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Bikeways and cycling urban mobility

Hernán Gonzalo-Orden[a]*, Alaitz Linares[a], Lara Velasco[a], José María Díez[a], Marta Rojo[a]

[a]*Universidad de Burgos, C/ Villadiego, s/n, Burgos - 09001, Spain*

Abstract

During the past years, cycling use has been promoted in our cities as an alternative to other modes of transport. One of the main objectives of the utilization of the bicycles is to reduce the use of private vehicles powered by fossil fuel. In this paper some of the advantages and benefits of the cycling use are presented, and some factors that influence its utilization are analysed. In particular, the study is focused on the barrier elements and, more specifically, in the structural barrier factors. Further on, more than 70 kilometres of bicycle network in several cities of the region of Castile and Leon (Spain) have been analysed, in order to see their potential influence on the use of the bicycle. From the results of this analysis some recurring problems emerge and make us identify that the total length of the bicycle network is not so important as the number of destinations and completed itineraries that can be reached in an effective and safe way.

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Keywords: cycling; sustainable mobility; urban mobility

1. Introduction

During the past years, the cycling use has been promoted in Spain as a new mode of transport in urban areas. During many years in the past, our cities were transformed in order to facilitate the use of the private vehicle. As a result of this massive use and the rising motorization rate, which reached its maximum value in 2007 with 481 vehicles per 1000 inhabitants, our cities suffer nowadays problems of congestion, saturation of public areas, contamination and noise. The changes for increasing the capacity of the roadways used by private vehicles are more expensive to build and carry greater sacrifices.

* Corresponding author. Tel.: +34-947-25-90-72; fax: +34-947-25-94-78.
E-mail address: hgonzalo@ubu.es

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In high-density areas and for short distances, the car is an inefficient and unsustainable mode of transport. Cycling, together with public transport and walking are the main components of sustainable mobility. However, in many cases, public transport cannot satisfy the mobility needs of citizens: too complex and varied. Its timetables, frequencies, routes… do not always fit the mobility needs. Because of these problems, cycling is rising its proportion in modal split, especially for short trips, where its benefits make it one of the best alternatives.

2. Advantages and benefits of cycling

In order to achieve a more sustainable mobility in our cities it is necessary to bear in mind the bicycle as an essential mean of transport. In urban trips, the bicycle joins the advantages of the private vehicle and the public transport. Cycling presents the vantages of the private vehicle (mostly powered by fossil fuel) at the time of its high average door-to-door speed, freedom of timetables and flexibility in terms of itineraries. As well, presents the vantages of the public transport at the time of economic and environmental benefits, as it is a type of transport with an affordable cost and helps to reduce pollution by not using fossil fuels and no generating any noise. Other nonspecific advantages are that the overall duration of trips is often predictable, that it can be used in a very wide range of ages and, as walking, it not only improves the health of its users, but also for the rest of the inhabitants of the city, by reducing the number of trips in other more contaminants modes.

There is no clear agreement among experts in the field in order to analyse or divide bicycle benefits. Following the criteria of Sanz, Pérez Sanderos & Fernández (1996), IDAE (2007) and Monzón et al. (2010), Authors divide benefits into energetic, environmental or other types.

2.1. Energetic benefits

The bicycle is the most efficient mean of transport in energetic terms. Wilson (1973) presented a comparison of the energetic efficiency of different animals and machines by analysing the consumption of calories per gram and kilometre. This study demonstrated that travel by bike is five times more efficient than walking. However, this difference is shortened if we consider the energy consumption of the building and maintenance of infrastructures for cycling and their life cycle, i. e., the energy required to produce and repair them and manage their elimination.

Still, bicycle has a centesimal power use if we compare it with the car (Sanz, Pérez Sanderos & Fernández, 1996). Regarding its manufacture process, Hudson (1978) indicated that the energy consumed in the construction of one car would allow producing more than 70 bicycles.

