Assessing cycling social feasibility in a medium-size Patagonian city

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Abstract

At present there is a global tendency in urban planning to privilege active mobility, especially in the central areas of the big cities of the world. We address the case of a medium-size city in a developing country like Argentina, which shares characteristics with other Latin American cities.

The result of synthesizing experiences carried out in the city of Puerto Madryn, Patagonia Argentina is presented. The use of different instruments throughout various territorial actions allowed us to evaluate the social feasibility of implementing urban cycling policies in the city. Those instruments used were a specially designed mobile application for cyclists and two surveys that cover the cyclist's profile and behavioral aspects towards cycling, respectively. The three of them have the common characteristics of being

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low-cost and simple to implement.

The resulting social feasibility analysis reflects the importance of citizens' commitment to cycling mobility. This analysis also gives an idea of the efforts needed to implement a policy in that regard. The results obtained indicate a high level of willingness to cycling, particularly among women. Family and friends support appears as a strength. Although infrastructure emerges as an important issue, it is not considered as urgent as other initiatives like safety driving campaigns, bicycle commuting programs and low infrastructure cost parking places. Traveling long distances and rough weather are inherent drawbacks of the Patagonian cities, however they were not observed as major impediments. We conclude that Puerto Madryn has an acceptable level of social feasibility towards urban cycling policies.

Keywords: cycling mobility; social feasibility; cyclist profile; regression analysis; medium-size cities

1. Introduction

In the current global tendency towards urban cycling, cities like Amsterdam, London, Berlin, Paris and Copenhagen are considered models [39]. The benefits of cycling are mainly related to the environment, the people's health and the maintenance of streets. Although these benefits are important for cities of developed countries, peripheral countries' cities would leverage them the most [41]. In the development of an urban cycling strategy there are distinct phases and policies involved, which generally include infrastructure, promotion and education for both current and potential adopters [16].

In this paper, an exploratory study of social feasibility is presented. It is

based on a set of experiments conducted in an medium-size city, like Puerto Madryn, Argentina. Puerto Madryn, head of the Biedma department, is in the Northeast of the Chubut province, in the Atlantic coast of central Patagonia in Argentina (see Figure 1), approximately 1,300 km distant from Buenos Aires city. The city owns a natural deep-water port in the Golfo Nuevo (*New Gulf*) and is only a few kilometers away from the entrance to the Valdés Península, declared a World Natural Heritage Site by UNESCO (United Nations Educational, Scientific and Cultural Organization) in 1999. It has experienced important demographic and urban growth since the 1970s on, going from 6 thousand inhabitants to more than 80 thousand, as shown in the last national census [23]. In relation to cycling, this social movement is reflected in more than 20 cycling-related interest groups that can be found in the city of Puerto Madryn. These groups have from a few dozen members: those who make group outings to ride a bicycle; up to a few thousand members: those groups that buy, sell and exchange information mostly through Facebook [1].The study is based on two different self-administered surveys and datasets collected by a mobile application.

Dolowitz and Marsh [12] explain that the key factor of policy transfer is the application of different proven public mechanisms (administrative, institutional and political in a broad sense) to other political, geographical and social contexts. Global-south cities like Buenos Aires and Santiago are following the tendencies of the big cities and implementing cycling mobility policies. According to Bolay and Rabinovich [5] medium-size cities in Latin

[1]These data come from consulting key informants [27] who manage the "Madryn by Bike" community in Facebook

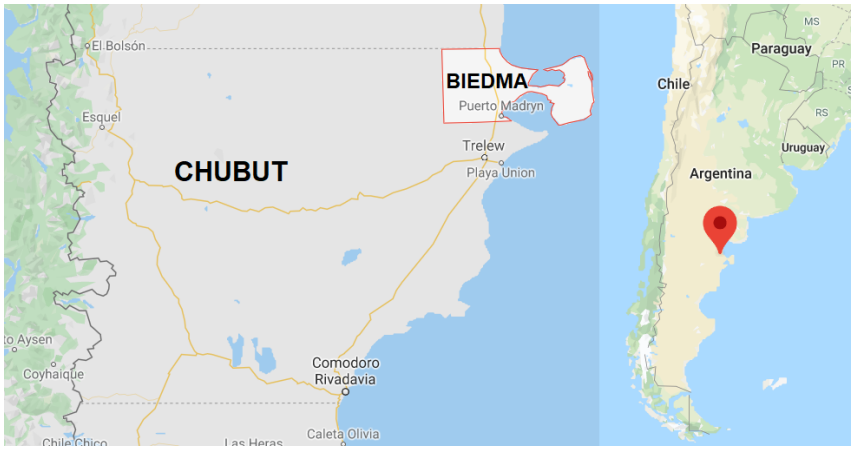


Figure 1: Location of Puerto Madryn.

America are defined not only by their population and territorial area, but because of their intermediation role with other rural or metropolitan areas. Nonetheless, the issues of small towns, medium-sized cities or intermediate cities in adopting global trends need special attention, mainly because of the sensitiveness of the actions taken, which are subject to a limited budget, a low population density and an immediate exposure to failures.

Thus, contextualizing the impacts of cycling policies, understanding pros and cons of transferring bicycle-friendly policies and building knowledge about cyclists and their sociodemographic characteristics become an unavoidable first step towards cycling policy transfer in medium-size cities.

Under the premise that social feasibility analysis should be conducted prior to implementing any kind of policy, a set of low-cost tools for measuring potential social impact is proposed. In this regard, understanding the behavior of the critical mass of cyclists (current and potential) is of paramount importance. In particular, the present work is based on the analysis of cycling

data collected through a specially-designed mobile app, the construction of a cyclist's profile for Puerto Madryn, a correlation of weather conditions with the app's data, and a behavioral and attitudinal study applied over the potential cyclist population, considering agreements and difficulties of cycling in everyday activities.

All these low cost efforts with the background of previous urban and demographic information lead us to a better understanding of the social context. To sum up, this paper presents the particular case of a low-cost technique for cycling policy transfers in a medium-size Patagonian city.

The rest of the paper is organized as follows: Section 2 succinctly performs a literature review of previous work using similar approaches from different viewpoints comparable to the one here proposed, along with a description of the city of Puerto Madryn; in Section 3, the materials and methods used to collect data are presented; the results of the three instruments applied are shown in Section 4; a discussion on the results is presented in Section 5; finally conclusions are drawn in Section 6.

2. Background

This section presents a literature review related to the research here presented. The selected works reinforce the empirical foundations of this paper and highlight the significance of social aspects when analyzing urban cycling. The review is organized in four categories.

