




Article

Assessing Cyclists' Accessibility into Railway Stations Through a User-Centered Indicator

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Abstract: Nowadays, there is a growing interest in integrated sustainable transportation. Bike–train intermodality is one of the sustainable modes of transport, combining long-distance service and reaching the last mile. However, bike–train intermodality development both presents challenges for transport service providers and has its drawbacks for users who prefer connections that do not require changing between transport modes. The challenge consists of providing a better transition during changes between transport modes. This can be accomplished through understanding the needs of travelers followed by the implementation of infrastructural changes and the expansion of targeted services that increase the accessibility of the nodal points. Cost-effectiveness analysis, cost–benefit analysis, and a multicriteria decision process are some of the methods that can be used to allocate resources that could improve bike–train intermodality. This research extended the concept of resource allocation to a new multilevel weighted indicator (AxI) that measured the level of accessibility of bikes into railway stations to identify the criticalities and define the priority of interventions. The proposed method was applied in thirty-three Italian railway stations of different sizes. The results showed that the proposed indicator was a valid tool for railway station infrastructure managers and all stakeholders involved for prioritizing interventions related to the advancement of bike–train intermodality. The AxI indicator is a lean methodology to identify the exigencies and communicate them to the parties involved in the management and actualization. The AxI lays the groundwork for a straightforward discussion on resource distribution priorities.

Keywords: bike–train intermodality; prioritization; accessibility



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1. Introduction

In the 2021 “Transport and Environment Report”, the European Environment Agency reported that unlike other sectors, greenhouse gas emissions from the transport sector have increased by 33.5% in the last three decades, and in 2019, transport was responsible for about a quarter of EU greenhouse gas emissions. According to available data, 72% of transport emissions come from roads. In this scenario, cars play a predominant role, contributing 60.6% of total emissions, followed by heavy trucks and buses, which together account for 27.1% of emissions. The climate impacts of a passenger-kilometer transported by car are substantially higher than those of public transport and active modes of travel (on

foot and by bicycle). One of the means to reduce the influence of transport on emissions is to switch to modes of transport that emit fewer greenhouse gases and to non-motorized modes such as cycling and walking. In 2018, only 0.4% of the EU's total greenhouse gas emissions came from the rail sector [1]. There are multiple benefits in the use of rail transport compared with other modes [2]. Baum-Snow et al. found that commuter travel times were significantly shorter in areas that had developed a strong rail system compared with similar places with no rail system [3]. On the environmental side, Shang et al. demonstrated that implementing an urban rail transit would drastically reduce emissions [4]. One of the rail transport issues is reaching the "last mile" [5]. Previous studies recommend that making the railway station more accessible to modes that could fulfil the last mile (bicycles, ride-hailing, or on-demand services) would encourage the use of the train as the main means of transport [6]. In the Netherlands, UK, and Germany, users would cycle up to 5 km to reach the railway station [7].

In recent decades, there has been a growing interest in the use of bicycles, for its low cost, the little experience required for the user, and the environmental impact. The promotion of cycling is one of the objectives that aligns with those of the European Community outlined in the 2030 Agenda. In Italy, the Ministry of Sustainable Infrastructure and Mobility published the "General plan of cycling mobility 2022–2024", which aims at improving a long-term plan on the cycling mobility system [8]. The two-year plan aims to strengthen the execution of the National Cycling Mobility System to build an integrated, multimodal, and sustainable mobility model, with cyclability as the focus [9]. The sustainable urban mobility plan contains actions to encourage cycling and adopt sustainable policies through understanding and sharing of good practices and providing adequate funding [3]. At a microscale, several cities have embraced initiatives to encourage micromobility as a viable mode of transportation [10]. Data show that in Italy, the use of dockless bike-sharing between 2021 and 2022 had an increase of 95% [11]. The Municipality of Bologna provided an urban plan to improve sustainable mobility through, among other actions, the improvement of the use of bicycles to reduce by 40% the emissions provided by motorized vehicles by 2023 [12]. In addition, Bologna has invested in cycle paths and services connecting the city, as well as providing guidelines and standard models for creating mobility hubs. The project aims to provide a safe network for cyclists, in order to involve more people in using the bicycle for commuting [13].

Mobility hubs are an urban infrastructure designed to provide a variety of shared transport modes (at least two) in the same place, where integration with public transport is highly recommended [14]. Mobility hubs emerge as central elements for the promotion of intermodality. In fact, these places act as points of convergence between different modes of transport, facilitating the integration of medium- and long-haul, suburban and urban travel. As indicated in the 20th Report on the Mobility of Italians, intermodality is crucial to promote a sustainable alternative to the private car.

The foundations of an intermodal and sustainable mobility system are made up of rail transport, local public transport, "soft" mobility (such as walking, cycling, and electric micromobility), and sharing mobility, especially when connected to public transport [15]. Specifically, bike–train intermodality is a significant opportunity to promote integrated travel modes that respect the environment. Railway stations are the nodal points of this interconnection, acting as an interface between rail and two-wheeled transport. The attractiveness of the bike-and-ride mode of transport is strictly connected to the accessibility of railway stations [7]. Arthur et al. demonstrated that there is a positive correlation between cycling and the number of facilities dedicated to it, especially for commuters [16]. Numerous studies have identified the relationships between rates of bicycling and provision on infrastructure [17]. Handy et al. found that a short distance to work, safe streets for

cycling, and high monthly parking costs are associated with bicycle commuting [18]. Moreover, the presence of traffic lights, a low traffic volume, and congestion, as well as bicycle ownership and frequency of use, increase the propensity to cycle as they are factors that increase a positive perception of the surroundings [19]. A study also showed that infrastructure, communication, incentive, and regulative measures are also of importance for making intermodal transportation a viable option for commuters [20].

