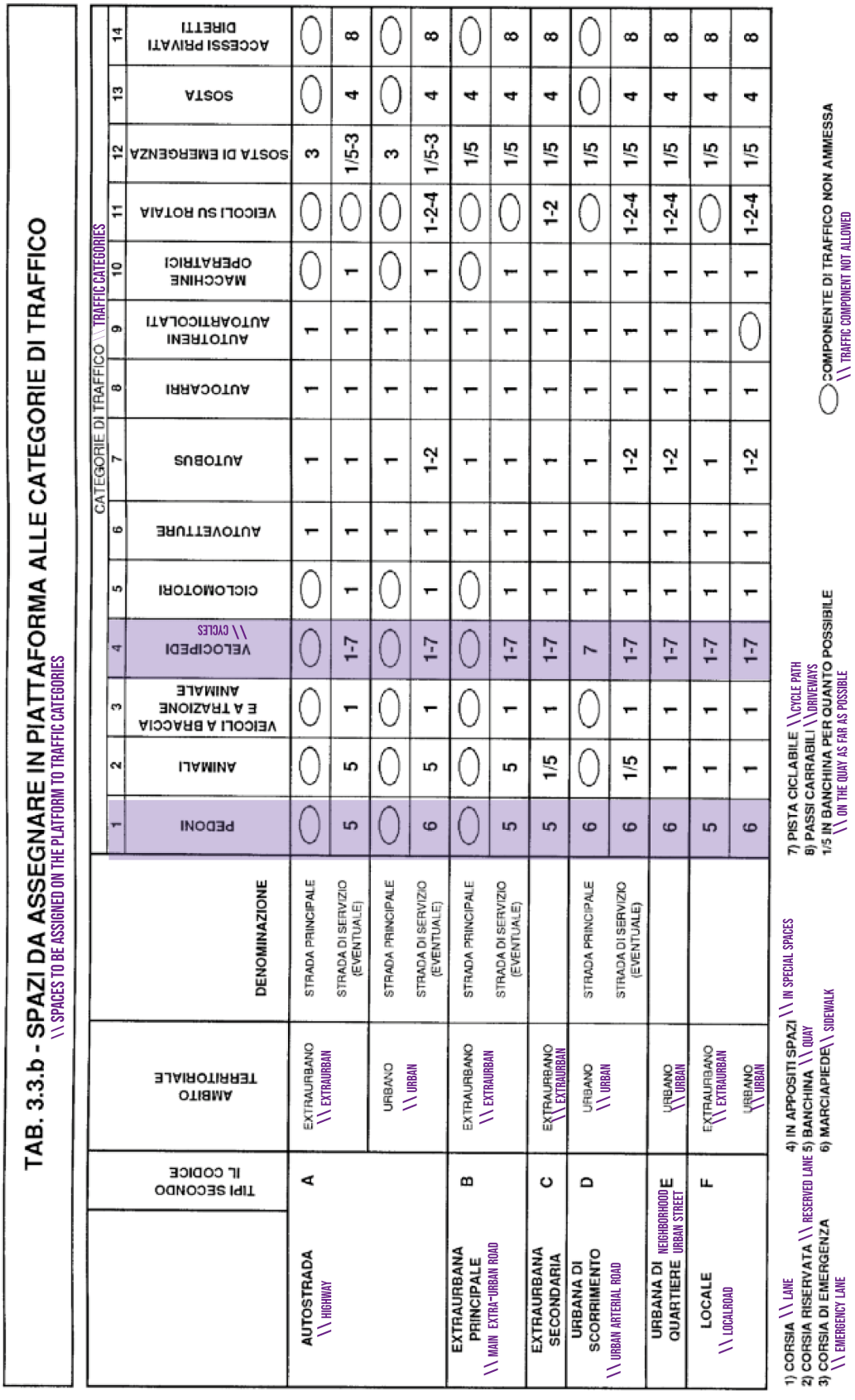
1990s is when Italy started legislating on cycling mobility. To have a clearer view of which have been important passages during these thirty years, a timeline collecting regulations starting from the first law – L n.208/91 - in 1991 has been created *(Figure 43* and *Figure 44).*

Law no. 208/1991 - *Interventi per la realizzazione di itinerari ciclabili e pedonali nelle aree urbane*[18] - instituted a fund of 50 billion Lire to finance the construction of cycle or pedestrian routes. The maximum amount of funding was 80% of the cost of the work and interventions aimed at decongesting the historic centers were favored. Already in 1991, the Italian parliament had in mind the problem of congestion in urban centers and cycling as a possible solution (Deromedis, 2019, p. 58).

The decree n. 467 of 1992 - *Regolamento concernente l'ammissione al contributo statale e la determinazione della relativa misura degli interventi per la realizzazione di itinerari ciclabili e pedonali nelle aree urbane, in attuazione all'art. 3, comma 2, della legge 28 giugno 1991, n. 208* - for admission to the state contribution of cycle routes, together with its explanatory circular no. 432/1993, introduce the first design criteria and standards for the construction of cycle paths in Italy. The standard costs of this document can be considered the only regulatory reference (Ibid.).

Law no. 366 of 1998 - *Norme per il finanziamento della mobilità ciclistica* – as it was previously already written, is the first law on bicycle mobility approved in Italy. It entrusts the regions with the task of drawing up regional plans for the distribution of funding for cycling and for the creation of integrated cycle path networks. Priority is given to connections with school buildings, with green areas, with areas intended for services, with social and health structures, with the public transportnetwork, with public offices and with leisure and tourist areas. The law establishes a fund for the financing of interventions in favor of cycling at the Ministry of Transport and Navigation.

[18] see *Figure 43* and *Figure 44* for the corresponding English translations of this and the following laws.



TAB. 3.3.b - SPAZI DA ASSEGNARE IN PIATTAFORMA ALLE CATEGORIE DI TRAFFICO
\\ SPACES TO BE ASSIGNED ON THE PLATFORM TO TRAFFIC CATEGORIES

TIPI SECONDO IL CODICE		AMBITO TERRITORIALE	DENOMINAZIONE	CATEGORIE DI TRAFFICO \\ TRAFFIC CATEGORIES													
				1 PEDONI	2 ANIMALI	3 VEICOLI A BRACCIA E A TRAZIONE ANIMALE	4 VELOCIPEDI \\ CYCLES	5 CICLOMOTORI	6 AUTOVETTURE	7 AUTOBUS	8 AUTOCARRI	9 AUTOTRENI AUTOARTICOLATI	10 MACCHINE OPERATRICI	11 VEICOLI SU ROTAIA	12 SOSTA DI EMERGENZA	13 SOSTA	14 ACCESSI PRIVATI DIRETTI
AUTOSTRADA \\ HIGHWAY	A	EXTRAURBANO \\ EXTRAURBAN	STRADA PRINCIPALE	◯	◯	◯	◯	◯	1	1	1	1	◯	◯	3	◯	◯
			STRADA DI SERVIZIO (EVENTUALE)	5	5	1	1-7	1	1	1	1	1	1	◯	1/5-3	4	8
		URBANO \\ URBAN	STRADA PRINCIPALE	◯	◯	◯	◯	◯	1	1	1	1	◯	◯	3	◯	◯
			STRADA DI SERVIZIO (EVENTUALE)	6	5	1	1-7	1	1	1-2	1	1	1	1-2-4	1/5-3	4	8
EXTRAURBANA PRINCIPALE \\ MAIN EXTRA-URBAN ROAD	B	EXTRAURBANO \\ EXTRAURBAN	STRADA PRINCIPALE	◯	◯	◯	◯	◯	1	1	1	1	◯	◯	1/5	4	◯
			STRADA DI SERVIZIO (EVENTUALE)	5	5	1	1-7	1	1	1	1	1	1	◯	1/5	4	8
EXTRAURBANA SECONDARIA	C	EXTRAURBANO \\ EXTRAURBAN		5	1/5	1	1-7	1	1	1	1	1	1	1-2	1/5	4	8
URBANA DI SCORRIMENTO \\ URBAN ARTERIAL ROAD	D	URBANO \\ URBAN	STRADA PRINCIPALE	6	◯	◯	7	1	1	1	1	1	1	◯	1/5	◯	◯
			STRADA DI SERVIZIO (EVENTUALE)	6	1/5	1	1-7	1	1	1-2	1	1	1	1-2-4	1/5	4	8
URBANA DI QUARTIERE NEIGHBORHOOD URBAN STREET	E	URBANO \\ URBAN		6	1	1	1-7	1	1	1-2	1	1	1	1-2-4	1/5	4	8
LOCALE \\ LOCALROAD	F	EXTRAURBANO \\ EXTRAURBAN		5	1	1	1-7	1	1	1	1	1	1	◯	1/5	4	8
		URBANO \\ URBAN		6	1	1	1-7	1	1	1-2	1	◯	1	1-2-4	1/5	4	8

1) CORSIA \\ LANE
2) CORSIA RISERVATA \\ RESERVED LANE
3) CORSIA DI EMERGENZA \\ EMERGENCY LANE
4) IN APPOSITI SPAZI \\ IN SPECIAL SPACES
5) BANCHINA \\ QUAY
6) MARCIAPIEDE \\ SIDEWALK
7) PISTA CICLABILE \\ CYCLE PATH
8) PASSI CARRABILI \\ DRIVEWAYS
1/5 IN BANCHINA PER QUANTO POSSIBILE \\ ON THE QUAY AS FAR AS POSSIBLE
◯ COMPONENTE DI TRAFFICO NON AMMESSA \\ TRAFFIC COMPONENT NOT ALLOWED

Figure 42. D.M. (M.D.) 5/11/2001 n. 6792 "Norme Funzionali e Geometriche per la Costruzione delle Strade". From Tabella 3.2.d pag. 12 [Source: Gazzetta Ufficiale D.M. 5/11/2001 n. 6792]

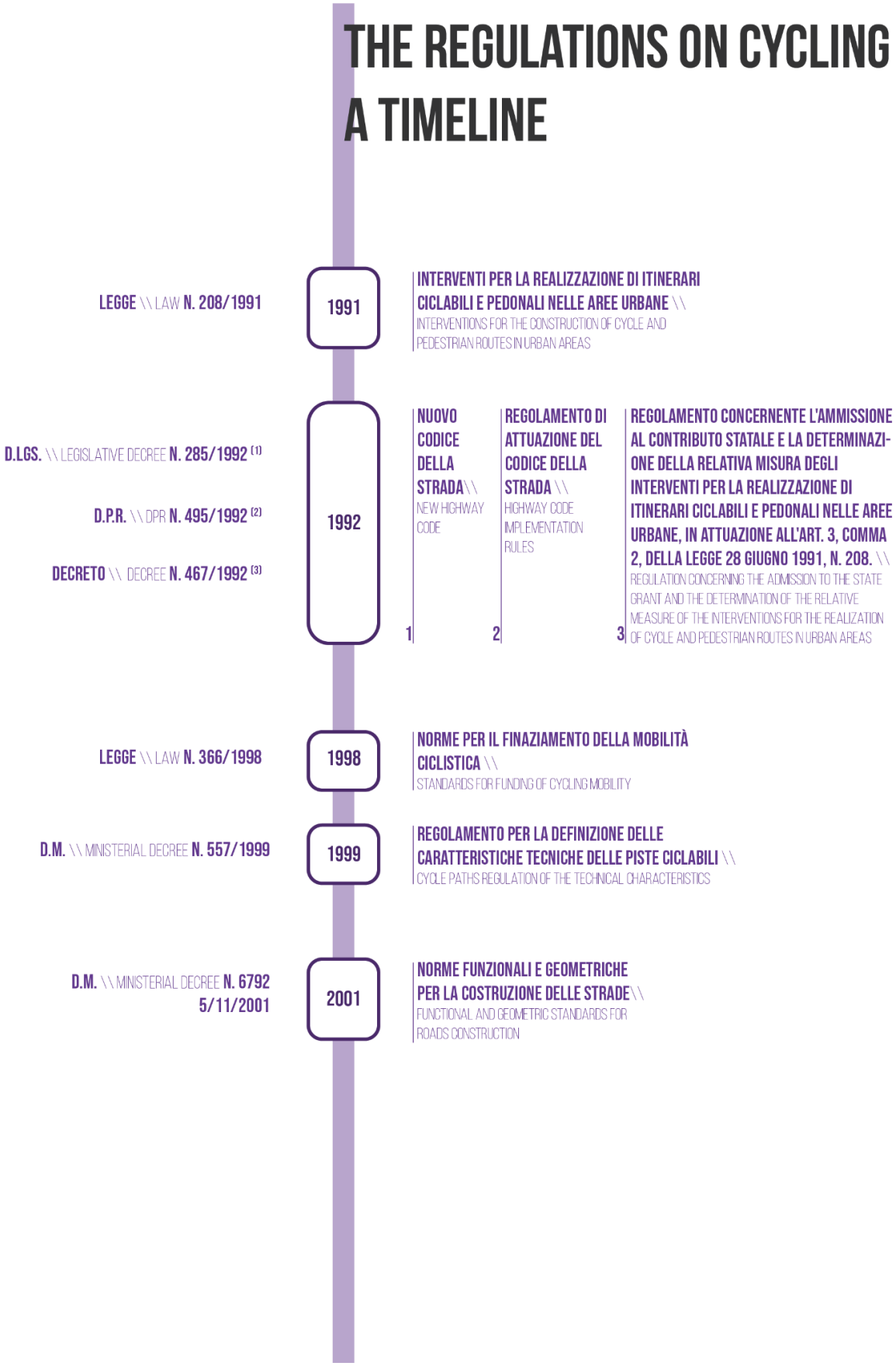


Figure 43. Timeline part 1 of Italian regulation on cycling [Source: Traore, 2021]

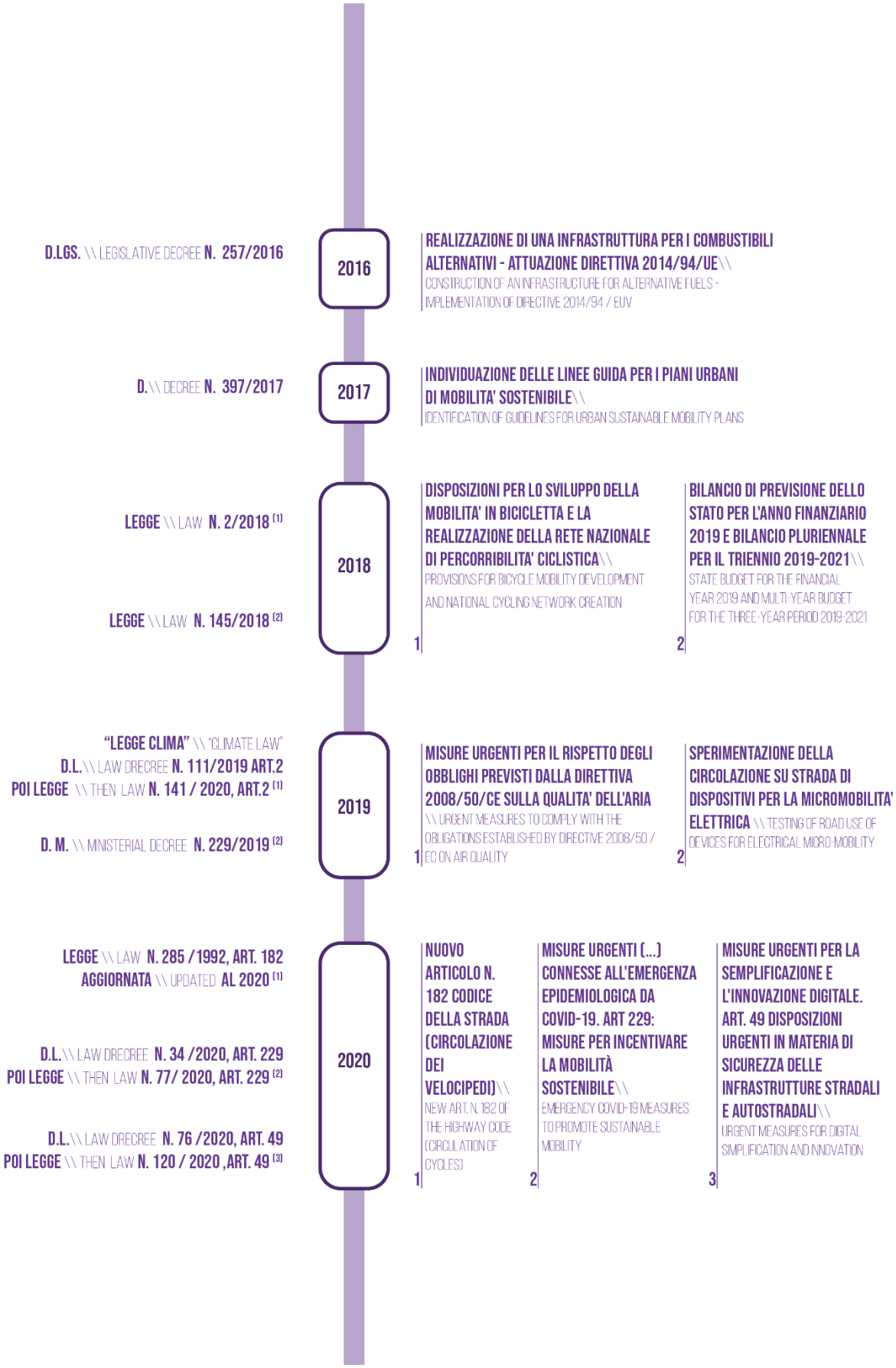


Figure 44. Timeline part 2 of Italian regulation on cycling [Source: Traore, 2021]

The articles n. 6 and n. 8, respectively concerne the type of interventions allowed and the possibility of using disused railway sediments, river banks to create cycle paths, are of relevant importance (Deromedis, 2019). Unless there are proven safety problems, newly built roads classified with the letters C, D, E and F must have an adjacent cycle path for the entire development (article 10). Finally, this law would have provided for the obligation to donate at least 20% of the administrative sanctions' revenues to carry out interventions in favor of cycling. Unfortunately, it was repealed two months after the approval of the law, however leaving the possibility of allocating a portion of the proceeds in an amount not less than 10% to road safety interventions in particular to protect pedestrians, cyclists, people with disabilities, the elderly .

The current Italian legislation on cycling refers to Law 2 approved on 11 January 2018 - *Disposizioni per lo sviluppo della mobilità in bicicletta e la realizzazione della rete nazionale di percorribilità ciclistica*. It promotes daily travel, tourist and recreational activities using the bicycle as a means of transport. In addition to improving urban mobility, its role is to protect the environment and people' health, to reduce land consumption (a negative effect of mobility), to enhance the territory and cultural heritage and to develop tourism. The will of Law 2/2018 is to make the development of cycling mobility and the necessary network infrastructures a fundamental component of mobility policies throughout the national territory, and to achieve a general and integrated system of sustainable mobility from the point of view economically, socially, environmentally and accessible to all citizens. It is clear that from a regulatory point of view Italy is in line with the main sustainability objectives in the field of mobility. The experience in the field, however, tells of a different reality made up of interventions that are still too slightly different from a car-centric mentality far from the idea of integration that L 2/2018 describes. There are case studies which are more virtuous than others, such as that of the Autonomous Province of Trento taken as an example by the engineer Sergio Deromedis, author of "The manual of cycle paths and cycling[19]" in which engineering logics follow the intuitions of those who, like him, really use the bicycle as a means of transport. An example of this is the criticism of the bollards on the roadway, with the function of dissuading access to cycle paths from motor vehicles, but whose

[19] Original title: *Il manuale delle piste ciclabili e della ciclabilità*

presence is not required by the regulations and it is also dangerous for users. This practice is used by many Italian municipalities, often at the edge of bridges or underpasses, nonetheless this solution does not exist in countries with a more mature cycling culture. The use of carriageway narrowings is not recommended, therefore Deromedis proposes a solution used in the cycle and pedestrian network of the Autonomous Province of Trento: a high, removable, colored steel pole with a soft coating so as to be clearly visible and less hard in the event of an accidental collision.

Law no. 2/2018 is remarkable due to the introduction of relevant plans for the promotion of cycling mobility (Deromedis, 2019, p. 60). *Table 7* reassumes which are the tools this law sets up.

Art.	Plan	Description
n.3	*Piano generale della mobilità ciclistica* (General plan of cycling)	It constitutes an integral part of the General Transport and Logistics Plan and is adopted in accordance with it, and is valid for a period of three years. However, the Plan can be updated annually also in order to take into account any additional resources that may be made available. It is articulated with reference to two specific sectors of intervention: at urban and metropolitan level (1) and at regional, national and European level (2). It contains: - annual objectives for the development of cycling and the identification of the cycle paths of national interest that make up the «Bicitalia[20]» national cycle network. The national network must have a development of not less than 20000 km and it is integrated into the EuroVelo European cycle network system; - the definition of the framework of public and private financial resources to be distributed for the financing of the interventions of the General Plan as well as those indicated in the cycling mobility plans of the regions, municipalities, metropolitan cities and provinces;
	Continue on next page...	

[20] It has been planned by FIAB along eighteen cycle routes. It will connect all Italian regions and each route will be 500 to 1000km long on average. The Italian cycling network can be recognized by the initials "BI 1,2, 3...,18" and its main goal is free-time cycle tourism. Although it has already been drawn it has not yet been realized (Deromedis, 2019).

Art.	Plan	Description
		- the guidelines aimed at ensuring effective coordination of administrative action at the various levels; - promotion of the participation of users in the planning, implementation and management of the cycling network.
n.5	*Piani regionali della mobilità ciclistica* (Regional plans for cycling)	Its main purpose is the promotion of cycling with various actions in the regional territory. It is approved every three years, in line with the Regional transport and logistics plan and with the National plan for cycling and it is drawn up on the basis of urban sustainable mobility plans and related programs and projects presented by municipalities and metropolitan cities. It identifies the cycle routes that fall within the regional territory including those of «Bicitalia», making any proposals for integration or modification. It defines the itineraries of areas of naturalistic interest included in the regional territory, in rural areas, lakes / streams and natural reserves aimed at their knowledge and use also of the surrounding areas. It has the task of creating the system of parking areas. It educates and trains through the promotion, also via communication actions, of bicycle travel and integrated transport between bicycles and public transport.