It is clear that transferring private car users to cycling involves significant energy savings. Currently most of the energy used to transport people and goods comes from imported petroleum of third countries. So, its reduction would bring us both economic and environmental benefits.

2.2. Environmental benefits

Nowadays we are more aware of the environmental degradation of our cities. Unfortunately it is increasingly common to see news about big cities like Paris, Milan, London, Turin, Beijing... which have to restrict private vehicle traffic in order to reduce concentrations of hazardous substances in the atmosphere. The quality of life in the cities is being deteriorated due to the air pollution and the noise.

The main air pollutants associated with road transport are, Greenhouse gases (GHG), Carbon monoxide (CO), Non-methane volatile organic compounds (NMVOC), Nitrogen oxides (NOx), Total suspended particulate (TSP), Sulfur dioxide (SO2) and Ammonia (NH3).

Their toxicity and environmental impact, in addition to the production of acid rain, impact on the ozone layer, contribution to global warming... affect the health of people in urban areas.

The European Commission has been warning of the problem of air pollution and its consequences and, therefore, some regulations have been adopted, such as Directive 2008/50/EC (EC, 2008), where some measures were established to encourage increased cooperation between Member States to reduce air pollution. In a similar way, the governments of the Member States have developed their own regulations about the improvement of air quality (R.D. 102/2011, 28th January, BOE, 2011, in Spain). These concerns should not be taken lightly, as the European

Commission reminds us that air pollution causes more than 350,000 premature deaths, about 16,000 of them occurred in Spain (IDAE, 2007).

In Spain (CNE, 2013), transport CO_2 emissions did not stop growing until 2007. Emissions in 2007 were over 93% higher than in 1990. From 2007 to 2012 these emissions have been reduced from 97,540 to about 76,361 kilotons as a result that in the same period it has also been significantly reduced fuel consumption. The emission of various pollutants (CO, NMVOC, NOx, SO_2, NH_3...) is decreasing for several years due to the different standards adopted, the requirement to install catalysts, fuel improvement (sulfur adding prohibition in gasoline), technological improvements in vehicles, etc. But while global emissions decline in many parts of the big cities, recommended or regulated limits are often exceeded throughout the year.

In addition to emissions must be considered the traffic noise supported in cities. Spain is one of the noisiest countries in the world and the excessive noise, like emissions, affects the health of its citizens.

The IDAE (2007) indicates that the promotion of cycling in detriment of private vehicles would help to improve the quality of cities, because the bikes:

- Do not use fossil fuels (non-renewable resources).
- Do not emit air pollution.
- Do not produce any noise.
- Have a very sustainable life cycle (manufacture, repair, end-use, etc…).
- At the end of their life they are very easy to recover and reuse.
- Need little surface to circulate.

Therefore, the transfer between users of private vehicles to the bicycle brings significant environmental benefits.

2.3. Other benefits

In addition to the energy and environmental benefits, cycling brings other benefits such as:

- It is possible to learn how to use it in a short time.
- Age is not a very important limitation.
- The purchase price of a basic bike (enough for urban mobility) is not a limitation. The same applies to the cost of operating and maintenance (for example in the case of public bicycle).
- Helps to maintain and improving the physical health of its users.
- Is not usually severely affected by traffic congestion.

3. Barriers / motivations in the use of bike

In recent years the number of bicycle users has increased. Two major factors that are driving this change, usually referred by its users, are health and cost. Monzón et al. (2010) indicate that the users have expressed other motivations of using this mode of transport which are speed, efficiency, ease to use, flexibility, ecology, needs small amount of space, fun and healthy. Some of them are clarified:

- Speed. For A to B trips the bicycle is not affected by congestion, and presents a good average speed in the city.
- Efficiency regarding the energy consumption.
- Flexibility. No limitations of schedules, routes, destinations and parking.
- Healthy. Walking or biking regularly keeps fit, helps to reduce the problems of obesity and risk of coronary heart disease.

Regarding cycling barrier factors, the PROBICI Guide (Monzón et al., 2010) classifies them as:

- Social-demographic factors. Such as age, family size, level of income, availability of car and bike, gender...