2.1. Social analysis of cycling

Gonzalo-Orden *et al.* [20] show that it is essential to know where people move to, in order to achieve a high level of connectedness. The importance

of social issues (specially communication systems) beyond physical ones is shown in a study over students in the London School of Economics (LSE) [45].

In order to achieve a socially inclusive proposal, aspects of the relations of human beings in a community and with its environment must be considered. Green *et al.* [21], argues about the moral discourses of traveling in opposition to the livable experiences of them. This emphasizes the need for a social study of travelers, both current and potential. The work of Sardianou and Nioza [43] report on the influence of "environmental awareness" upon bicycle use. Although a significant aspect, the authors found out that it is not decisive. However, this is an aspect to consider in Puerto Madryn, since the city has a sustained social movement towards environmental consciousness. In this regard, Jensen [22] highlights the importance of cultural aspects when analyzing mobility and how it is intertwined with the environment and the infrastructure.

Evren and Akad [15] argue that transportation planning in Latin America has become not only a methodological problem but a modeling one, due to the lack of appropriate models and their corresponding methods. As Fernández [18] states, the difficulty of planning in developing countries must be characterized. In particular, he emphasized volatility and difficulty of carrying out long-term and stable planning. These two aspects are characteristics of the context analyzed in this paper. Given the lack of resources affecting many cities in Latin America, infrastructure investments have to be made with an extreme level of certainty about the results. Thus, before those investments, social concerns and policies become essential. This in-

volves dealing with different interests and initiatives usually opposed to each other. The existence of a cycling culture as an innate quality that requires deliberate planning support [1] is an advantage of Puerto Madryn.

In a pioneering work, Burkhardt *et al.* [6] introduced general concepts of social impacts and their importance for transportation planning. The concepts of the "affected", characterized as "those displaced", "those remaining" and "the community" are useful in the context of a medium-size Patagonian city due to its increasing territorial expansion.

Yago [49] analyzes several aspects that are affected by transportation projects, such as ecological processes, urban economics and political science, among others.Those contexts proposed by Yago are considered in our study by analyzing the transportation means used for doing different activities and the aspects affecting cycling mobility, such as the coastal scenery. In turn, Black [3] underlines the need for research that evaluates transportation "policies and trends in terms of their human impacts".

The concept of "bikeability" [25] defined as the level of comfort experienced by cyclists is verified in our research considering that commuters in Puerto Madryn prefer to ride on the coastal promenade, which is a pleasant zone of the city. Though, Peer [38] concludes that the cycling behavior is persistent regardless of cycling conditions.

Alternatively, Ducheyne *et al.* [13] and Emond and Handy [14] argue about the social importance of family and friends in the cycling behavior of infants and teenagers. This feature is explored in the case of Puerto Madryn resulting in a strong level of agreement by different membership groups.

Attitudes towards cycling are analyzed for the case of Puerto Madryn

in line with the work of Fernández-Heredia *et al.* [17], by considering variables like "convenience", "pro-bike", "physical determinants" and "exogenous restrictions".

2.2. Puerto Madryn: a mid size Patagonian city

Puerto Madryn has experienced a huge demographic transformation since 1970 when ALUAR[2], the biggest aluminum factory in Latin America, was set up [42]. The local population was multiplied by thirteen from 6,100 inhabitants in 1970 to more than 80,000 in 2010. Although during the nineties the situation seemed to be stabilizing, the process has been intensified in the last decade (Tables 1 and 2). This had significant effects on the urban scene, which has been in constant change since then.

Area\Year	**1970**	**1980**	**1991**	**2001**	**2010**
Argentina	23,364,431	27,949,480	32,615,528	36,260,130	40,117,096
Chubut	189,735	263,116	357,189	413,237	509,108
Biedma	6,981	21,689	45,494	58,677	82,883
Puerto Madryn	6,183	20,903	45,047	57,614	81,995

Table 1: Population in the last 5 national censuses. **Source**: National Institute of Statistics and Censuses (INDEC). General Directorate of Statistics and Census of the Province of Chubut. Own elaboration

[2]ALUAR is the acronym for *Aluminio Argentino*, Argentinean aluminum.

Area\Period	1970-1980	1980-1991	1991-2001	2001-2010
Argentina	19.60%	16.70%	11.20%	10.60%
Chubut	38.70%	35.80%	15.70%	23.20%
Biedma	210.70%	109.80%	29.00%	41.30%
Puerto Madryn	238.10%	115.50%	27.90%	42.30%

Table 2: Population growth in the last four decades with data from the last 5 national censuses. **Source**: National Institute of Statistics and Censuses (INDEC). General Directorate of Statistics and Census of the Province of Chubut. Own elaboration

The main problems that emerged were the access to adequate housing and an unplanned urban expansion, especially in the last two decades. This included no mobility planning processes, but urgent and spontaneous extensions following a traditional transport paradigm of Argentinian mid size cities [2]. As a consequence, the outline of the bus lines and the services' hours ended up reproducing urban inequalities [24].

At this point, it is conclusive to say that Puerto Madryn is a medium-size city and also it is a city that intermediates in its own region [4], fulfilling the two criteria, both demographic (or size), and functional. Its Patagonian location implies long distances, isolation from other parts of the country, along with difficulties to meet the agglomeration and scale needed for investments to yield returns. Climate is also a key determinant in everyday choices, not specially cold weather but wind and desert dryness.

2.3. Cyclist's Profile

A key element in urban cycling planning is the identification of actual and potential users, in order to ensure that they maintain their bicycle usage or to encourage them to start cycling, respectively [16].

It is important to remark that the *profile* is understood as the observable behavior of cyclists along with their choices made [7, 37, 8, 46]. There is neither typification of cyclists here nor consideration about their psychological aspects. In this paper, the cyclist's profile is presented as a series of indicators with no further interpretation of it.

2.4. Behavioral aspects of cyclists

Once a rough cyclists' profile is established and real cyclists' data is analyzed, it becomes necessary to determine other factors that could influence the cycling mobility choice. These aspects are mainly related to behavioral or attitudinal concerns and decisions, both among actual and potential riders. Consequently, in order to characterize cyclists, psychological aspects have to be explored. Therefore, a second survey was conducted, following [26]. Specifically, we adapted one of her surveys to be conducted in Puerto Madryn.

It is important to note that the previously mentioned works [26, 28, 29, 17, 48] in which we base ours, focus on an on-going cycling policy. The case presented here is previous to that situation in the sense that we are analyzing the social context to know which actions to take. This is, before building infrastructure or implementing traffic policies, we want to know the willingness of Puerto Madryn's people to use the bike.