Table 8. Plans and tools introduced by law no. 2 of 11 January 2018 [Source: Traore, 2021 from Deromedis, 2019 and L 2/2018]

Continue on next page…

Art.	Plan	Description
n.6	*Piani urbani della mobilità ciclistica* o *Biciplan* (Urban cycling mobility plans \CyclePlan)	They are sector plans of SUMPs, Sustainable Urban Mobility Plans - D.Lgs. No. 257/2016 - (*Piani urbani della mobilità sostenibile,PUMS*). They define the objectives, strategies and actions, to be achieved in the territory of the municipality, necessary to promote and intensify the use of bicycles as a means of transport, also with promotion and education activities. They define: - the network of priority cycle routes or cycleways in the municipal area for crossing and connecting the city along the main traffic routes; - the secondary network of cycle paths within neighborhoods and inhabited centers; - the network of green cycling routes; - the connection between cycle networks and priority cycle areas, environmental islands, roads 30 km/h, pedestrian areas, residential areas and restricted traffic areas; - interventions on the main nodes of interference with motor vehicle traffic, on the points of the road network most dangerous for pedestrians and cyclists and on the crossing points of railway or motorway infrastructures with the aim of improving the safety of cyclists; - actions to combat the theft of bicycles also with possible extensions of parking spaces (for example measures in the municipal building regulations to favor their storage); - the types of transport services for goods or people with cycles;

Table 7. Plans and tools introduced by law no. 2 of 11 January 2018 [Source: Traore, 2021 from Deromedis, 2019 and L 2/2018]

FinaIncial resources, completed interventions, state of implementation of the plan <<Bicitalia>> and other results related to air pollution, increase in modal share of cycling mobility and lower road accidents with cyclists and pedestrians involved are

collected in the Annual Report on Cycling (*Relazione annuale sulla mobilità ciclistica*) (Deromedis, 2019).

For what concerns the definition of the technical and construction standards of cycle infrastructures the Ministerial Decree no. 557/1999 is the fundamental regulatory text for their design, "Regulation containing standards for the definition of the technical characteristics of cycle paths" (*Regolamento recante norme per la definizione delle caratteristiche tecniche delle piste ciclabili*), hence it is the cycling sector standard as required by Article 7 of Law 366/1998.

Among the cycling planning tools provided by the M.D no. 557/1999, the Plan of the network of cycle routes (*piano della rete degli itinerari ciclabili*) is introduced, in which the interventions to be carried out are foreseen, including data on cycling flows, the length of the paths, the economic estimate of expenditure and a justified scale of priorities and implementation times (technical-economic feasibility).

3.2. Typologies of cycle ways

The first series of articles (1-5) of the M.D no. 557/1999 defines the guidelines for the design of itineraries with the aim of favoring and promoting a high degree of cycling and pedestrian mobility as an alternative to the use of motor vehicles aiming at attractiveness, continuity and the recognition of the cycle route, favoring the shortest, most direct and safest routes. It classifies cycle routes in four typologies based on the organization of road space:

1. Cycle paths (*piste ciclabili in sede propria)*
2. Separated in-roadway bikeways (*piste ciclabili su corsia riservata*)
3. Shared-use paths (*percorsi promiscui pedonali e ciclabli*)
4. Shared in-roadway bikeways (*percorsi promiscui ciclabili e veicolari*)

Four summary sheets, stated in the three schemes below of *Figure 47, Figure 48, Figure 49*, were created with examples and schemes to give a clearer idea of the various types of cycle infrastructures envisaged by the decree.

3.2.1. Cycle paths *(piste ciclabili in sede propria)*

It is characterized by having a space physically separated from that of motor vehicles and pedestrians, by means of suitable longitudinal physically impassable traffic dividers (Ministerial Decree 557/99, art. 6, paragraph 2). It can be one-way or two-

way. This solution is optimal in highly urbanized areas with high pedestrian flows as it guarantees greater safety and smoothness (Deromedis, 2019).

3.2.2. Separated in-roadway bikeways *(piste ciclabili su corsia riservata)*

It is obtained from the roadway and it follows the direction of the contiguous lane for motor vehicles. A longitudinal delimitation strip and lane delimiters represent the separation element of the path. The cycle lane is usually located to the right of the vehicular lane (Ministerial Decree 557/99 art.6, paragraph 2b). There are two strips which identify the cycle lane: both continuous, side by side, and 12 cm apart; one line is 12 cm wide and white, the other one is 30cm wide, yellow and it is placed on the side of the rider. This is a case of integration type of intervention between motorized vehicles and cycles in which bicycles and motor vehicles have well-defined spaces in conditions of acceptable safety, but without any physical separation. To achieve this cohabitation roads must have speeds below 50-70 km/h. This solution is applied when road space is insufficient or the numbers of cycling demand are such as not to justify separate paths and traffic moderation interventions are not sufficient to guarantee safety (Deromedis, 2019).

3.2.3. Shared-use paths *(percorsi promiscui pedonali e ciclabli)*

It is a one or two-way cycle path, obtained from a part of the sidewalk when the space is wide enough and it does not limit pedestrians circulation. It is located on the external side adjacent to the roadway (Ministerial Decree 557/99, art. paragraph 2c). It can be defined as a "separated-from-pedestrians shared path" when a simple line divides in two the sidewalk leaving the users in two specific spaces, otherwise it is a "mixed cicle-pedestrian path" where bikes and pedestrians share the same area without any type of separation. This solution has many disadvantages due to conflicts between bicycles and pedestrians and the possibility of the velocipede falling off the sidewalk which might lead to a dangerous invasion of the carrageway used by motor vehicles.

Therefore, this shared-use path solution should be avoided in highly urbanized areas with high pedestrian flows; in fact, in built-up areas it is important to separate bicycles from pedestrians. Furthermore, article 4, paragraphs 5a and 5b DM No. 557/99 indicates how a shared-use path:

a) Should have increased width compared to the minimums set for cycle paths which article 7 describes. The widths should be 1.50m, which can be reduced to

1.25m and exceptionally can reach 1.00m (only for short stretches of the route and suitably indicating the lower width);

b) Should be built only along lowpedestrian traffic flows sidewalks and thus it cannot be realised in the presence of activities which increase them. Commercial routes, high density population neighbourhoods are example of urban space where a division is needed to avoid accidents between the two user categories.

Italian administrations relatively respect these conditions and evidence can confirm that.

3.2.4. Shared in-roadway bikeways *(percorsi promiscui ciclabili e veicolari)*

On highways (type A), main extra-urban roads (type B) and urban arterial roads (type D) – see *Figure 42* - cycling is prohibited, according to the article No. 175 of D.Lgs. 30th April no. 285/92 "New Highway Code".

Road safety is governed by two parameters, traffic load and speed. Street promiscuity between pedestrian or cycling users and motorized vehicles is possible with speed differences of less than 30 km/h (Deromedis, 2019). In fact, consequences of an accident with a heavy vehicle are a function of its speed and therefore at a higher speed (40-50-70km/h or more) death probability increases dramatically. Suitable roads for cycling are traffic with speeds equal to or less than 50km/h, "Zone 30" or roads subject to a speed limit of 30km/h, roads without traffic or close to zero, and street regulated by interventions such as LTZ (Limited Traffic Zones). These are acceptable situations that allows velocipedes and motor vehicles to share the same road space.

3.2.5. Cycle highways

Cycle highways, also known as "fast cycle routes", are an emerging concept in urban planning that describes long-distance, high-quality bicycle routes built for commuter use. Cycle highways can be considered as the infrastructure providing the fastest, most direct, and most efficient route between two places over relatively longer commuting distances, directly connecting suburbs or decentred neighbourhoods to urban centres (Liu, te Brömmelstroet, Krishnamurthy, & van Wesemael, 2019). A cycle highway is a mobility product that provides a high-quality functional cycling connection. As backbone of a cycle network, it connects cities, which are the major workplaces, with suburbs, mostly residential areas or with other urban areas. They

can serve bicycle journeys on longer distances, 5-30 km (Interreg CHIPS project, 2020). The cycle highway will have a clear start and end, but few cyclists will use it from start to end since several destinations will be connected by this "backbone" network. Hence, connections with cycle network around the cycle highway are as important as the cycle highway itself (Ibid.). Since cycle highway has basically the same function that a traditional highway has for car, quality of construction plays a key role to encourage cyclists of all fits and experience. But the design of cycle highways cannot be wholly copied from automobile infrastructure (Liu, te Brömmelstroet, Krishnamurthy, & van Wesemael, 2019).

In combination with the growing number of e-bikes, at EU level Italy included *(Figure 45)*, they can bring a city's cycling policy to a new level and incentive a wider set of the population to change their commuting habits (Interreg CHIPS project, 2020).

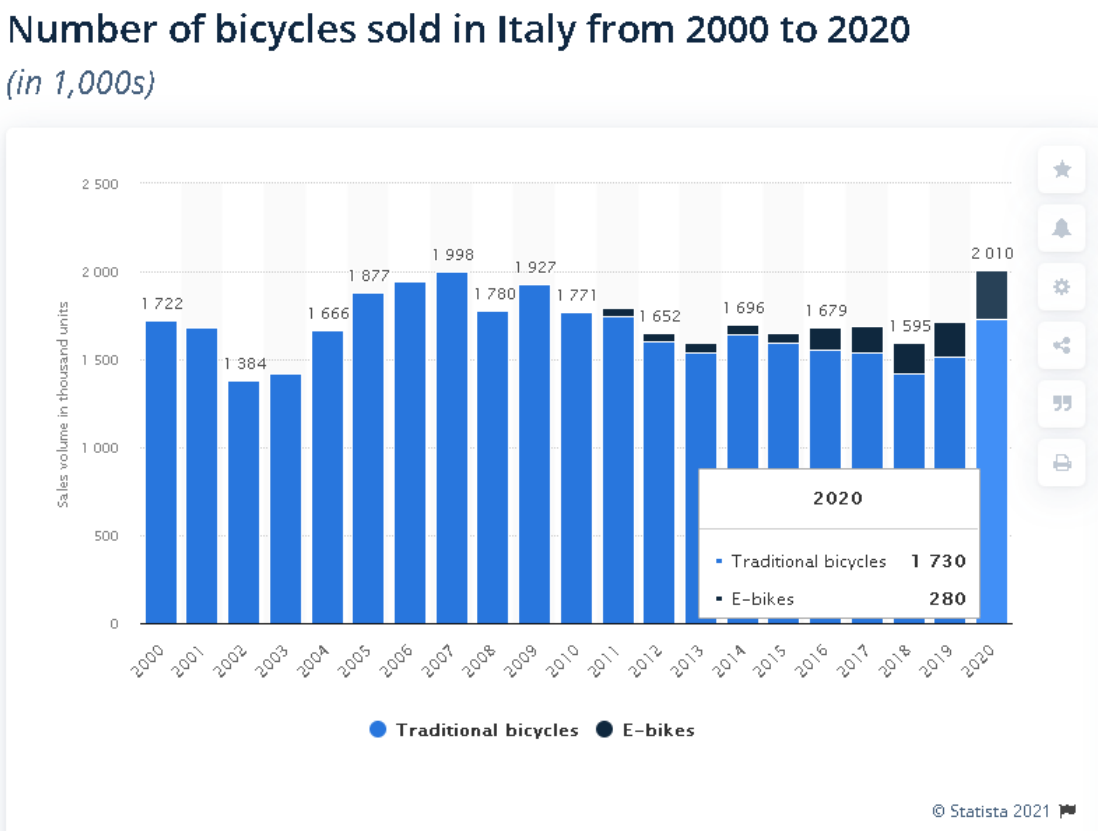


Figure 45. Bicycle (traditional and e-bikes) sales volume in Italy 2000-2020. E-bikes market is constantly growing [source: Statista, 2021]

Indeed, electrically power Assisted cycles create a possibility to cycle faster and on longer distances. They also make cycling a viable option for new groups of users such as those less fit (Ibid.), but also medium-distance commuters or the elderly (ECF, 2020). In 2020, Florence announced the construction of the first Italian

cyclehighway connecting Florence to Prato (Di Stefano, Bonus mobilità: cosa si sa finora dell'incentivo da 500 euro?, 2020a) (*Figure 46*). It will received funds from Regione Toscana and 20% from Municipality of Florence. Tiziano Carducci, vice-president of FIAB, declared the work took inspration from cyclehighways of North

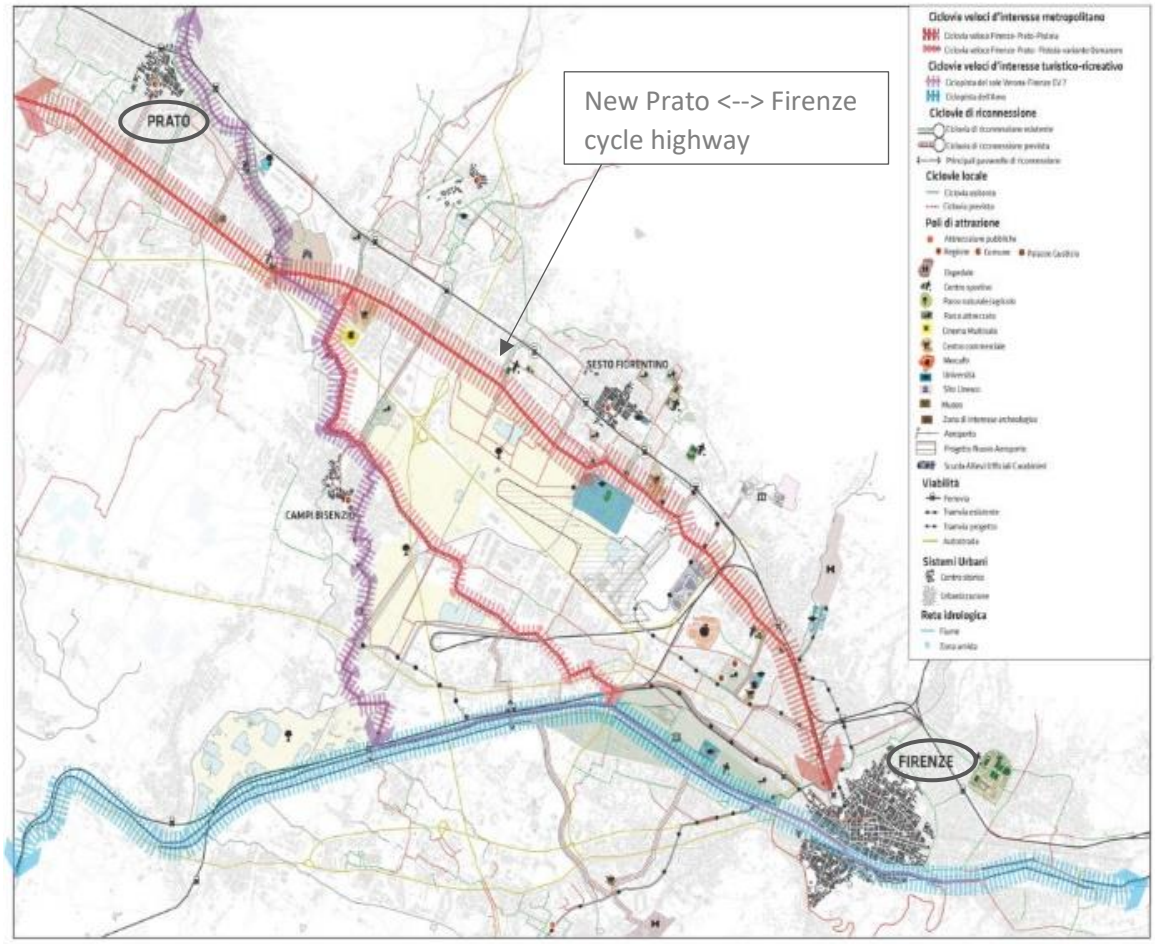


Figure 46. First Italian cycle highway will be 38km long and it will connect Florence to Prato. [source: arch. Nadia Bellomo]

ITALIAN REGULATION ON CYCLE ROUTES

CLASSIFICAZIONE DEGLI ITINERARI CICLABILI | ART. 4 D.M. 557/1999

CLASSIFICATION OF CYCLE ROUTES | MINISTERIAL DECREE 557/1999

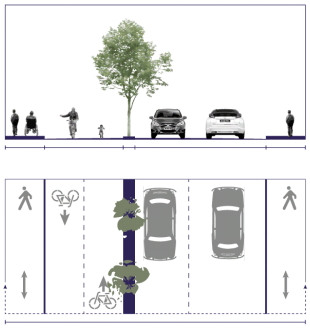
**piste ciclabili in sede propria **
cycle path

**Segnaletica stradale **
Road sign
(D.P.R. 495/1992)

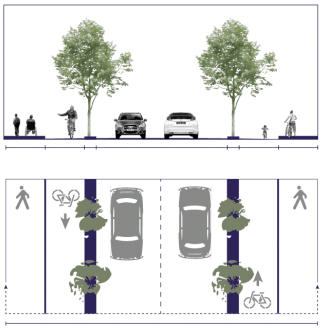
**Inizio della pista ciclabile **
beginning of the bike path
|fig. II 90 art.122 DPR 495/92|

**Fine della pista ciclabile **
end of the bike path
|fig. II 91 art.122 DPR 495/92|

**Schemi strada **
Road schemes
types



**Pista bi-direzionale **
bi-directional separated bike lane



**Pista mono direzionale ** one-way
separated bike lane

**Esempi reali **
application
examples

Firenze, Via di Novoli (2021)

Firenze, Via di Novoli (2021)

Firenze, Via del Gignoro (2021)

Firenze, Viale Ferruccio Valcareggi
Stadio A. Franchi (2021)

Figure 47. Classification of cycle routes following DM No. 557/99. "Cycle paths" [source: author]

ITALIAN REGULATION ON CYCLE ROUTES

CLASSIFICAZIONE DEGLI ITINERARI CICLABILI | ART. 4 D.M. 557/1999

CLASSIFICATION OF CYCLE ROUTES | MINISTERIAL DECREE 557/1999

percorsi promiscui pedonali e ciclabili \\ shared use path

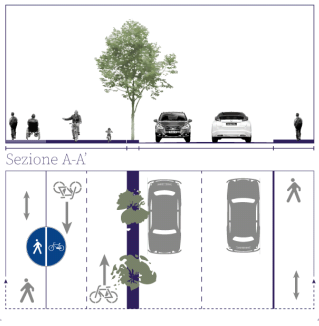
Separati Separeted cycle-pedestrian paths

Segnaletica stradale
Road sign
(D.P.R. 495/1992)

Inizio della pista ciclabile e pedonale \\ beginning of the bike and pedestrian path
|fig. II 92/a art.122 DPR 495/92|

Fine della pista ciclabile e pedonale \\ end of the bike and pedestrian path
|fig. II 93/a art.122 DPR 495/92|

Schemi strada
Road schemes types



Esempi reali
application examples

Firenze, Piazza Libertà (2021)

Firenze, Viale Michelangiolo (2021)

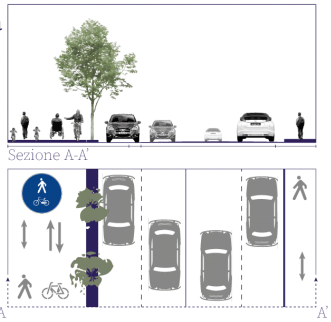
Promiscui Mixed cycle-pedestrian paths

Segnaletica stradale
Road sign
(D.P.R. 495/1992)

Inizio della pista ciclabile e pedonale \\ beginning of the bike and pedestrian path
|fig. II 92/a art.122 DPR 495/92|

Fine della pista ciclabile e pedonale \\ end of the bike and pedestrian path
|fig. II 93/a art.122 DPR 495/92|

Schemi strada
Road schemes types



Esempi reali
application examples

Firenze, Viale Forlanini (2021)

Firenze, Ponte M. Hack (2021)

Figure 48. Classification of cycle routes by DM No. 557/99. "Shared use path typologies"

Figure 49. Classification of cycle routes by DM No. 557/99. Separated in-roadway cycle path and shared in-roadway bikeway. [source: author]

3.3. Road signs

The issue of road signs is a complex procedure. The application of road signs to cycle paths is further complicated as the Italian Highway Code is mainly aimed at mobility for motor vehicles (Deromedis, 2019).

Road signs increase the safety and usability of cycle routes, as they provide users with rules on behaviour, direction, and other useful information. For these reasons, the incorrect and inadequate application of road signs can have negative consequences in terms of safety and responsibility. To obtain successful cycling infrastructures, it is important that projects include road signs documents (Deromedis, 2019).

Road signs can be vertical and therefore positioned on the vertical plane or horizontal if they are arranged in the street level by means of colours. Since cycle paths or pedestrian paths are roads it is necessary to use the signs required by the Highway Code and D.P.R. n. 495/92. Three categories of signs are useful for cycling, two of which are provided for by the Highway Code while the latter is of local administration decision. *Table 8* summarises the main vertical cycling related road signs in use in Italy according to Highway Code. For each sign it has been assigned its respective category (warning, regulatory or indication), its related code inside DPR 495/92 and a concise description of the drawing.

Table 8. Main signs of the Highway Code useful for cycling. [source: (Deromedis, 2019, pp. 176-179)and author] Continue on next page...

Sign	Category	Code	Description
	Beginning of the cycle path REGULATORY – MANDATORY INSTRUCTION	Fig. II 90 art.122 DPR 495/92	beginning or continuation of cycle path Access is allowed to cycle only.
	End of the cycle path REGULATORY – MANDATORY INSTRUCTION	Fig. II 91 art.122 DPR 495/92	end of a cycle reserved path
	Beginning of shared-use path REGULATORY – MANDATORY INSTRUCTION	Fig. II 92/a art.122 DPR 495/92	regulatory sign giving mandatory instructions allows cycles and pedestrians only on the shared path
	No bicycles REGULATORY – PROHIBITION	Fig. II 55 art. 117 DPR 495/92	regulatory sign prohibiting transit to bicycles and it applies to all vehicles like bicycles
	Pedestrian zone REGULATORY – MANDATORY INSTRUCTION	Fig. II 320 e fig. II 320/P art.122 DPR 495/92	beginning or continuation of a road reserved for pedestrians, cycles, and other types of authorized vehicles, such as emergency or maintenance vehicles.