Despite the many advantages and investments made to encourage sustainable mobility, and especially bike–train intermodal trips, there is currently no method for allocating resources efficiently. There is a need for an effective way to improve services and infrastructure in order to increase the number of passengers and commuters using intermodal travel. Past research has studied methodologies used for resource allocation. Cost–benefit analysis is a quantitative method that compares the total expected costs against the total expected benefits of one or more actions, to choose the most profitable option [21]. It is highly concentrated on economic aspects as it states how prepared an individual is to pay for a reduced risk or improvement of a service [22]. Browne et al. studied and compared the use of the cost–benefit analysis and the cost-effectiveness analysis on the transportation sector and found out that the two methods did not provide complete results and that they should be associated with the multicriteria decision analysis [23]. The multicriteria decision analysis is a decision-making framework that evaluates multiple conflicting criteria in decision making. In this case, each criterion is assigned a different weight [24]. The analytical hierarchy process (AHP), among others, is one of the many methodologies developed to define each weight, specifically the modification to the fuzzy AHP method [25].

Research was carried out in the past on specific applications of these methodologies at railway stations. Coppola et al. implemented a multicriteria decision-making tool to prioritize investments in railway stations using a multidimensional cost-effectiveness analysis. The methodology focused on a series of successive phases, proposing several interventions to achieve strategic objectives that acted to reduce costs while maintaining high standards [26]. Another tool used to prioritize interventions related to railway stations is the condition-based monitoring method; however, it is used to detect faults in the rail system and focuses only on the maintenance of existing facilities [27]. To prioritize the importance of services, Geetika et al. carried out a passenger survey of 16 items at an Indian railway station platform and then applied principal component analysis [28]. Gupta et al. developed a methodology to prioritize interventions related to services inside Indian railway stations [29]. Here, the use of Likert scale data is substituted with the law of categorical judgment. Although many methods have been studied to prioritize interventions, the specific improvements in the accessibility of bicycles inside a railway station from the user and potential user have not yet been studied. The accessibility level has been widely used as an indicator of equity. For instance, parks accessibility is studied through an OD cost model based on the minimum cost analysis of travel time between residents and parks [30]. Many methodologies show how the executions on infrastructure and services can be economically quantified and prioritized. However, each methodology is either too complex and non-cost-effective or non-specific to bike–train intermodality.

In this research, a specific method is proposed to explore and identify a multidimension of key performance indicators for prioritizing interventions. This paper builds upon the above methodologies introducing some innovative aspects. In particular, it takes advantage of a sample of more than 1000 people, allowing us to obtain a robust user-centered tool. The methodology is divided into three main steps:

1. Identification of elements defining bike accessibility and bike–train intermodality;
2. Connection of each element with a weight since not all items have the same importance;

3. Setup of an equation as the final AxI value calculation.

2. Materials and Methods

The model defined for this research followed the sequential structure represented in Figure 1 and included three main parts. The first part consisted of the definition of the categories and their indicators. A category defined the set that contained the indicators. The indicator was the specific characteristic of a category that was being evaluated. The categories that were identified were as follows:

- A—Quality of cycle track infrastructure direction north;
- A—Quality of cycle track infrastructure direction south;
- A—Quality of cycle track infrastructure direction east;
- A—Quality of cycle track infrastructure direction west;
- B—Visibility of the area outside the railway station and signs to direct cyclists inside the railway station;
- C—Services for cyclists near the railway node;
- D—Bike deposit;
- E—Bike sharing.