3. Materials and Methods

In this section the three instruments used to collect data about cyclists in Puerto Madryn are presented. The methods for collecting information have an exploratory nature and consequently data collected is not statistically representative. An important aspect to mention is that the population over which the instruments were applied are not coincident nor related, which inherently introduces a bias on the sampling. In all cases, the individuals were anonymous, random and spontaneously agreed to participate in our research either using the app or answering some of the surveys. Despite not being statistically representative, the quality of the data collected is useful and the amount of them sufficient for providing a cycling feasibility insight on the citizens. For the case of the mobile application and the cyclist's profile, the population was composed of people living in Puerto Madryn and using the bicycle. For the case of the behavioral and the attitudinal survey, the population considered was the people living in Puerto Madryn, which are more than 80,000 inhabitants considering last national census.

3.1. PMYLap Mobile Application

A mobile app was developed in order to collect cyclists' travel data. In parallel, we worked with members of the municipal government to cover aspects of dissemination and promotion in order to achieve the adoption of the app by users. The app was designed to provide data on how people move and to allow better decisions regarding the layout of streets, cycle paths and other mobility channels.

We obtained sample data [19] from the app's use during 3 weeks in March

2018. In this observation period of 21 consecutive days, the app was used by a total of 59 cyclists. Of these 59 cyclists, 52 were citizens of Puerto Madryn and the remaining 7 were people from other nearby towns of the Patagonia region, such as Esquel, Trelew, Comodoro Rivadavia, Playa Unión, Las Grutas, Lagunita Salada and Cholila.

3.2. Cyclist's Profile in Puerto Madryn

Puerto Madryn was one the Argentinian cities selected to participate in Latin American study of Cyclist's Profile [48]. However, since the sample did not reach the established minimum (273 samples for a population of up to 100,000 inhabitants) it was not included in the final report. In the present work we analyze those samples collected. As mentioned earlier, despite not being statistically representative, we found the sample data useful for exploratory means. The questionnaire and the data obtained can be found in [35].

The survey design can be summarized as follows. The target audience of the study is made up of people who use the bicycle as a mode of transport at least once a week. The survey was designed to collect the following data:

- Bicycle trips main destinations;
- Bicycle frequency of use;
- Bicycle trips average duration;
- Combination with other modes of transport;
- Reasons to start and continue to use the bicycle;

- Daily barriers faced during the use of the bicycle and motivations to use it most frequently;
- Socio-economic characteristics of the user (age, occupation and income).

In Puerto Madryn, 122 individuals comprised the sample data set, though not all questions were answered by each of them, since there were not compulsory questions. It was conducted in different points around the city, specially during popular events and festivals. Respondents were randomly chosen with the only condition of using the bicycle as one of their transportation means. The sample had an average age of $\mu = 30.9$ years, with $\delta = 10.3$. In terms of education, 35.25 % expressed having completed university studies and the same percentage did it for Secondary School; while 20.49 % completed Primary School and 5.74 % obtained a Postgraduate degree. Concerning gender, the sample was composed of 39.34 % females and 60.66 % males. The survey was supervised and respondents filled it in a printed form. Then the results were digitalized and processed. The Origin-Destination information was used to validate the model proposed in [36].

3.3. Behavioral and Attitudinal Survey Description

As previously mentioned, the survey conducted was adapted from the one presented in [29]. It was implemented using an on-line form and sharing it in different social networks under the premise that it was a research work for the good of the community and that it was not related to the government. The submissions were open for 22 days in November 2019. The only condition for

answering the questionnaire was living in Puerto Madryn. The questionnaire and the raw data obtained can be found in [34].

The survey was answered by 270 anonymous respondents. After a process of cleaning empty answers and people not living in Puerto Madryn, 262 individuals constituted the sample data set. It is worth noting that there were no compulsory questions. As a consequence, a different amount of answers for each of the questions can be seen in the results obtained. The sample was not limited to cyclists only, but people in general. The average age was 38.5 years, with $\delta = 12.3$ years; 48.85 % were female, 50.76 % were male and one respondent identified as trannsexual. Regarding how many people they lived with, the mean value was 2.9 persons with $\delta = 1.5$. Concerning education, 40.8 % individuals finished Secondary School and 37.79 % completed College studies, while 18.32 % completed Tertiary studies and 2.29 % completed Elementary School.

Along with a descriptive statistical analysis a Multinomial Logistic Regression (MLR) analysis is performed. Multinomial logistic regression is used in nominal-type dependent covariant models with more than one category and is a multivariate extension of the classical binary logistic regression. Thus, a MLR is considered as a set of independent binary regressions. In this case, it is considered that if there are N possible outcomes, and one of them is taken as a "pivot", then that would result in $N-1$ independent binary logistic regression models. Consequently, except for the "pivot", $N-1$ outcomes are independently regressed against the pivot outcome. Independent variables can be both continuous (regressors) or categorical (*factors*). In the performed experiments all the independent variables were categorical.

The tool used to make the calculations was *Jamovi*[3].

The experiments were conducted by selecting a dependent variable and a set of factors (could be only one). The tool, for both types of variables, establishes that a particular value has to be taken as a *reference level* (pivot), in which case it is recommended to choose the most frequent one.

In MLR, Odds Ratios (OR) is interpreted as the effect of one unit of change in X in the predicted odds ratio with the other variables in the model held constant. That is, how the change of one unit in X affects the log of the odds holding the other variables in the model constant.

The experiments performed are enumerated as follows. Due to the extension of the tables resulting from the experiments, it was decided to allocate them in external repositories, which are appropriately referenced in each case:

1. The dependent variable chosen was *the potential increment in the use of bicycle in the next 12 months* and the factors were the cycling *social approval of different membership groups*. Particularly, the groups considered were *family*, *peers* and *friends*. It is described in detail in [32].

2. The dependent variable was the *potential increment in the use of bicycle in the next 12 months* and the factors were the *difficulties commonly found* in everyday cycling. In particular, the difficulties considered were: *Long distances*, *Bike damage or steal*, *Carry objects*, *Carry people*, *Not like being sweaty*, *No secure parking (destination)*, *Slopes and hills*, *Aggressive traffic*, *Falls or accidents*, *Weather conditions* and *No shower*

[3]https://www.jamovi.org/.

(destination). It is reported in detail in [31].