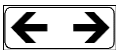
Sign	Category	Code	Description
	End shared-use path REGULATORY – MANDATORY INSTRUCTION	Fig. II 93/a art.122 DPR 495/92	end of bike and pedestrian path
	Segregated pedestrian and cycle path REGULATORY – MANDATORY INSTRUCTION	Fig. II art.122 DPR 495/92	beginning or continuation of segregated bike and pedestrian path
	End of segregated pedestrian and cycle path REGULATORY – MANDATORY INSTRUCTION	Fig. II art. 122 DPR 495/92	end of segregated bike and pedestrian path
	Pedestrian crossing ahead WARNING	Fig. II 13 art. 88 DPR 495/92	Warning sign pedestrian crossing ahead
	Cycle crossing ahead WARNING	Fig. II 14 art. 88 DPR 495/92	Warning sign bicycle crossing ahead
	Pedestrian crossing INDICATION SIGN	Fig. II 303 art. 135 DPR 495/92	Pedestrian crossing far from intersections and not regulated by traffic light
	Bicycle crossing INDICATION SIGN	Fig. II 324 art. 135 DPR 495/92	Bicycle path crossing of the carriageway characterized by dedicated horizontal sign
	Bend, to right WARNING	Fig. II 4 art. 86 DPR 495/92	Dangerous bend to right characterized by bad visibility
	Bend, to left WARNING	Fig. II 5 art. 86 DPR 495/92	Dangerous bend to left characterized by bad visibility
	Double bend, first to left WARNING	Fig. II 6 art. 86 DPR 495/92	A series of bend the first of them is to left
	Double bend, first to right WARNING	Fig. II 7 art. 86 DPR 495/92	A series of bend the first of them is to right
	Other danger WARNING	Fig. II 35 art. 103 DPR 495/92	Generic danger sign used with additional panel for further information
	Continuation ADDITIONAL PANELS	Mod II 5/a2 continua art. 83 DPR 495/92	Continual of a danger or a prescription (vertical)
	Continuation ADDITIONAL PANELS	Mod. II 5/b2 art. 83 DPR 495/92	Continual of a danger or a prescription (horizontal)

Table 8. Main signs of the Highway Code useful for cycling. [source: (Deromedis, 2019, pp. 176-179)and author]

Warning and regulatory signs (priority and prohibition signs, mandatory instructions) preserve the safety of users and are therefore the most important classes.

The indication signs provide necessary information for users to find the cycle or pedestrian path. The third type of signage, that of information or wayfinding, is not provided by the Highway Code but is useful for providing additional material not included in the others. This typology of road signs is indeed decided by the local administrations and thus they are not nationally coordinated which could represent a great advantage in terms of cycle tourism.

Warning signs are of triangular shape, white background, and red stroke. Regulatory signs differ in shape due to multiple categories:

- priority (*precedenza*)
- prohibition sign (*divieto*), round shape, tick red stroke
- mandatory instructions (*obbligo*), round shape, blue background, and white drawing.

It is necessary to define dedicated road signs to be used on urban and extra-urban cycle paths since they are currently not provided for by the Highway Code. Their dimensions should be reviewed and so reduced compared to vehicular ones. Furthermore, times distance and distances are useful information to communicate to the cyclist (Deromedis, 2019).

Horizontal road signs are guided by art. No.40 of the Highway Code and chapter 4 of Presidential Decree No. 495/1992. Colours allowed are white, yellow, blue, yellow/black and colours of the vertical signs. Road signs for cycle routes are:

- continuous or discontinuous longitudinal strips. The firsts are required to demarcate the edge of the carriageway, it is generally white, but it might be also yellow to emphasize the cycle in-roadway path. The latter is used, for example, to realize cycle lane since according to the Highway Code discontinuous strips can be overpass by vehicles.
- Cycle crossing, according to article No. 146 of DPR 495/92, which gives priority to cyclists over motorised vehicles, is realized by two parallel discontinuous white strips. Segments composing the strip, which is one meter apart from the other, are 50 cm long. They must be realised to give continuity to an existing cycle path.
- Figure II 442/b art. 148 DPR 495/92 (see *Figure 48* – "shared in-roadway bikeway") is the official bicycle symbol used for cycle path painted on the street pavement

but representing also the standard symbol used for vertical cycling related road signs. Its value is particularly relevant in shared in-roadway bikeway (*Strada condivisa*) to remind drivers that people riding a bicycle might occupy the whole carriageway if necessary. Furthermore, it is essential in shared-use paths, combined with continuous strips since it indicates which part of the sidewalk is dedicated to cyclists.

Vertical and horizontal road sign are complementary especially in cycling sector. Indeed, while horizontal signs might be seen generally better by cyclists (Deromedis, 2019), vertical ones are those most visible for drivers. Hence, it is crucial that cycle infrastructures are built with both road sign typologies to guarantee a good level of safety to all road users.

4. GeoDB for cycle paths' management

4.1. The importance of mapping

The process of creating and implementing cycling infrastructures emerges from the idea, the will and then the act of a political subject to achieve a certain goal. When the political phase ends, the technical phase begins to achieve the objective (Deromedis, 2019, p. 165). Graphic material is essential technical documentation to further understand a plan; it is, in fact, through this that location and types of infrastructure are represented (Ivi, p. 93). The evaluation of a cycle route must be based on the type of user of the path under study. Indeed, users' needs, such as daily or free time trips, must be understood to create an effective itinerary. For example, itineraries intended for daily travel must allow users to reach a specific place - workplace, schools, shops - in the most direct way possible as the road represents a means to reach the destination. Hence, directness is the quality indicator to be privileged in urban context. On the other hand, leisure paths must be able to create a situation that confers a high level of landscape quality of the itineraries, as the road itself is the destination. This type of itinerary must be attractive and could be done in quiet areas due to the secondary importance attributed to directness. Attractiveness is, thus, the quality indicator to be privileged in extra-urban context. Both urban and extra-urban cycling network should have good quality road surface, which should be smooth without bumps or holes to make the ride comfortable. Enough punctual infrastructures should be guaranteed such as decent cycle parking facilities and service hubs in strategic places as train stations. No access to decent cycling parking facility does not encourage multimodal trips (Interreg CHIPS project, 2020).

It has been written how cycle-pedestrian shared-use path should not be built in areas with high pedestrian flows, hence segregated cycle-only paths are the optimal solution in urban context. The reason supports the principle of directness which should be applied in built-up environments to encourage daily trips. It follows, therefore, the need to know the type of cycle paths that extend along the case study. Safety, in addition, is an essential element all types of routes should satisfy. Research shows that for people to embrace cycling, they need to feel safe, welcomed and considered in the street (Marie, 2020). This aspect is particularly relevant when

referring to people with disabilities. Indeed, a large part of this population category does not get to enjoy the benefits of cycling because of non-inclusive cycling infrastructures (Wheels for Wellbeing, 2019).

Most of bicycle accidents with vehicles happen in road intersections (Agerholm, Caspersen, & Lahrmann, 2008) underling the great consideration that part of the road needs. All dangerous intersection for cyclist and pedestrian must be categorised and implemented in safety.

Cycling infrastructures should be properly maintained to prevent directness or safety problems and even difficulty in wayfinding. For instance, decent minimum standards of road surface maintenance must be ensured allowing practicability of cycle route. Moreover, vertical, and horizontal roads signs are fundamental and should be well maintained apart from being fully visible by all types of road users.

Greater speed levels, it is nothing new, exclude certain user categories from the street (Deromedis, 2019) leaving it as a mere physical space for transportation (Nello-Deakin, 2019). Such aspect must be taken always into account as it contributes to encourage more extensive use of traffic calming solutions.

Collecting all this information in a Geodatabase supports a further knowledge and wider view about the case study and the environment in which the cycle infrastructure is or might be realised. This is an essential process to evaluating both ex ante and ex post (Deromedis, 2019) environment in which the cycling facility is or is planned to be built. When mapping is done during planning or design phase it aims at identifying the qualitatively best route before starting to build (Ivi, p. 94). Alternatively, it can be used to monitor results of the intervention during implementation phase through strategic indicators (Ivi, p. 152).

D.Lgs. No 257/2016 art. 3, paragraph 7 introduces the SUMP (*PUMS*) initials of Sustainable Urban Mobility Plan. It is the most suitable planning tool to define cycling mobility strategy of a municipality. Each municipality and metropolitan city must draft one and guidelines were published in DM No. 397/17[21] to promote homogenous and coordinated application of EU instructions for the preparation of the plan. SUMP documentation includes the cartography collecting the state of the art of urban and extra-urban cycle infrastructures and additional information and those still-to-be-realised. Monitoring and implementation are integrated phases of

[21] "Individuazione delle linee guida per i piani urbani di mobilità sostenibile, ai sensi dell'articolo 3, comma 7, del decreto legislativo 16 dicembre 2016, n. 257"

SUMP process scheme (Fig. 4.14 in Deromedis, 2019, p. 152).This creates the need for constant updated data to learn from what has been done and evaluate the impact of the policies.

"Biciplan" according to Law No. 2/2018, art.6 (*Table 7*) is its cycling mobility sectoral plan. It defines the objectives, strategies, and actions, to be achieved by the municipality and short-term interventions (2-5 years), to promote and intensify the use of the bicycles as a means of transport, also through promotion and education activities. It must include all the contents of the bigger scale plans but with a higher degree of details.

Hence, mapping is not only important for a wider knowledge of an area but a necessity of the Laws and Decrees ruling over cycling mobility.

4.2. BDTRE Regione Piemonte

D.Lgs. January 27th, No. 32/2010[22] for "Implementation of Directive 2007/2 / EC, establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)" – was published by Italy aimed at the creation of a national infrastructure for spatial information and environmental monitoring allowing the Country to participate at INSPIRE. Services are available to the public free of charge, but the State may limit (art. 13) public access to spatial data sets and services for many reasons such as public security or national defence. Article No. 3 of Directive 2007/2/EC establishes a set of definitions that should be applied while Article No. 11 sets the rules for network services.

Article 3

> 1. "infrastructure for spatial information" means metadata, spatial data sets and spatial data services; network services and technologies; agreements on sharing, access, and use; and coordination and monitoring mechanisms, processes and procedures, established, operated or made available in accordance with this Directive;
>
> 2. "spatial data" means any data with a direct or indirect reference to a specific location or geographical area;

[22] "Attuazione della direttiva 2007/2/CE, che istituisce un'infrastruttura per l'informazione territoriale nella Comunità Europea (INSPIRE)"

3. "spatial data set" means an identifiable collection of spatial data;

4. "spatial data services" means the operations which may be performed, by invoking a computer application, on the spatial data contained in spatial data sets or on the related metadata;

5. "spatial object" means an abstract representation of a real-world phenomenon related to a specific location or geographical area;

6. "metadata" means information describing spatial data sets and spatial data services and making it possible to discover, inventory and use them;

7. "interoperability" means the possibility for spatial data sets to be combined, and for services to interact, without repetitive manual intervention, in such a way that the result is coherent, and the added value of the data sets and services is enhanced;

8. "Inspire geo-portal" means an Internet site, or equivalent, providing access to the services referred to in Article 11(1);

9. "public authority" means:

(a) any government or other public administration, including public advisory bodies, at national, regional or local level;

(b) any natural or legal person performing public administrative functions under national law, including specific duties, activities, or services in relation to the environment; and

(c) any natural or legal person having public responsibilities or functions or providing public services relating to the environment under the control of a body or person falling within (a) or (b).

Member States may provide that when bodies or institutions are acting in a judicial or legislative capacity, they are not to be regarded as a public authority for the purposes of this Directive;

10. "third party" means any natural or legal person other than a public authority

Article 11

1. Member States shall establish and operate a network of the following services for the spatial data sets and services for which metadata have been created in accordance with this [2007/2/EC] Directive:

(a) discovery services making it possible to search for spatial data sets and services on the basis of the content of the corresponding metadata and to display the content of the metadata;

(b) view services making it possible, as a minimum, to display, navigate, zoom in/out, pan, or overlay viewable spatial data sets and to display legend information and any relevant content of metadata;
(c) download services, enabling copies of spatial data sets, or parts of such sets, to be downloaded and, where practicable, accessed directly;
(d) transformation services, enabling spatial data sets to be transformed with a view to achieving interoperability;
(e) services allowing spatial data services to be invoked.
Those services shall take into account relevant user requirements and shall be easy to use, available to the public and accessible via the Internet or any other appropriate means of telecommunication.

2. For the purposes of the services referred to in point (a) of paragraph 1, as a minimum the following combination of search criteria shall be implemented:

(a) keywords;
(b) classification of spatial data and services;
(c) the quality and validity of spatial data sets;
(d) degree of conformity with the implementing rules provided for in Article 7(1);
(e) geographical location;
(f) conditions applying to the access to and use of spatial data sets and services;
(g) the public authorities responsible for the establishment, management, maintenance and distribution of spatial data sets and services.

3. The transformation services referred to in point (d) of paragraph 1 shall be combined with the other services referred to in that paragraph in such a way as to enable all those services to be operated in conformity with the implementing rules provided for in Article 7(1).

Hence, each Italian region must own spatial data sets, related to the specific geographic area of pertinence, collected in a geo-portal providing public access to these services organized in standard spatial information of the territory. Piedmont region has BDTRE. The BDTRE initials of Spatial Data Base Reference for the authorities - *Base Dati Territoriale di Riferimento degli Enti* - is the geographical database of whole Piedmont promoted by the Piedmont Region (*Regione Piemonte*) authority, whose contents are structured according to the national "Technical rules for the definition of the content specifications of the geo topographic databases" primarily aimed at supporting the planning, governance, and protection of the

territory. The BDTRE therefore assumes the role of shared and free-to-use "container" of all spatial data, from which Regional Technical Cartography (CTR) derives.The document "Specifica2.0" defines the contents and structure of the Geotopographic Databases produced by the Piedmont Region which constitute a base for public administrations on spatial information, according to Art. No.59 of D.Lgs. No. 82/2005 (Digital Administration Code, *Codice dell'amministrazione digitale*). The Specifica2.0 identifies territorial data in which the main natural and anthropic aspects of the territory are represented and described. It is organized in layers, themes, and classes, indicating relationships and constraints between the data.

The Class (*Classi*) is the reference structure defining the representation of a specific typology of territorial objects: ownership, data structure, acquisition and structuring rules and relationship with other objects. Layers (*Strati*) and Themes (*Temi*) aim to organize Classes in morphologically and functionally homogeneous subdivision, whose homogeneity in the data structure is exploited to simplify the description or specification of the Classes that belong to it. The numerical code of the Class is therefore a six-digit string, consisting of two number of the Layer code, two number of the Theme and two digits corresponding to a numbering of the Class in the Theme. The numbering has no hierarchical value.

Pages of the "Specifica2.0" document related to cycling infrastructure elements are shown in *Figure 50* and *Figure 51*, indicating in detail the information to be attributed to the data. Collecting spatial data of a municipal, or higher administrative level, cycle network requires a classification of the spatial elements according to the technical specification of the Piedmont region. Hence, elements are divided into edges and junctions or nodes.

CLASSE: **Elemento ciclabile** **(EL_CIC - 010112)**

	RPIE1
Popolamento della classe	

Definizione

Si rappresenta l'asse dell'area di circolazione ciclabile. L'insieme degli elementi costituisce la rete delle piste ciclabili, a sua volta connessa con la rete veicolare attraverso le giunzioni ciclabili. Ogni tracciato lineare, che deve appartenere all'area di circolazione ciclabile (in funzione dell'accuratezza del rilievo), è delimitato da due giunzioni di pista ciclabile, corrispondenti ad intersezioni a raso con altri elementi di pista ciclabile.

Componenti spaziali della classe							RPIE1
010112101	EL_CIC_TRA	**Tracciato**	GU_CPCurve3D - Composite Curve 3D				
Si acquisisce la mezzeria delle piste ciclabili.							
Attributi di questa componente spaziale							RPIE1
01011201	EL_CIC_POS	**Posizione**	**Enum**	aTratti su	Tracciato		
		attributo che identifica se l'elemento è relativo a pista ciclabile si trova all'interno della piattaforma stradale che accoglie anche altri tipi di mobilità o se è in sede isolata e specificamente adibita alla circolazione dei soli cicli. NOTE: attributo derivato per intersezione dall'attributo posizione della classe area di circolazione ciclabile.					
	Dominio (Posizione)						RPIE1
	01	**isolata**	il percorso ciclabile si sviluppa al di fuori della sede stradale, ed è specializzata per la sola viabilità ciclabile				
	02	**su sede stradale**	l'area ciclabile si trova all'interno della sede stradale e può essere sovrapposta o complementare ad altre aree che la costituiscono				
01011202	EL_CIC_FON	**Fondo**	**Enum**	aTratti su	Tracciato		
		tipo di pavimentazione dell'area ciclabile di cui l'elemento di pista ciclabile è sintesi. Questo attributo ha una ulteriore esplicitazione che riguarda il tipo di materiale che costituisce il fondo dell'area. Qualora non si disponga o non si voglia disporre dell'informazione del materiale si farà riferimento al livello superiore di definizione dell'attributo al solo tipo fondo. NOTE: Le strade con fondo pavimentato potranno raggruppare ad esempio un manto asfaltato od in calcestruzzo Derivato per intersezione dall'attributo fondo dell'area ciclabile cui appartiene.					
	Dominio (Fondo)						RPIE1
	01	**pavimentato**	corrisponde ad un tipo di manto stradale che può essere di tipo flessibile (asfalto) o rigido (calcestruzzo) a seconda del materiale utilizzato.				
	02	**non pavimentato**	non pavimentato, composto da materiale a granulometria variabile.				
01011203	EL_CIC_SED	**Sede**	**Enum**	aTratti su	Tracciato		
		attributo che definisce se l'elemento si trova si trova su opera d'arte: su ponte, viadotto, in galleria ecc… NOTE: Attributo derivato per intersezione con l'area di circolazione ciclabile oppure attributo derivato per intersezione con le classi del tema opere d'arte					

Figure 50. and Figure 51. BDTRE Classification of cycling edges and junctions according to "Specifica 2.0" tecnical documentation [source:Specifica 2.0 CATALOGO DEI DATI TERRITORIALI - Specifiche di contenuto per i DataBase Geotopografici della Regione Piemonte]

	Dominio (Sede)						**RPIE1**
	01	**a raso**	l'area poggia sul suolo in assenza di ulteriori manufatti				
	02	**su ponte/su viadotto/su cavalcavia**	viabilità che si sviluppa su opera d'arte ponte, su viadotto, su cavalcavia in sovrappasso di corso o specchio d'acqua, di altra infrastruttura di trasporto o di alcunchè (che capita sovente nei viadotti)				
	03	**in galleria**	viabilità che si sviluppa lungo opera d'arte galleria. Comprende i percorsi sotterranei ma non quelli in sottopasso.				
01011204	**EL_CIC_LIV**	**Livello**	**Enum**	aTratti su	Tracciato		
		attributo che definisce se l'elemento è in sottopasso con entità dello stesso o di altri strati. NOTE: Nei casi complessi di articolazione dei livelli, ad esempio quando i livelli di sovrapposizione sono maggiori di tre, si dovrà fare riferimento ad ulteriori informazioni come max altezza transitabile, ecc… Attributo derivato per intersezione con l'area di circolazione ciclabile					
	Dominio (Livello)						**RPIE1**
	01	**in sottopasso**	sottopasso di medesima o altra viabilità ma anche sottopasso di manufatti, edifici, elementi idrografia				
	02	**non in sottopasso**	l'entità non si trova in condizioni di sottopasso rispetto ad alcunchè.				

CLASSE: **Giunzione ciclabile** **(GZ_CIC - 010113)**

	RPIE1
Popolamento della classe	

Definizione

Punti di connessione tra elementi di pista ciclabile o di inizio/fine di elementi di pista ciclabile. Le giunzioni intermedie si verificano nei casi di intersezione a raso di più elementi ciclabili.

Attributi					
Attributi della classe					**RPIE1**
01011301	**GZ_CIC_TY**	**tipo [1..*]**	**Enum**		
	Attributo che definisce il tipo di giunzione che si considera				
	Dominio (Tipo)				**RPIE1**
	01	**inizio/fine elemento**	nodo di inizio/fine dell'elemento dove non convergono altri elementi del grafo.		
	04	**incrocio/biforcazione**	intersezione a raso/biforcazione con altro elemento di pista ciclabile		

Componenti spaziali della classe				**RPIE1**
010113101	**GZ_CIC_POS**	**Posizione**	**GU_Point3D - Point 3D**	
Punto terminale o di intersezione di uno o più elementi di pista ciclabile con classificazione come da attributo tipo, quindi in corrispondenza di incroci, con elementi di pista ciclabile o con elemento di grafo di altra viabilità.				

Figure 51. The alphanumeric coding represents a semantic title identifying the Class. It was created to facilitate object recognition and was produced with a limited set of characters that recall the name of the object represented (e.g., GZ_CIC - 010113=giunzione ciclabile). Class coding is the root of each attribute hence junction typology is GZ_CIC_TY 01011301 and its values will be represented by progressive numbering, without the assumed value represents a hierarchy.

4.3. OpenStreetMap

The OpenStreetMap Project (OSM) is an initiative to create and provide free increasingly geographic extensive map data of the entire world to anyone. This information can be downloaded and use for any purpose such as personal or commercial use, community, educational, government reasons. Indeed, the OpenStreetMap Geodata Licence "Open Database License" (ODbL), shown in *Table 9*, is not considered as a licence, therefore it has no legal value, but few key terms to use the database.

Open Data Commons
LEGAL TOOLS FOR OPEN DATA
Open Data Commons Open Database License (ODbL) Summary
This is a human-readable summary of the ODbL 1.0 license. Please see the disclaimer below. You are free: • *To share:* To copy, distribute and use the database. • *To create:* To produce works from the database. • *To adapt:* To modify, transform and build upon the database. As long as you: • *Attribute:* You must attribute any public use of the database, or works produced from the database, in the manner specified in the ODbL. For any use or redistribution of the database, or works produced from it, you must make clear to others the license of the database and keep intact any notices on the original database. • *Share-Alike:* If you publicly use any adapted version of this database, or works produced from an adapted database, you must also offer that adapted database under the ODbL. • *Keep open:* If you redistribute the database, or an adapted version of it, then you may use technological measures that restrict the work (such as DRM) as long as you also redistribute a version without such measures.
Disclaimer
This is not a license. It is simply a handy reference for understanding the ODbL 1.0 — it is a human-readable expression of some of its key terms. This document has no legal value, and its contents do not appear in the actual license. Read the full ODbL 1.0 license text for the exact terms that apply.

Table 9. Human-readable summary of the Open Common Database License ODbL released by OSM Foundation [Source: https://opendatacommons.org/licenses/odbl/summary/]

Millions of volunteers *(Figure 52)* around the globe contributed to this project widening the possibility to have free of charge spatial data. *Figure 53* and *Figure 54* reveal how mainly European and US contributors make map edits but areas subject to change are beyond the territorial boundaries of the users, resulting in a rather homogeneous coverage of all continents except Africa which shows insufficient data compared to the others.

