THE CIRCULATION OF BICYCLES IN BARCELONA, STREET BY STREET

BiciZen
CYCLING CITIZEN SCIENCE

ICTA-UAB

bacc
Bicicleta Club de Catalunya

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Acknowledgments
We thank the volunteers who collected data for this project: Albert Orta, Álvaro Urbano, Andrés Navarro, Carlos Ortí, Carlos Padilla, Carlos Ramiro, Claudio Cattaneo, Dani Rodés Almer, Eduard Folch, Erundina González, Felix Vilaseca, Fred U., Gerard Feliu, Guiller, Ignasi Orta, Ingrid Vives, John Owen, Juan Granero, Laura Heckmann, Mercedes Vidal, Mònica Enrich, Montse Aulinas, Rosemarie Nagel, Silvia Martin, Toni Carneros, Xavier Ballart, Xesc Arbona.

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Citation
Honey-Rosés, J., L. Liebscht, G. Castilla, A. Arenas, H. Ballart, L. Chaves, M. Miah, S. Nel.lo-Deakin, G. Simón-i-Mas, C.G. Treviño, F. Udina, P. Reyes (2025). Bicycle Traffic in Barcelona, Street by Street. City Lab Barcelona, Institute of Environmental Science and Technology (ICTA-UAB), Barcelona Supercomputing Center (BSC), Bicycle Club of Catalonia (BACC).

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September 2025

Executive Summary

This report presents a first estimation of the volume of bicycles and scooters moving through Barcelona, street by street. Using advanced modeling techniques, we estimate the Average Annual Daily Bicycle Traffic (AADBT) at the street segment level for over 20,000 road segments. We rely on data from automatic counters managed by the city council as well as data collected by volunteers and civil society.

The most accurate model, XGBoost, allows visualization of bicycle flows across the entire city and is a valuable tool for urban planning, infrastructure improvement, and road safety studies. One of the study's main achievements has been to demonstrate how citizen participation improves the quality and representativeness of the estimates: thanks to the work of 43 volunteers, it was possible to cover street typologies and areas outside the reach of automatic counters.

Despite these improvements, the model still presents some overestimations, especially on streets without cycling infrastructure. Nevertheless, this beta version offers a solid foundation for future developments.

This project illustrates the potential of citizen science and interdisciplinary collaboration to advance towards more sustainable, equitable, and evidence-based mobility in Barcelona.

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Introduction

Urban mobility is undergoing a significant transformation as cities seek sustainable alternatives to private vehicle use. In this context, bicycles and other micromobility modes have become key transport means to reduce congestion, improve air quality, and promote healthier mobility habits. However, their integration into the urban fabric requires data-driven planning to design safe and efficient infrastructure.

Compared to other modes of mobility, such as cars or public transport, less is known about bicycle mobility. A historical inertia favoring motorized vehicles has generated tools, technologies, models, and studies dedicated to motorized traffic. Conversely, for bicycle mobility, we lack the same degree of knowledge.

A clear example of this asymmetry is seen in traffic models. In Barcelona, as in most global cities, there is a sophisticated traffic model for private and motorized vehicles. By collecting data on city and metropolitan streets, technical teams and engineers have created dynamic and predictive models to estimate flows of cars and motorcycles circulating in the city.

Moreover, this road traffic model carries weight in decision-making, as street calming programs or proposals to reduce road capacity can be rejected due to their predicted impact on motorized mobility. These models influence important decisions and, therefore, materially affect how we design the city.

While the motorized traffic model holds a central place in urban design, no equivalent exists for bicycle mobility or walking. For example, in 2025 the Barcelona City Council funded public transport modeling work with a contract valued at 300,000 euros, but to date, no comparable investment is known for bicycle modeling (City Council of Barcelona, 2025). Bicycle mobility still lacks the same tools, data sources, and funding as motorized mobility.

Nevertheless, prioritizing active mobility has been included in strategic documents such as the 2024 Barcelona Urban Mobility Plan (City Council of Barcelona, 2024) and in evolving social values. This work aims to help us understand and visualize how the cycling community moves through Barcelona, street by street.

We have developed an estimate of the number of bicycles and scooters circulating on bike lanes by combining data from various sources: automatic counters from the Barcelona City Council, data collected by over 40 volunteers through the collaborative platform BiciZen, and data gathered by the BACC.

The results allow characterization of the existing network and identification of opportunities for its expansion and improvement. This work is the result of collaboration between the Institute of Environmental Science and Technology (ICTA-UAB), the Barcelona Supercomputing Center (BSC), and the Bicycle Club of Catalonia (BACC). Combining data analysis and advanced modeling, this study lays the groundwork for more informed and tailored bicycle planning according to the city's needs.

Objectives

General Objective

Develop a first micromobility traffic model (bicycles and scooters) for Barcelona.

Specific Objectives

- **Knowledge Contribution**
  - Provide new knowledge about bicycle traffic on the streets of Barcelona.

- **Scientific and Methodological Contribution**
  - Develop new models to estimate bicycle flows in the city.
  - Compare models and identify the most accurate ones.
  - Integrate data collected at different scales, from citizen science to automatic counters, to improve estimates.

- **Traffic and Safety Estimation**
  - Contribute to road safety studies by offering essential 'exposure' layers to identify risk points based on cyclist volume per street and intersection.

- **Inclusion and Participation**
  - Promote collaboration and citizen participation in generating knowledge, diagnosing, and analyzing bicycle mobility through the BiciZen platform.

- **Outreach and Communication**
  - Advance the conversation in the city about the importance of developing improved understanding of bicycle ridership modelling, and motivate further work on this topic, led by the City.

Research Questions

What is the estimate of the number of cyclists and other users, calculated as Average Annual Daily Bicycle Traffic (AADBT) per street segment in Barcelona's road network?

How can crowdsourcing and citizen science contribute to improving bicycle demand estimation models and what are their limitations?

Methods
Data origin

Map of counting points in Barcelona

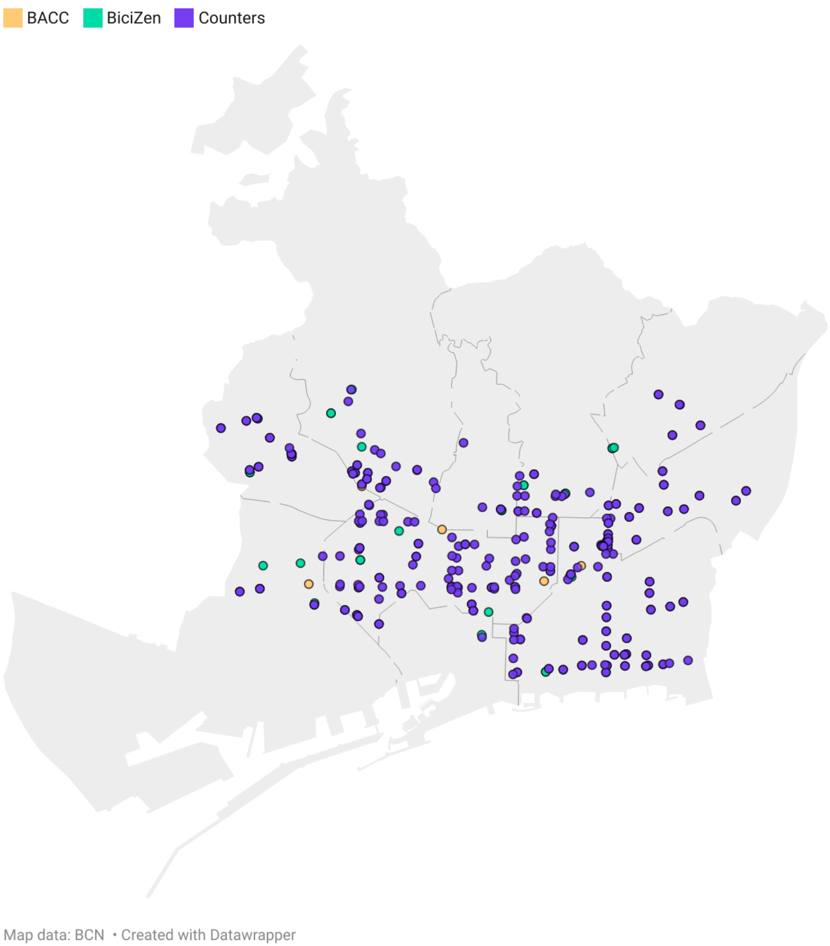


Figure 1.
Data collected on bicycle traffic in the city of Barcelona.

- **Municipal Counters:** Barcelona has a network of counters along its cycling infrastructure that continuously capture data on bicycle flows at different points, times, and directions. A request for public information was made to obtain higher temporal resolution data, resulting in a dataset with 15-minute intervals between 2017 and 2024, totaling 66.5 million observations. Each record includes the counter ID, date, time, bicycle count, and associated error.

  The number of stations has varied over the years, reaching a maximum of 381 counters in 2024. Stations are exclusively located on bike lanes, which complicates modeling bicycle flows on roads without cycling infrastructure. Additionally, fixed counter data is biased as they are installed on streets with high bicycle traffic and specific infrastructure.

- **BiciZen:** To complement automatic counter data, a citizen counting campaign was carried out using the collaborative platform BiciZen (bicizen.org), a citizen science tool that allows collective recording of observations (Honey-Rosés et al., 2025). The mobilization of volunteers also enabled collecting data on age and gender and sampling street typologies outside the cycling network where city counters are absent.

  43 volunteers were recruited who collected data at 30 strategic points, achieving 1,063 counts over 182 hours and 32 minutes of observation. Locations were selected based on street typology and traffic volume, ensuring data quality and representativeness. Direct observation also allowed recording additional information such as vehicle type (bicycle, scooter, or others), perceived gender (male or female), and perceived age (child, adult, or senior).

  This report only presents total count results; gender and age analysis will be left for future reports.

- **BACC:** To complement BiciZen and fixed counter data, data from the Radiografia ciclista de Barcelona (2023–2024) by BACC were obtained. Observations were made with cameras at six locations selected based on the cycling network, absence of counters, type of lane, and usage flow. Recordings enabled identification of bicycle type, propulsion type (electric or mechanical), and perceived gender. In 2024, 11,322 observations were counted across five different locations (BACC, 2024).