3. The dependent variable was the *potential impact of cycling infrastructure* and the factors were all the *difficulties commonly found when cycling*. In this case, the difficulties considered were: *Long distances*, *Bike damage or steal*, *Carry objects*, *Carry people*, *Traffic pollution*, *Not like being sweaty*, *No secure parking (destination)*, *Slopes and hills*, *Aggressive traffic*, *Falls or accidents*, *Weather conditions* and *No shower (destination)*. It is elaborated in detail in [30].

4. The dependent variable was the *likelihood of commuting* and the factor was *bikelane construction*. Is described in detail in [33].

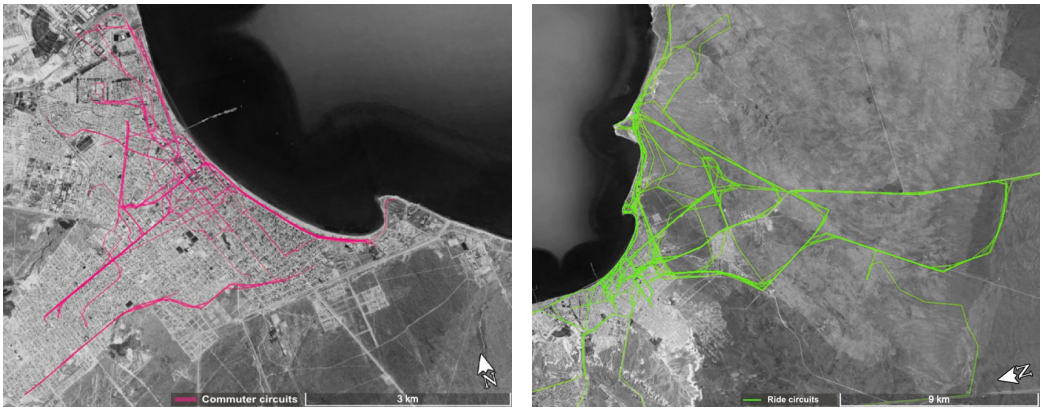
4. Results

In line with the order of the three instruments presented in Section 3, in this section the results obtained from them are shown.

4.1. Mobile App Experimental Evaluation

Taking into account the data obtained in relation to the city of Puerto Madryn, it was possible to collect 87 records made by 24 cyclists who had used the application more than once. Among the variables observed during these routes are the geographical positions in which the cyclists were at each moment, the duration of the ride, the average speed and the distance traveled.

To facilitate the understanding and analysis of data, each of the routes was exported in KML format to be imported and displayed on Google Earth. As shown in Figure 2, this allowed us to determine in each case whether it

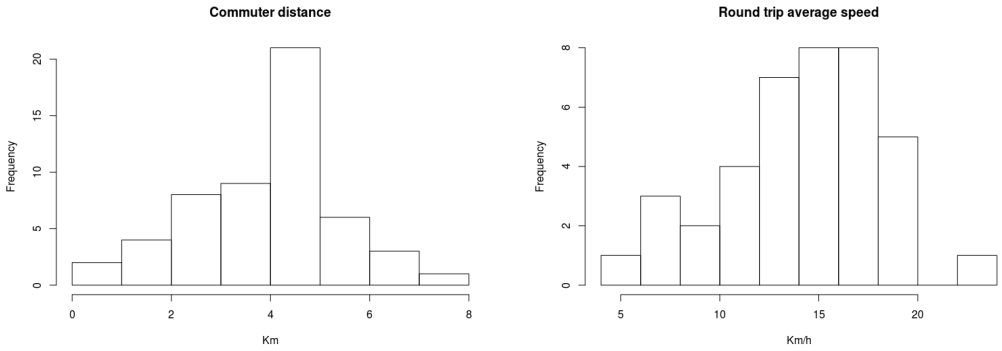


(a) Commuter circuits. (b) Recreational circuits.

Figure 2: Types of cycling circuits.

was a utilitarian (pink-colored) path or recreational (green-colored) path. The distinction of utilitarian trips (U trips) and recreation trips (D trips) is a rough classification based on our observation of the sample data. We noted that some trips, named *recreational*, begin and end in the same geographic point and perform a continuous path along time (there might be a few discontinuities of a couple of minutes, which can be assumed as stops). On the other hand, certain trips, named *utilitarian*, present a clear continuous time path from a starting geographic point to a different end point. This is also coincident with the idea of commuting trips.

From our statistical analysis of the variables observed in the commuter's circuits, it was possible to determine that the distance variable follows a normal distribution with a median of 4.05 km and a standard deviation of 1.4 (Figure 3a). These routes last an average of 21 minutes and are performed at an average speed of 11.7 km/h. It can be seen in Figure 2a that cyclists' routes cover parts of the city, and that commuters prefer to ride on the coastal



(a) Commuter distance histogram

(b) Ride average speed histogram

Figure 3: Speed and distance of cyclist collected by the mobile app.

promenade when it is possible.

Regarding recreational circuits, they show a normal behavior in variable speed with a median of 15.02 km/h and a standard deviation of 3.8 km/h (see Figure 3b). As can be seen in Figure 2b, these routes are usually carried out along the coastal promenade in a large percentage of the cases, as well as extending beyond the urbanized boundaries of the city to the south. With an average distance of 20.69 km, in these routes the cyclists performed an average speed of 14.26 km/h.

4.1.1. Impact of weather conditions

Weather is a relevant aspect when choosing bicycle as a mean of transportation. This is especially the case in Puerto Madryn, which has wide temperature variations between winter and summer, about -2°C to 35°C respectively, as well as between day and night with about 15°C of variation. Wind is another important factor to consider in this place where it can vary between 8 km/h and 40 km/h with gusts up to 60 km/h.

Wind and Temperature records [9] were obtained from CENPAT - CONICET's[4] weather station. This records have been mapped with the cycling paths recorded by the PMYLap Mobile Application along the observation period mentioned in 4.1. The weather conditions of the observed period correspond to the beginning of autumn, when the wind and cold are not yet so severe.

The Beaufort scale shown in table 3a was used to rate the wind measurements. However, for temperature, an *ad-hoc* scale that classifies the level of warmth according to the usual sensations of citizens was used. This ad-hoc scale is shown in Table 3b.

For each time interval (day-hour) throughout the observation period, the most significant bicycle trips were quantified. Based on bicycle trips, a *cycling level* was computed. This cycling level expresses the number of people cycling at each time, varying in a range from 0 to 6. The temperature and wind levels, classified according to the above-mentioned tables, were also normalized to ranges from 0 to 6 to be plotted.

Bicycle trips were classified into utilitarian (U) and sporting or recreational (D), according to route followed and time of the day. Consequently, the cycling level was analyzed separately as *Cycling.U* and *Cycling.D*. The result of this composition is shown on the plot present in Figure 4.