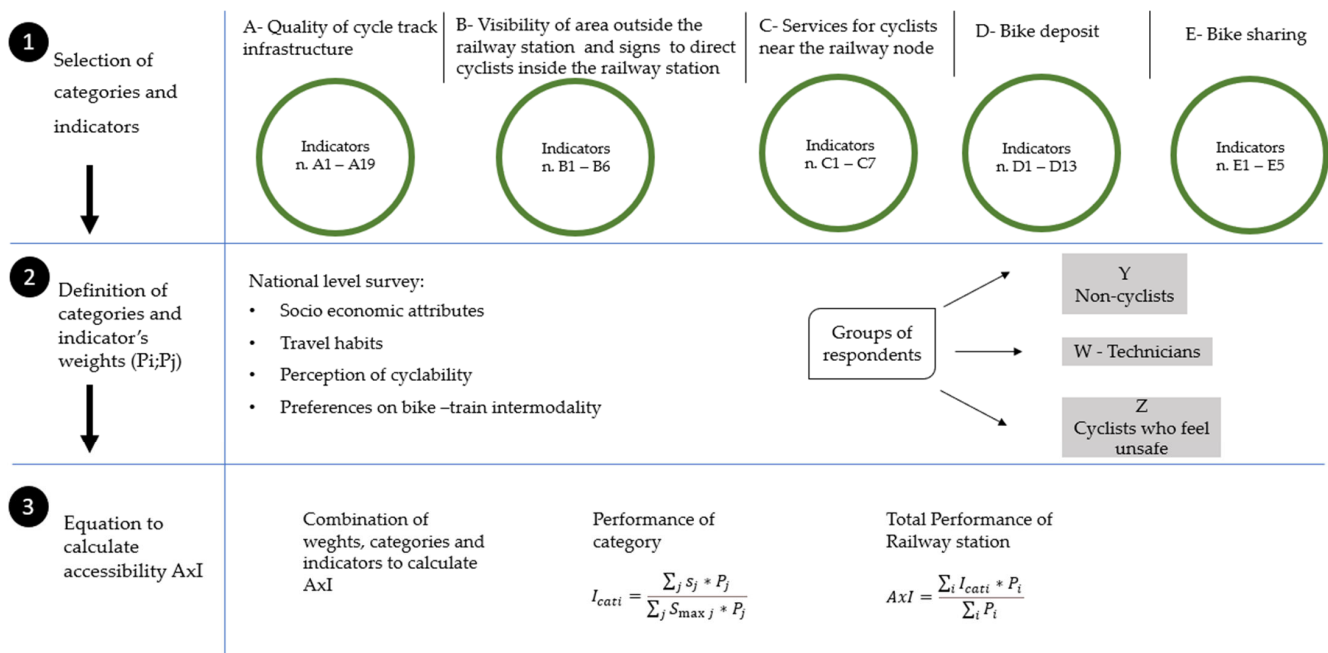


Figure 1. Path diagram of the proposed model to obtain the AxI.

Each of the above categories had a specific number of indicators, based on the elements evaluated inside the railway station.

The second part of the sequential structure was the weighting and normalization of indicators. The weighting process was based on a survey conducted on the Italian population. Here, the respondents were divided into three groups. The main identified groups of respondents were non-cyclists, regular cyclists who did not feel safe while riding, and technicians. Each survey response could be directed to a specific category and indicator. Finally, in the third part of the methodology, the final calculation of the accessibility indicator to measure bike–train intermodality (AxI) was defined through the combination of the weights, indicators, and categories.

2.1. Selection of Categories and Indicators

The accessibility indicator to measure bike–train intermodality was developed through understanding of the needs of cyclists who reached the railway station. The Highway Code, the Regional Guidelines on Cyclability, and the International Manuals on Cyclability define the qualities required to create an accessible environment for cyclists [31–33]. These qualities could be classified into infrastructural elements and services. The infrastructural characteristics included cycle tracks that allow access to the railway station. The presence of bike sharing, of a bike deposit, or of bike racks were some of the evaluated services.

2.1.1. A—Quality of Cycle Track Infrastructure

Category A defines the quality of cycle track in access to the railway station. To provide the most effective results, category A is repeated for the four main cardinal axes. The aim is to understand if the railway station is accessible from every direction. The indicators from category A are listed in Table A1 of Appendix A.

2.1.2. B—Visibility of the Area Outside the Railway Station and Signs to Direct Cyclists Inside the Railway Station

The evaluation of signs inside the railway station and lighting outside the railway station addresses the presence of vertical signs inside and on the immediate external area of the railway station, with a focus on ensuring clear communication and visibility for cyclists. The indicators evaluated are listed in Table A2 of Appendix A.

2.1.3. C—Services for Cyclists near the Railway Node

Specific services for cyclists should be available near the railway station to improve the attractiveness of the trip. Services include bike parking spots, a bike repair kit, lifts or ramps to access platforms, and the ticket office. The indicators from category C are listed in Table A3 of Appendix A.

2.1.4. D—Bike Deposit

Theft risk is one of the factors included in the cyclist mobility costs that affect the choice of taking this means of transport [34]. A bike deposit is a good solution to prevent bicycle thefts as it is a protected facility, usually separated by free parking racks and accessible through specific modalities. The elements evaluated within the bike deposit are listed in Table A4 of Appendix A.

2.1.5. E—Bike Sharing

A bike sharing service is a fast-growing transport mode that allows people to rent bicycles for short-distance trips and last-mile connections [35]. The choice of a user to engage in the use of bike sharing depends on many factors. One of these includes the dockless bike share, which has a broader use, especially when integrated with transit [36]. The indicators included in category E are listed and described in Table A5 of Appendix A.

2.2. Definition of Categories and Indicators' Weights

Each category and indicator was assigned to a weight in a multilevel weighting system, to allow a rewarding macrodecision and to also be able to prioritize interventions on a microlevel scale [26]. The weight associated with each category and indicator was defined by a population survey where cyclability and bike–train intermodality elements were requested to be rated [37]. The survey collected information concerning the following:

- The socioeconomic attributes of the respondents, which include the sex, age, occupation, level of education, and residence;
- The mobility habits, the use of bike, and the use of bike combined with the train;

- The preferences regarding cycling and the combination of biking and riding on the train: 52 indicators were included according to a five-point structure on the Likert scale. The indicators were intended to capture the attitudes or psychological traits of the quality-of-service demand behavior.

Figure 2 shows how the respondents to the survey were divided into groups. First, respondents were divided into regular cyclists and non-cyclists. In case they were non-cyclists (15.69%) (group Y), they were asked what elements would drive them to the opposite trend. If they already used their bike frequently (at least once a week) (84.31%), they were asked what elements affected their perception of safety while riding. Among frequent bike users, 84.83% (35.80% females; 1.22% others) stated that they did not always feel safe (group Z), and 15.17% (44% females) stated that they always felt safe. In case the respondent did not feel safe, questions were asked about what affected their perception of safety. All respondents (non-cyclists and regular cyclists) were then asked specific questions on bike–train intermodality. Finally, group W, which included technicians, had to respond to a specific set of technical questions on bike–train intermodality.