Methodology

In addition to collecting relevant data for counting users of cycling infrastructure, the following steps were followed:

1. **Characterization of City Streets:** Streets in Barcelona were classified according to cycling infrastructure, lane type, and traffic level.

2. **Data Collection with BiciZen:** Volunteers collected data via the BiciZen platform.

3. **Data Quality Control:** SData from fixed counters were reviewed to identify and correct errors such as incorrect locations or inconsistent data. Citizen observations were also validated to ensure quality.

4. **Temporal Patterns and Expansion:** Patterns from fixed counters were analyzed to generate expansion factors. These factors allowed better adjustment and estimation of volunteer data at different times and places.

5. **Modeling and Prediction:** A model was developed to predict AADBT from contextual variables such as infrastructure and traffic. This model was applied to all street segments in the city, providing a comprehensive view of bicycle flows.

1. Characterization of city streets

To estimate the AADBT at the street segment scale, it was necessary to characterize the road network of Barcelona. The city has 3,976 streets divided into 21,661 segments, which constitute the unit of analysis for the study.

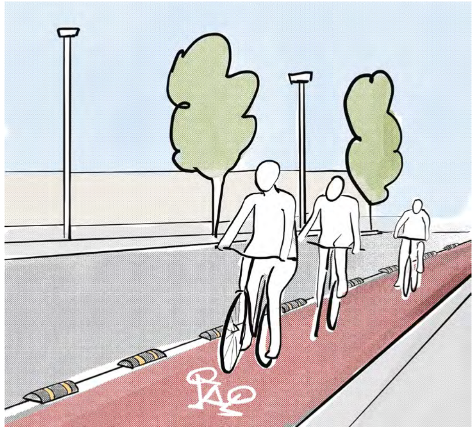
To define the road network, different sources were compared: a simplified version from the City Council in its motorized traffic model, a more detailed one from the National Geographic Institute, and another from OpenStreetMap. Finally, the road network used to model motorized traffic was chosen, due to its level of detail and attributes (number of lanes, direction, road classification, AADT, etc.).

The last step consisted of linking the cycling network with the road network. This was resolved through a spatial join, assigning each street segment the nearest cycling infrastructure to its centroid.

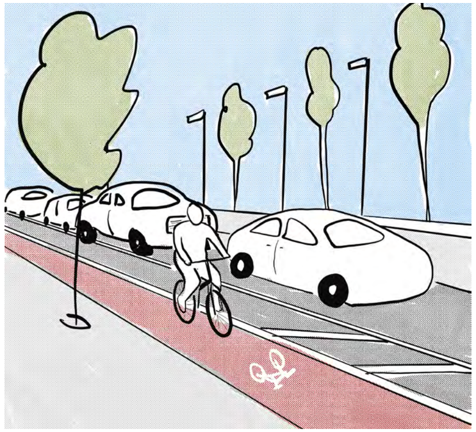
One of the key attributes considered is the type of cycling infrastructure, since higher volumes of use are expected on streets with higher-quality infrastructure.

The classification distinguishes, first, between segments shared with other users (cars, pedestrians, or buses) and segregated segments. Shared segments are further reclassified according to who they are shared with, and segregated ones according to their location and type of separation. This classification is not intended to be exhaustive—a task more suitable for the administration—but rather useful to distinguish between typologies with different impacts on cycling use. We classified Barcelona's cycling infrastructure into seven categories (Figure 2).

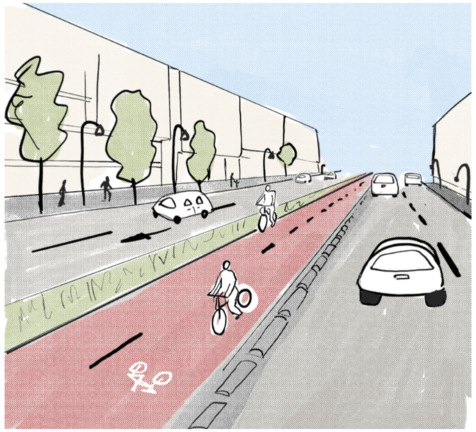
The first version of this classification was developed using open data from the City Council, enriched with information on separators and parking spaces, and later reviewed in collaboration with BACC. Subsequently, an improved version of the municipal cycling network was integrated, which included details such as year of construction, location (roadway or sidewalk), and whether it was shared with other vehicles.



Protected Bike Lane
Roadway reserved exclusively for bicycles with physical separation from motorized traffic.

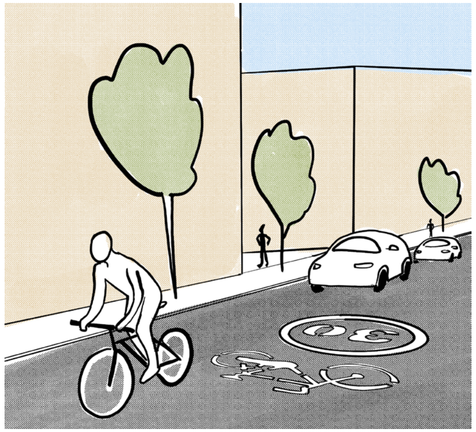


Bike Lane Protected by Parking
Separated from the roadway by a row of parked cars or other elements.

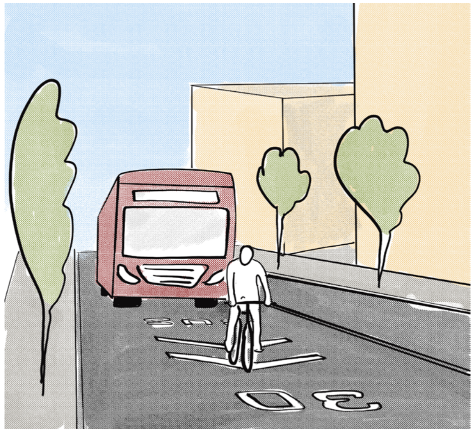


Bike Lane in Central Axis
Located in the center of a roadway, sometimes with physical separators.

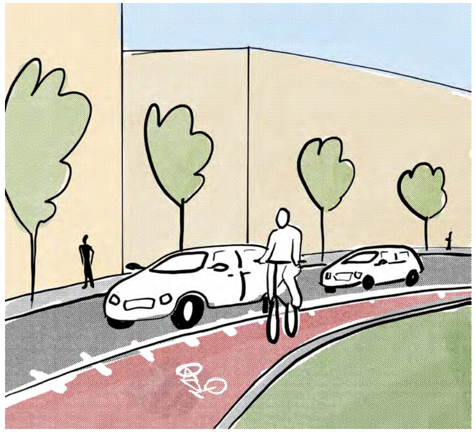
Sidewalk-Bike
Pedestrians and bicycles share the sidewalk, with a reserved and properly marked cycling space.



Shared Lane with Vehicles
Streets limited to 30 km/h with shared space indicated, giving priority to bicycles.



Bus-Bike Lane
Exclusive space for buses and bicycles (marked with pictograms).



Bike Lane (Unprotected)
Roadway exclusively reserved for bicy-cles, located on the street and separated from other traffic by road markings.

Figure 2. Typology of Cycling Infrastructure in Barcelona.

2. Data Collection with BiciZen

- *Recruitment and Training of Volunteers*
  More than 40 volunteers were recruited to observe bike lane usage in the city. Online and in-person training sessions explained the methodology, and detailed materials were shared via email lists and WhatsApp.

- *Sampling Strategy*
  The sampling had two goals: (1) obtain a balanced sample of observations in streets with and without cycling infrastructure, and (2) characterize usage patterns in locations where automatic counter data exist but no age or gender information is available. Random and stratified sampling was used for both cases. It is important to highlight that citizen science sampling is essential to balance the model since using only automatic counter data could lead to overestimation.

- *Sampling of Street Segments Stratified by Cycling Infrastructure and Traffic Volume*
  Street segments were randomly and stratified selected according to: **(i) type of cycling infrastructure, and (ii) traffic level (high, medium, or low).** This approach allows measuring micromobility flows on lower-traffic streets, avoiding overestimation of actual volumes if only automatic counters were considered.

- *Sampling of Counters Stratified by District*
  Counters were stratified according to the 10 districts of Barcelona, selecting one per district using a random number generator in Excel. This guarantees representation of one counter per city district.
  Although age and gender results are not presented in this report, the sampling strategy included observation of demographic characteristics of bicycle users at points with automatic counters.

Selected Streets for Sampling

Streets	District	Infrastructure	Daily Vehicle Volume
C/ Aristides Maillol 3106	Les Corts	Protected Bike Lane	1422
Av. d'Icària 178	Sant Martí	Sidewalk -Bike line	1680
Av. Maria Cristina – Palau de Congressos	Sants-Montjuïc	Central Bike Lane	1602
Av. Meridiana 82	Sant Martí	Protected Bike Lane	1104
Av. Rio de Janeiro 59	Nou Barris	Parking Protected	406
Av. Diagonal 670	Sarrià-Sant Gervasi	Sidewalk -Bike line	246
Av. d'Icària 178	Sant Martí	Sidewalk -Bike line	1110
C/ Calabria	Eixample	Protected Bike Lane	1038
C/ d'Àngel Guimerà 14	Sarrià-Sant Gervasi	Bike Lane (no protection)	516
C/ de Bac de Roda 42	Sant Martí	Parking Protected	876
C/ de la Creu Coberta 113	Sants-Montjuïc	Protected Bike Lane	3186
C/ de la Diputació 385	Eixample	Bike Bus Lane	1824
C/ de Pi i Margall 114	Gràcia	Bike Lane (no protection)	1596
C/ de Sants 403	Sants-Montjuïc	Bike Bus Lane	342
C/ Gran de Gràcia	Gràcia	No infrastructure	186
C/ Joan Blanques	Gràcia	No infrastructure	36
C/ Jocs Florals 175	Sants-Montjuïc	No infrastructure	974
C/ Pontons 1	Sants-Montjuïc	No infrastructure	114
C/ Pujades 3	Ciutat Vella	Parking Protected	468
C/ Torrent de la Carbassa 20	Horta-Guindardó	No infrastructure	0
C/ Bisbe Català 3	Sants-Montjuïc	No infrastructure	60
C/ Bonaplata 22	Sarrià-Sant Gervasi	No infrastructure	870
C/ Calabria 166	Eixample	Bike Lane (no protection)	4572
C/ Garcilaso 64	Sant Andreu	Protected Bike Lane	54
C/ Rosselló 161	Eixample	No infrastructure	354
C/ Sant Antoni Maria Claret amb Rambla Volart	Horta-Guinardó	Central Bike Lane	3210
Pg. Maragall 242	Horta-Guinardó	No infrastructure	1764
Pg. Maragall 84	Horta-Guinardó	Parking Protected	2490
Pg. de la Zona Franca 189	Sants-Montjuïc	Parking Protected	1488
Pg. de Valldaura 259	Nou Barris	No infrastructure	396
Pg. Pujades 3	Ciutat Vella	Central Bike Lane	2892
Pg. Sant Joan 8	Eixample	Central Bike Lane	5404
Rambla de Badal 125	Sants-Montjuïc	Central Bike Lane	84
Rambla de l'Onze de Setembre 2	Sant Andreu	Shared bike lane	146
C/ Ramelleres 15	Ciutat Vella	No infrastructure	174
Ronda Guinardó 111	Horta-Guinardó	Protected Bike Lane	4362
Travessera de Gràcia 260	Gràcia	Protected Bike Lane	10302
Via Augusta 360	Sarrià-Sant Gervasi	Protected Bike Lane	564
C/ de Bilbao 117	Sant Martí	Protected Bike Lane	54