- Direct observable factors. They can be subdivided into: personal factors (travel time and travel distance, type of rider), environmental factors (weather, orography) and structural factors.
- Subjective factors (rider). The perception of risk, traffic and lack of habit.

This paper has focused on the second group, the direct observable factors.

The distance (and time) travel in urban areas is usually in most trips less than 5-6 km (about twenty minutes). Above these values, for many people, bike is not anymore as an alternative.

Velasco et al. (2012) show that depending on the type of user, some barrier factors may be more or less important or even not be perceived as real barrier factors.

Among the environmental factors, the weather is the most complex. This is seen differently depending on the type of rider. A regular or frequent rider will appreciate it as a lower barrier than an occasional cyclist. A clear example of this situation is shown in many countries of the European Union where with a more unfavorable climate, bike modal percentage is still high. The wind, the precipitation and the extreme temperatures are traditional barriers to bicycle use, especially when they appear together or combined with other factors. Similarly, the rapid changes in the weather throughout the day affect its everyday use.

Another limiting environmental factor is the orography. Usually bikers tend to take a little longer and plain itinerary than a shorter and steeper one. This factor is a lower barrier than the previous ones.

Finally, other environmental factors affecting the use of bicycle are pollution and noise. These often are not considered because they are equally encountered by all users and are only evident in some period of the year, when they are high. But the reality is that they can limit the choice of the bicycle as transportation.

The last group of direct observable factors is the structural factors group.

4. STRUCTURAL FACTORS

The structural factors considered are the cycling networks and the auxiliary facilities such as bicycle parking and changing rooms.

4.1. Cycling networks

Bicycle networks should be designed and built to meet, as best as possible with the following criteria: security, connectivity (evidence of a real network), accessibility, direct, attractive, comfortable and integrated with the public transport system.

All networks must have as a basic requirement to be safe. Linares et al. (2009) fixed various aspects to be controlled regarding minimum widths, pavement, safeguards respect to the road, parking, curbs, urban furniture… to reduce the risk in the bike lanes.

In areas where the bike coexists with other users, a similar speed for all the users must be implemented. If this is not possible, a segregation (Fig. 1), should be considered and, where it is not possible, the signalization should be strengthen.

Fig. 1 – Example of segregated bikeway along footpath in Edinburgh.

The network has to link with the major trip generation and attraction points, and has to be within a reduced walking distance and easy to access from the rest of the city parts.

The main origins and destinations in the network should be joined as directly as possible. If the routes are increased with detours or present crosses and interrupts at many points, it will be difficult to compete with the car.

To attract users, the bicycle network has got to be attractive and comfortable. If the network is giving, in addition to safety, a nice image and pleasant experience, the number of users will be increased or maintained. If the itineraries are poorly preserved and lit, or they are irregular or they have many stops and obstacles, the won´t be fully utilized.

Within the city cycling network, two mayor barriers are the slopes and the number of intersections per kilometer of track.

The slopes, in many cases, can cause considerable variations in the speed, promote changes of routes or directly, that the bicycle mode is not considered as an alternative.

In regards to the intersections we will focus on two aspects: the first, as a point of stopping or interruption of the trip and, the second, as the place where the danger increases.

In a similar way to the slopes, the continuous stops or changes of pace in the intersections discourage the use of a particular route. These stops involve a decrease in the average speed and elevate the effort that the cyclist has to do to travel a certain distance.

In regards to the potential danger, it must be remembered that it is at the intersections or in its immediate vicinity where the majority of the accidents are located. At the intersections we need to find a good visibility, a reduction in the speeds of all the vehicles and the construction or design, if necessary, of specific facilities for the bike.

4.2 Auxiliary facilities.

In addition to a good bicycle network we need other auxiliary facilities that enable the use of the bicycle.