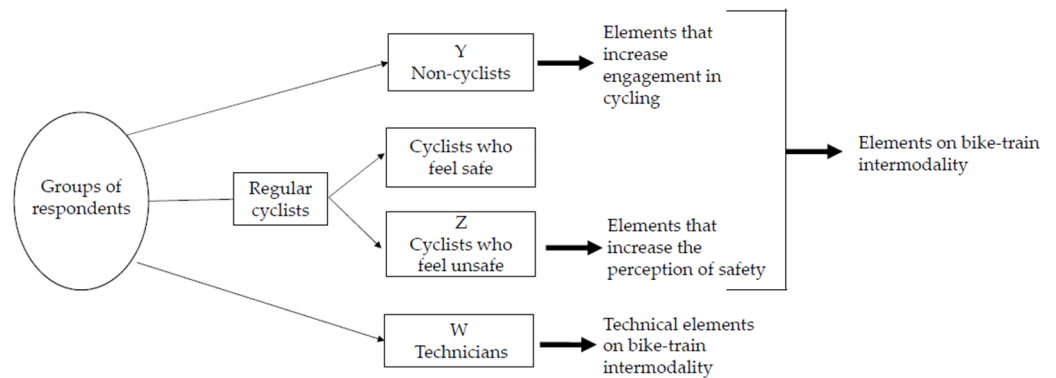


Figure 2. Identification of groups of respondents.

This methodology allowed for a more heterogeneous sample and more precise results, including all types of travelers and all different perceptions regarding cyclability.

The elements evaluated by groups Y, Z, and W separately and by regular cyclists and non-cyclists are listed in Table 1, associated with the indicator they refer to.

Table 1. Elements evaluated by the different participants of the survey, each related to an indicator from the AxI (see Appendix A for the definition of each indicator).

| Element Evaluated | Regular Cyclists and Non-Cyclists | W | Y | Z | Category | Indicator Number |
|---|-----------------------------------|---|---------------|---|----------|------------------|
| | Intermodality Specific | | Bike Specific | | | |
| Direct and fast cycle paths even if they mean the use of a cycle lane | | | ✓ | ✓ | A | 1 |
| Closeness to points of interest | ✓ | | ✓ | | A | 2 |
| The type of road paving | | ✓ | | | A | 3 |
| The quality of the road paving | | ✓ | | | A | 4 |
| Cycle paths at raised level | | | ✓ | ✓ | A | 6 |
| Cycle paths protected with curb | | | ✓ | ✓ | A | 7 |
| The presence of a one-lane cycle path rather than two lanes in a two-way cycle path | ✓ | | | | A | 8 |

Table 1. Cont.

| Element Evaluated | Regular Cyclists and Non-Cyclists | W | Y | Z | Category | Indicator Number |
|---|-----------------------------------|---|---|---|----------|------------------|
| | | | | | | |
| The respect of the geometric standards | | ✓ | | | A | |
| Lower slope of the street | | | ✓ | ✓ | A | 9 |
| The absence of fixed obstacles | ✓ | | | | A | 10 |
| The absence of lateral conflict due to driveways | ✓ | | | | A | 11 |
| The absence of interference with pedestrians | ✓ | | | | A | 12 |
| Low conflict with vehicular traffic | ✓ | | ✓ | ✓ | A | 13 |
| The coloring of the cycle path compared with the external asphalt | ✓ | | | | A | 14 |
| The presence of signs dedicated to the points of interest | ✓ | | | | A | 17 |
| A good cycle path lighting | | | ✓ | ✓ | A | 18 |
| The source of lighting of the cycle path | | ✓ | | | A | 19 |
| Good signs dedicated to cyclists | | | ✓ | ✓ | A | 15–16 |
| Direction of the cycle path | | | | | A | |
| The maintenance of the cycle path | ✓ | | | | A | |
| The absence of vehicles parked by the cycle path | ✓ | | | | A | |
| The lighting at the entrance of the railway station | ✓ | | | | B | 2 |
| The visibility of bike racks entering/exiting the railway station | ✓ | | | | B | 4 |
| A sign to distinguish the bike parking | | ✓ | | | B | 5 |
| Signs direct to lifts/ramps/cycle paths | ✓ | | | | B | 1_3 |
| The presence of bike racks | ✓ | | | | C | 1 |
| The possibility to tie up the bike frame and the wheel | ✓ | | | | C | 2 |
| The number of bike parking slots | | ✓ | | | C | 3 |
| The presence of a pumping column | ✓ | | | | C | 4 |
| The presence of ramps/lifts to reach platforms | ✓ | | | | C | 5 |
| The accessibility of bikes to the ticket box | | ✓ | | | C | 6 |
| The presence of toilets inside the railway stations | | ✓ | | | C | 7 |
| The possibility to bring the bike on the bus | | ✓ | | | C | 8 |

Table 1. Cont.