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Table 1. Selected streets for sampling: street name, district, type of infrastructure, and volume of motorized vehicles.

3. Data Quality Control

3.1 Automatic Counter Data

Several measures were taken to ensure the quality of data collected by automatic counters. First, data were filtered based on the estimated error (%)—an attribute provided by the City Council—with the aim of discarding observations recorded during periods when the sensor was malfunctioning. This process allowed analyzing the dynamics and retaining only observations where the sensor was fully operational.

Once cleaned, the data were aggregated on an hourly level and the following rules were applied to determine which observations were considered valid:

1. The same counter cannot have 90 consecutive hours or more with a zero value.
2. There cannot be 6 or more identical observations greater than 5.
3. The total number of nighttime records (8 PM to 8 AM) cannot exceed the total number of daytime records (8 AM to 8 PM).
4. Hourly volume cannot exceed 885 bicycles, and daily volume cannot exceed 11,225 bicycles.
5. A day is considered invalid if it has fewer than 22 hours of valid data.
6. A month is considered invalid if it does not have at least three weeks of valid data.
7. A year is considered invalid if it lacks data for at least 11 months (this rule applies only to the month-year factor calculation).

After quality control, the daily bicycle volume (DBT) was calculated, followed by the annual average daily volume per counter (AADBT) (Miah et al., 2024).

From the data collected by the automatic counters during 2023 and 2024 (over 24 million observations), 5.5% were discarded due to errors detected by the system itself—according to the reliability indicator provided by the City Council—which signaled sensor malfunctions.

Subsequently, data were aggregated hourly, retaining only hours with at least 30 minutes of valid data. After this aggregation, the previously described quality control rules were applied, resulting in 79.2% of observations being classified as valid.

3.2 Observation Data

- **BiciZen Data**
  Regarding BiciZen data, the main challenge was ensuring that the number of observations at a specific sampling point was sufficient to obtain reliable results. Initially, a minimum of 30 observations was set—a common threshold in mobility studies—but this threshold was lowered to 10 to retain a larger number of sampling points.

- **BACC Data**
  BACC data were grouped into one-hour intervals based on counts taken every 15 minutes. When the full hour was not available, values were proportionally scaled. Since many locations correspond to bidirectional lanes and flow direction was not distinguished, the total observed bicycles were divided by two. As a result, data were obtained for 6 stations with a total of 21 months of valid observations.

4. Temporal Patterns and Expansion

Observational data consist of counts lasting between 10 and 30 minutes for a specific location and direction. The purpose of this section is to explain how these observations have been transformed into an estimate of the Average Daily Bicycle Traffic (AADBT). For this, expansion factors have been generated from seasonal patterns derived from automatic counters.

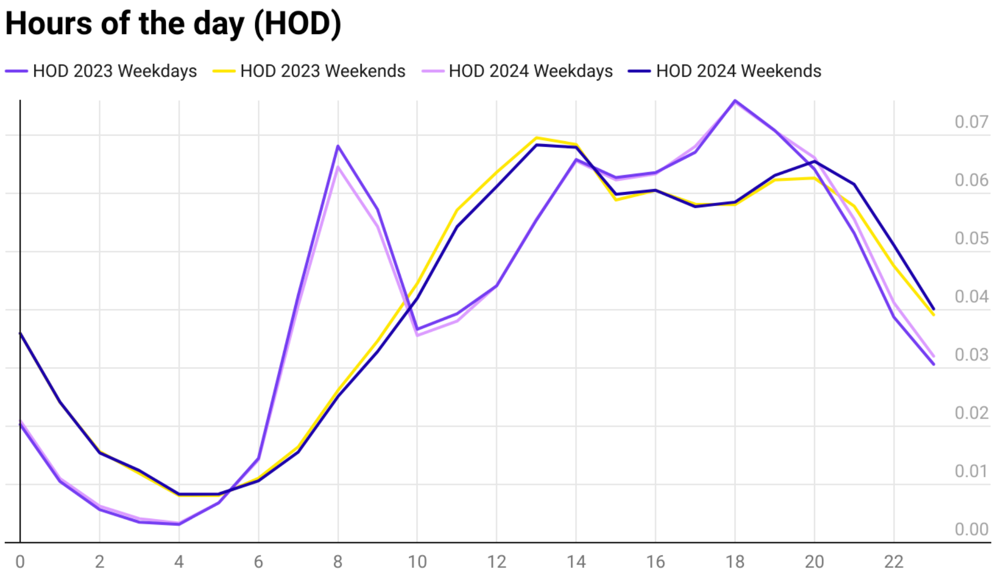


Figure 3. Hourly distribution of weekday mobility.

4.1 Generate Expansion Factors

Expansion factors are proportions or indices that allow "scaling up" short-period count data to estimate bicycle traffic for an entire year. Three expansion factors have been calculated:

- **Daily Pattern (HOD, Hour of Day):** Relates traffic during a specific hour to the total daily traffic, calculated separately for weekdays and weekends.
- **Weekly Pattern (DOW, Day of Week):** Relates traffic on a specific day of the week to the weekly average, capturing variations between weekdays and weekends.
- **Annual Pattern (MOY, Month of Year):** Relates monthly traffic to annual traffic, accounting for seasonality in bicycle use.

5. Modeling and Prediction

The following subsections explain how counting locations were characterized, how the most relevant explanatory variables were selected, which models were generated, how the best model was chosen, and finally, how the final model was used to predict flow for each street segment.

5.1 Characterization of Counting Points and Variable Selection

Counting points were characterized by enriching their context with variables such as proximity to educational centers and different land uses (including green areas and water bodies). Mobility elements (bike parking, Bicing, bike signage, public transport), sociodemographic data (age, gender, income), cycling infrastructure features, traffic flows, road morphology, as well as altitude and terrain slope were also added.

Variable selection started by filtering those with a correlation greater than 0.15 with the dependent variable. Then, variables exhibiting multicollinearity were removed, and finally, explanatory variables with mutual correlations above 0.6 were discarded.

5.2 Development of the AADBT Prediction Model

Once explanatory variables were selected, four types of models were trained to predict AADBT: Poisson regression, Random Forest, XGBoost, and a Convolutional Neural Network (CNN). These models cover approaches from traditional statistical methods to advanced machine learning and deep learning techniques.

Four complementary metrics were used to evaluate and compare performance: MAE (Mean Absolute Error), RMSE (Root Mean Squared Error), MAPE (Mean Absolute Percentage Error), and R^2 (coefficient of determination). These metrics assessed the accuracy, robustness, and explanatory power of each model.

5.3 Application of the Model for Road Network Prediction

Once the best-performing model was selected, centroids of street segments were extracted as the basis for prediction. These points were enriched with the explanatory variables used in model training. For bidirectional streets, attributes were generated for both traffic directions.

AADBT was predicted independently for each direction, then totaled by summing both. Finally, results were joined with the original geometry of the street segments, allowing spatial visualization and analysis across the network.

Results

1. Characterization of city streets

A classification of cycling infrastructure in Barcelona was created, grouped into five categories for visualization purposes. To facilitate reading at an urban scale, all bike lanes located on the roadway were represented as a single category.