[4]CONICET-CENPAT Technological Scientific Center. Puerto Madryn. Location: Latitude 42° 46' South, Longitude 65° 02' West, Elevation: 13m.

From	To	Label
0	1,9	Calm
2	5,9	Light air
6	11,9	Light breeze
12	19,9	Gentle breeze
20	28,9	Moderate breeze
29	38,9	Fresh breeze
39	49,9	Strong breeze
50	61,9	Near gale
62	74,9	Gale
75	88,9	Severe gale
89	102,9	Storm
103	117,9	Violent Storm
118	-	Hurricane

(a) Beaufort scale (km/h)

From	To	Label
-12	-0,9	Freezing
0	4,9	Very Cold
5	7,9	Cold
8	11,9	Getting Cold
12	14,9	Cool
15	19,9	Mild
20	23,9	Moderate
24	27,9	Warm
28	30,9	Very Warm
31	34,9	Hot
35	-	Scorching

(b) *Ad-hoc* scale (^{o}C).

Table 3: Scales used.

4.2. Cyclist Profile Experimental Evaluation

In this section, results of the Cyclist Profile survey described in Section 3.2 are analyzed. Based on the characterization of results exposed in [47], those obtained for Puerto Madryn are presented.

In the first place, Figure 5 summarizes main aspects of the average expected answers. The "five or more days of use" aspect is high ($> 70\%$) in Puerto Madryn. However, the item "five years or more of use" is relatively low in Puerto Madryn, 37.7%. On the contrary, the duration of the "most frequent trip" is high (72.13%). Finally, considering the respondent's age

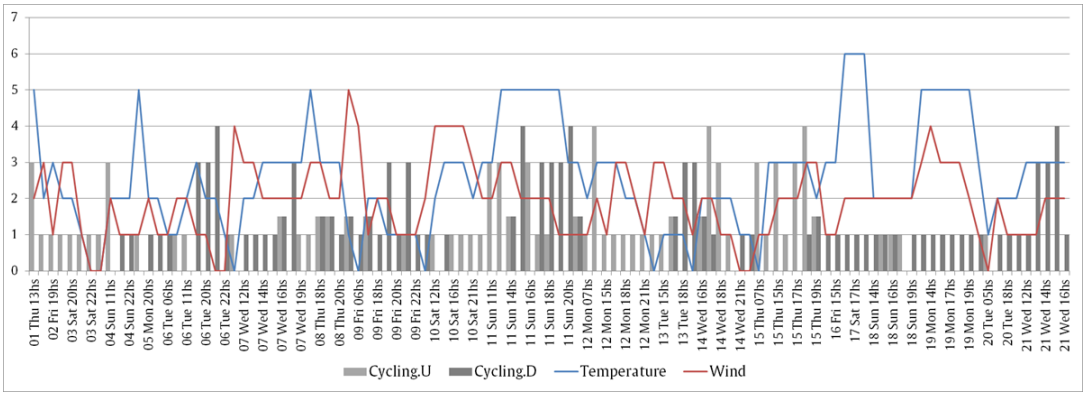


Figure 4: Cycling level regarding weather conditions

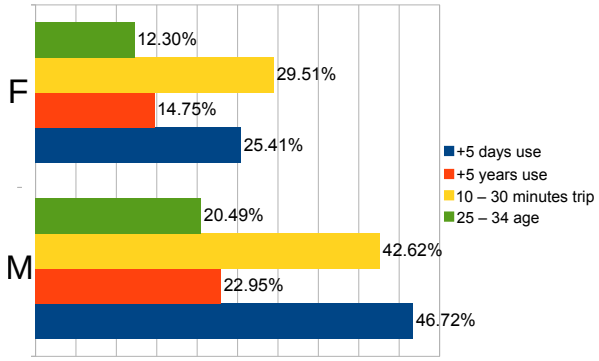
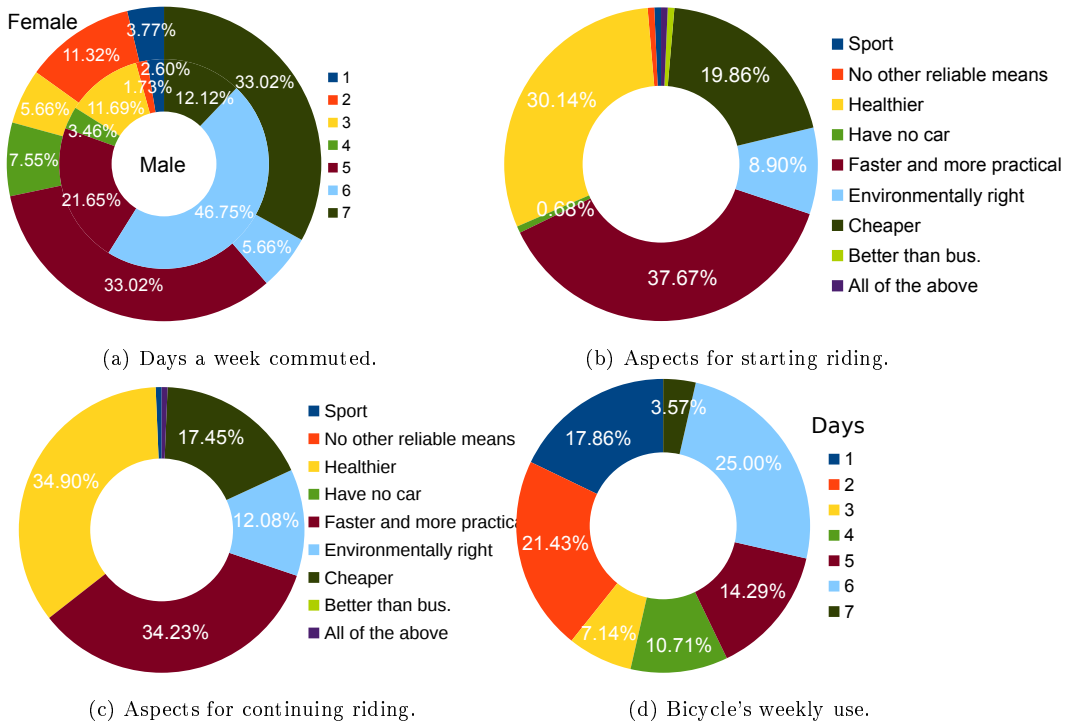


Figure 5: General characteristics of average respondents. M: Male, F: Female.

being "between 25 and 34", the city presents a 32.79%.