| Element Evaluated | Regular Cyclists and Non-Cyclists | W | Y | Z | Category | Indicator Number |
|---|-----------------------------------|---|---|---|----------|------------------|
| | | | | | | |
| Bike parking spots not overcrowded | | | ✓ | | C | |
| Lower probability of theft | | | ✓ | | C | |
| Presence of bike deposits | | | ✓ | ✓ | D | 1 |
| The presence of a deposit inside the railway station | | ✓ | | | D | 2 |
| The distance of the bike deposit from the railway station | ✓ | | | | D | 3 |
| The presence of more than one bike deposit | | ✓ | | | D | 4 |
| The number of bike spots inside the bike deposit | | ✓ | | | D | 5 |
| Safe, free parking spots | ✓ | | ✓ | ✓ | D | 6 |
| The level of occupancy of the bike deposit | | ✓ | | | D | 9 |
| The presence of video surveillance inside the deposit | | ✓ | | | D | 10 |
| The possibility to book in advance a slot inside the bike deposit | ✓ | | | | D | 11 |
| The opening hours of the bike deposit | ✓ | | | | D | 12 |
| The method to access the bike deposit | ✓ | | | | D | 13 |
| The presence of services for the cyclist inside the bike deposit | ✓ | | | | D | 7_8 |
| Bike sharing availability | ✓ | | ✓ | | E | 1 |
| The presence of micromobility services other than bike sharing | | ✓ | | | E | 2 |
| The distance of the bike sharing from the railway station | | ✓ | | | E | 3 |
| The number of bikes of the bike sharing service | | ✓ | | | E | 4 |
| The presence of bike sharing without obligation to return in specific areas | ✓ | | | | E | 5 |

The seventh column of Table 1 shows that some questions were not assigned to an indicator but only to a category (e.g., “Bike parking spots not overcrowded”, category C). The elements associated with a category and not a specific indicator were used to calculate the weight of the category.

The survey was diffused online to the Italian population via LinkedIn and the regional company. The map (Figure 3) shows a heat map of the distribution of responses in the country; the heat map indicates that the majority of responses came from the northern half of the peninsula.

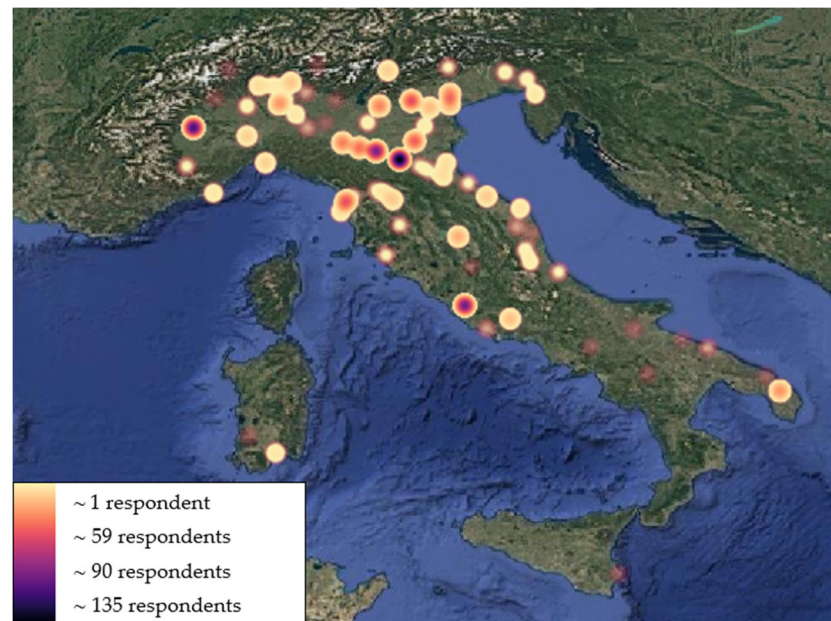


Figure 3. Distribution of respondents in Italy. Our own elaboration.

The total number of respondents to the survey was 1125, but only 1080 (96%) specified the regular transportation mode. The main transportation modes of the survey respondents are summarized in Table 2. The sample of respondents included mostly bike users (43.06%). The second and third main categories of respondents were motorized vehicle users (18.15%) and train combined with other mode users (13.43%). Among the means of transport combined with the train, the bicycle was present for 73.10% of the respondents. The age distribution in the sample was not fully representative of the targeted population, with an overrepresentation of individuals aged over 50 years old. However, it should be noted that the average age of the Italian population was 48 years old. The lowest mean age of respondents was the one for bus users (39 years old). Of the respondents, 61% were employed, and 4% were students.

Table 2. Sample distribution for the main transport modes.

| Travel Mode | % of Sample | Mean Age (M) | SD | Sex |
|---|------------------|------------------|------------------|---------------------------|
| Bicycle | 43.06 | 55.34 | 13.72 | 37.63 females; 0.65 other |
| Train only | 4.72 | 48.90 | 14.94 | 41.18 females |
| By foot (pedestrians) | 7.5 | 53.09 | 16.04 | 37.04 females |
| Train combined with other transport modes (Other transport mode is bike) | 13.43 (73.10) | 50.15 (48.38) | 15.44 (15.01) | 30.34 females; 0.69 other |
| Multiple transport modes excluding train | 2.59 | 58.82 | 12.43 | 28.57 females |
| Bus | 2.22 | 39.75 | 15.79 | 37.50 females |
| Motorized vehicles (scooter, private car, car sharing) | 18.15 | 54.16 | 12.38 | 43.00 females |
| The mode of transport varies based on weather conditions | 8.3 | 54.4 | 12.28 | 41.11 females; 3.33 other |

2.2.1. Weights of the Indicators Common to the Groups

The indicators common to the different groups of respondents, which can be identified from Table 1, were calculated as the normalization from 0 to 1 of the weighted average of the answers to the survey, through the formula

$$P_j = \frac{\left(\frac{\sum n_k * r_k + \sum n_h * r_h + \sum n_l * r_l}{n_k + n_h + n_l} - 1 \right)}{4} \quad (1)$$

where

- P_j = the weight of the j -th indicator;
- r_k = the response of a single person from generic group $k \neq h \neq l$;
- r_h = the response of a single person from generic group $h \neq k \neq l$;
- r_l = the response of a single person from generic group $l \neq k \neq h$;
- n_k = the number of respondents from generic group $k \neq h \neq l$;
- n_h = the number of respondents from generic group $h \neq k \neq l$;
- n_l = the number of respondents from generic group $l \neq k \neq h$.