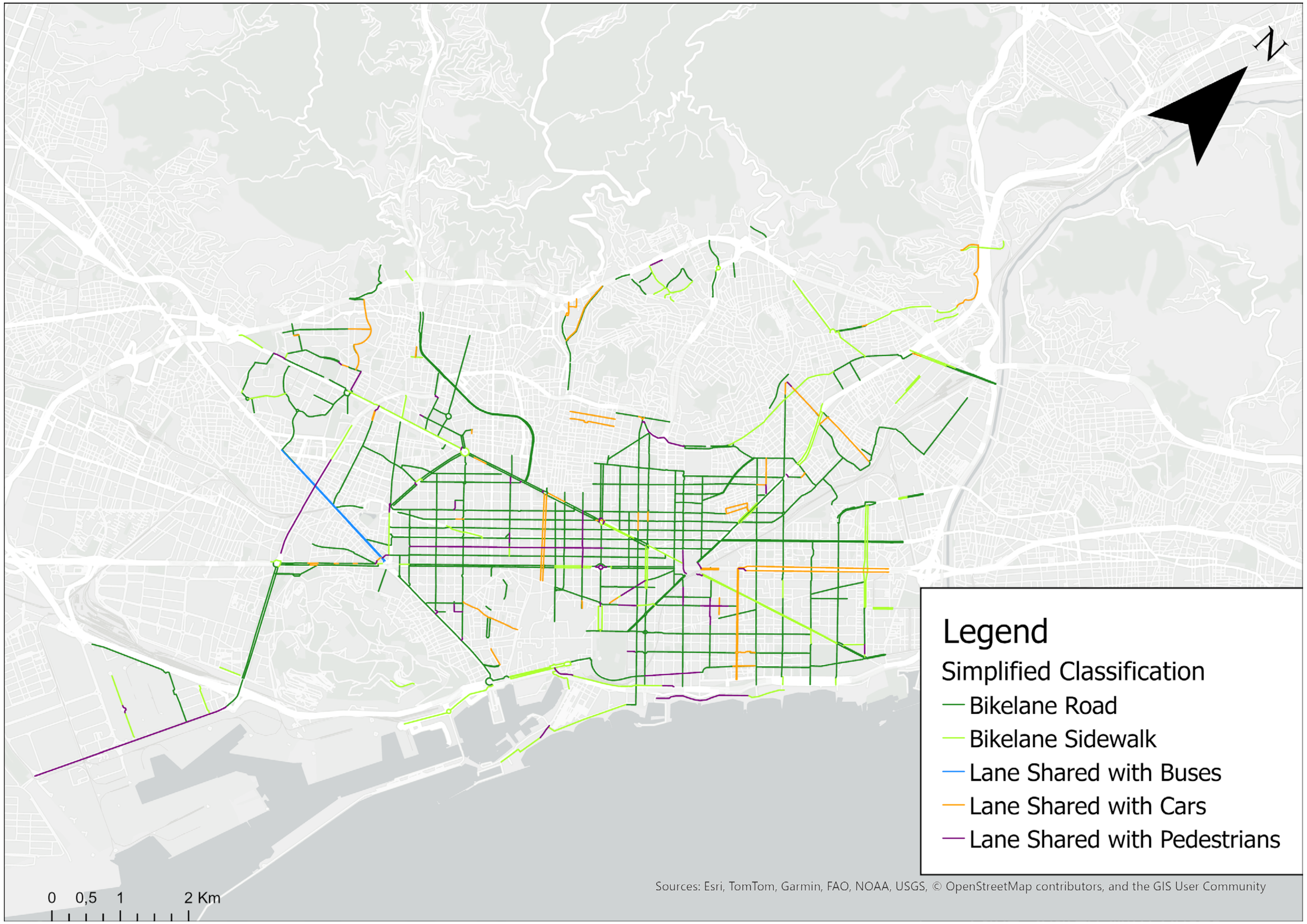


Figure 4. Cycling routes in Barcelona 2024

2. Data Collection with BiciZen

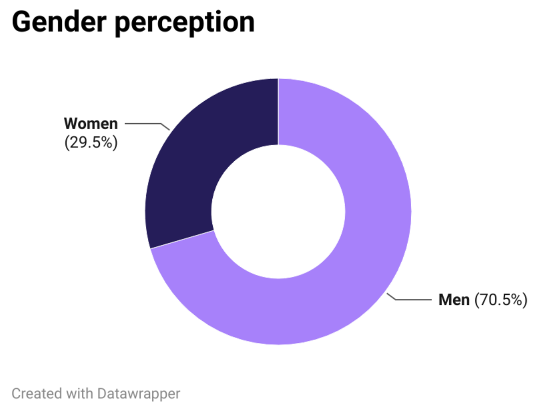
Using theBiciZen platform, a total of 182 hours and 32 minutes of observations were collected at the locations mentioned previously. This recording period resulted in 1,063 observations from 43 volunteer participants. *(Appendix, 3-4)*

This information, allowed us to observe the following cycling dynamics in Barcelona.In the graphs, information is presented on the three main differentiations of the study

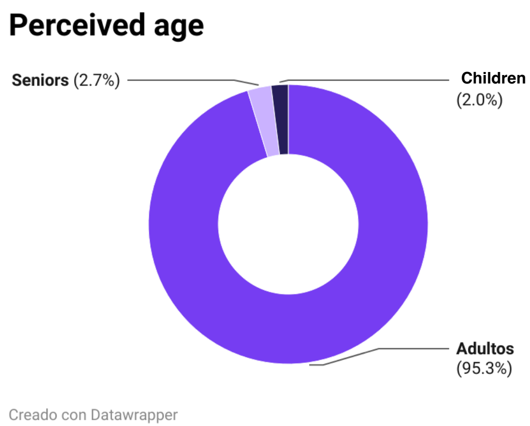
The graphs present the information on the study's three main differentiations:

- **Vehicle Type,** which clearly shows that the most used mode of transport is the bicycle, representing 74.3% of observations, followed by the electric scooter at 24.3%.
- **Perceived Gender of cyclists,** 70.5% were men and 29.5% women.
- **Perceived Age,** lof users of cycling paths: the majority (95.3%) were adults (18–64 years), while the presence of older adults (65 years or older) and children and adolescents (17 years or younger) were both under 3%.

5a.



5b.



5c.

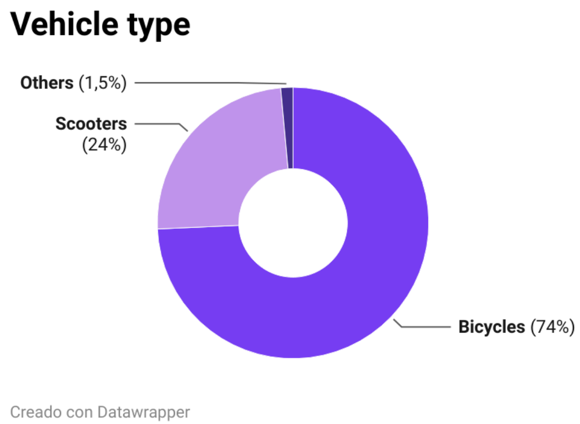


Figure 5. Distribution of perceived gender **(5a),** age **(5b)** and vehicle type **(5c)** in citizen science observations with the BiciZen platform.

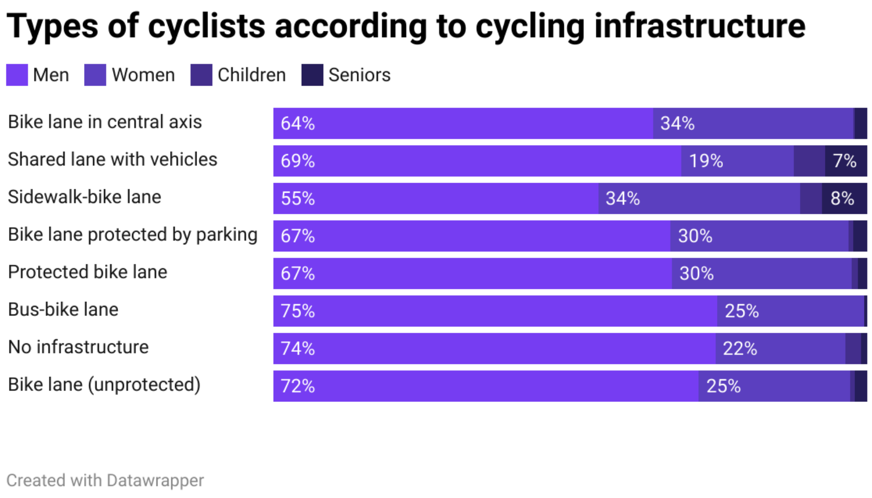


Figure 6. Cyclist typology by cycling infrastructure

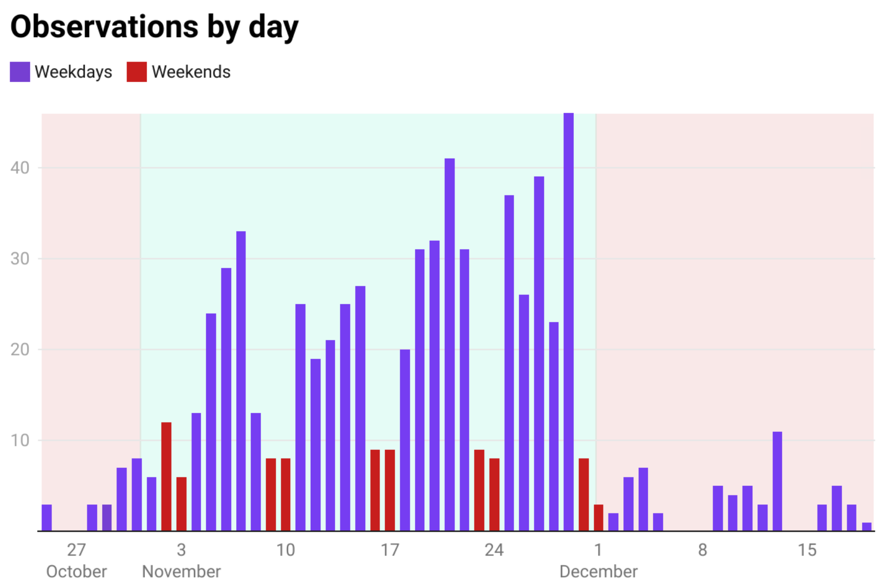


Figura 7. Number of observations per day with BiciZen counts

An additional breakdown considering cycling infrastructure type and user profile was also made. This analysis highlights that the daily median number of cyclists, by infrastructure type, shows a low percentage of women in areas where cycling lanes are poor or nonexistent.

3. Generation of Traffic Models (AADBT)

3.1 Characterization of Counting Points and Variable Selection

Seventy-one variables were generated for the 642 annual observations (AADBT), increasing to 122 after converting categorical variables into dummies, including 605 counters, 26 BiciZen points, and 11 BACC data points.

During selection, 86 variables were discarded due to low correlation, 6 for multicollinearity, and 7 for high mutual correlation, leaving a total of 23 explanatory variables.

3.2 AADBT Model

Seventy-one variables were generated for the 642 annual observations (AADBT), increasing to 122 after converting categorical variables into dummies, including 605 counters, 26 BiciZen points, and 11 BACC data points. During selection, 86 variables were discarded due to low correlation, 6 for multicollinearity, and 7 for high mutual correlation, leaving a total of 23 explanatory variables.