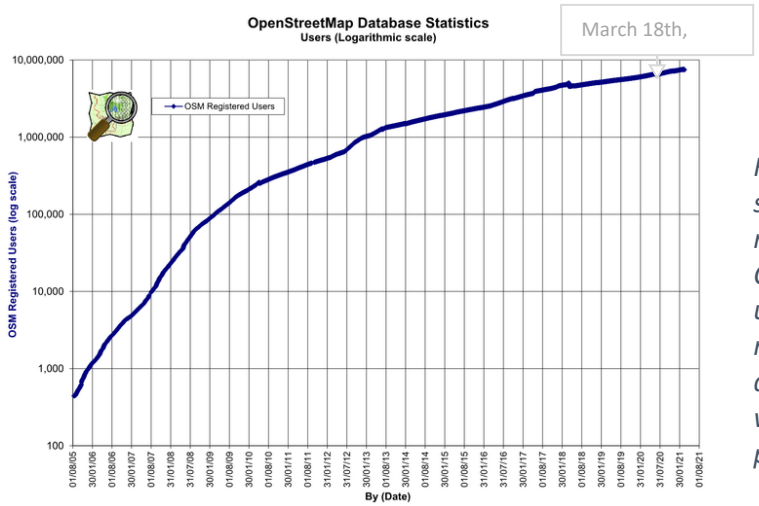
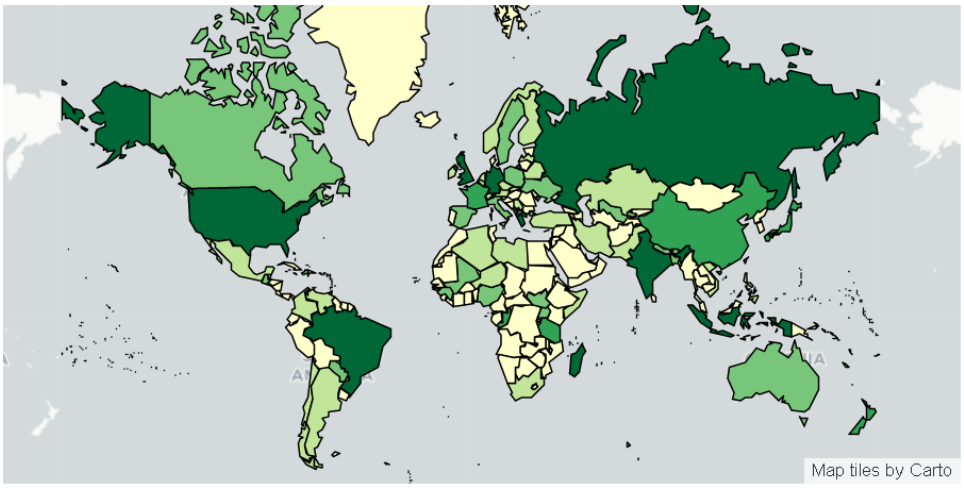
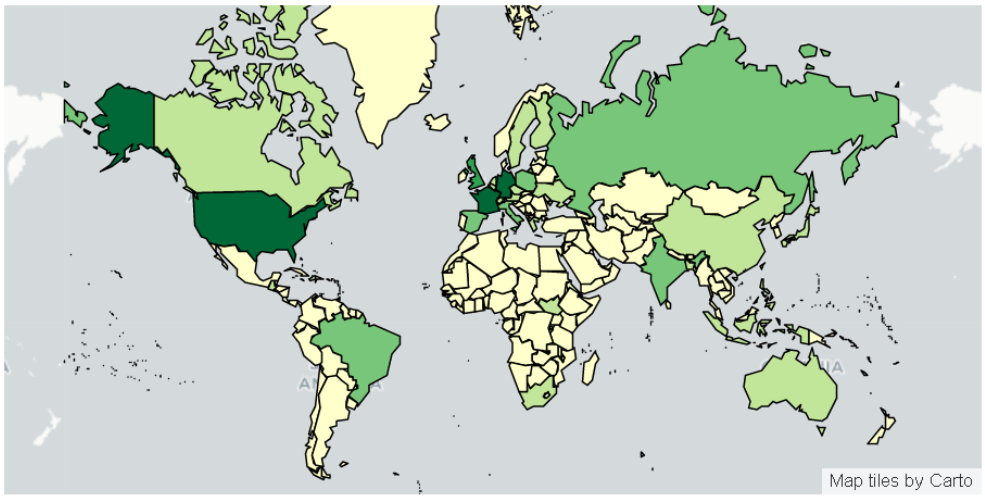


Figure 52. Registered users' statistics reports. Accumulated registered users (log scale). Contributors editing nodes or uploading GPX nodes are respectvely around 20 000 and almost 2000 individuals per week.Nodes represent the major part users of edited elements



Notice: The changeset's bbox center is utilized for counting. This can cause inaccuracies between ~2% and ~10%.

Figure 53. Classification by mapping activity in August 2021. Albeit Western countries are the highest contributors to OSM project, their activities go beyond their national borders. [Source: https://osmstats.neis-one.org/?item=countries]



Notice: The changeset's bbox center is utilized for counting. This can cause inaccuracies between ~2% and ~10%.

Figure 54. Classification of countries by number of contributors in August 2021. [Source: https://osmstats.neis-one.org/?item=countries]. Western countries are those contributing most to the project.

Open Transport Map (OTM) displays a road network covering the whole European Union allowing routing and visualization of traffic volumes of the whole EU. It is derived from OpenStreetMap database. Data model, shown in *Figure 55*, is a structure of OSM attributes and code lists. To make a network analysis, OTM needs to know which type of vehicle is moving along the route and if it is allowed to transit on the selected roads, if roads are paved, one or two-way and their hierarchy (highway, urban or extra-urban road..)

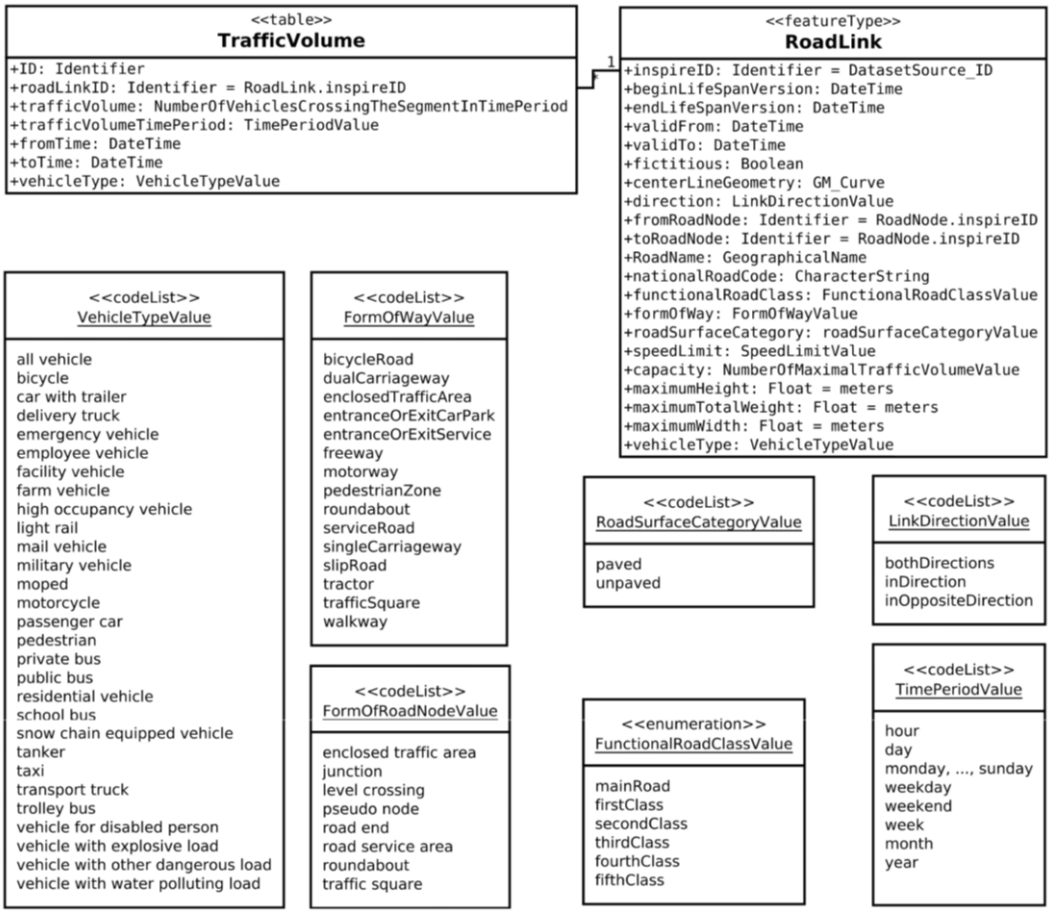


Figure 55. Data model of OTM is based on OpenStreetMap attributes and code lists. Data structure is filled with information that respect OSM data values. [source:

4.4. The data infrastructure project for the municipality of Mappano. Design of a GIS

4.4.1. External model

Necessary information to satisfy the BDTRE Piemonte data structure on cycle paths is divided into cycle elements and cycle junctions, respectively coded in EL_CIC - 010112 and GZ_CIC - 010113. The attributes of the cycle elements, shown in the

Figure 50 and *Figure 51*, are however not sufficient for the purpose to have a complete picture of the cycle mobility status of the case study. It was therefore decided to create a complex structure made up of three data structures with the aim of forming a GeoDB containing more complete information of the cycle infrastructures of the case study. The same situation occurred again considering only OpenStreetMap attributes and values. The motivation behind the inclusion of OpenStreetMap data model is related to the idea that public administration cannot go over a specific area with the same data results as a cyclist who regularly commute along that route. This interpretation is particularly valid when conversation bring cycling infrastructure's argument up. Advantages of a shared acquisition of spatial data related to cycling infrastructures are many. First, acquisitions could become quicker and constantly updatable, a higher group of individuals checking on the same area might increase collected data details. Being an active citizen could result in stronger feel of responsibility and identity with positive effect for the municipality. Daily bike commuters are a great resource of information. The reason is that defects are more perceptible to this category of users (Deromedis, 2019) since the person finds themselves completely exposed to the surrounding environment instead that in a car passenger compartment. Engineer Deromedis (2019, p. 350) confirms this opinion in his book "Cycling and cycle paths manual[23]":

> The user is the best ally for live detection of any anomalies on the infrastructure; through new communication technologies, anomalies can be easily reported to the managing body by communicating the position and the photographic documentation, and even through specific applications developed by the manager.

Argentinian writer Juan Carlos Kreimer (2019) in his book "Bike Zen" explains well the reason behind the great attention of cyclists:

> From the bicycle the view is very different from that inside a car or a bus. In this type of vehicle, the windshield and the windows are television screens on which scenes of the city flow, frame by frame. The bike has no roof, walls, or windows to protect the rider from the elements. The circular vision that extends in every direction, even to the ground and the sky, gives the feeling of being part of what we see. It is a formidable sensation that is sometimes extremely enjoyable. [...] produces a mixture of hypnosis and disconnection [...] even without being aware of everything, in this state we are reactive to every signal.

[23] *Il manuale delle piste ciclabili e della ciclabilità*

Therefore, in addition to the BDTRE Piemonte and OpenStreetMap data, a third component has been added containing additional information which were missing in the two previous databases. The information useful for understanding cycling infrastructures has therefore been developed and grouped in a conceptual model *(Attachment A)*. The data are both spatial and non-spatial.

4.4.2. Conceptual model

Conceptual model *(Attachment A)* is the second phase's result of the process for the realisation of the geospatial data infrastructure. For a better representation and management of a database it is useful to have a reference as a conceptual model to stem any ambiguity in the interpretation of represented data. Legend below *(Figure 56)* explains which are the chosen typologies of data, dividing them per origin of the attributes – OpenStreetMap, BDTRE Regione Piemonte, Additional data. In order to make value assignation to each feature simple, it was decided to use a progressive numerical coding with a hierarchical value, when indicated, for the attributes that fall within the Additional data section. The progressive alphanumeric coding of the Piedmont Region BDTRE is provided for in the technical document "Specifica 2.0" but without hierarchical value; therefore, a higher value does not correspond to a more positive situation. Numeric coded values of OpenStreetMap, on the other hand, were created even if not foreseen by the OpenStreetMap data model. It was decided to use a progressive numeric coding following the same logic applied by Piedmont Region. Coded values are convenient as they increase speed compilation yet minimizing the possibility of error during the assignment of the value. This is a significant aspect with the increase of the subjects involved in data collection work. This model expresses which are the attributes' values allowing the interpretation of numerical coded values which is essential for setting domains. Focusing on the third part, that of new additional information, the values of particular importance are those of the linear elements as they identify aspects not mentioned in the attributes of OpenStreetMap and BDTRE Regione Piemonte. The presence of vertical or horizontal road signs, adequate street lighting along the cycle path, the presence of obstacles, the level of maintenance of the road surface, the type of cycle path as well as the speed limit of the road section on which the cycle path insists, and the danger of the route are all necessary data so that information on the managed elements is available.

Legenda		
	Origin of the data	**Data Type**
	OpenStreetMap	Lines\edge
	OpenStreetMap	Nodes\ junctions
	BDTRE - Regione Piemonte	Elementi lineari
	BDTRE - Regione Piemonte	Elementi puntuali
	Additional data (Project)	Edges, Lines, Elementi Lineari
	Additional data (Project)	Nodes, junctions
	Additional data (Project)	Tables
	Additional data (Project)	Polygons

Figure 56. Legend of conceptual model. [source: author]

Another non-secondary aspect is the evaluation of the safety at the intersections which, as previously written, are where most of the accidents involving bicycles take place. Road accidents and traffic flows are values that cannot be directly attributed to the linear or punctual element through on-site analysis, but it is possible to provide them through updated data produced by the municipality together with the local police. It should be geo-referenced datum so that a map can be created from which the level of danger of that edge or node can be obtained. Traffic levels, on the other hand, are useful for understanding the type of cycle path most suitable for that road section. In fact, it should be remained that along roads with low or zero traffic levels and reduced speeds - below 30 km/h and less than 3000 vehicles/day (Deromedis, 2019) - the necessity of a segregated cycle path is no longer needed. The data is completed by mapping low-speed areas, such as school zones or pedestrian areas. This type of information is particularly useful for bike and scooter sharing services so that the speed of the vehicles can be arranged based also on these areas. An updated and complete database is a useful tool for managing spatial information of cycle infrastructures and maintenance will be easier and faster. Indeed, even cycling infrastructures like any construction requires maintenance operations. If this does not happen within a few months of construction, functionality and security are compromised making the infrastructure almost futile. After a few years of lack of maintenance, the infrastructure risks degrading significantly wiping out the investments made. (Ivi, p. 344). Hence the implementation and updating of the GIS relating to the infrastructure is essential and it might include even more attributes than those of the created data structure, for example, it might include the dates or periods of extraordinary and ordinary maintenance. A WebGIS of cycling infrastructure might be developed for easier and faster share and different purposes such as marketing promotion or the creation of GPX tracks, but also editable by citizens.

4.4.3. Logical model

Some attributes' values are hierarchical coded values meaning that classification is based on a range -in this case from 1 to 5 – depending on the condition of the element. For this reason, it has been developed a logical model *(Attachment B)* to simplify interpretation during data collection and classification. Some parts of the entire model are inserted below to better clarify the structure *(Figure 57, Figure 58* and *Figure 59)*. *Figure 59* is a part of the GeoDB logical model *(Attachment B)*, with the aim of clarifying schematically which are the attributes that belong to the three categories previously listed: OpenStreetMap (1), BDTRE Regione Piemonte (2), Additional data (3). It also specifies data type for each field (numbers and text). The result obtained must be thought of as a Geodatabase containing a dataset with feature classes. *Figure 57* shows the logical model of the database for scheme concept only. Readable version is in *Attachment B*. This logical model is a useful and necessary tool for understanding data in natural language as well as to set the domains. Each attribute value is accompanied by a brief explanation of what is meant by attributing a certain value to an element. *Figure 58* below is an example of the codes and descriptions that might apply to the field.

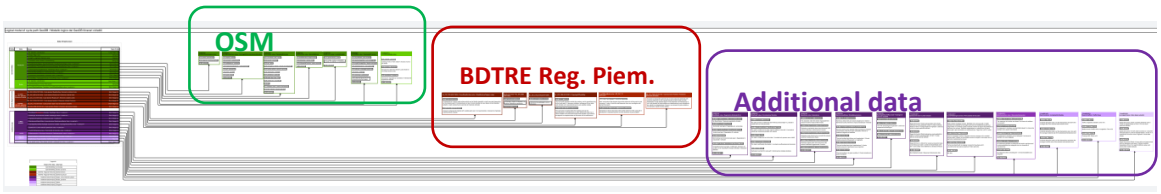


Figure 57. Logical model of cycle path GeoDB data infrastructure. This figure shows how the model should be read. Readable version at Attachment B. [source: author]

«codeList»
MaintenanceStatus \ StatoManutenzione

+ 01 = Insufficient \ Insufficiente

Numerous deep holes and cracks dangerous for transit \\ Numerose buche profonde e crepe pericolose per il transito

+ 02 = Slightly Insufficient \ Insufficienza Leggera

Pits and cracks on the asphalt make the trajectory irregular and annoying \\ Buche e crepe sull'asfalto rendono la traiettoria irregolare e fastidiosa

+ 03 = Good \ Buono

The road surface has ditches and irregularities \\ Il fondo stradale presenta affossamenti e irregolarità

+ 04 = Very Good \ Molto Buono

The road surface has minor imperfections \\ Il fondo stradale presenta imperfezioni poco importanti

+ 05 = Great \ Ottimo

The road surface is in good condition \\ Il fondo stradale è in buone condizioni

+ 999 = No data

«codeList»
Impedance value \ Impedenza

+ 01 = Unsustainable \ Insostenibile

The obstacles make the stretch impassable\\Gli ostacoli rendono impercorribile il tratto

+ 02 = Many impediments \ Tanti impedimenti

Obstacles considerably slow down the transit \\Gli ostacoli rallentano notevolmente il transito

+ 03 = Some impediments \ Alcuni impedimenti

Obstacles make transit not so smooth\\Gli ostacoli rendono il transito poco fluido

+ 04 = Few impediments \ Pochi impedimenti

Obstacles slightly slow down the transit \\Gli ostacoli rallentano leggermente il transito

+ 05 = No impediment \ Nessun impedimento

+ 999 = No data

Figure 58. Domain application examples with accepted maintenance and impedance values. Full version available in Appendix A [source: author].

Body	Data	Values	Type of data
OpenStreetMap 1	RoadLinks	+ ID: Identifier \ identificatore	Long Integer (10)
		+ Shape: Edge \ arco	String (10)
		+ Length \ Lunghezza: Numeric value	Float (6.1)
		+ RoadName \Nome Strada: CharacterString	String (30)
		+ RoadSurfaceCategory \SuperficieStradale: RoadSurfaceCategory Value <<codeList>>	Short Integer (2)
		+ RoadSurface \TipologiaDiPavimentazioneStradale: RoadSurface Value <<codeList>>	Short Integer (2)
		+ VehicleType\TipologiaDiVeicolo: VehicleType Value <<codeList>>	Short Integer (2)
		+ Direction\SensoDiMarcia: LinkDirectionValue <<codeList>>	Short Integer (2)
		+ RoadLevel\LivelloStradale: RoadLevel Value <<codeList>>	Short Integer(2)
		+ FormOfWay \ TipologiaDiTransito: FormOFWay Value <<codeList>>	Short Integer(2)
	Nodes	+ ID: Identifier \ identificatore	Long Integer (10)
		+ geometry(shape) \ Forma: Point \punto	String(10)
		+ formOfWayRoadNode \ TipoNodo: FormOfWayRoadNode value <<codeList>>	Short Integer (2)
BDTRE Regione Piemonte	CLASSE: EL_CIC - (010112) Elemento Ciclabile	EL_CIC_FON (01011202) - Cycle element RoadSurface \ Elemento ciclabile Fondo	Short Integer (2)
		EL_CIC_SED (01011203) - Cycle element RoadLevel \ Elemento ciclabile Sede	Short Integer (2)
		EL_CIC_LIV (01011204) - Cycle element RoadLevel \ Elemento ciclabile Livello	Short Integer (2)
		EL_CIC_POS (01011201) - Cycle element position \ Elemento ciclabile Posizione	Short Integer (2)
	CLASSE: GZ_CIC - (010113) GiunzioneCiclabile	GZ_CIC_TY (01011301) - Cycle junction Type \ Tipo di Giunzione Ciclabile	Short Integer (2)
		GZ_CIC_POS (010113101) - Cycle junction Position \ Posizione Giunzione Ciclabile	Short Integer (2)
Additional data 2	LINKS EDGES	+ RoadSigns\Illuminazione Stradale: RoadSigns Valus <<codeList>>	Short Integer (2)
		+ StreetLight \Illuminazione Stradale: StreetLight value <<codeList>>	Short Integer (2)
		+ Impedance\Impedenza: Impedance value <<codeList>>	Short Integer (2)
		+ MaintenanceStatus\Stato di manutenzione: MaintenanceStatus Value <<codeList>>	Short Integer (2)
		+ TypologyOfCycleWay\Tipologia di percorso ciclabile: TypologyOfCycleWay value <<codeList>>	Short Integer (2)
		+ SpeedLimit \ Limite velocità: SpeedLimit value <<codeList>>	Short Integer (2)
		+ CyclePathDangerousness \ Pericolosità del tracciato value <<codeList>>	Short Integer (2)
	NODES	+ SafeIntersection \ Sicurezza Intersezioni: SafeIntersection value <<codeList>>	Short Integer (2)
3	TABLES \ TABELLE	+ Road incidents \ Incidentalità stradale: RoadIncidents value <<codeList>>	Long Integer (5)
		+ Traffic flows \ Flussi di traffico: TrafficFlows values	Float (5.2)
	POLYGON	+ Low speed zones \ Zone bassa velocità: LowSpeedLimit value <<codeList>>	Short Integer (2)

Figure 59. Logical model of cycle path GeoDB data infrastructure. Division of the sections by origins of the attributes [source:author]

5. State of the art of Cycling mobility in Mappano

5.1. Municipality of Mappano as a case study

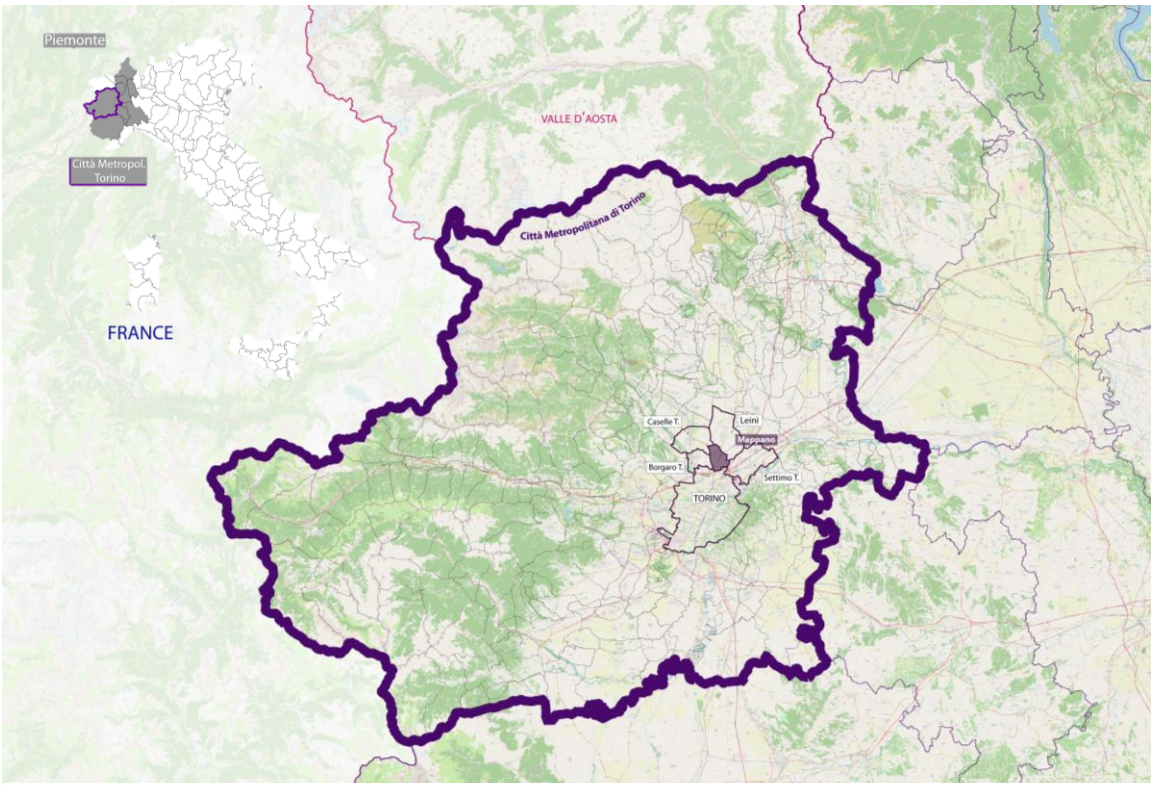


Figure 60. Mappano Geographic position in relation to Italy and metropolitan city of Turin. The area with violet fill and stroke in the middle is Mappano [source: author]

Mappano *(Figure 60)* is a town in the first belt of the metropolitan city of Turin not far, less than five kilometres, from the Turin Stura railway station. It is characterized by being defined as the youngest municipality in Italy as it was officially formed in 2017. For an historic contextualisation *Table 10* has been developed reassuming the main periods in the evolution of the municipal territory.