2.2.2. Weights from Technicians

The weights from group W were the normalized mean of the responses provided by technicians.

$$P_j = \frac{\left(\frac{\sum n_w * r_w}{n_w} - 1 \right)}{4} \quad (2)$$

where

- P_j = the weight of the j -th indicator;
- r_w = the response of a single person from group W ;
- n_w = the number of respondents from group W .

2.2.3. Weights of the Categories

The calculation of the weight corresponding to a category was performed through the following formula:

$$P_i = \frac{\left(\frac{\sum_i \bar{P}_{ji} * n_i}{\sum_i n_i} - 1 \right)}{4} \quad (3)$$

where

- P_i = the weight of the i -th category;
- n_i = the number of respondents from the group (Y , Z , W , and regular cyclists and non-cyclists).

3. Equation to Calculate the Accessibility (AxI)

For the definition of the AxI indicator, the last required step consisted of applying the different indexes calculated in Section 2, according to the following formula:

$$AxI = \frac{\sum_i I_{cati} * P_i}{\sum_i P_i} \quad (4)$$

where

- AxI = the total station accessibility value;
- I_{cati} = the performance of the i -th category;
- P_i = the weight of the i -th category;
- I_{cati} = the performance of the i -th category, calculated as follows:

$$I_{cati} = \frac{\sum_j s_j * P_j}{\sum_j S_{maxj} * P_j} \quad (5)$$

where

- s_j = the value obtained during the inspection of the j -th indicator;
- S_{maxj} = the maximum value obtainable during the inspection of the j -th indicator;
- P_j = the weight of the j -th indicator.

The results of applying the indicator to a single railway station may be displayed on a weight- I_{cati} graph. This type of graph showed on the x-axis the performance of each

category (I_{cati}) and on the y-axis the corresponding weight (P_i). The graph was used to clearly define the priority of intervention among the categories of a single station.

Figure 4 shows the value of the eight categories for one railway station. For each railway station the priority of intervention was ordered when the value of I_{cati} was related to the weight P_i . In Figure 4 the priority of intervention is as follows:

1. The quality of infrastructure direction south (A dir. South);
2. The quality of infrastructure direction north (A dir. North);
3. Bike deposit (D);
4. Services for cyclists near the node (C);
5. The quality of infrastructure direction east (A dir. East);
6. The quality of infrastructure direction west (A dir. West);
7. Bike sharing (E);
8. Visibility of the area in front of the railway station and signs to direct cyclists inside the railway station (B).

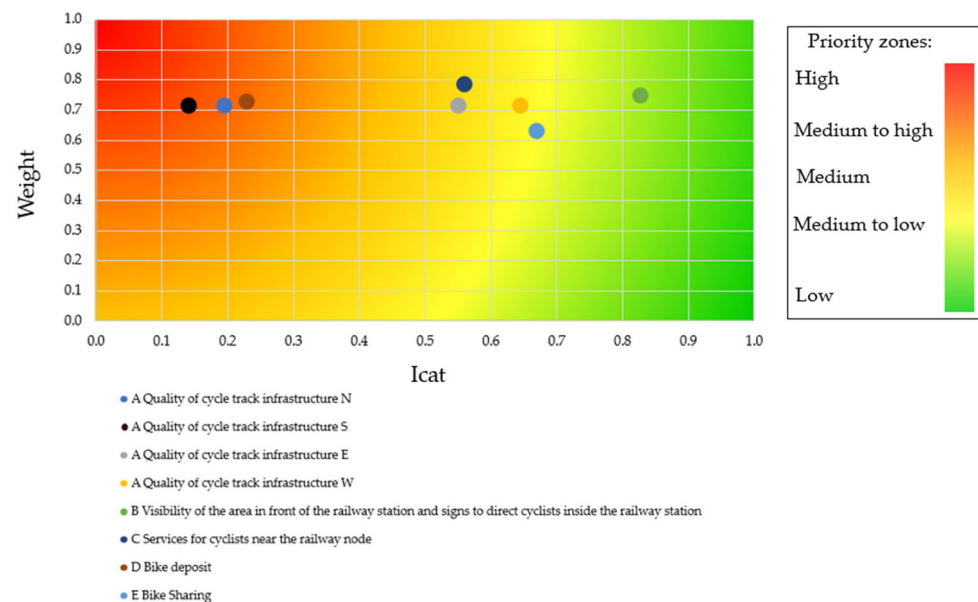


Figure 4. Representation of results for the single railway station.