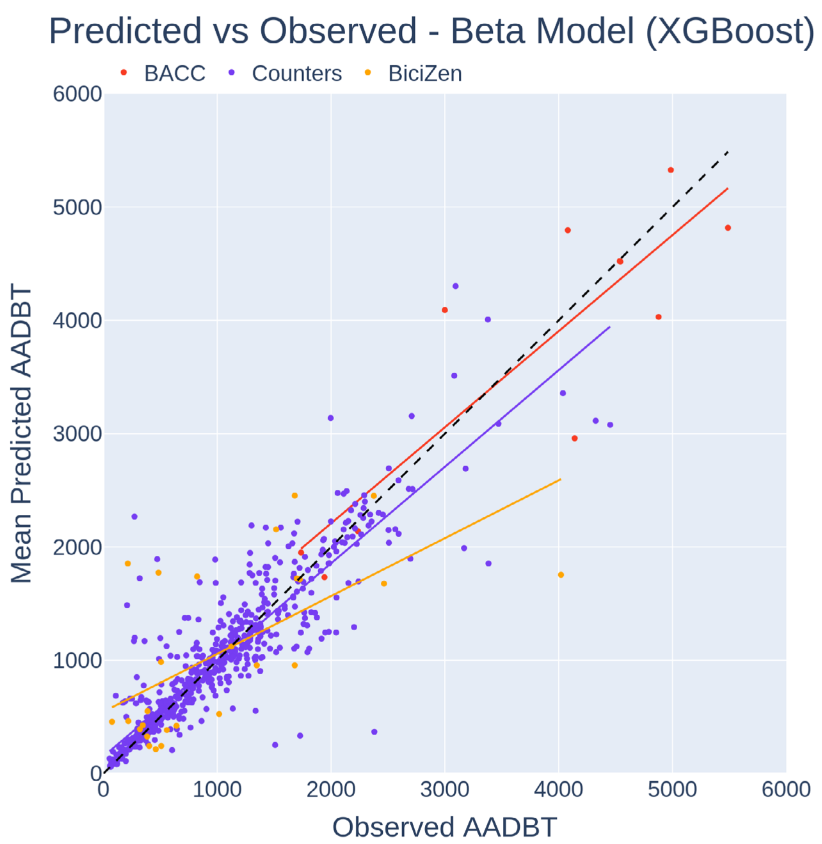


Figura 8. The beta model was evaluated by comparing predicted AADBT (y-axis) with observed values (x-axis). A perfect model would align with the line y = x. Overestimations are observed, especially at lower values.

Model Comparison

Model	MAE	RMSE	MAPE	R2
Poisson Regression	399.74 ± 38.51	581.72 ± 88.38	63.60 ± 6.92	0.433 ± 0.096
Random Forest	242.41 ± 27.89	386.93 ± 59.54	36.60 ± 4.14	0.748 ± 0.057
XGBoost	235.28 ± 33.09	376.34 ± 67.18	35.20 ± 5.39	0.750 ± 0.102
CNN	754.42 ± 113.48	1122.24 ± 221.15	34.67 ± 18.94	0.646 ± 0.176

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Table 3. Comparison of bicycle and scooter traffic models in Barcelona

4. Prediction for Street Segments

A total of 17,787 street segments were extracted, of which 3,077 were bidirectional and duplicated, resulting in 20,864 segments. For each segment, the centroid was calculated and enriched with the 23 model variables. Individual predictions were generated per segment. For bidirectional segments, predictions for both directions were aggregated. Results were joined to the original geometry, enabling visualization of estimated flows in Figure 10.

While a naive estimate using only automatic counter data suggested an average volume of about 4,000 bicycles and scooters per street, incorporating citizen science observations reduced this estimate by 17%, approaching more realistic estimates. Currently, the beta model estimates that on an average day, 3,284 bicycles and scooters circulate per day. This value likely remains an overestimate, especially on streets without cycling infrastructure and low traffic streets.

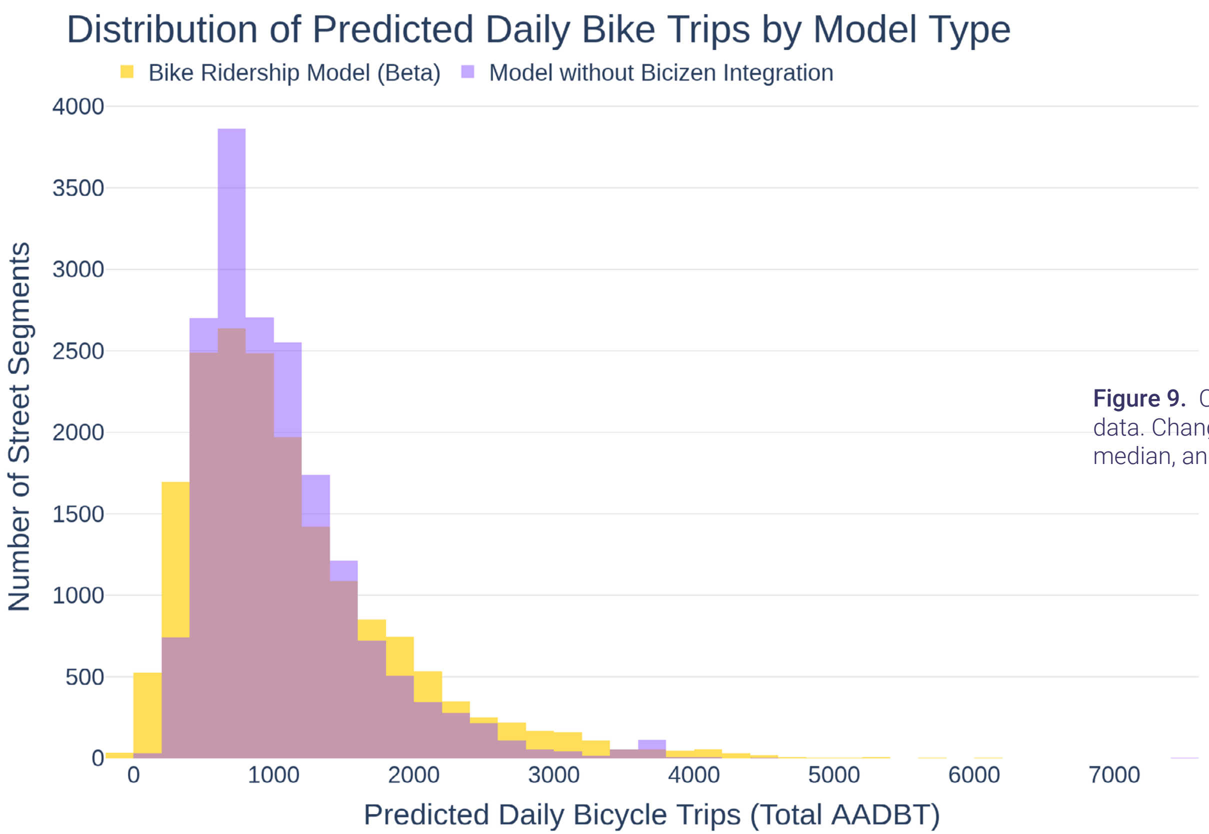


Figure 9. Comparison of our beta model with the same model excluding citizen science data. Changes in the distribution of estimates are observed with a reduction in the peak, median, and many of the highest values disappear.

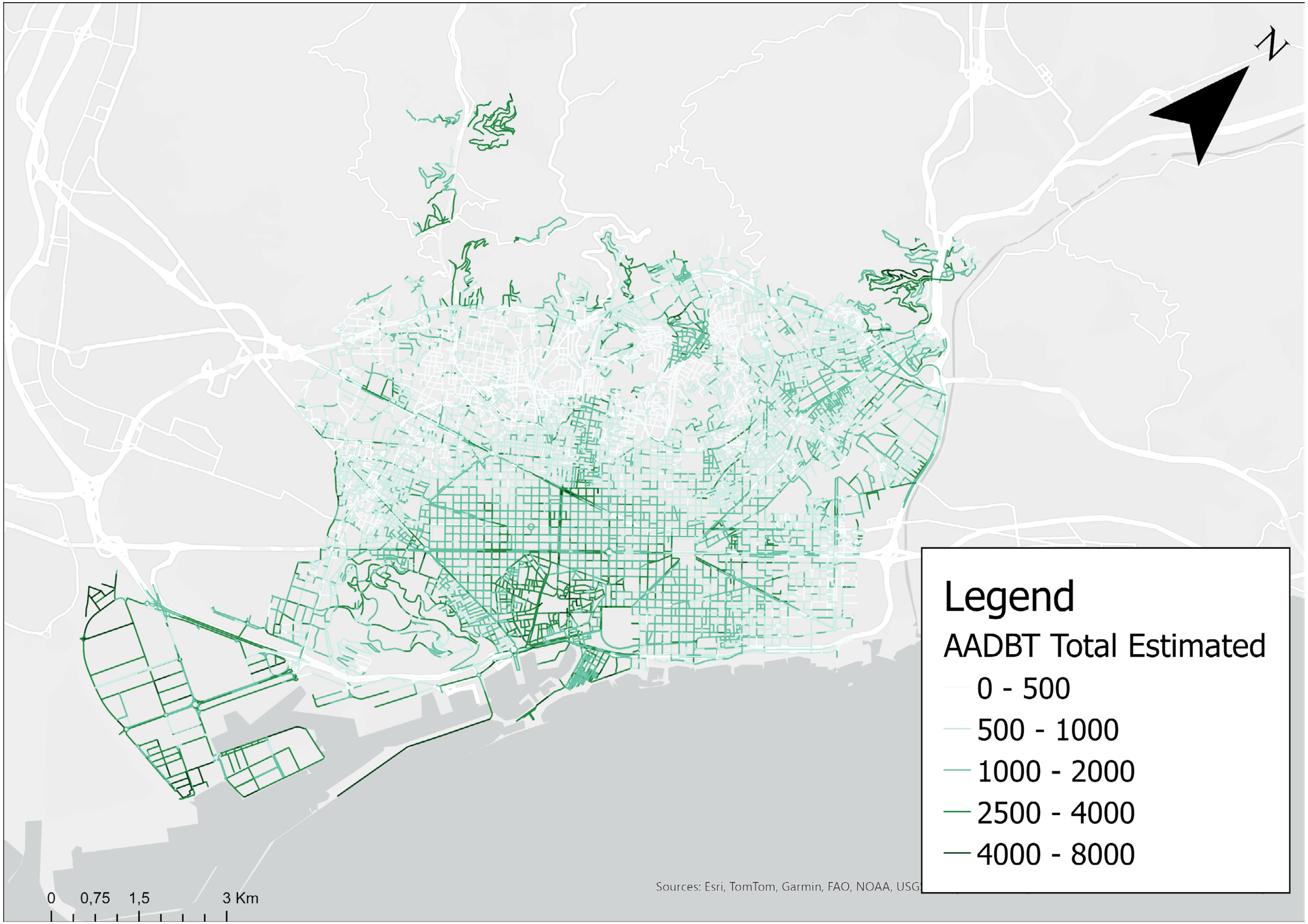


Figure 10. Bicycle and scooter estimates on Barcelona's streets according to the beta model..