13th century	Permanent settlements are present
15th century	Antonio de Amapano reclaimed the territory constructing farms and cultivated the land
16th century	A network of irrigation canals is created.
19th century	Family of washers started to populate the area attracted by the presence of drainage channels and large open spaces. At the end of the century settlements consisted of a group of farms scattered along the road between Turin and Leinì that did not expand significantly during the boom after the Second World War

Table 10. Evolution of building expansion in Mappano. continue on next page...

20th century	Territory developed during the 1980s in a concentrated way around a traditional core. Most of the houses were built in the decade between 1961 and 1971 followed by a drop in construction between 1971 and 1981 which resumed from 1981 to 1991. Units with 16–30 or more than 30 homes increased substantially in the period between 1981 and 1991. A great part of the houses is single-family type.

Table 10. Evolution of building expansion in Mappano. [source: (Pileri & Scalenghe, 2016)]

Its proximity to the capital makes it particularly interesting for any experimentation of alternative modes of mobility. Indeed, since the entire territory is flat and entering Turin required to cross a single bridge, cycling policies promotion could has positive results. Its central position with respect to the municipalities of Borgaro Torinese, Caselle, Leinì and Settimo Torinese, due to the formation of Mappano through the separation of the four listed municipalities, could make it a common promoter of alternative mobility. Although it might appear as a fortune, it must be remined the motivations behind the location of the actual municipality. Indeed, Mappano was born from <<the supremacy of the local identity [which] is the main driver of social actions. [...] Until the time of the referendum in 2012 there was no official, unique, or shared definition of what the territory of Mappano is, a conurbation that extends over the territory of the municipalities of Borgaro Torinese, Caselle Torinese, Leinì, Settimo Torinese, and Torino *[Figure 60]*>> (Pileri & Scalenghe, 2016). The actual boundaries of the City were established after the referendum on November 11, 2012 (Ibid.). This <<administrative fragmentation>>, occurred with the birth of a small new municipality, brought environmental issues up, since at greater number of units governing a territory, each of them maximising its own goal on a small territory, increase the need for inter-agency dialogue and coordination (Ibid.) other than difficulties in finding a shared line of planning view, time, and costs.

> From the land consumption point of view, fragmentation is a serious menace as it is a process that separates and divides the continuity of the landscape. We cannot forget the available data illustrating that in small towns, the most common type of residence is the single-family home that continues to survive because of its perverse symbiosis with the private car, which in turn paradoxically survives only by consuming non-renewable energy resources such as petrol and diesel.

The quote overhead is part of an article published by professors Pileri and Scalenghe (2016). It clearly explains the connections that hides behind the use of car, considered

as an apparently individual- without-consequences behaviours. Single-family houses in suburbs create low density urban fabric which induced car dependency to reach any destination. The higher the density the more activities and services can be found and the more cyclable and walkable a place became. Hence, avoiding excessive settlement dispersion is crucial also in the optic of reducing the environmental impact of soil sealing. Wise policies and projects implementation could positively influence the demand for cycling. This is also confirmed by the results of the online questionnaire on "home, school, work mobility" published by the Municipality of Mappano (2020) submitted to its citizens. 75% of the 316 participants said they considered themselves in favour of building a cycle path connection between Mappano and Torin-Stura railway station. Although this positive attitude related to the connection to the capital, Mappano has the perfect size for urban cycling mobility other that extra-urban one.

In 2018, a monitoring plan was created by the Municipality of Mappano aimed at analysing traffic flows characterizing the entire road network (Andrea Marella Traffic Lab, 2019). To count and classified passing vehicles along the main roads, they installed five traffic radars for automatic vehicle pick-up, a fixed video camera and two on-site inspections were carried out by professionals for manual surveying (*Figure 61*). Results shows that the largest number of vehicles passes along the provincial road SP 267 with an average daily flow that exceeds five thousand vehicles for each direction. Cars are the dominant category. Data recorded by P05 radar located on Via Mappano is also significant, both in the direction of the town centre and in the direction of Borgaro Torinese, recording an average flow of over two thousand vehicles per day. The data acquired by the radar in Via Reisina (P04) show a lower but significant average vehicular flow both in the direction of the centre and in the direction of Settimo Torinese with about one thousand five hundred vehicles a day. The average speed is 56 km/h for 85% of vehicles and during few hours maximum speeds of 90 km/h were recorded. The highest number of movements are towards Turin from all the analysed directions but also those from Caselle to Settimo Torinese. Finally, experts observed (*Figure 62*) that the busiest flow is Via Torino (Leinì) towards Strada Cuorgnè (Mappano). In addition, they revealed that the origin of most trafficked road is Mappano with 525 vehicles in output, and Leinì with 506 vehicles. Conversely, the busiest destination road is Settimo T.se as there are 537 vehicles, followed by the city of Mappano, where 425 vehicles enter.

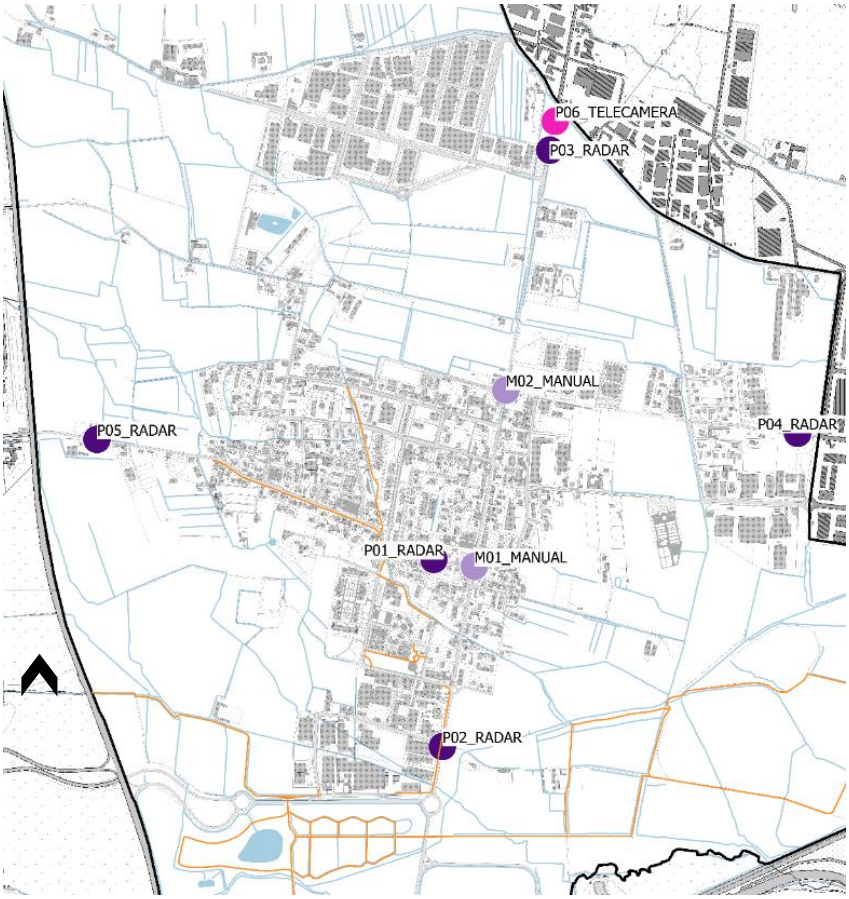


Figure 61. Localization of the 5 radar stations, the camera, the manual surveys superimposed on the cycle paths [source: Traffic Lab data and author]

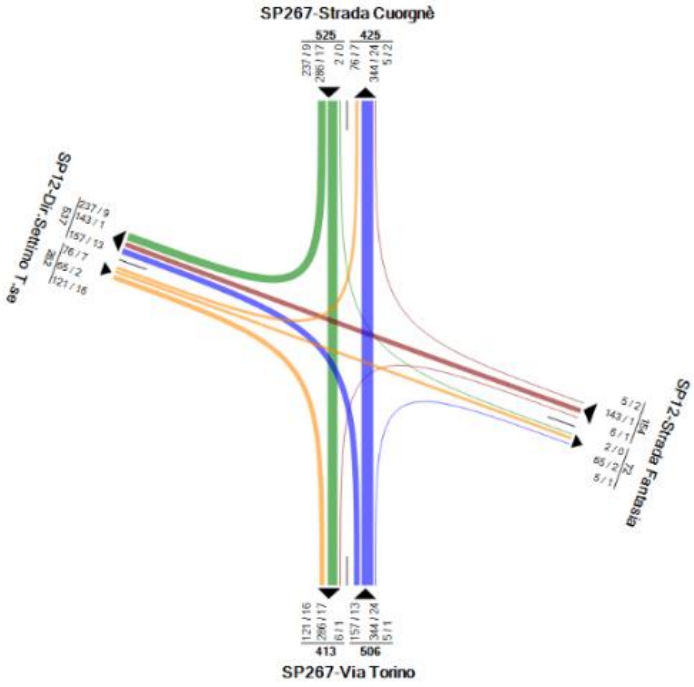


Figura 109- Rappresentazione grafica dei flussi veicolari

Figure 62. Graphic representation of vehicular flows. Blue line is Via Torino to Strada Cuorgnè and Settimo T.se; green line is Strada Cuorgnè to Via Torino and Settimo T.se, orange is Settimo T.se to Strada Cuorgnè, Caselle T.se and Via Torino; red is Caselle T.se to Settimo T.se. [source: (Andrea Marella Traffic Lab, 2019)]

Traffic Lab also carried out a traffic simulation process to understand the behaviour of vehicles aiming to know traffic volumes, average delays, and queues. Results of the simulation of the actual situation are shown in *Figure 63*.

Figure 63. Actual traffic volumes are slightly more than 2500 veh/h, speed 38,07 km/h and maximum queue, 32 vehicles in Scenario 0 simulation (actual situation) along the main routes of the Municipality of Mappano. Via Rivarolo-Strada Cuorgnè is where traffic flows are more concentrated.

5.2. Site inspection

Implementation of the first General Town Plan (Italian *Piano Regolatore Generale*) of the Municipality of Mappano created the ideal conditions for empirically apply the cycle infrastructures' GeoDB. The Municipality has established an institutional collaboration agreement with DIATI, DIST, R3C Departments of the Politecnico di Torino for the analysis, design, development, and protection of the territory also for drafting the General Plan. This means that the Municipality needs to know and understand its territory to plan and design it in the right direction. Maintenance degree of itineraries, elements of street furniture, condition of road surface, parks and playground, and any element that needs management within its borders need to be detected. Therefore, several site inspections were carried out by experts, professors, researcher, and students to build up an updated version of municipal spatial data. One of these was used for the survey of cycle infrastructures and data collection. Extra outings at different times of the day were necessary for a deeper and above all diversified knowledge. Together with the traffic analysis realised by Traffic Lab these site inspections were useful to understand traffic flows and categories during various time of the day, the type of user and the state of lighting in night hours.

Hence after delays due to COVID-19 restrictions which were imposed during the first months of 2021 a site inspection was planned in the end of March. All the instrumentation was courtesy of the Engineering Department of the Environment, Territory, and Infrastructures (DIATI) of Politecnico di Torino. Researcher Nives Grasso and PoliTo Geomatics Lab technical manager Paolo F. Maschio played and essential role in the organisation, material transfer and help with assembling the equipment other than support during the ride along municipal cycling routes of Mappano. Researcher Grasso helped also for data extraction and transfer from the instrument to memory device.

In the urban environment, the bicycle is a means of transport that has the same potential in terms of distance (*Table 11*) as motor vehicles, therefore it must be considered within the urban mobility plans (Deromedis, 2019), and this is another reason for making spatial data collection on a cycle. The extension of the Municipality of Mappano along the main road (*Figure 64*) is close to four kilometres, hence, following *Table 11* there would be no complications in mapping cycling

infrastructures around the municipal territory. Widening the concept, it could be said that the entire Municipality would be able to travel by cycling given the size and orography of the territory.

MODE OF TRANSPORTATION	RANGE	TRANSPORT DISTANCE
walking	Urban	0-2 km
normal bicycle	Urban	0-7 km
pedal assisted bike	Urban	0-10 km
motorcycle	Urban	2-10 km
bus	Urban	2-10 km
car	Urban	2-10 km
suburban bus	Extra-urban	10-500 km
car	Extra-urban	10-500 km
train	Extra-urban	50-1000
airplane	Extra-urban	500 – 5000 km

Table 11. Potential in terms of distance of the different and air transport modes. [source: Deromedis, 2019]

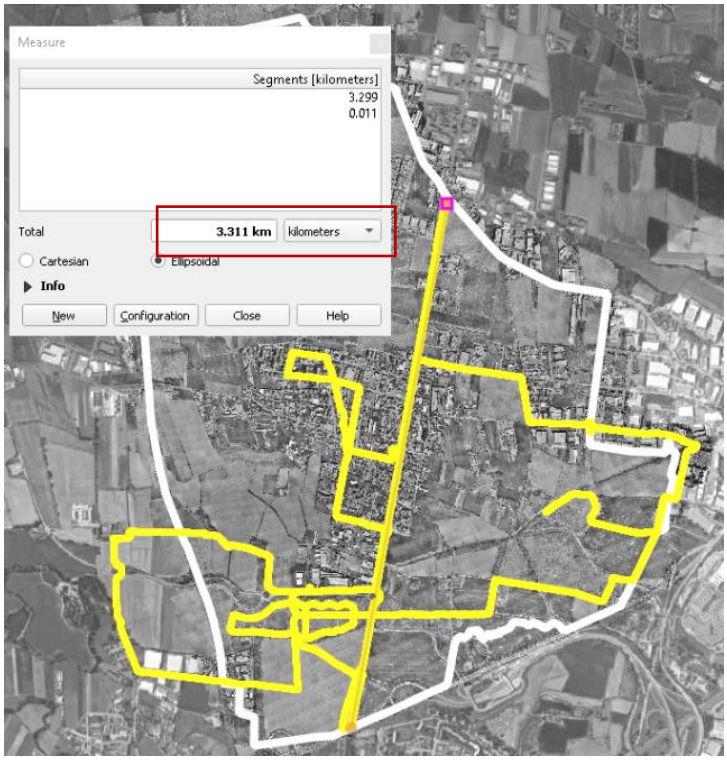


Figure 64. Relative extension of Via Rivarolo and Strada Cuorgnè [source:author]

5.3. The importance of site inspection

The right way to learn briefly about a place is the first site inspection. Although when it comes to make a cycling infrastructure survey, this step become fundamental as well as it is important doing it by a cycle or scooter (*monopattino*). If it is true that users are those who can give the most accurate feedbacks since they are the people

experiencing the final project, the suitable way to carry out a study is to become a user of that infrastructure. Limited speed of the cycle, around 20-25km/h allows the individual to notice more details and road sections in need for maintenance. Indeed, driving at very high speeds can result in tunnel vision and decreased depth perception for the driver. At lower speeds, individuals have a wider field of vision and are more likely to notice more elements of street's section (Bray Sharpin, Banerjee, Adriazola-Steil, & Welle, 2017). This should be considered especially in those routes where there are no dedicated cycling infrastructures as shared-use paths with motorised vehicles. Hence when field analysis cannot be done by bike, cyclist daily commuters could come forward. Cyclists better look defects over streets, especially if they daily commute along that path since they are not inside a car passenger compartment but exposed. They are strongly conscious of the condition in which an infrastructure is also due to finer wheels which have a greater sensitivity on the imperfections of the road, potholes, cracks, wet leaves.

5.4. The equipment

Mapping the state of the art of Mappano's cycle paths required a limited and relative unexpensive equipment. Cheap and easy-to-use machineries have been the idea behind the collection of these data. Indeed, quality management of the cycle and pedestrian infrastructure should be carried out, where possible, with sustainable means of transport and work, such as: bicycles, e-bikes, cargo bikes, electric vehicles, low-polluting means of work; vehicles powered by fossil fuels and in particular those with diesel engines should be excluded from cycling infrastructures, or in any case to be reduced to a minimum (Deromedis, 2019, p. 348).

5.4.1. Cargo e-bike

One of the most comfortable means of transportation for mapping cycle paths is ironically or obviously a cycle. A cargo bike *(Figure 65)* can be considered as the most suitable solution between traditional bicycles since it indirectly provides information related to the accessibility of the path to cycles other than traditional two-wheels ones. Indeed, the advent of different types of bicycles, such as cargo bikes and electric bikes, and their speed and size variations require infrastructure design to respond to these different types of cyclists.

Figure 65. An e-cargo bike was provided by the DIATI Department of the Politecnico di Torino for mapping [source: author]

The reason behind the choice of this mean can also rely on the more stability and so it could be hypothetically used by technicians and other professionals for on-site analysis of cycle paths but also pedestrian zones, walkways. A GNSS system, an Action Cam and a 360 camera have been mounted of the cargo bike to collect quantitative and qualitative data.

5.4.2. GNSS RTK system

RTK initials of Real-time kinematic *(Figure 66)* surveying is a method of geodesy for measuring or staking out points with the help of satellite-based navigation systems (GNSS) such as GPS (USA), GLONASS (Russia), Beidou (China) or Galileo (EU). Accuracies of few centimetres are achieved (Wikipedia Die freie Enzyklopadie, 2020). The purpose of this instrumentation was to provide the position of the person along the whole path of the mapping. The result obtained was therefore thousands of points and their coordinates, which once extracted and put on a GIS program as a point feature class, gave the idea of the track. These surveyed points were then transformed into linear elements grouped in a line feature class to allow the selection and classification of the routes.

Figure 66.RTK system and antenna detail
[source: author]

5.4.3. Garmin Virb Elite Action Cam

The brand name is reported only with the intention of providing more detailed information but does not prevent the same function from being performed by action cams of different brands, perhaps cheaper, with higher or lower resolution and different characteristics. The purpose of this camera was to film the entire path paving for the entire duration of the site inspection in order to then be able to assign a rating from 1-5 to each section based on its state of maintenance, presence of holes or cracks, of vertical horizontal signs. This tool was also essential to assign the type of pavement to each section and indicate whether it was paved or unpaved as regards the classification of the BDTRE Piedmont Region which limits itself to knowing the presence or absence of asphalt without considering the enormous inconvenience caused by cobblestones, or similar pavement, on the quality of cycling experience. Since the camera was mounted on a tube positioned above the cargo bike front box it was also possible to understand damages severity of the routes encountered by the user while pedalling; this is because the video recorded a change of framing of varying degrees based on the worst road sections.


Figure 67. Garmin Virb Elite Action Cam [source: author]

5.4.4. GoPro Fusion 360

The brand is also indicated for this device with the aim of providing more complete information without however suggesting that this model is better in some respect. 360 videos can also be made with tools from other brands. The GoPro 360 Fusion was used with the purpose of understanding the user's perception while pedalling. In fact, having the opportunity to look at the environment surrounding the cycle infrastructure in a deferred 360 ° way can help understand, even to those who have not been on that track, the feeling of safety or danger experienced by the person. A dangerous experience could be, for example, an intersection of the segregated cycle path with motorized-vehicles routes. The result obtained is also useful because often if someone is not on board a bike it is difficult to identify with the cyclist. Firstly, a driver passing less than 1.50 m away from the cyclist cannot understand the sensation of close overtaking, unless they are in the place of the user on two wheels; it is also difficult to understand the sounds that are perceived when moving in a space without the protection of a partially soundproofed vehicle, as it is the car. In fact, hearing the engine of a car at a very short distance from their rear wheel or even hearing it approaching at high speed could lead the cyclist to actions dictated by fear that could have negative effects. Negative effects do not necessarily mean road accidents but could also lead the user to stop pedalling with negative consequences on their health, on their mental state and all those consequences avoided or alleviated by cycling. Having a 360 ° video therefore allows people to identify themselves by being able in some way to train their empathy towards other road users. So, viewing this video through a viewer would be even more complete.