Reasons for beginning and continuing cycling are shown in figures 6b and 6c, respectively. In both cases, the main basis are related to practicality and health (more than 60% between the two). However, other important aspects that emerge are economy and environmental consciousness.

Concerning the *issues that affect cyclists daily*, the main concern is *the lack of infrastructure* (47.71 %). Then, there is a distinction between *traffic safety* (27.45%) and *public security* (16.34%). Lasting *lack of appropriate*



(a) Days a week commuted.

(b) Aspects for starting riding.

(c) Aspects for continuing riding.

(d) Bicycle's weekly use.

Figure 6: Analysis of ciclist's profile survey of 2017 in Puerto Madryn

signaling with 8.50 %.

On the other hand, since Puerto Madryn has no cycling *infrastructure* it is reasonable that most people identified it (50.33%) as the main aspect that would improve cycling. The aspects that followed it were *more traffic safety and education* (23.84 %) and *more public security* (16.56 %).

In turn, Figure 6a shows the percentage of people commuting, according to gender and the number of days a week. While in Figure 6d the percentage of broadly bicycle usage by number of days a week is presented.

4.3. Behavioral and Attitudinal Survey Analysis

In this section, results obtained from the Behavioral and Attitudinal survey described in Section 3.3 are presented. Over the 262 samples left after processing raw data, two types of analysis are presented.

4.3.1. Descriptive Analysis

An initial aspect to consider is that 98.1% of the respondents said they knew how to ride a bicycle, while 84.7% said they had a bicycle.

Table 4 shows the estimated bicycle's use for the next year considering the information by gender about the previous one. For the *negative-conservative* cases (*i.e.*, "Certainly not" and "Probably not"), these cases show reticence towards increasing (or starting) cycling. For example, 58.06% out of 31 respondents said they were male and that, with respect to the previous year, they cycle equally and that they would not probably increase that in the following year. However, considering *positive-progressive* cases (*i.e.*, "Probably yes" and "Surely yes"), the first thing that can be noted is a considerable increment in the number of answers. Another important aspect is the amount of people (male and female) that increased their bicycle use in the previous year and plan to increase it even further in the following one. Finally, note that these two cases (written in bold face) are the only cases in which the percentage of female answers is higher than the male's.

A comparison between traveling by car or by bicycle for a comprehensive set of life activities is shown in Figure 7 in the form of a stacked bar chart. The chart shows that, although there is a majority of car trips, bicycle travels are almost equally distributed between men and women.

Table 5 shows the level of support or agreement to cycle of different social

	Willingness to increase bicycle use in the next year (%)											
	Certainly not			**Probably no**			**Probably yes**			**Surely yes**		
Last year use	*EQ*	*GT*	*LT*	*EQ*	*GT*	*LT*	*EQ*	*GT*	*LT*	*EQ*	*GT*	*LT*
Female	100	0	50	42	0	47	43.6	**52.4**	48.5	37.5	**59**	0
Male	0	100	50	58	100	47	56.4	**47.6**	51.5	62.5	**41**	100
Trannsexual	0	0	0	0	0	6	0	0	0	0	0	0
Respondents	*3*	*2*	*2*	*31*	*4*	*17*	*39*	*63*	*33*	*8*	*44*	*5*

Table 4: Estimated future bicycle's use with respect to previous year by gender. EQ: equal, GT: greater, LT:lower.

groups distinguished by *potential* cyclist's gender. In the first place, it is important to remark that there is a strong agreement (over 80%) to cycle in all social groups independently of gender. Delving into the categories from Table 5, it can be seen that concerning women, their membership groups would definitely support them to cycle and the percentage is greater than for men (see bold data in row *A lot*). However, this is reversed in the case of *Quite*.

Table 6 shows the commuting difficulty by gender categorized in four level. In this case, it is observed that for women, 50 % considered non-deniable difficulty level (*i.e.,* Much o Quite); while for men that level reaches 37.4 %. This is emphasized in the case of the lowest level, which is inverted in the extreme answers (*i.e.,* Much and None) of the genders.

Analyzing in depth the difficulties of cycling in the city, Figure 8a shows the degree of affection of a comprehensive list of factors involved in cyclist mobility. Detailed references of the factors can be seen in Table 8b. In

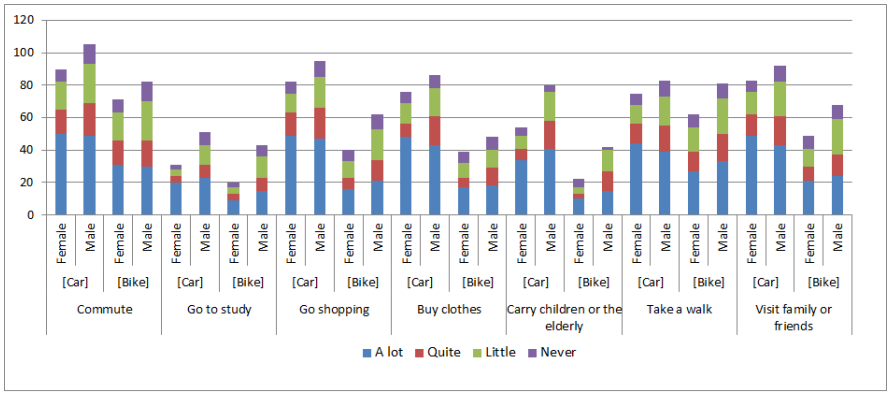


Figure 7: Car vs. Bicycle according to activities by gender.

	Close family		**Peers**		**Friends**	
	Female	***Male***	***Female***	***Male***	***Female***	***Male***
A lot	**53.91%**	47.24%	**54.72%**	47.97%	**54.72%**	48.00%
Quite	26.09%	**34.65%**	25.47%	**34.15%**	24.53%	**34.40%**
Little	16.52%	16.54%	16.04%	16.26%	16.98%	16.00%
Nothing	3.48%	1.57%	3.77%	1.63%	3.77%	1.60%
Respondents	115	127	106	123	106	125

Table 5: Level of agreement by membership group.

Figure 8a it can be seen that there is a clear difference in gender responses. For the case of *A lot* men are barely above 20%, while women are around 10% over that. With respect to factors, "long distances" is the primary problem. Next, in the case of women, "slopes and hills" is marked as an important issue; while, for men, "not like being sweaty" and "aggressive traffic" come at second place.