Conclusions

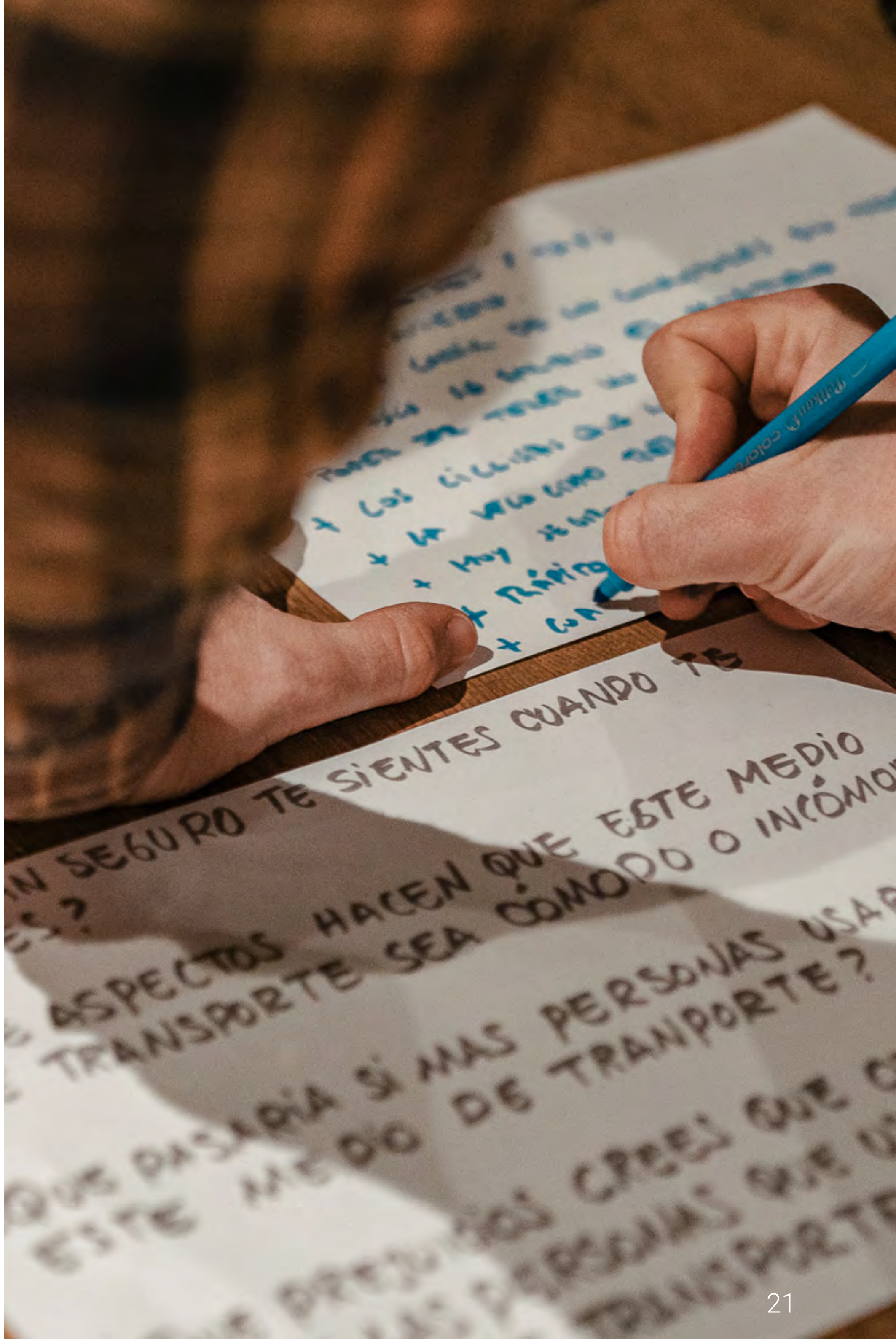
This work brings us closer to understanding micro mobility flows in Barcelona at the street segment scale. For decades, while traffic engineers have developed models to obtain these values for motorized mobility, the equivalent for cycling mobility remained unknown. We contribute by presenting the first micromobility traffic model in Barcelona.

We observe that estimates of bicycle and scooter volumes in Barcelona have been improved thanks to citizen science contributions. Across all street types, estimates decrease when observations gathered by volunteers are included.

Model comparison confirmed that the XGBoost algorithm consistently provides the best results. The beta model has its deficiencies but remains an important advance over previous work. It incorporates conditions and characteristics of each street and the presence of cycling infrastructure. Furthermore, the model accounts for the directionality of bike lanes.

The generated map offers insight into the movement pattern of bicycles and scooters circulating in Barcelona, considering factors influencing micromobility use. Future work will need to integrate Strava data, separate bicycles from scooters, and disaggregate user flow by age and gender.

This project illustrates what can be achieved with the collaboration of the cycling community, cycling organizations, and an international research team. It offers a first initial estimate of bicycle and scooter flows on Barcelona's streets. This model is not only a technical advance but also an example of the power of citizen science to transform urban mobility knowledge and support city decision-making.



Bibliography

- **Ajuntament de Barcelona (2025).** "Servei d'assistència tècnica a la Direcció de Serveis de Mobilitat lligada al Pla de Mobilitat Urbana (PMU) 2025-2030 per la modelització de la xarxa de transport en superfície, metro i ferrocarril suburbà, si s'escau, la xarxa de transport en bicicleta." MOMENTUM GABINET D'ENGINYERIA SL. 368.318,26 €: URL https://licitacions.bcn.cat/licitacion/licitaciones/detalle?id=9587091 URL:https://contractaciopublica.cat/ca/detall-publicacio/4fd78048-9ee6-4ab7-af00-729842f26157/300439880

- **Ajuntament de Barcelona. (2024)**. Pla de Mobilitat Urbana de Barcelona 2024. https://bcnroc.ajuntament.barcelona.cat/jspui/bitstream/11703/128157/1/Pla%20de%20Mobilitat%20Urbana_bcn_2024.pdf

- **Bicicleta Club de Catalunya (BACC). (2024).** Radiografia ciclista de Barcelona 2024: Resultats de l'estudi. Recuperado de https://bacc.cat/radiografia-ciclista-de-barcelona-2024-resultats-de-lestudi/

- **Generalitat de Catalunya, Departament de Política Territorial i Obres Públiques. (2005).** Manual de diseño de vías ciclistas de Cataluña. Recuperado de https://terra.bibliotecadigital.gencat.cat/bitstream/handle/20.500.13045/262/manual-dise%C3%B1o-vias-ciclistas-catalu%C3%B1a.pdf?sequence=1&isAllowed=y

- **Honey-Rosés, J., Liebscht, L., Batista, P., Benatallah, B., Brussel, M., Flacke, J., Häkli, J., Kallio, K. P., Lynn, T., Mäkelä, M., Melo, L., Simón-i-Mas, G., & Vilariño, F. (2025).** BiciZen: Lessons in the development of a crowdsourcing mobile app to make cities more bikeable. Journal of Participatory Research Methods, 6(1), 143–168. https://doi.org/10.35844/001c.126552

- **Nelson, T., Roy, A., Ferster C., Fischer J., Brum-Bastos V., Laberee K., Yu H., Winters M. (2021).** Generalized model for mapping bicycle ridership with crowdsourced data. Transportation Research Part C: Emerging Technologies. 125, April 2021,https://doi.org/10.1016/j.trc.2021.102981

- **Miah, Md. Mintu, Hyun, K., & Mattingly, S. (2024).** A review of bike volume prediction studies. Transportation Letters: The International Journal of Transportation Research, 16. https://doi.org/10.1080/19427867.2024.2310831

- **Miah, Md. Mintu, Griswold, J., Proulx, F., Bigham, J., & Grembek, O. (2024)**. Methodology of a large-scale bicycle exposure estimation.

- **Sevtsuk, A., Alhassan, A., (2025).** Madina Python Package: Scalable Urban Network Analysis for Modeling Pedestrian and Bicycle Trips in Cities. Journal of Transport Geography 123:104130. https://doi.org/10.1016/j.jtrangeo.2025.104130.