Another function of this type of video can be useful, for example, to get to environments that are difficult to reach and that could be used as areas for illegal

landfills or other illegal actions with environmental consequences: a simple ride could reveal a lot of the whole environment around the road under study.

Figure 68. helmet with GoPro 360 Fusion on and GoPro Fusion 360 in detail. [source: author]

Figure 69. E-cargo bike with mounted equipment used to carry out the recording of spatial data of the municipality of Mappano. [source: author]

5.5. Data acquisition and extraction

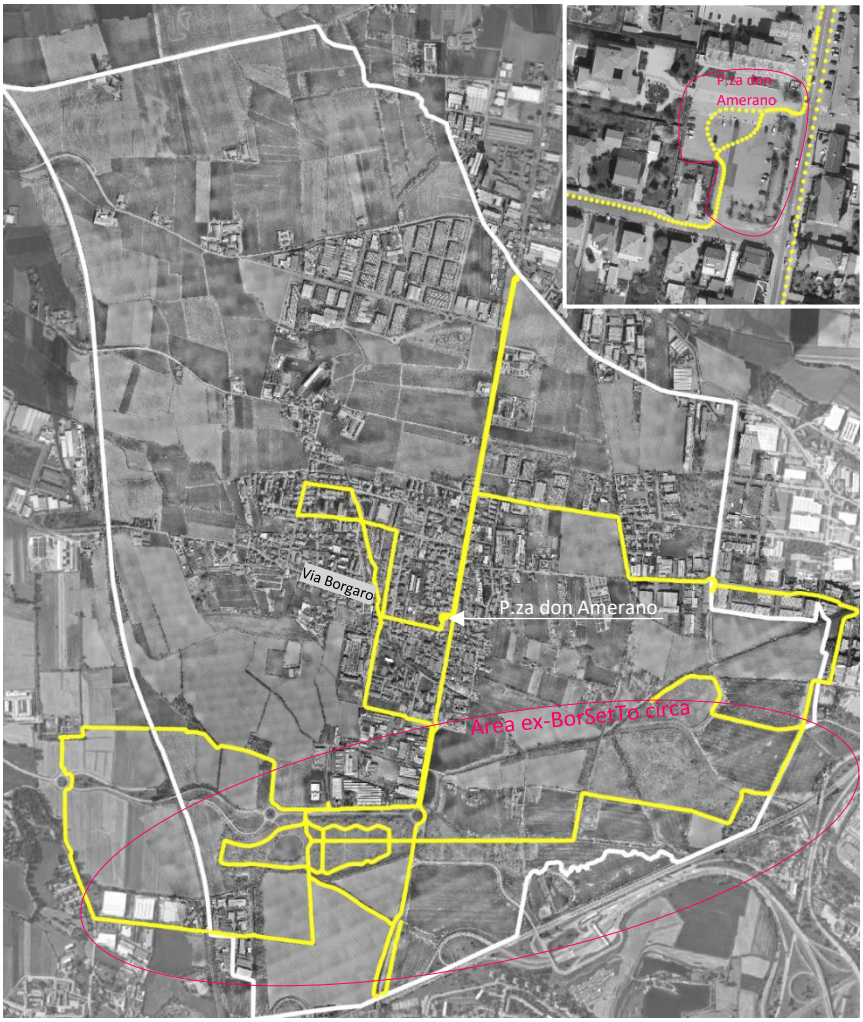


Figure 70. Mapped points through RTK GNSS system extraction resulted as an apparently single line since points were collected every two seconds. Yellow is for the points [source:author]

On March 24th, 2021, a site inspection took place for the spatial data collection of cycle infrastructures of the Municipality of Mappano *(Figure 71)*. It required around half of the day to record the whole territory.

The GNSS antenna was set to map points every two seconds automatically and a cleaning process was then carried out later to have a more readable punctual shapefile (*Figure 70*) once put on GIS. Garmin action cam was started and let go for the entire duration of the work this model also includes high-sensitivity GPS for data stamping and GPS-based "smart" recording profiles since Garmin is a US company that produces GPS devices also for sports. The action cam also recorded the speed of the bicycle even if the usefulness in this case is relative because it was preferred to be able to have footage of greater quality and detail (especially for 360 videos) rather than going fast. The GoPro Fusion 360 was mounted above the helmet and was set in video and for some sections in photos with frames every two seconds.

The pedal assisted cargo bike made pedalling a little easier, especially along the most disconnected unpaved sections; its main comfort, however, were the three wheels, two front and one rear as well as the front box in which various objects were stored as the antenna controller. The ride has intentionally extended beyond the boundaries as it can be observed from *Figure 70* of the Municipality of Mappano to understand the existing connectivity with the neighbouring municipalities. In particular, the inspection reached the Municipality of Borgaro T.se from which a section of the segregated cycle path begins, part of the wider "Corona Verde" cycle path. Moving east, on the side of the Municipality of Settimo T.se, the Municipal boundaries have been exceeded passing through the park of the former "BorSetTo" area, then crossing the industrial area of Settimo T.se and continuing eastwards, which returns to the Municipality of Mappano. The riding is then continued by connecting to Via Reisina which, turning into Strada Cuorgnè, arrives back to *Piazza don Amerano*, the starting point of the registration.

Figure 70 shows the complete route that has been taken, i.e., also including the passage from roads where there are no cycle infrastructures. This is since the itineraries are not connected to each other and therefore it was necessary to cycle often on the road to reach them all. In particular, the cycle path that is cut from Via Borgaro is interrupted by an element preventing the transit of large cycles such as the cargo bike used for mapping. It was decided to record these sections as well precisely to emphasize the lack of connection between the routes. Via Rivarolo - Strada Cuorgnè have been mapped even if the cycle path has not yet been built because it is planned and should have been approved. Thus, it seemed particularly useful to know the environment around this street. As the future cycle path of the Municipality of Mappano will extend until it joins the existing one of the Municipality of Leinì, the mapping process has reached the *Leinicese* cycle path via the provincial road SP267. The whole *Parco Europa* has been mapped but it was already present in its entirety both in the OpenStreetMap database and in the BDTRE *Regione Piemonte* database. However, it was useful to carry out the mapping connecting in a circular way the Borgaro T.se segregated cycle path with the "*Corona Verde*" itinerary and then W-E direction with the Municipality of Mappano, which finally ends in *Parco Europa*.

The data extraction took place in the laboratory a few days later and were then transformed into a linear feature class. Due to some prolonged stops in which there

was no interruption of the recording of points, it was also necessary to clean the linear shapefile. Mapping points with RTK system is particularly effective and efficient but when an automatic mapping with such a short interval is set, when pausing is forget it continues to record generating a whole series of points in the same place which will make the data processing more time-consuming.

Figure 71. Six frames of one 360 video recorded during the site inspection in March 2021. [source: author]

Figure 72. Example of application of the acquired material. Frames extracted from the action camera are useful for evaluating the cycling infrastructure Scan the QR-Code to watch the GoPro Fusion 360 video on YouTube

5.6. Data processing and analysis, results

Next step after data extraction is their processing. The purpose is the classification of the cycle routes of the Municipality of Mappano based on the type of pavement, the state of maintenance of the road surface, their position, the type of cycle way and all the other attributes that have been implemented in the cycling infrastructure GeoBD model (*Figure 73*). For example, it has been indicated whether the route is a segregated cycle path or a cycle-pedestrian path with a strip dividing cyclists from pedestrians or mixed, if there are cycle lanes on the roadway, thus sharing the space with motor vehicles. To realize this current scenario to understand how advanced the cycling infrastructures of the Municipality of Mappano are to be able to define itself as a municipality thoughtful of cycle mobility, the previously created linear feature class was subjected to a process of selection and classification.

First result is one feature dataset in a database with a feature class containing the edges classified with all the attributes values of OpenStreetMap, BDTRE Regione Piemonte and Additional data *(Attachment C).* The DB then contains a Network Dataset, ortofoto at 10 cm realized by DIATI Department of Politecnico di Torino, junctions. Photos and videos taken using Garmin action cam and GoPro Fusion 360 proved to be crucial for the classification. Indeed, it is difficult to rely only on human memory when that process occurs in a second stage. On the other hand, the possibility of reviewing all the places contributed to classify in detail all the mapped routes.

Maps of *Figure 74* are six results of the cycling infrastructure's evaluation of the municipality of Mappano. Complete representation of data is in *Attachment D.* most of the cycle ways are shared-use paths *(Figure 74 b)* but maintenance status is mainly good *(Figure 74 d).* However, streetlight is almost absent as well as road signs *(Figure 74 a, e).*

Total length of the infrastructure resulted to be 15 km. As Table 12 shows most of them are outside of the urban centre but in green areas, Parco Europa and former "BorSetTo" area (*Figure 75*), emphasizing the recreational role that cycling plays in the municipality. Indeed, circa slightly more of one kilometre and half are inside the built-up area while remaining ten kilometres surround the agricultural fields of the municipal territory. The presence of such a big green belt is clearly a positive aspect for the community who can spend there their free time and making sport activity. Indeed, maintenance status of Parco Europe, expect for the bridges, obtained high

values during path valuation. The lack of connectivity and continuity of the cycling infrastructure is self-evident, but this thesis is confirmed by ArcGIS Network Analyst from which it is possible to generate route directions simulations through a customized network dataset *(Figure 76)*. It has been created from data of Municipality of Mappano and then used to generate routes and driving directions. Road links from OpenTransportMap were implemented adding mapped cycle ways and then classified following attributes values of OSM.

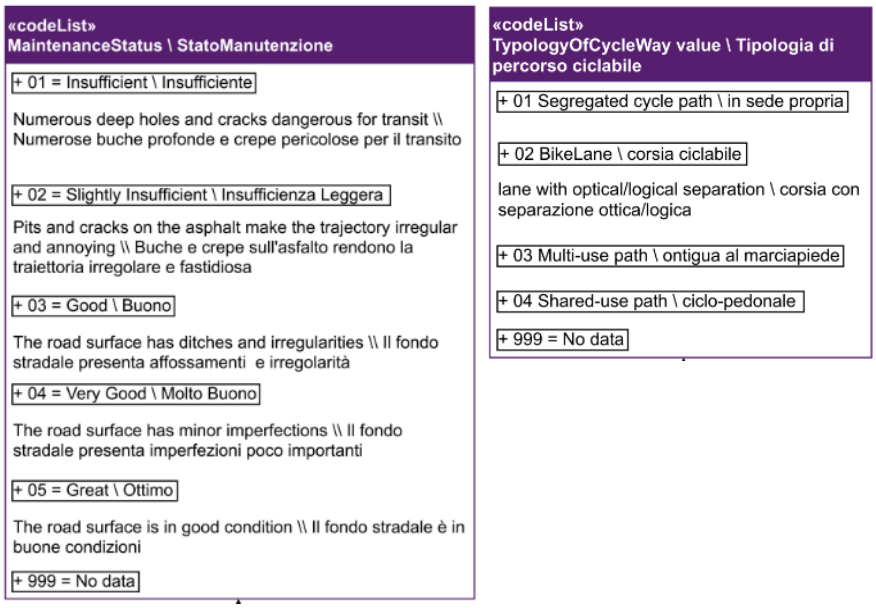
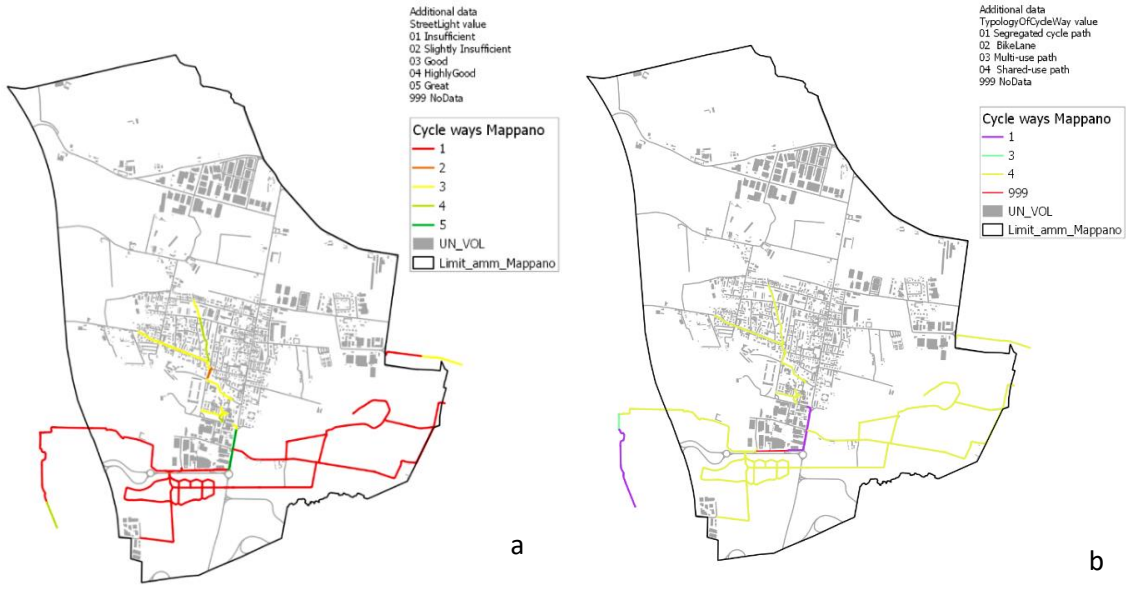


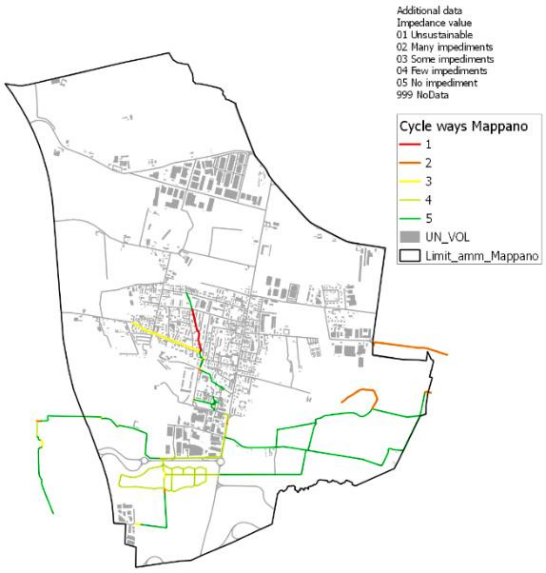
Figure 73. Attributes values of "Additional data" section (violet) and OpenStreetMap (green). While TypologyOfCycleWay and PavedRoadSurface are simple progressive numeric coded value, MaintainanceStatus has been thought with hierarchical values [source: author]



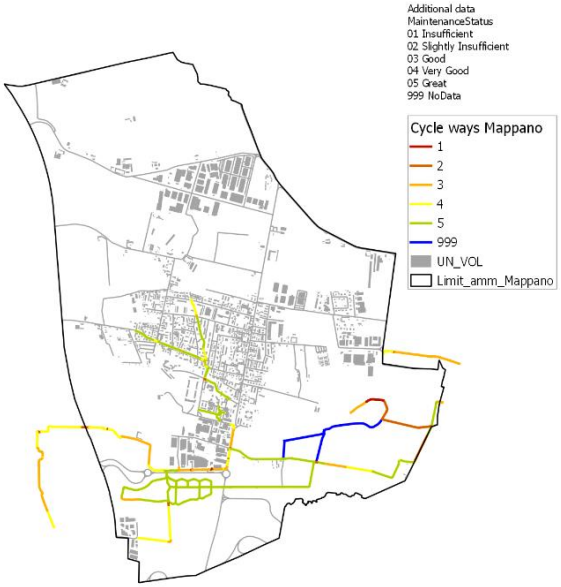
STREETLIGHT
1: Highly insufficient, 2: insufficient,
3: slightly insufficient, 4: good,
5: highly good

TYPOLOGY OF CYCLE WAYS
1: Segregated cycle path, 2: BikeLane,
4: Shared-use path, 999 NoData

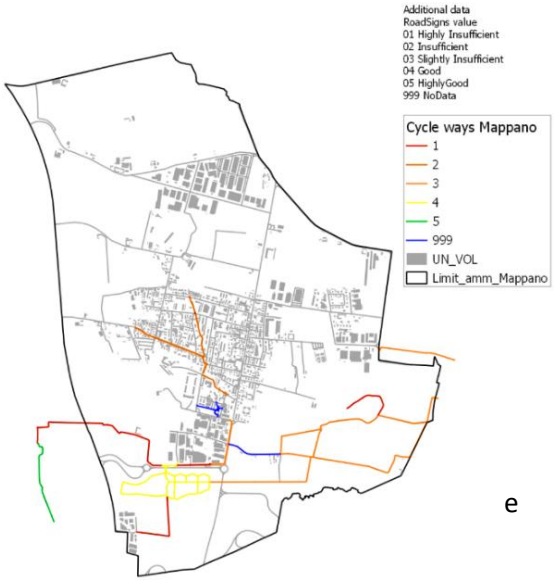
Figure 74. Six results of cycling tracks classification. Continue on next page....



IMPEDANCE STATUS
1: Unsustainable, **2**: Many impediments,
3: Some impediments, **4**: FewImpediments,
5: No impediment

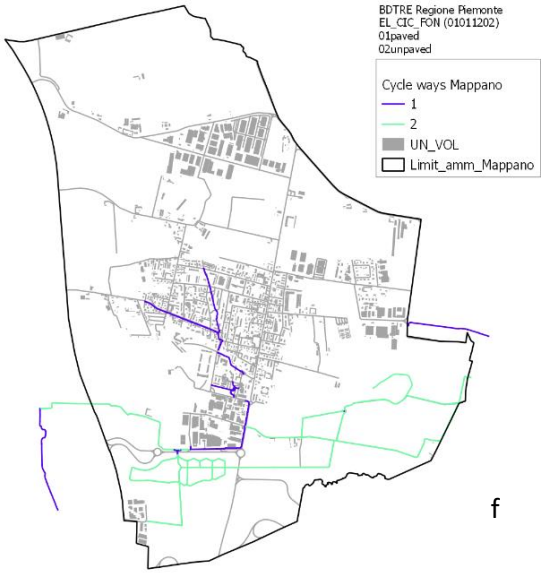


MAINTANANCE STATUS
1: Insufficient, **2**: Slightly Insufficient,
3: Good, **4**: Very Good, **5**: Great, **999**NoData



e

ROAD SIGNS
1: Highly insufficient, **2**: Insufficient,
3: Slightly Insufficient, **4**: Good,
5: HighlyGood, **999** NoData



f

EL_CIC (ELEMENTI CICLABILI)
1: paved, **2**: unpaved,

Figure 74. Six results of cycling tracks classification. It can be observed how most of the cycle ways are of shared-use type showing an infrastructure with a more recreational function than connectivity. [source: author]

TOTAL LENGTH OF CYCLE TRACKS (KM)	
Urban	1.64 km
Green areas	13.36 m
Total Mappano only	15 km
Borgaro T.se	1.40 km
Settimo T.se	671.3 m
Total	17 km

Table 12. Total cycle tracks' length in the municipality of Mappano

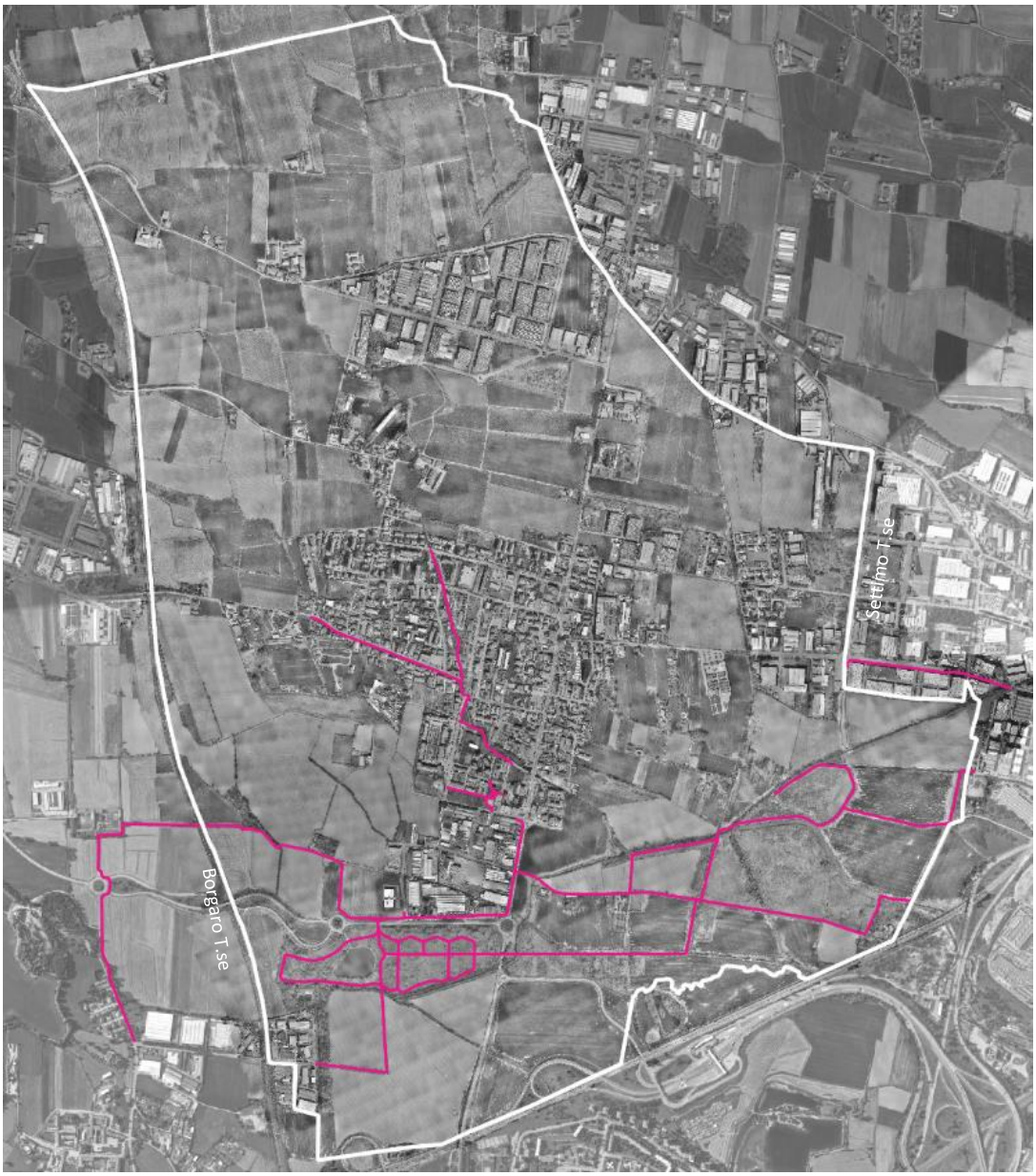


Figure 75. Cycle ways in the Municipality of Mappano are mainly distributed along the southern part where Parco Europa and other green areas are. [source: author]

> What you consider a barrier for me is a life saver. I feel safer with those since my kid can be blocked before jumping in the street.