After arriving at the destination, if the bicycle user is not happy with the idea of parking his or her bike and he or she is afraid of the theft or vandalism, he or she will not use this mode of transport. This also happens if the bikes are left exposed to the elements of the weather. Thus, it is necessary specific bicycle parking in the origin and the destination points.

In many cases there are difficulties in storing the bicycle at home due to the size of the house hold, the difficulty of access with the bike or the absence of communal places in the building designed for that purpose.

For the outside bike parking facilities, it is necessary that they are located close to the possible destinations, suitable for reducing or preventing the theft and protected from the bad weather.

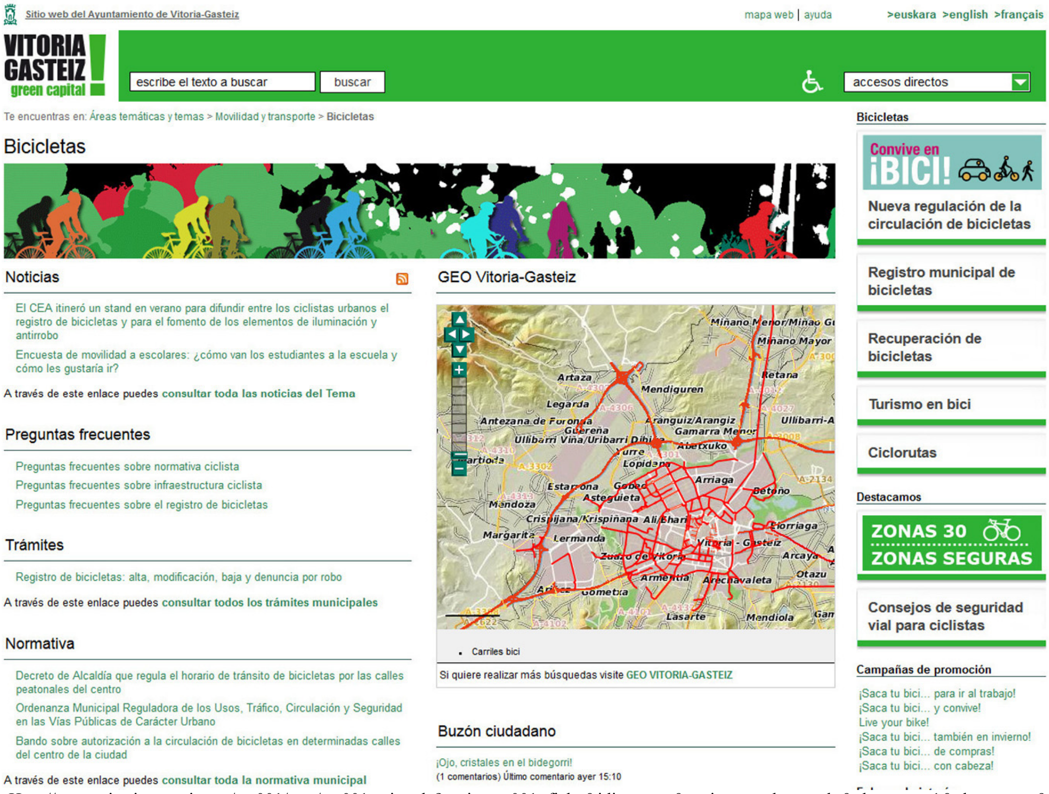
In some cities, in order to prevent theft, registration services for bicycles have been launched where the city council records a number on the bike and it is archived along with data such as name, phone or address of the owner, type or characteristics of the bike… to facilitate its recovery in the event of theft.

The existence of changing rooms, lockers, showers/bathrooms are another auxiliary facility that helps the day by day use.

5. Case study and methodology

In the past years the use of the bike has increased. This increase of users has been accompanied by an introduction, development or expansion of the bicycle networks and the bike parking facilities. In order to analyse if this development has served to break or decrease the structural barriers, the Spanish cities of Burgos, Valladolid and Palencia have been analysed.