The comparison among the different railway stations was performed by comparing the AxI values of the railway stations. This allowed a ranking among the railway stations where the least effective, the medium to least effective, the medium to most effective, and the most effective ranges could be identified. In particular, when $0 \leq AxI \leq 0.25$, the railway station was classified with a high priority of intervention; when $0.25 < AxI \leq 0.50$, the railway station had a medium-to-high priority of intervention; when $0.50 < AxI \leq 0.75$, the railway station had a medium-to-low priority of intervention; and when $0.75 < AxI \leq 1$, the railway station had the least priority of intervention.

4. Results

The proposed methodology was applied to 33 railway stations in a specific Italian region. Located in the northern part of Italy, this region has one of the highest gross domestic products per capita in the country. The region has an area of 22,446 m^2 and counts 4.5 million inhabitants (2023). The population density is 200 inhabitants per km^2 , and, being one of the richest regions of Italy, it has a heterogeneous economy that includes agricultural activities, manufacturing activities, food industries, automotive, and tourism. The railway stations analyzed were of different dimensions, including different types of

services and train types. The railway stations examined had a daily passenger flow of 100 to 39,000 passengers in the capital of the region. Here, the railway station was served by high-speed and regional trains. It was connected to the city airport by an elevated monorail and to the city center and peripheral areas through the bus service. Other analyzed railway stations include 11 railway stations with a flow of passengers between 3100 and 9000 passengers, 7 railway stations with a flow of passengers between 700 and 1700 passengers per day, and 14 railway stations with a flow of passengers from 100 to 700 passengers per day. The 33 railway stations were all surveyed from November 2021 to February 2022. The results of the application of the AxI are reported in Table 3. The number of railway station was related to the number of passengers boarded on a train in one day. Railway station “1” was the one with the lowest passenger flow, up to station “33”, which was the one with the highest flow.

Table 3. Application of the AxI to 33 railway stations of a specific Italian region. The table is ordered from the highest AxI to the lowest.

| Railway Station | Passengers/Day | Category of Indicator | | | | B | C | D | E | AxI |
|-----------------|----------------|-----------------------|--------------|-------------|-------------|------|------|------|------|-------|
| | | A dir. North | A dir. South | A dir. East | A dir. West | | | | | |
| 30 | 5350 | 0.75 | 0.68 | 0.84 | 0.75 | 1 | 0.86 | 0.69 | 0.79 | 0.8 |
| 32 | 11,235 | 0.71 | 0.79 | 0.80 | 0.80 | 0.49 | 0.95 | 0.84 | 1.00 | 0.80 |
| 26 | 3118 | 0.00 | 0.89 | 0.84 | 0.91 | 0.83 | 0.72 | 0.75 | 0.62 | 0.7 |
| 31 | 7836 | 0.56 | 0.64 | 0.64 | 0.59 | 0.83 | 0.54 | 0.55 | 0.88 | 0.65 |
| 33 | 46,483 | 0.74 | 0.40 | 0.74 | 0.77 | 0.50 | 0.77 | 0.61 | 0.61 | 0.64 |
| 19 | 862 | 0.69 | 0.75 | 0.70 | 0.74 | 0.66 | 0.77 | 0.00 | 0.70 | 0.63 |
| 9 | 300 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.54 | 0.00 | 0.00 | 0.59 |
| 25 | 2947 | 0.74 | 0.71 | 0.79 | 0.79 | 0.33 | 0.77 | 0.00 | 0.49 | 0.58 |
| 22 | 2011 | 0.57 | 0.61 | 0.59 | 0.71 | 0.66 | 0.95 | 0.00 | 0.16 | 0.54 |
| 23 | 2321 | 0.00 | 0.62 | 0.74 | 0.64 | 0.66 | 0.68 | 0.75 | 0.18 | 0.54 |
| 29 | 5281 | 0.46 | 0.74 | 0.49 | 0.00 | 0.83 | 0.68 | 0.94 | 0.00 | 0.53 |
| 20 | 1099 | 0.54 | 0.00 | 0.00 | 0.69 | 0.66 | 0.86 | 0.61 | 0.70 | 0.51 |
| 21 | 1521 | 0.59 | 0.62 | 0.59 | 0.39 | 0.50 | 0.68 | 0.50 | 0.00 | 0.49 |
| 12 | 377 | 0.00 | 0.78 | 0.83 | 0.00 | 0.66 | 0.86 | 0.00 | 0.70 | 0.48 |
| 10 | 300 | 0.78 | 0.74 | 0.00 | 0.74 | 0.49 | 0.72 | 0.17 | 0.00 | 0.47 |
| 24 | 2481 | 0.63 | 0.00 | 0.64 | 0.63 | 0.49 | 0.68 | 0.00 | 0.63 | 0.46 |
| 8 | 290 | 0.00 | 0.47 | 0.00 | 0.81 | 0.83 | 0.72 | 0.00 | 0.70 | 0.44 |
| 7 | 240 | 0.71 | 0.00 | 0.00 | 0.68 | 0.83 | 0.54 | 0.00 | 0.70 | 0.43 |
| 11 | 300 | 0.53 | 0.57 | 0.65 | 0.42 | 0.66 | 0.56 | 0.00 | 0.00 | 0.43 |
| 6 | 231 | 0.63 | 0.37 | 0.58 | 0.58 | 0.49 | 0.52 | 0.00 | 0.00 | 0.4 |
| 14 | 434 | 0.62 | 0.00 | 0.59 | 0.55 | 0.50 | 0.86 | 0.00 | 0.00 | 0.4 |
| 2 | 150 | 0.75 | 0.27 | 0.65 | 0.00 | 0.84 | 0.56 | 0.00 | 0.00 | 0.39 |
| 18 | 788 | 0.47 | 0.00 | 0.74 | 0.44 | 0.49 | 0.56 | 0.00 | 0.18 | 0.366 |
| 1 | 100 | 0.00 | 0.00 | 0.58 | 0.65 | 1.00 | 0.56 | 0.00 | 0.00 | 0.36 |
| 27 | 3539 | 0.00 | 0.89 | 0.00 | 0.00 | 0.50 | 0.79 | 0.00 | 0.70 | 0.35 |
| 16 | 700 | 0.65 | 0.54 | 0.00 | 0.00 | 0.49 | 0.54 | 0.00 | 0.16 | 0.3 |
| 5 | 200 | 0.71 | 0.00 | 0.00 | 0.00 | 0.83 | 0.68 | 0.00 | 0.00 | 0.29 |
| 28 | 3809 | 0.34 | 0.32 | 0.00 | 0.25 | 0.28 | 0.28 | 0.36 | 0.30 | 0.27 |
| 4 | 190 | 0.00 | 0.00 | 0.63 | 0.00 | 0.66 | 0.72 | 0.00 | 0.00 | 0.26 |
| 15 | 455 | 0.00 | 0.37 | 0.49 | 0.00 | 0.49 | 0.54 | 0.00 | 0.00 | 0.25 |
| 13 | 387 | 0.67 | 0.57 | 0.00 | 0.00 | 0.33 | 0.23 | 0.00 | 0.00 | 0.23 |
| 17 | 778 | 0.00 | 0.00 | 0.00 | 0.43 | 0.33 | 0.36 | 0.00 | 0.32 | 0.18 |
| 3 | 170 | 0.00 | 0.00 | 0.00 | 0.00 | 0.49 | 0.72 | 0.00 | 0.00 | 0.16 |