These are the words in response to the analysis results *(Figure 72 a)* showed to the Municipality of Mappano. While they might sound harmless, really it explains the cycling perception of Municipality of Mappano. If the urban element of *Figure 72 a* is considered a life saver for kids instead of reporting the excess speed of the street cutting the cycle path and if no questions arose from the reason that brought to define that urban element as a barrier, urban cycling mobility in Mappano is perceived as a recreational activity. Continuity is one of the most important aspects to consider when planning and designing cycling infrastructures, hence, obstacles in the centre of the lane should not be planned. Better solutions might be interventions for motorised-vehicles' speed moderation through, for example, raised cycling and pedestrian crossing which force car and other heavy vehicles to speed down, and street sensors could be installed to light up cycling and pedestrian crossing when a person came close by. The response was not contested by anyone of the municipality which reveals an apparent car-centric urban planning opinion other than a recreational approach about cycling.

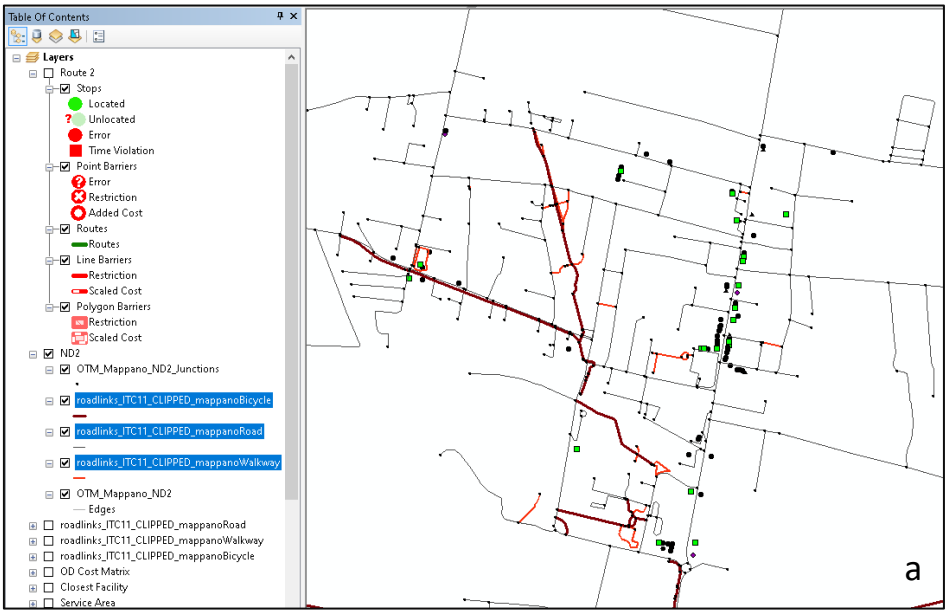


Figure 76a, 76b, 76c, 76d. Network Analysis of the cycling roads show the impossibility for cyclist to reach a destination along the main road (Strada Cuorgnè) remaining on a cycle path.
Fig. 76a shows road link classified by roads, bicycle, and walking [source: author]

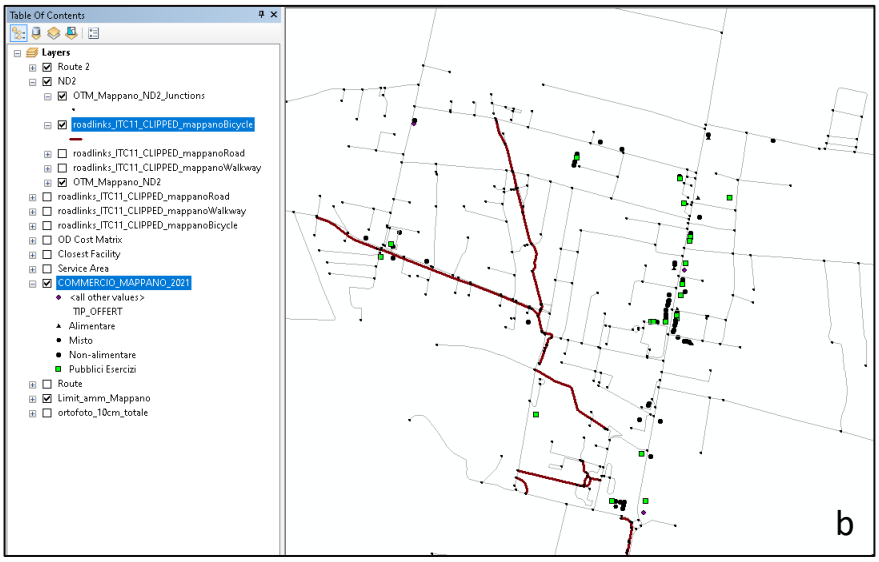
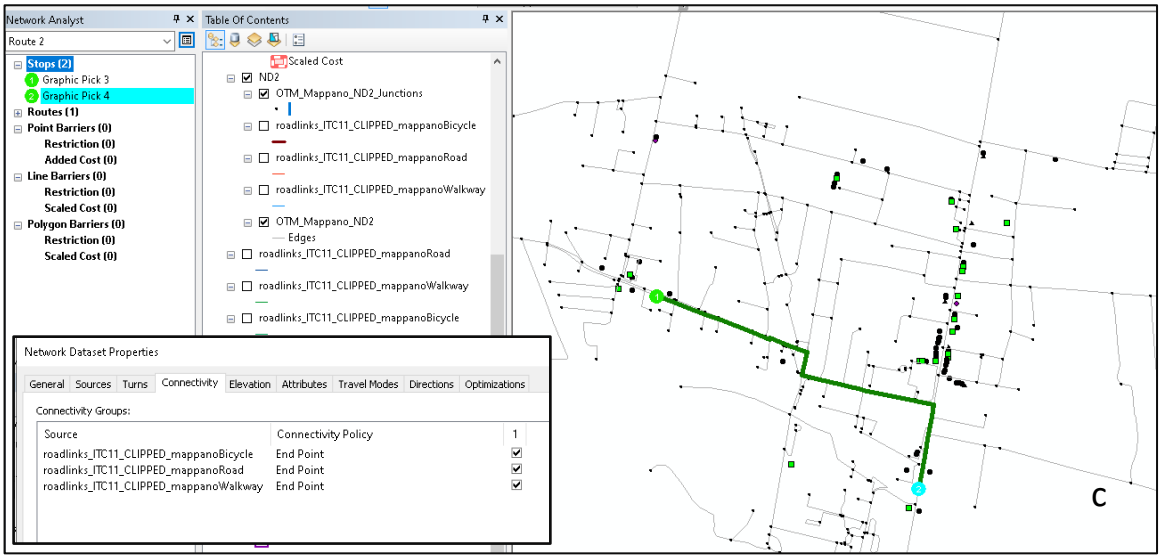


Fig. 76b is a focus on the distribution of cycle paths and local business. They do not interact expect for few businesses on the west.



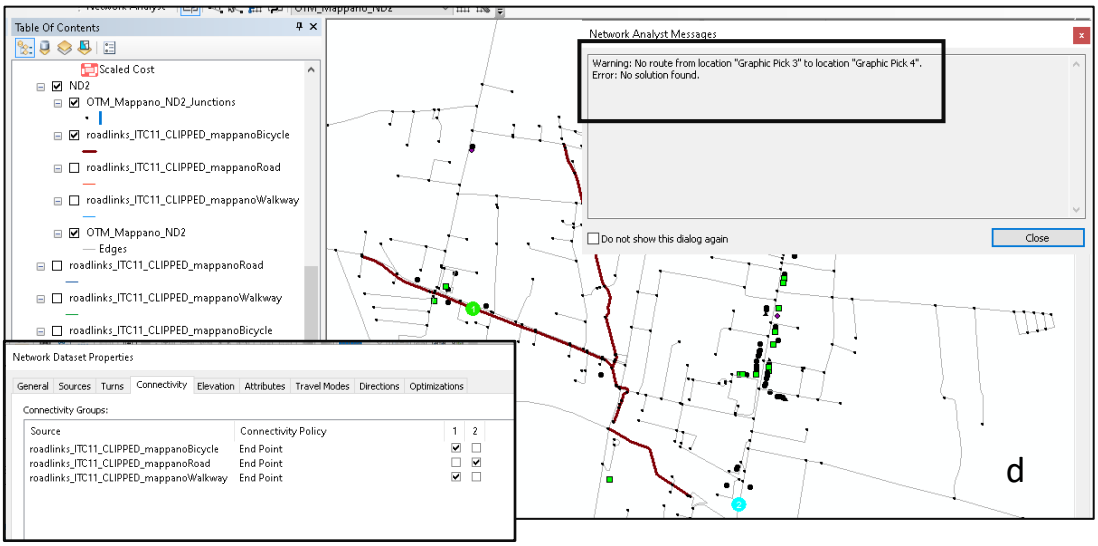


Fig. 76c.Directions and routes are generated when all roads are in the same level of connectivity, hence interacting with each other [source: author]

Fig. 76d. If Cycle ways and roads are in two different level directions are not generated since cycle ways have a lack of connectivity. [source: author]

Cycle paths' intersections evaluation (*Attachment D*) of the Municipality is reported on the maps *(Figure 77)*. The stretch along Via Borgaro that connects to Piazza Giovanni Paolo II is disturbed by numerous accesses to the residential buildings. Cycle-pedestrian crossing on Via Borgaro-Via Tibaldi is not raised but has a change of flooring which makes it more visible; a raised crossing would still be a better solution from a safety point of view. Via Rivarolo cycle path is also disturbed by numerous accesses to companies as well as a parking lot between the track and the entrances. Pedestrian crossing at Conad supermarket, Via Rivarolo 49, is not adequate but a suitable crossing is planned. Finally, the track up to the entrance of the Europa of the service road parallel to Via G. Galilei stops in the middle and enters the road, becoming a shared-use path between cars, trucks, and cycles. Since Parco Europa is a place frequented by the population, a higher quality as well as safer access should perhaps be planned. The crossings within the extension to the east of the Europa Park are instead assessed as safe (5 points) as they are mainly intended for non-motorized vehicles, service vehicles, and emergency ones.

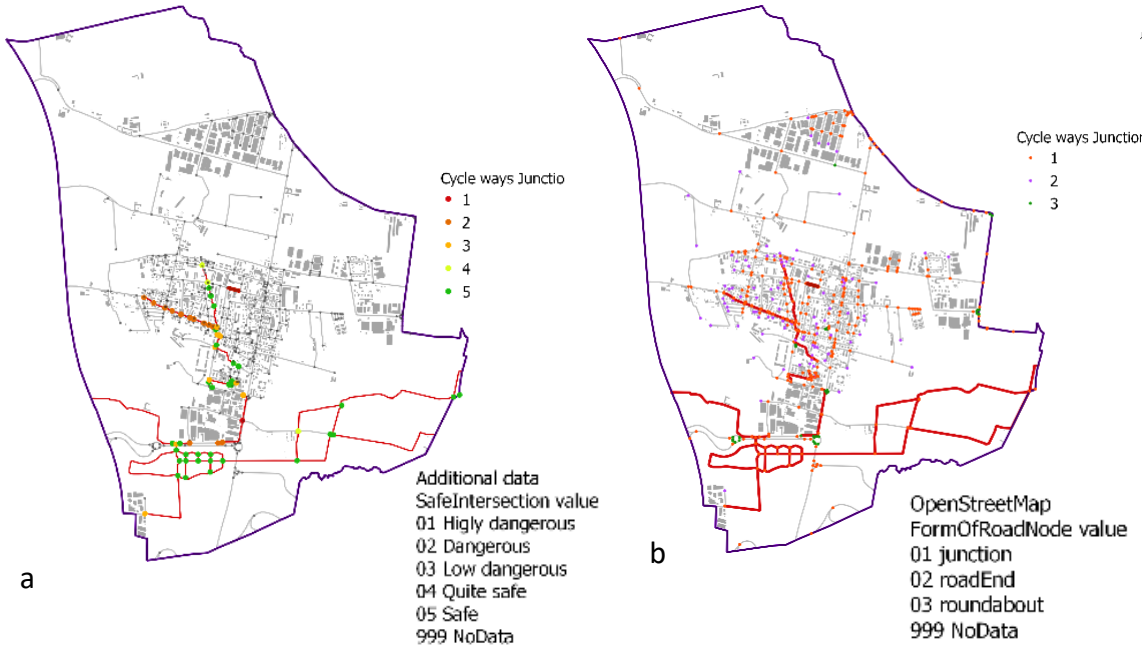
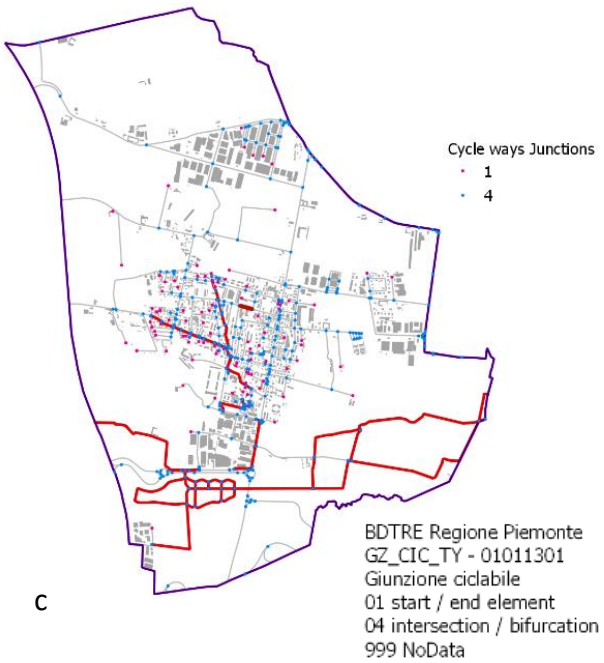


Figure 77a, 77b, 77c. Intersection's evaluation of cycle paths In the Municipality of Mappano.

77a. Level of intersection's safety
77b.OpenStreetMap, type of intersection
Continue on next page.....



c

Figure 77a, 77b, 77c. Intersection's evaluation of cycle paths In the Municipality of Mappano.

77c. BDTRE Regione Piemonte, type of intersection
[source: author]

5.7. Local Mappanese business: can cycle mobility represent an advantage for local economy?

A study conducted by the European Cyclist Federation (2016) showed that the benefits of cycling do not fall only in a specific field such as mobility and the environment, but in a much broader spectrum such as health and industrial policies, employment, and social policies (Deromedis, 2019). In fact, greater contributions are given by the reduced health costs due to a better state of physical health which count as about 191 billion euros of estimated savings per year, from shopping by bicycle for a value of 111 billion euros per year, from cycle tourism - 44 billion euros per year - from social repercussions - 50 billion euros per year-, and from cycling mobility due also to reduced congestion-30 billion per year (ECF, 2016) (Deromedis, 2019). ECF (2016) also touches on the issue of jobs and how at the current levels of cycling there are more than 650 000 jobs in the EU related to this sector.

A 2003 study by the French Cycling Federation and the French National Centre for Scientific Research (CNRS) supported by the French government found that cyclists and pedestrians spend more on shopping than motorists and passengers, dispelling the widespread belief that favouring more cycle and pedestrian mobility, compared to the car, leads to a reduction in sales (Deromedis, 2019). The study shows that motorists spend 54% of what pedestrians spend, while cyclists spend 60% of pedestrians, and users of public transport 56%. Therefore, motorists are in last place. It is estimated that in Europe the retail purchases of bicycle customers are over 111 billion euros per year (*Table 13*), which could increase if the bicycle modal share grows and in the case of Italy improvements would be even greater as its modal share is among the worst in Europe. Pedestrians, cyclists, and public transport users spend less money on per-visit purchases than motorists but demonstrate greater loyalty to their local vendors by visiting them on average 2 times, 1.3 and 1.2 times more respectively. Retail sales at roads with cycle path along, according to the New York Department of Transportation (Ivi, p. 31), increased by 49% compared to those along other streets in the same area (3% of growth). According to the Copenhagen experts, investments in bicycle parking spaces in Denmark generate a turnover four and a half times higher than those for car parks. This is because eight cyclists spend more than one car for the same seat occupied (Ibid.).

Finding the right arguments at the local level for investment to cycling mobility also remains crucial (Haubold, 2016). Indeed, this is the level where funds are spent and concrete decisions on cycling-friendly transformations of certain streets are made. Local administrations still have uncertainty about the benefits of cycling, and local retailers often fear that they would lose customers and turnover if more space is given to cyclists and pedestrians taking it off the cars. European Cyclist Federation spends itself strongly to demonstrate how these fears are unfounded by quantifying the greater amount of shopping by bike and how cyclist could be a source of growth for the local retail sector if the goal of reaching the double of the current modal share of cycling is achieved (Ibid.). Thus, it would be reductive considering cycling as a simple infrastructure and to adopt the same organizational model as other forms of mobility, such as road or rail. There would be a risk of creating a good infrastructure which does not produce the desired impacts as it has not been accompanied by adequate communication campaigns or does not meet the tastes of tourists, or even gets bogged down in the bureaucratic delays that usually accompany large infrastructures (Deromedis, 2019, p. 341).

The map in *Figure 78* wants to illustrate cycling path distribution in relation to the highest concentration of local retails, which are mainly along Strada Cuorgnè. The actual main square in which the weekly market resides is one of the main meeting points for the community hosting also the city Hall and many shops. Strada Cuorgnè is trafficked, and heavy vehicles pass through during the day creating a hostile environment for cycling. Trucks and bicycles can have problems living together along a shared road due to their much greater height which could lead to safety risks. Diverting that traffic category off the main road by evaluating an alternative route without extending the distance too much could be an idea solution, also due to the shape of the road which in that section has an apparently narrower section than others. This would create a slightly more favourable environment for pedestrians and cyclists favouring the local economy although there would still be the problem of all the other vehicles passing by in not insignificant numbers. More in-depth and specific studies should be made to the Municipality of Mappano to find customized solutions.

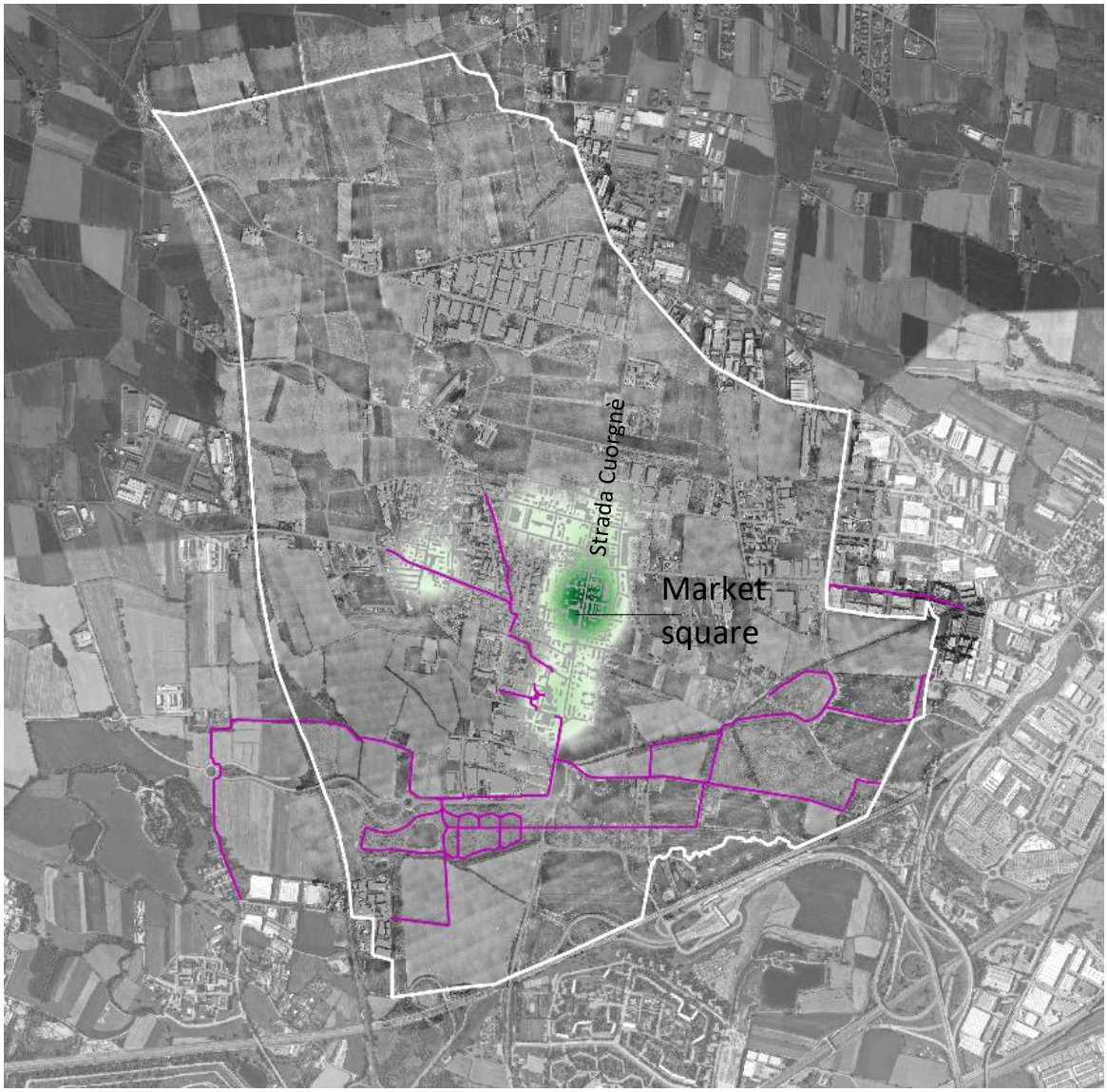


Figure 78. Heat map of local businesses in the Municipality of Mappano. It is evident how Strada Cuorgnè represent the road along which most activities are. [source: author]

COUNTRY	CYCLING MODAL SHARE	VOLUME OF SHOPPING BY BIKE (MLN EUR)
EU 28	**7.9%**	**111.476**
Belgium	13.0%	5.483
Bulgaria	1.9%	92
Czech Republic	7.1%	1139
Denmark	18.9%	4847
Germany	13.0%	36734
Estonia	5.0%	77
Ireland	3.1%	527
Greece	3.1	1129
Spain	1.9%	2509
France	3.1%	6910
Croatia	6.0%	419
Italy	5.0%	10788
Cyprus	1.0%	29
Latvia	8.1%	205
Lithuania	5.0%	258
Luxembourg	1.9%	49
Hungary	18.9%	1898
Malta	1.5%	18
Netherlands	31.0%	16442
Austria	8.1%	3011
Poland	9.0%	3912
Portugal	1.9%	353
Romania	5.0%	830
Slovenia	7.1%	357
Slovakia	9.9%	629
Finland	13.0%	2834
Sweden	17.1%	6102
United Kingdom	1.9%	3895

Table 13. Financial volume of purchases in 28 European countries based on the modal share of the bicycle [source: Deromedis, 2019 from ECF, 2016]

6. On urban design

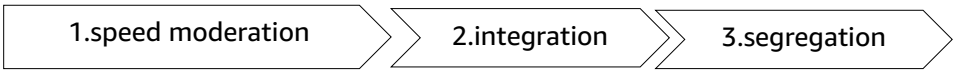
Before planning or designing a new cycle route, a reflection must be made on the organization of the space. It would be wrong to start immediately from the idea of designing a cycle path, since the equation: <<cycle infrastructure = cycle paths>> is not always correct. Indeed, the combination of different technical possibilities of using the space suitable for the specific situation is the most effective solution (Deromedis, 2019, p. 213). The quantity of cycling infrastructure is ever increasing but the average quality of what is provided is low. Many highway authorities still put most of their cycling budget into moving cyclists onto footways and other shared-use paths, which are problematic when cycling flows are over 600-1000 bike/hour since probability of colliding increases. Since on average a person on foot move at 5km/h and a bike could reach up to 30 km/h, if the accident happened there might be not negligible consequences although not statistically severe (Ivi, p. 83). New realities in cities require new design choices for public space and infrastructures. To do so, current logics must be critically assessed to fit with these changing needs (te Brömmelstroet, 2014). However, when "fair" distribution of road space is problematic, it might be fruitful to focus on traffic speeds since measuring the distribution of street speed limits might potentially offer a simple but useful measure of equity between different forms of transport (Nello-Deakin, 2019). This approach could lead to shared spaces at low speeds which might be more equitable than a city with high levels of traffic segregation (Ibid.). Practitioners should become more sensitive for the specifics of local context, which requires less modelling and more observation, less thinking big and more acting small and less rigidness and more flexibility and learning (te Brömmelstroet, 2014). Additionally, cyclists but also pedestrians cannot be seen as smaller versions of cars and therefore have a need for new and radically different metaphors. Otherwise, crucial mistakes are made in transplanting solutions from the car domain onto this new urban mobility challenge. (Ibid.).