Before analysing these bicycle infrastructures, it has been studied the information offered regarding the bicycle mobility in the web pages of the city councils and in others surrounding cities. In figure 2, as an example, the web site of the bicycles in Vitoria-Gasteiz (Spain) is shown. Mainly, information of the bike network and parking facilities was searched.



Http://www.vitoria-gasteiz.org/we001/was/we001action.do?accionwe001=ficha&idioma=es&accion=cuadromando&clavearea=1&clavetema=9

Fig. 2 - Example of city cycling information in the city of Vitoria-Gasteiz.

Once the information available from the web sites was collected, we bike through most of the bike networks of the three previously mentioned cities storing information on video and through photographs. To do this, the cameras were docked to the handlebar of each bike as it is shown in figure 3.

Almost 10 km in Palencia, 37 km in Burgos and 26 km in Valladolid were analyzed.

The information gathered was studied to see if the infrastructures analysed met the requirements outlined in paragraph 4 of this paper and to analyze if there are structural barrier effects that appear several times and can have an impact on the use of the bicycle.

Fig. 3 -Adapter and one of the cameras attached to the handlebars of the bicycle.

6. Aspects identified. Results.

This section shows some of the problems encountered in order to improve future designs that will enhance cyclist mobility and not with the aim of comparing the different cities. Paragraphs 6.2 and 6.3 focus only in the three cities analyzed.

6.1 The information in the Municipality web site

The first surprise found was that the web sites of the municipalities, under the heading of Mobility or Transport do not always mention the bike. It has been necessary to try in the "search" section of these web sites to find information related to the bicycle. Even so, in some cases we only found information regarding future plans or projects and fieldworks. In figure 2 a screenshot of the web site of the city of Vitoria-Gasteiz is showed. This can be taken as an example because it facilitates a fairly complete data on:

- Regulations about the bicycle.
- Map of the bicycle network.
- Bicycle Master Plan.
- Municipal bicycle registration system.
- Tourism in bicycle.
- Advices on road safety for cyclists.
- Promotion campaigns (bike to work, bike in winter, cycling wise, shopping on a bike...).
- Other sections or news of interest, faqs, procedures, citizen's mailbox…

In several municipalities, where specific information about the bicycle public loan systems were found, unfortunately did not show any information about the bicycle network or about bike parking racks. Luckily, not all was lack of information because in some of them they indicated the type of each bike parking racks or the capacity of them. In general, the maps of the bicycle networks also provide information of the points of the bicycle public loan system (if any), the bike parking facilities and about bicycle advice and safety tips.

In most cases we find that bicycle users, on external webs out of the public administrations, provided much more and very useful information.

6.2 The Bicycle Network

Based on conclusions from section 4.1, there are some aspects which are recurrent along the analyzed networks.

In order to increase the security it is necessary to homogenize the speed of the different users or segregate the network (fig. 4). It was noted that on many occasions when the bike path is achieved at the expense of reducing the sidewalk, this was still used by pedestrians (fig. 6, fig. 10 and fig. 11.) In these cases it will be necessary to strengthen signaling, to promote awareness campaigns and to ask for some patience to the riders. Some problems of minimum size of widths, pavement in poor condition, missing or worn road markings and poor curves radios (fig. 5, fig. 6 and fig. 8) were as well found.

In terms of security, we must mention the guards in front of the driveway, parking, curbs, tree wells, street furniture as they overpass in some cases the minimum distance of half a meter. A high proportion of bicycle lanes present this lack of shelter against obstacles as seen in many of the photos in figures 4-11.

Figure 4 - Bicycle lane with and without segregation.

Figure 5 - Two designs in wide streets.

Figure 6 - Design with sharp turns, poor visibility and limited distance with designated on road parking areas.

Figure 7 - Bike path next to facade areas in pedestrian access.

Figure 8 - Street furniture, curbs and railings.