Figure 9 shows the potential impact of building specific cycling infrastructure. There were 254 respondents, equally distributed by gender. Note

	Female	Male
Much	24.19%	**13.74%**
Quite	25.81%	23.66%
Little	32.26%	29.77%
None	**17.74%**	32.82%
Respondents	124	131

Table 6: Difficulty level in commuting by gender

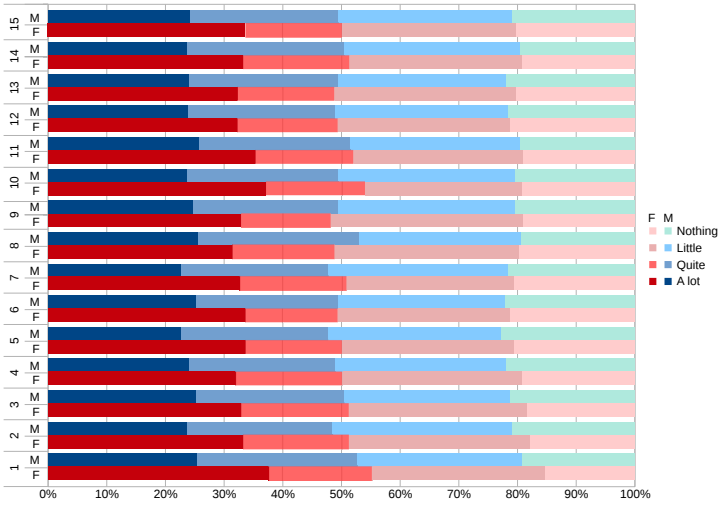
the relationship between answers from Table 6 and those presented in this figure.

4.3.2. Inferential Analysis

The first experiment explores the impact of *social approval of different membership groups* in the *potential increment in the use of bicycle in the next 12 months.* Two borderline cases are considered: 1) *friends* (Nothing - A lot) with respect to Probably no - Probably yes, which gives $p = 0.063$ with $OR = 21.655$; and 2) *family* (Little - A lot) with respect to Certainly no - Probably yes, obtaining $p = 0.057$ with $OR = 17.827$. Although the cases did not show statistical significance, since their 95% confidence intervals span 1.0 and were extremely large, they suggest an aspect to be considered marginally.

A second MLR experiment, explores the impact of issues commonly associated to cycling with increment in the use of bicycle in the next year. Here, the noticeable result is related to the importance given to parking facilities.

No secure parking (destination): *Quite* - A lot (factor) / *Probably no* -



(a) Levels by gender.

Ref.	Difficulty type
1	Long distances
2	Bicycle damage or stealing
3	Carry objects
4	Carry people
5	No secure parking (home)
6	Traffic pollution
7	Not prepared for traffic
8	Not like being sweaty
9	No secure parking (dest.)
10	Slopes and hills
11	Aggressive traffic
12	No physical condition
13	Falls or accidents
14	Weather conditions
15	No shower (destination)

(b) Difficulties

Figure 8: Level of difficulties found in cycling by gender.

Probably Yes (dependent) ($p = 0.023$ with $OR = 17.3407$)

No secure parking (destination): *Little* - A lot (factor) / *Probably no* - Probably Yes (dependent) ($p = 0.018$ with $OR = 18.1990$)

A third experiment, elaborates on the impact of building bikelanes subject to the difficulties commonly found in cycling. The following situations are highlighted:

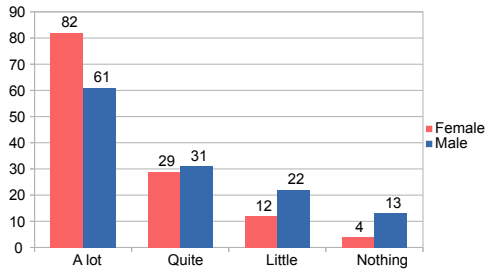


Figure 9: Potential impact of specific cycling infrastructure

Effect in commuting (*No shower (destination)*): *A lot* - Nothing (factor) / *Quite* - A lot (dependent) ($p = 0.026$ with $OR = 9.7889$)

Effect in commuting (*Aggressive traffic*): *Little* - A lot (factor) / *Quite* - A lot (dependent) ($p = 0.049$ with $OR = 9.3190$)

Finally, a fourth experiment explores the relationship of building specific cycling infrastructure and the likelihood of commuting by bicycle. Six out of nine cases show a strong relation between the likelihood of commuting by bicycle and the availability of proper infrastructure (*i.e.*, $p < 0.046$ and $OR > 3.1465$ for the six cases).

In line with this last experiment, another one is performed in order to elaborate on the actual impact of bikelane building. In this case, the dependent variable chosen was *level of difficulty in commuting* and the factor *bikelane construction*. The experiment showed no statistical significance in this association. Table 7 shows the result of the experiment.

5. Discussion

A first aspect to highlight is the use of mobile applications to obtain information. Our research has shown that with relatively low effort it is possible to build them and potentially reach a high level of adoption, if they are able to accompany the daily activities of people. In Puerto Madryn there is good connectivity infrastructure but there are not many local mobile applications, for example, for delivery and on-line purchase of products and services. This is a drawback in terms of urban data collection. For these purposes, it would be desirable for the government sectors to incorporate

Difficulty in commuting by bicycle	Predictor	Estimate	p	OR
A lot - Little	Intercept	-0.3529	0.168	0.703
	Effect of bikelanes implementation			
	Quite – A lot	-0.4943	0.296	0.610
	Little – A lot	-0.6025	0.303	0.547
	Nothing – A lot	0.1987	0.746	1.220
Quite - Little	Intercept	0.0526	0.819	1.054
	Effect of bikelanes implementation			
	Quite – A lot	-0.4580	0.269	0.633
	Little – A lot	-0.3149	0.511	0.730
	Nothing – A lot	-1.9990	0.068	0.135
None - Little	Intercept	0.0526	0.819	1.054
	Effect of bikelanes implementation			
	Quite – A lot	-0.3890	0.341	0.678
	Little – A lot	-0.8257	0.129	0.438
	Nothing – A lot	-0.9000	0.216	0.407

Table 7

participatory government strategies, incorporating mobile applications and making the collected data available.

From app's data we can finally observe that both, in the use of bicycles for sports or recreation, and in its use for transportation (utilitarian), the cyclists of Puerto Madryn prefer to ride through the boardwalk. Likewise, we have observed that cyclists who use their bicycles for transportation do not use it as a means of exercising and vice versa. This last assessment does not involve a hypothesis test, because both data sets (commuters and ride routs)

turned out to be simply disjoint. A possible explanation of this behavior could come from the usage of different apps or even not using an app at all in a particular mobility mode.