The Municipality of Mappano has recently approved the project for the implementation of the cycle network inside the town and the extra-urban cycle path connecting Leinì, Mappano and Torino. Leinì already has its part since some years

but the first part of the path that will be realised is the one connecting Mappano to Torino Stura train station. The quote below is the description of the definitive project:

> The overall route of the project network is divided into a main route and a series of secondary branches. The secondary network is instead designed for internal mobility in the town, in fact, the various sections will connect the main points of interest and services present in Mappano, including, for example, schools, churches, cemetery, oratories. The network has been divided into fifteen homogeneous sections, by characteristics or type of path, which constitute the backbone of the cycle network, for a total of about 8 km of tracks; 2.1 km already exist, while 5.6 km are newly proposed. The main interventions that will be carried out along the route are the redevelopment of the existing damaged road surface when a cycle path already exist, the partial demolition and extension of the existing sidewalks for shared-use paths between cyclists and pedestrians, the construction of a cycle lane on the carriageway, where there are no sidewalks or do not have suitable road sections space for hosting a cycle path and finally the construction of new paths where there are no sidewalks or road embankments suitable for hosting the track.

Key principles of attractiveness, directness, capillarity, clearance, safety, readability, and wayfinding have been used for the design of the project. Still some considerations might be done. Most of the routes have been designed to be built on the sidewalks. In "the manual of cycle paths and cycling routes" S. Deromedis (2019, p. 83) explains how in urban environments this a design choice is to be evaluated on a case-by-case basis, but which should generally be avoided by separating cycle users from pedestrians. In extra-urban areas, on the other hand, generally with low pedestrian flows, the choice of promiscuity is allowed. However, it is important to underline that traffic moderation interventions should be privileged by designing integration solutions - such as cycle lanes - or separation interventions - as segregated cycle paths- along the most dangerous roads only, therefore when the previous solutions are not feasible. The most important variable in the choice of the various types of intervention is the speed difference between the vehicles, indeed, safety between cyclists and motor vehicles that move promiscuously with speed differences of less than 30 km/h is possible (Ivi, p. 84).



A segregated cycle path requires the availability of important spaces and funding, so it must always be checked in advance whether moderation or integration solutions are possible (Ivi, p. 213).

Article No. 142 on "Speed Limits" in Highway Code, Title V, of the D.Lgs No. 285/92 establishes the circulation limits of vehicles on the basis of the road category and type of means of transport. Paragraph 1 says:

> art. 142, paragraph 1 [partial]
> For the purposes of traffic safety and the protection of human life, the maximum speed cannot exceed 130 km/h for highways, 110 km/h for main extra-urban roads, 90 km/h for secondary extra-urban roads and for local extra-urban roads, and 50 km/h for urban and local roads in built-up areas, with the possibility of raising this limit up to a maximum of 70 km/h for urban roads whose construction and functional characteristics allow it, after installation of the appropriate signals.[…]

Until last year Italian Highway Code limited urban speed to 50km/ and in particular cases set the limit to 70 km/h. European studies such as the one carried out by the European Commission in 1999 " *città in bicicletta, pedalando verso l'avvenire*[24]" of which Deromedis (2019) reports the results, show how, depending on the speed, effects, spaces and response times change substantially, passing from 30, 40 , 50 to 70 km/h and how death probability passed from zero - at 30km/h -to 90% - at 70 km/h. In 2020, Italian "*Semplificazioni*" Decree-law No. 76/2020 converted into Law No. 120/2020 introduced measures for road safety and "Urgent measures for simplification and digital innovation." It set "urban cycle road" (*strada urbana ciclabile*), a new type of urban road inside official road classification. It is defined as a << single carriageway, with paved platforms and sidewalks, with a speed limit not exceeding 30 km/h, defined by special vertical and horizontal signs, with priority for velocipedes>> (art.49, L. 120/20). In fact, talking about sustainability by promoting the construction of cycle paths but leaving the speed limit, in an urban setting, at 50 km/h or even 70 km/h means continuing to contribute to the growth of the polluting model from which societies are trying to escape. Traffic calming solutions, limiting speed at 30 km/h produces positive effects on the safety of users but also on the environment (European Commission, 1999). It has been shown that low speed limits also reduce pollution as it is a function of speed.

[24] city on a bicycle, pedalling towards the future

Reading the project, most used solution is the creation of cycle- pedestrian paths on sidewalks, replaced by a cycle lane when no sidewalks are present and only as a last option the establishment of zones 30 is considered. It is necessary to underline that there are numerous interventions of raised crossings. However, there are many techniques of speed moderation, and their combination is perhaps the key to designing successful interventions. Traffic calming was born in 1971 in the Dutch city of Delft at the urging of the inhabitants as a response to the numerous accidents caused by the excessive speed of cars and then quickly spread to Europe. It arrived in Italy in the 1990s. Among the infrastructural solutions there are "Zone 30", roads or residential areas, pedestrian areas, slow-motion bumps, altimetric offset, central reserves, deviation of trajectory, access gates, mini-roundabouts, moderate intersections, protected crossings *(Figure 80, Figure 81)*. Finally, all those intangible traffic moderation actions such as paid parking, improvement of public transport service, entrance fees in the most sensitive areas of the city, the installation of speed control systems and compliance with the rules of the road *(Figure 82)*. It is, therefore, possible to obtain more results with these more political than technical choices with lower costs of infrastructural interventions. For example, Deromedis (2019) recalls the introduction in Italy of the points driving license which resulted in a 20-30% reduction in road accidents after only three months of entry into force.

In most cities separated bicycle paths are considered as the goal standard. The Dutch apply the concept of "*ontvlechten*" which means disentangling. Free for all roads strongly encourage driving which induced car traffic leading to streets congestion. Greater distances discourage walking or cycling encouraging car dependency. The Netherlands takes a different approach, limiting the access to cars (*Figure 79*).

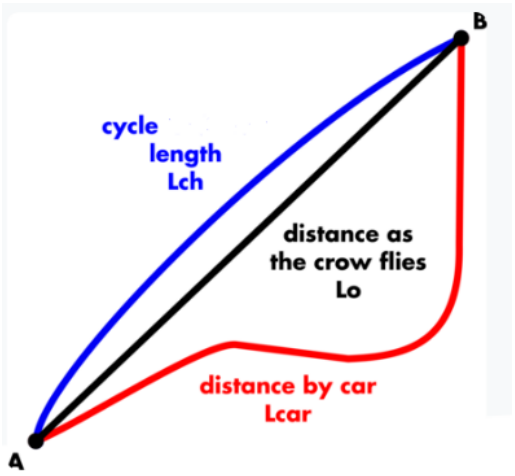


Figure 79. For creating an attractive alternative to car trips, directness can also be considered in comparison to the car route. Cycle path should offer more direct connection than the route for cars. [source: cyclehighways.eu]

There is a conscious effort to separate or disentangle some routes from car. Dutch cities have a "*Hoofdnetten*" Plan for public transportation, bicycles, car, and walking. "*Hoofdnetten*" or the main networks is the design of different roads for different types of traffic. In Amsterdam they have created also a "*plusnetten*" indicating which mode of transport has priority over others. Hence, for example, one lane of car could be removed to make space for bicycles and tram (Slaughter, 2020).

A separate network plan by vehicle type can be a way to ensure that cycling infrastructures are inclusive for all. This aspect is particularly relevant when referring to people with disabilities. Indeed, a large part of this population category does not get to enjoy the benefits of cycling because of non-inclusive cycling infrastructures (Wheels for Wellbeing, 2019). Urban design, therefore, could intervene after the whole process of analysis and evaluation of the cycle paths of the previous chapters (chapters 4 and 5) to ensure connectivity and the removal of architectural barriers that prevent people with reduced mobility or no mobility from autonomously taking advantage of cycle infrastructures with. However, <<knowledge needs to be developed about the needs of all groups of disabled cyclists, not only (for example) wheelchair users.>> (Andrewsa, Clement, & Aldred, 2018). When it is not possible to create segregated paths, traffic moderation interventions will have to be carried out so that the level of safety perceived by users is such as to encourage them to pedal even along roads without dedicated cycle infrastructures.

CHAPTER 6. ON URBAN DESIGN

DESIGNING STREET SPACE: SPEED AND TRAFFIC MODERATION, INTEGRATION, AND SEPARATION INTERVENTIONS

SPEED AND TRAFFIC MODERATION

Zone 30

WHERE
Individual roads or urban areas
ALTERNATIVES
Zone 20 or Meeting Zones. No traffic lights and crossings only the right of way rule
It is the simplest, cheapest, and most effective measure of restraint.

||Fig. II 323/a and 323/b art.135 DPR 495/92||

Application examples

A, B. SESTO FIORENTINO, FI (2021)

Residential zones or streets

WHERE Individual roads or urban areas
Residential areas allow the creation of high-quality urban spaces in which pedestrians, cyclists and motor vehicles move on the same site with equal rights. The speed limit is 10 or 20km / h and access is restricted to certain vehicles such as those of residents.

||Fig. II 318 and 319, art. 135, paragraph 12 DPR 495/92||

Application examples

A, B, C. FREIBURG IM BREISGAU(2018)

Pedestrian areas

Pedestrian areas are areas off-limits to the circulation of vehicles, except for those in emergency service or subject to derogation such as cycles. The exceptions must be reported on the supplementary panel, in fact, the establishment of a pedestrian area without exceptions constitutes an intervention of separation and not of traffic moderation.

||Fig. II 320 and 321 art.135, DPR 495/92||

Application examples

A. PIAZZA IV NOVEMBRE, SESTO FIORENTINO, FI (2021)
B, C, D, E. FIRENZE. (2021) VIA DEGLI STROZZI(B), VIA DE'MARTELLI (C), VIA DE' CERRETANI (D), VIA DEI PECORI (E)

Figure 80. Speed moderation interventions could be considered as less expensive solutions for the creation of safe environments where non-motorised and motorised vehicles could share street space. [source: author]

CHAPTER 6. ON URBAN DESIGN

DESIGNING STREET SPACE: SPEED AND TRAFFIC MODERATION, INTEGRATION, AND SEPARATION INTERVENTIONS

SPEED AND TRAFFIC MODERATION

Speed bumps

Speed bumps are traffic calming devices using vertical deflection of road pavement, they have the purpose of slowing down vehicles' speed; they are the only slowing-traffic devices explicitly provided for by the Italian regulations in article 179 of Presidential Decree 495/92. They can only be implemented on roads where speed limit is lower than or equal to 50 km / h, on residential streets, in public and private parks or in residences. The bumps must be highlighted with yellow and black zebra stripes and have dimensions according to speed limits. Speed bumps represent major aesthetic problems of noise, disturbance for cycling circulation, and management especially in the presence of snow and ice.

||Fig. II.2 art. 85, DPR 495/92|| also used to indicate a convex elevation anomaly of the road

Application examples

A, B, C. SESTO FIORENTINO, FI(2021)
A. VIA UGO BASSI
B,C. VIA F.LLI ROSSELLI

Speed tables

Speed tables constitute an improved evolution of the speed bumps and are flat-topped to create, for example, raised crossings or raised intersections. The design of the speed tables must comply with the traffic code signage rules and the prescriptions on the geometric characteristics of the roads. The height offset must have a trapezoidal shape and ensure the safety and comfort of the users.

Application examples

A, B. SESTO FIORENTINO, FI(2021) A. VIA DEL RISORGIMENTO; B. VIA UGO BASSI

Median island

They can be of three types: insurmountable like traditional traffic dividers; surmountable with horizontal signs or material change; if semi-surmountable they are a middle ground between the previous ones as they can be overcome at low speeds. The traditional traffic divider, compared to simple signs, is very effective but has the defect of creating a tunnel effect increasing speed and the possibility of congestion in the event of accidents and vehicle breakdowns. The semi-surmountable traffic dividers are less rigid and easier to insert on existing roads as they can be easily passed by vehicles albeit at reduced speeds, allowing the possibility of guaranteeing turns for side accesses.

Application examples

A, B. FIRENZE (2021)
A. VIA DI CACIOLLE
B. VIA DE PERFETTI RICASOLI

Figure 81. Speed moderation solutions: speed bumps, speed tables, and median island are intervention intended for slow down motorised vehicles along intersections and at pedestrian crossings. [source: author]

CHAPTER 6. ON URBAN DESIGN

DESIGNING STREET SPACE: SPEED AND TRAFFIC MODERATION, INTEGRATION, AND SEPARATION INTERVENTIONS

SPEED AND TRAFFIC MODERATION

Chicane

They are a series of curves in sequences, of opposite directionality and of contained radius, which are usually positioned in the middle of a long straight or near a dangerous section with the function of slow down vehicles' speed. These are very effective devices for safety purposes when combined with a pedestrian or cycle crossing, especially at the entry points and an urban agglomeration or neighbourhood. They are still little used in Italy if not even opposed.

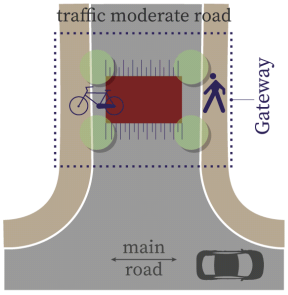
Application examples

A, B. SESTO FIORENTINO, FI(2021) A, B. VIALE PALMIRO TOGLIATTI

Gateway

Gateways are traffic calming interventions that mark the entrance from a main urban road to a moderate traffic zone. They consist of elements aimed at emphasizing the concept of threshold through the combination of some measures such as: raising surface road facilitating pedestrian and cycle crossing; carriageway narrowing; horizontal and vertical signs; urban furniture of various types and plant species.

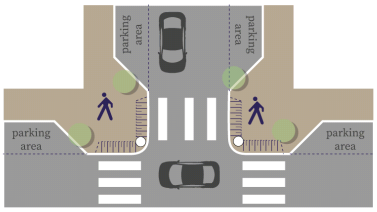
Scheme



Dedicated intersections

Moderate intersections are intended to protect weaker users near intersections which are notoriously the highest risk areas.

Application examples



Mini roundabouts

The mini roundabouts are urban roundabouts with a small diameter, that is between 14 and 25 m, characterized by the central circular island that can be partially or completely crossed and where the mixing of bicycles with motor vehicles is acceptable. In mini-roundabouts with an external diameter between 18-25m the central island is partially passable, while in those with an external diameter between 14 and 18m it can be completely traversed.

Application examples

A, B. SESTO FIORENTINO, FI(2021)
A. VIA XX SETTEMBRE
B. VIA DEGLI ARTIERI

Figure 82. Speed moderation intervention could be introduced in several environments starting from residential areas, where traffic speed should be slow. Most of the accidents happen at intersections hence particular attention should be paid there. [source: author]

CHAPTER 6. ON URBAN DESIGN

DESIGNING STREET SPACE: SPEED AND TRAFFIC MODERATION, INTEGRATION, AND SEPARATION INTERVENTIONS

SPEED AND TRAFFIC MODERATION

Protected crossings

The most classic solutions of protected crossings are raised crossings, a narrow lane with a life-saving island and advanced sidewalk. Traffic calming techniques can also be used in combination, for example, it is possible to make a raised crossing together with a curb extension (chicane).

A, B. SESTO FIORENTINO, FI(2021)
A. VIA PISA
B. VIA DEL RISORGIMENTO

Application examples

Intangible traffic moderation actions

Intangible traffic moderation actions are **political non-infrastructural interventions aimed at reducing traffic and vehicle speeds.** These give much more effective results than infrastructural ones **at much lower costs**. Preventive policies to reduce mobility are policies **influencing mobility demand** and are the most effective ones, since **they aim at creating the necessity to move less or not move at all**. "Air pollution and urban structure linkages" study by OECD (Organisation for Economic Co-operation and Development) shows that continuous urban areas are characterized by a more **compact urban fabric improving connections, reducing travel needs and dependence on cars**. Policies to facilitate the use of non-motorized vehicles are, for example, **limited access in cities** to the most polluting vehicles, or **abolition of free or unlimited public parking**; more **widespread and faster telematic networks**. Even in the transport of goods it is possible to implement preventive policies.
Only when mobility is necessary policies should increase mobility, however, orienting towards a sustainable mobility offer. **Private vehicles**, **although electric** and therefore with a low environmental impact, are less effective than alternatives to car. They reduce emissions' problem, but they **do not solve traffic congestion and the problem of urban space occupation**.

Application examples

A. SESTO FIORENTINO, FI(2021). LIMITED TRAFFIC ZONE.
B. AMSTERDAM (2017)

Figure 83. Filtered permeability is part of urban design intervention which applied the concept of filtering out through car traffic on selected street. This creates more attractive environments. Indeed, low carbon emissions vehicles neither solve congestion problems nor space occupations of cars. [source: author]

7. Conclusions

This thesis has tried to use geomatics to map not only the quantity but also the quality of cycle infrastructures with the aim, therefore, of knowing something more than just the single number that can be published on the website of a municipality in the sustainable mobility section. The video equipment was of enormous usefulness as well as the bicycle which allowed to move in total freedom reaching every place. Probably a traditional bicycle with two wheels could provide more flexibility regarding the choice of the route but the convenience of a cargo bike, which allows to carry additional tools, is undoubted. The evaluation work was based on a customized data infrastructure made by two official DB structures (OpenStreeMap and BDTRE Regione Piemonte) and a new additional section. If this data infrastructure were implemented through an application also easy to be used by the population, it could prove to be a useful tool for administrations so that the management of cycle infrastructures is facilitated and updated in a very short time. It is important that the maintenance level of the roads is good, especially along the sections on which non-motorized vehicles move. Good connectivity and excellent road surface can entice potential users to try and eventually switch definitively to the use of non-motorized vehicles for their daily and non-daily journeys. These aspects are essential to break down the barriers encountered by users with disabilities, too often excluded from the discussion on non-motorized mobility. This part of the population has an equal right to benefit from the positive effects of cycling. Therefore, the customized created data infrastructure could also be used to assess the level of accessibility for these people. For this reason it is important to carry out simulations through, for example, the creation of a network dataset (*Figure 76*) to understand if the existing paths, lanes, cycling-related interventions are coherently connected and if they link areas of the city with more services.

A step further could be the calculation of the "Cyclability index" with the attribution of weighted values allowing the municipality to understand how much cycling is currently considered and how positive effects might derive if it is improved.

Working at this thesis has strengthened the idea of how much speed, hence motorised vehicles, affects the urban form of the city and people's lives. It would be interesting to further research on the implementation of cycle infrastructures without the creation of traditional paths but through a whole series of moderation and possibly integration interventions. This is because by continuing to implement

segregated cycle paths without combining them with effective speed moderation interventions, the risk is to create an environment made of segregated spaces where the lack of interaction between all means of transport and no permeability between roads could result in the increase of accidents. Another reason why moderation may prove to be a better solution than separation is the positive effect it could have on users with reduced skills. Existing Italian roads are on average of dimensions that do not always allow the creation of a segregated cycle paths, and the existing paths are of dimensions that do not allow users with larger cycles than the traditional bicycle. A shared-use road space would create a safe environment where all vehicles can move with greater freedom also for the benefit of cargo bikes for the transport of objects or people and tricycles.

In addition to cycle infrastructures mapping, it would certainly be interesting to be able to understand the movements that citizens and city users make using the bike sharing service. Indeed, companies providing these services are owners of extremely useful data for urban planning since they would allow to know how people move where, when and for how long. It would also be interesting to understand how much people nowadays travel for free time as well as for home-school/work trips. In fact, as reported by the fourth ISFORT Report of 2019, free time covers an important slice of the movements of Italians, and this could therefore lead to innovations in the way of thinking about urban planning as it would no longer be a question of daily journeys but non-repetitive ones. Data availability is essential for rationally planning with the context in which the infrastructure must fit. For this reason, it is necessary that the data on the modal share of the bicycle increase to better understand the categories of people who pedal, not only men and women, also people with disabilities.

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ATTACHMENTS