- **Simón-i-Mas G., Honey-Rosés, J. (2024).** A Global Overview of Bike Bus: A Journey Toward a Child-Friendly City. International Journal of Sustainable Transportation. 18(12):1012-1025 doi: 10.1080/15568318.2024.2432654

- **Tacq, Roxy, Knol, Arjan. (2025)** 75% Bicycle Intensity Maps. How intensity maps can support cities to achieve UN Road Safety Performance Target 4. Accessed: 2025-05-08. dokdata.nl and iRAP, 2024. https://storymaps.arcgis.com/stories/4c3d8d6d9b53499d97ca1768e26058b0

- **Vuk G., Bradley, M. Bowman, J., Overgard C. 2022**. Modeling of Bicycling in the COMPASS Activity-Based Model for Copenhagen. TRB presentation RSG. URL: https://rsginc.com/wp-content/uploads/2022/01/Modeling-of-Bicycling-in-the-COMPASS-Activity-Based-Model-for-Copenhagen.pdf

Funding

This project received funding from the European Union’s Horizon 2020 research and innovation program under Grant Agreement No. 101016888, through the ECIU’s SMART-ER program. This result reflects only the author’s view, and the EU is not responsible for any use that may be made of the information it contains. Jordi Honey-Rosés received support from the Ramón y Cajal program (RyC-2019-027279-I) and from the Spanish Ministry of Science, Innovation and Universities through the “María de Maeztu” program for Units of Excellence (CEX2019-000940-M)

Counters selected for citizen science sampling

District	ID	Locations
Ciutat Vella	20112	Pg. Pujades - Lluis Companys (towards Llobregat)
Eixample	20326	C/ Calabria - Aragó (towards the mountain)
Gràcia	20099	Travessera de Gràcia - En Grassot (towards Besòs)
Horta-Guinardó	20347	Ronda Guinardó - Torrent Melis 2 (towards Llobregat)
Les Corts	20241	C/ Aristides Maillol - Cardenal Reig (bike lane)
Nou Barris	20194	C/ de Pi Ferrer - C/ del Garrofers (towards the mountain)
Sant Andreu	20227	C/ Garcilaso - Av. Meridiana (dtowards Llobregat)
Sant Martí	20248	Av. Meridiana - Clot (bike lane)
Sants-Montjuïc	20169	Av. Maria Cristina - Pl. Espanya (towards the sea)
Sarrià-Sant Gervasi	20404	Via Augusta - Pg. de la Bonanova (towards the mountain)

Created with Datawrapper

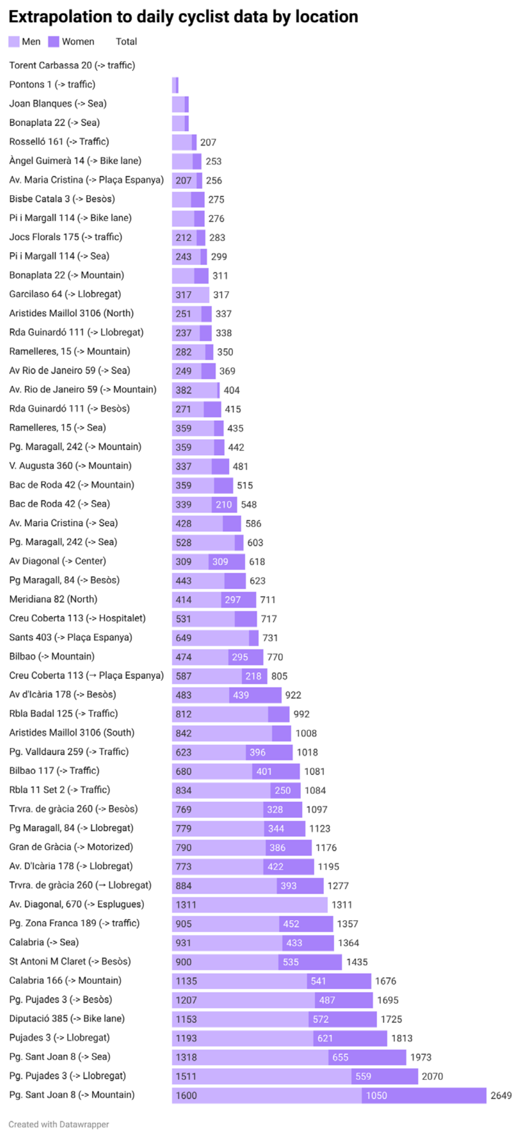
Appendix 1. Counters selected for citizen science sampling

Length and segments by type of cycling infrastructure

Infrastructure	Total length	Segment counts
Central lane	9,947	35
No separation	848	3
Protected by parking	62,130	246
Protected by separator	107,586	526
Shared Bus/Bike lane	4,156	14
Bike streets	34,467	207
Sidewalk	53,392	250

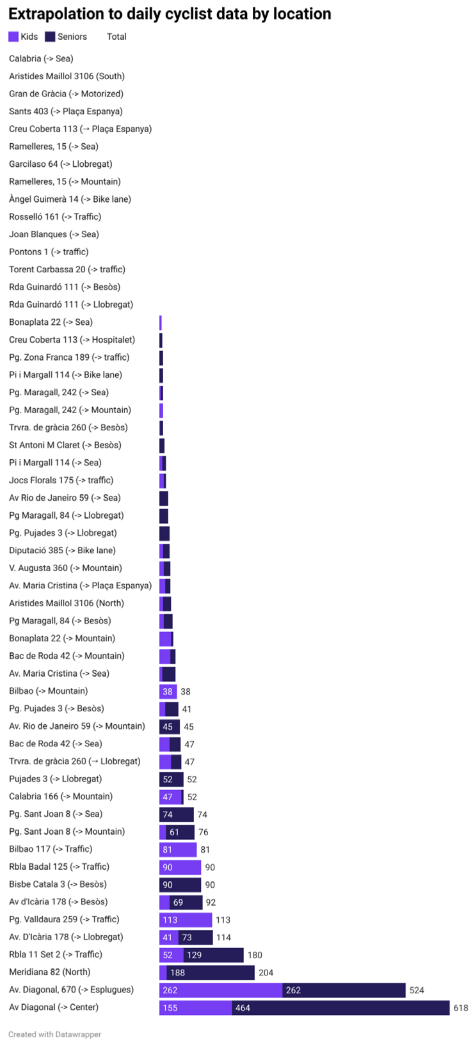
Created with Datawrapper

Appendix 2. Length and segments by type of cycling infrastructure.

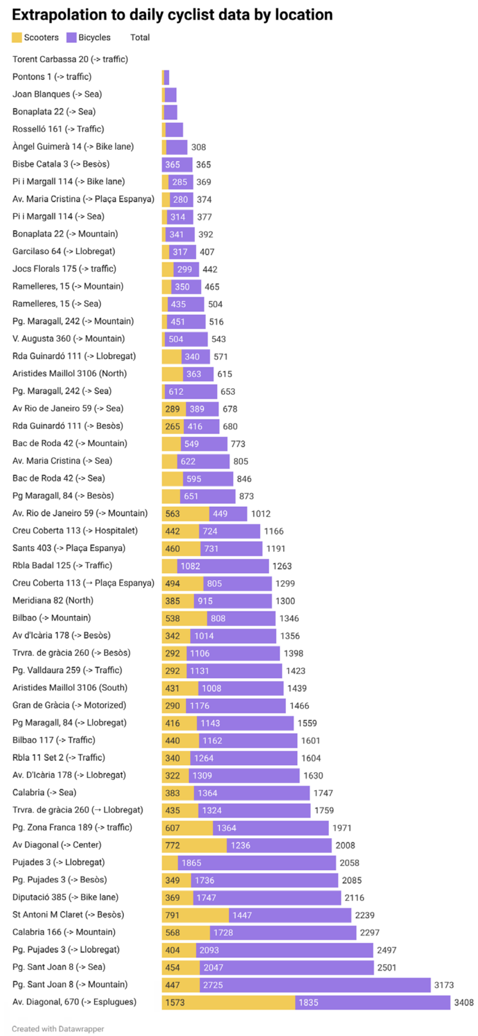


(a) Number of BiciZen_Gender observations.

Appendix 3. Citizen science observations using the BiciZen platform at observation pointss. **(a)** Number of BiciZen_Gender observations, **(b)** Number of BiciZen_Age observations, **(c)** Number of BiciZen observations by vehicle type. Observation period: October to December 2025.

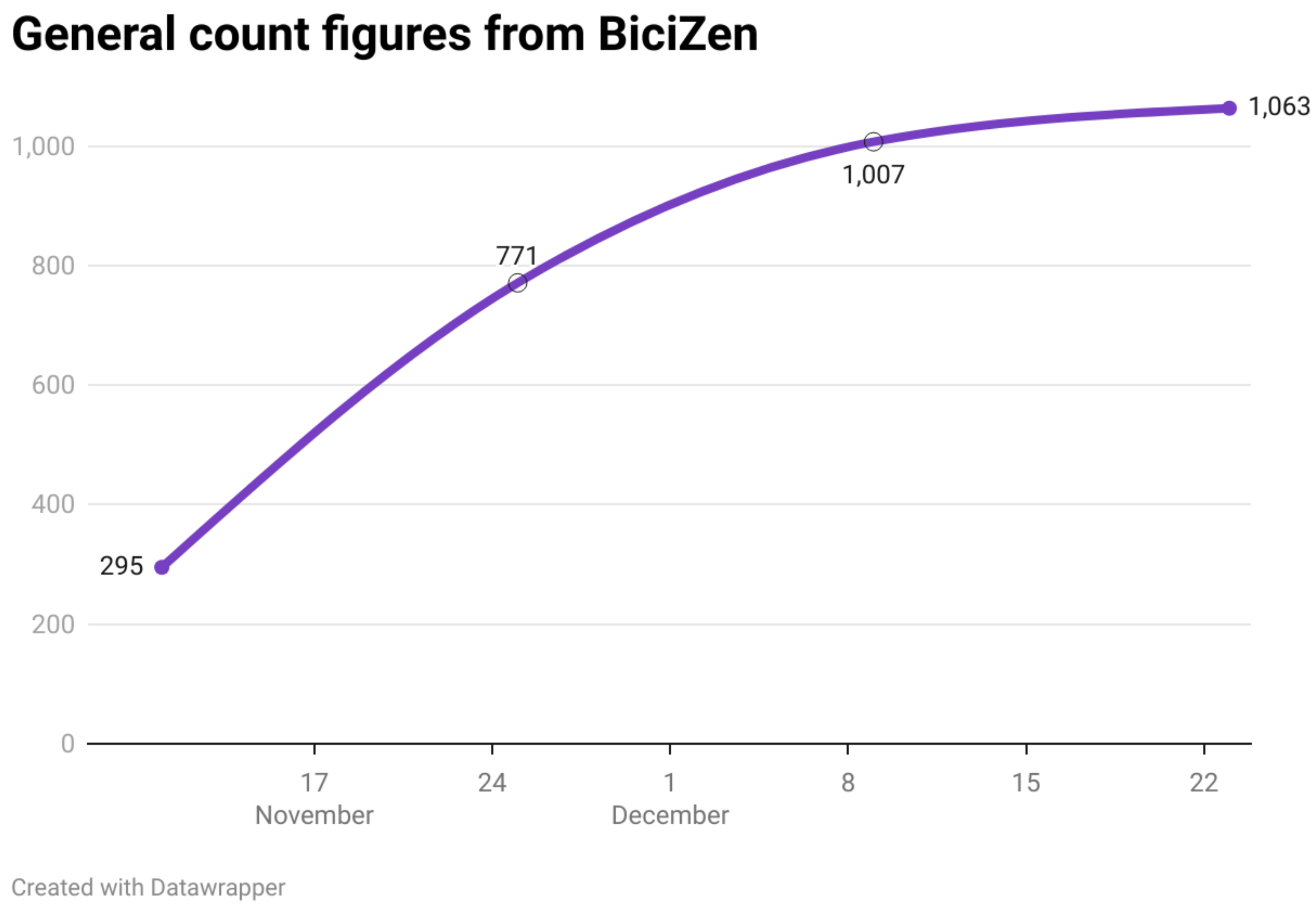


(b) Number of BiciZen_Age observations.