When analyzing weather conditions given during the trips collected by the mobile app, the results show that weather conditions do not affect utilitarian cycling greatly. However, for recreational or sports cycling there is a preference for days with lower winds. This aspect is also confirmed by the Behavioral Survey, in which *weather conditions* did not appear as an aspect to be considered.

From the Cyclist Profile study the following important aspects arise: environmental awareness, need for traffic education, health and practicality. Although infrastructure emerges as an important aspect, this could be because of a complete absence of bicycle lanes or any other kind of cyclist infrastructure.

Another important aspect is the amount of people (both male and female) that increased their bicycle use in the previous year and plan to increase it even further in the following one. It is important to highlight that the percentage of female answers is higher than the male's. This could be pointing out that women feel comfortable, safe and secure riding a bicycle in the city. In relation to this, when concerning women, their membership groups would definitely support them to cycle and the percentage is greater than for men. Nonetheless, when analyzing the commuting difficulty by gender, there is a clear gender situation. As some authors [11, 44] have exposed, this behavior has multiple causes, generally explained by the activities assumed to be done by women that mostly have to do with the broad concept of *care* [40].

Particularly, related to *care* activities, namely *going shopping* and *carrying children or the elderly*, even *visiting family and friends*. These activities have to be taken into account in a city planning process. Proximity facilities like health centers, schools, public spaces and stores, along with their communication roads and parking spaces, should be considered in terms of mobility, care activities and gender.

An issue exposed as a primary problem is that of "long distances". Notice that this is an inherent feature of Patagonian cities. However, through planning tools this aspect can be moderated, for example, by building parking stations with rest spaces or by implementing urban sub-centers that foster proximity.

The results of the Behavioral Survey confirmed that in transitioning to a bicycle-friendly city, "safety and comfort issues" are not the main impediments for commuters. A series of customized policies are recommended in the light of the research findings. As in [29], they should include "marketing campaigns to encourage non-commuting cycling trips, bicycle measures to target social groups as opposed to individuals, bicycle-specific programs such as *Bicycle-to-work Days*, and cycling courses".

Analyzing *the potential increment in the use of bicycle in the next 12 months* and the factors being the cycling *social approval of different membership groups*, no decisive conclusions nor statistical significance regarding increase in use related to social approval emerge. However, two borderline cases advise that support from friends and family could increase the willingness of cycling in some people, as proposed in [10]. This encouragement should be articulated with daily activities like working and studying.

Considering the *potential increment in the use of bicycle in the next 12 months* and the *difficulties commonly found* in everyday cycling, the aspects that emerged as important can be included in a category of relatively low-cost infrastructure. The previously mentioned secure parking spaces can contribute to lessen the effects of *Bicycle damage or stealing*, *No secure parking* and even *Weather conditions*.

A non-conclusive aspect present in various experiments is *No physical condition*. This health situation should be covered through a particular research which is out of the scope of the present one. However, publicity campaigns nurturing healthy habits and doing physical exercise could be helpful.

Although infrastructure emerges as a necessity, it is not immediate. The mentions about infrastructure could be influence by two non-negligible aspects like the current complete absence of any cycling infrastructure and the bias in the population sampled (in the three experiments). Particularly, the population could be composed mostly of non-starting cyclists, which have overcome several situations and have another level of requirements. Because of the characteristics of the Patagonian cities, which have a disperse urban sprawl and a limited budget, building cyclist equipment should be done through a deep mobility study. This study must include the suburbs and the necessity of traveling to different parts of the city, mainly the central area. However, during the time of the study different pro-cycling actions can be conducted, namely cycling awareness campaigns, installation of signage, building of parking spaces for cyclists, implementation of economic benefits (for example, a reverse parking system in which the cyclist gets points for parking his/her bicycle, which can be changed for shopping discounts) or

a gender public policy to reinforce bicycle usage among women, since they showed to be an important interest group, among other actions that would not be as expensive as building infrastructure.

In this regard, where mobility (particularly cycling) is materially and structurally constrained, rather than offering an opportunity to display committed citizenship, cycling is potentially an additional driving force of marginality. This aspect is crucial in a medium-size city like Puerto Madryn and it can be neither discarded nor underestimated. In fact this aspect should be considered from the very beginning of a cycling planning process, in order to achieve a socially inclusive proposal.

From the above, based on our research, we can conclude that Puerto Madryn presents an adequate level of social feasibility for the implementation of urban cycling policies. These policies, according to our results, should be focused on respect for the cyclist, environmental awareness, benefits in physical and mental health, as well as contact with the natural environment. Involving, in all respects, gender issues. Our study, based on the samples collected,shows that the population of Puerto Madryn latently presents a good predisposition towards cycling mobility.

6. Conclusions

There is an increasing and accelerated global trend in promoting active transport, especially cycling. Despite the large amount of research about urban cycling, only a small fraction of it focuses on medium-size or intermediate cities, and an even smaller fraction does it on cities of developing countries. In this work, we showed the importance of social aspects before implementing

a cycling policy. Based on the experience gathered in a medium-sized city like Puerto Madryn, we can state that prior to large infrastructure investments, it is important to strengthen people's willingness to ride a bicycle. Policies to promote bicycle use and awareness in traffic were positively valued by individuals. Encouraging respect for each other in traffic becomes essential.

In terms of gender, our findings show that women attitudes to cycling are positive. However, caring activities pose a strong constraint in their travels. This enforce urban planning decisions that consider proximity, parking spaces and children areas. Thus, cycling mobility policies should not disregard those aspects.

Although Patagonian cities are characterized by being windy and with temperatures mostly from mild to cool, we did not find weather as a strong impediment for cycling. On the other hand, another characteristic of these cities is their urban sprawl, referred to as the poorly planned, low-density expansion of the city. This naturally imposes long distances, specially to the downtown, however this was not highlighted as a strong negative factor; except for the case already mentioned about women.

The infrastructure deficiencies, the low population density and the unstable economic situation that characterize Patagonian cities were unavoidable aspects in the analysis. In this regard, a remarkable feature that emerged from the surveys of current and potential cyclists was the need to have parking spaces for bicycles instead of bikelanes, especially in commercial areas.

Finally, environmental awareness, though not definitive in decision making, has an influential weight in citizens. In fact, it was indicated as one the reasons for starting and continuing cycling.

In order to implement a cycling policy, either new or transferred from another city, we argued that it is necessary to establish a certain degree of people's willingness towards cycling. In this regard, our research problem was to determine if a cycling policy will be socially feasible and in what level. These questions should be posed before any other action. In relation to this, the exploratory study performed, demonstrated that a government initiative towards cycling would meet with people's approval.

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