Other characteristics required in bike lanes are regarding a connected and accessible network that allows direct travel. Firstly, it was observed that in some of the places with more trips as shopping centers, public administrations, education centers... could not be accessed by a bike path. But considering that part of the movements can be done on foot (if the rider does not feel safe on the road), we find large areas of the city that could be achieved not walking more than 300 m. In some cases some areas near the bike paths could not be accessed because of the riverbeds or train tracks. The absence of bridges or passages adapted below the roads limit their use.

Fig 9 - Bridge on a river and below the train tracks.

Also it was necessary that the bike lane was attractive and comfortable but because of the invasion of pedestrians, lack of security, lack of maintenance or numerous interruptions we find that a good number of the bike lanes were useless.

Figure 10 - Bicycle lanes on the sidewalk.

It was noted that in many cases, the interaction of the public transport infrastructure interfere the bike lanes and bothered the riders. The location of bike lanes and bus stops are mostly poorly resolved. If the user of the bus has no choice but to interfere with the bike path, it is necessary to strengthen the horizontal signage and to promote campaigns for pedestrians in order to wait next to the bus stop and not on the bike path.

Figure 11 - The bus stops and bike lanes.

Numerous sections of bike path ended abruptly without signaling, without elements to facilitate a safe incorporation into the driveway and it was observed a lack of planning waiting to be solved in future developments.

Finally, one of the major problems encountered are the intersections where driving disruptions discourage the riders, reduce the average speed, and make the riders to do an extra effort all along with an increase of the risk. There were detected visibility problems, big differences in speeds between users and non-existence or lack of conservation of specific and appropriate signage.

Several cross intersections meant a discontinuity in the bike lane and pedestrian routes which forced long detours and even make them to wait in three different traffic lights to keep on moving.

6.3 Auxiliary Installations.

As indicated in Section 4.2, the bicycle parking can make a difference when switching to cycling mode.

Basically it was found that most of the major destinations such as universities, hospitals, shopping centers, government offices, libraries, schools, sport and leisure centers ... they had bicycle parking nearby.

During the past years, the most implemented cycle parking is the inverted "U" as seen in Figure 12.

The problems encountered are that some of them were saturated, others were not prepared to properly secure the bike and some of them were in very poor condition. In general, it should be found a place in the website of the municipalities to request the provision of new bicycle parking. The best place to install the parking is prior to the crosswalks.

To prevent theft and make a correct bicycle padlock it was found that most of the municipalities with maps of the bicycle network offered some basic tips. In some cases also it is explained the possible registration of the bicycles for easy retrieval in the case of a theft. Many cities have this system. Through the Association of the Spanish

Network of Cities for the Bicycle many cities are sharing the system by means of a centralized service called www.biciregistro.es

In the study, the authors did not review the specific rules about parking and storage of bicycles in cities. Two general indications can be explained: it should be regulated in order to ensure that all residential buildings (at least new or those with major renovations) has a bike room and ensure that before all the main attractions points (shopping centers, government offices, Universities…) were available (before giving them permission to open) a certain amount of bicycle parking were installed near the area.

No storing services were found, in, for example, railway or bus stations, where riders come from other municipalities every day, and it is possible to keep your bike locked and stored for a low monthly rent as it was observed in other cities.

Likewise, it could not be verified whether big business and government centers offer others facilities such as changing rooms, lockers, showers / restrooms ... to assist the everyday use of the bicycle.

Figure 12 - Bicycle parking inverted U.

7. Conclusions

In the past years many kilometers of bike lanes have been implemented in Spain and more and more cyclists are enjoying the benefits of this mode of transport.

After cycling more than 70 kilometers of urban bike lanes and reviewing the web sites of many municipalities we have found that under the heading of Mobility or Transport do not always mention the bike and that a considerable amount of structural barriers are still present.

It is not enough to have many kilometers; users need a network 2.0 not only longer, but with a better quality. It has got to be safe, connected, accessible, direct, attractive, convenient, integrated with the public transport system, with intersections adapted to the bicycle and bicycle parking logically located and designed to minimize theft. If a city meets all these requirements it will be ready to launch this sustainable mode of transport.

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