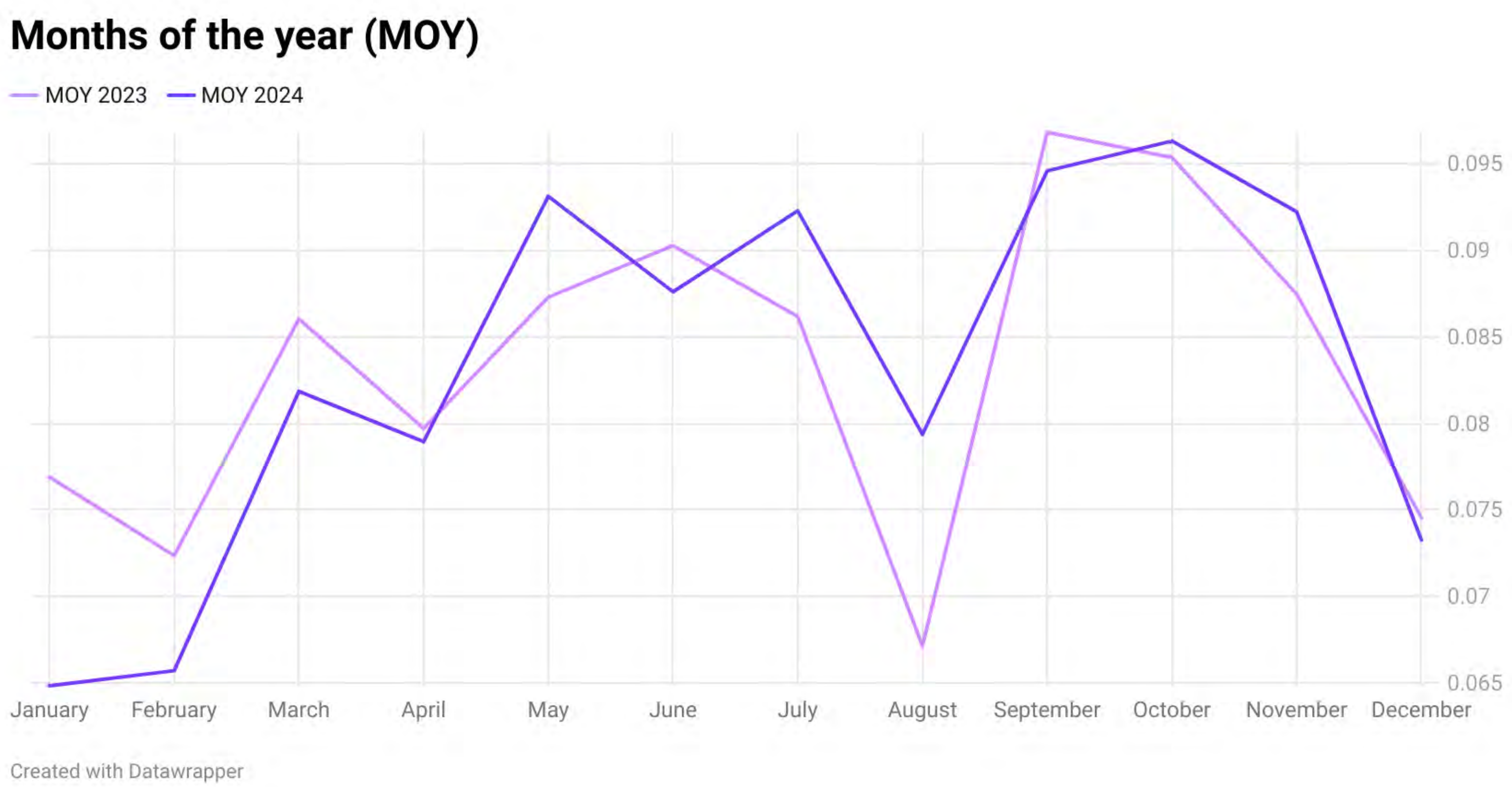


(c) Number of BiciZen_Age observations.

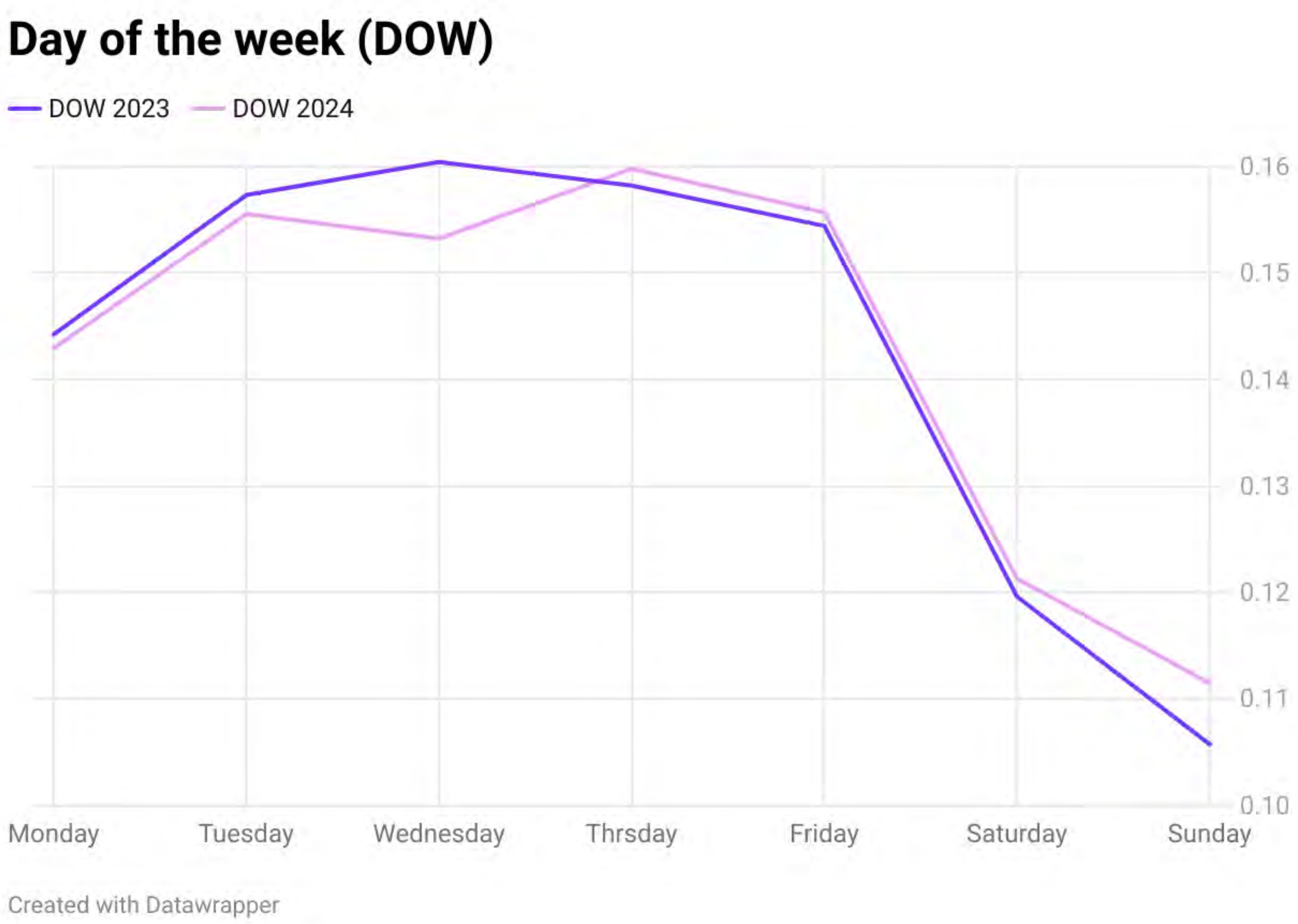
Appendix 3. Citizen science observations using the BiciZen platform at observation pointss. **(a)** Number of BiciZen_Gender observations, **(b)** Number of BiciZen_Age observations, **(c)** Number of BiciZen observations by vehicle type. Observation period: October to December 2025.



Appendix 4. Number of citizen science observations carried out during the observation period between October and December 2025.



Appendix 5. Automatic counters allow us to characterize seasonal bicycle use throughout the year and generate expansion factors to make annual estimates from observations gathered during only part of the year.



Appendix 6. Weekly patterns are derived from automatic counters to account for day-of-week variation.

AADBT estimates by type of cycling infrastructure

Type of cycling infrastructure	Average count (Beta Model)	% Reduction with citizen science
No cycle infrastructure	3193	−17
Protected cycle lane	3570	−22
Cycle lane protected by parking	3842	−19
Sidewalk-bike lane	3179	−12
Lane shared with vehicles	3594	−22
Cycle lane on central axis	4538	−17
Bus-bike lane	4569	−14
Cycle lane (unprotected)	3409	−49

Created with Datawrapper

Appendix 7. AADBT estimates by street typology with cycling infrastructure in Barcelona.
We observe that the beta model still produces high values, which are likely overestimations. However, the inclusion of volunteer observations helped reduce these estimates by between 12% and 49%