The results showed that only two of the railway stations analyzed fell within the least-priority intervention area (railway stations 30 and 32), and four railway stations

fell within the high-priority intervention area. Among the railway stations with a flow lower than 800 passengers per day, only one fell in the medium to low priority, with an AxI = 0.59 (station 9), while the others (57% of railway stations analyzed) had an AxI between 0.16 and 0.48; all of these railway stations scored 0 in the category of bike sharing, except for station 10, which scored 0.17. Of the total of the railway stations analyzed, 66.7% scored 0 in the bike deposit category. Of the railway stations, 42.4% scored 0 in the bike sharing category, while 21.2% of railway stations had a total AxI indicator between 0.16 and 0.49. Two categories that never scored less than 0.23 for any of the railway stations analyzed were categories B and C. Among the 10 railway stations with AxI indicators classified as medium to low priority of intervention, only two railway stations had all category values (Icati) higher than 0. However, station 26, which had an AxI = 0.70 and scored 0 in the category A, north direction, scored higher than stations 31 and 33, which had all categories Icati \neq 0.

The railway stations ordered from 1 to 33 showed, in Figure 5, only a slight increase in the value of AxI. In fact, the average AxI from railway station 1 to 16 was equal to 0.37 (SD = 0.11), that from railway station 17 to 23 was equal to 0.44 (SD = 0.16), and that from 24 to 33 was equal to 0.58 (SD = 0.18).

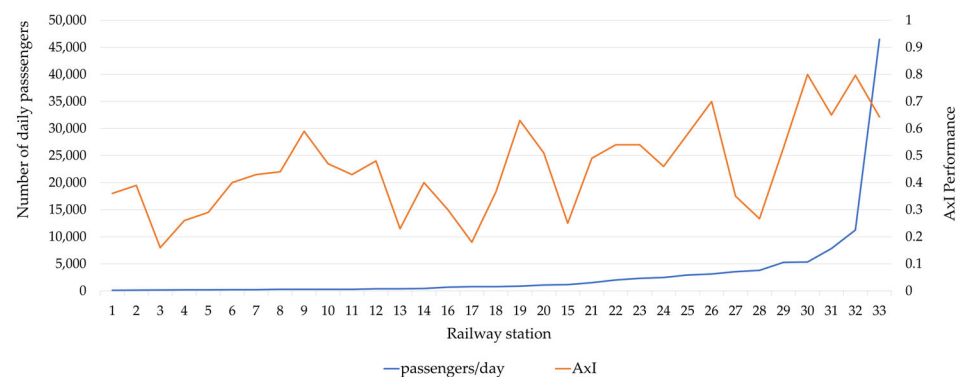


Figure 5. AxI value compared with the flow of passengers.

5. Discussion and Conclusions

The results of this study confirmed the applicability and effectiveness of the AxI indicator in evaluating the accessibility to railway stations for cyclists. By assessing 33 railway stations of different sizes in an Italian region, it was possible to identify critical areas for improvement and prioritize interventions. Railway stations with higher daily passenger flows exhibited a slightly higher AxI, which, however, did not indicate a correlation between station size and accessibility measures. The weak relation between the flow of passengers and AxI was confirmed from the linear regression analysis, where the number of passengers as the independent variable obtained an $R^2 = 0.190$ with p -value = 0.011. Some smaller stations demonstrated good accessibility scores, underscoring the importance of interventions on bike deposits, which were missing in most of the railway stations that had <700 passengers per day, and interventions on bike sharing, which were missing in 71% of the railway stations with <700 passengers per day. The linear regression analysis on the AxI showed that the most impacting categories with a null p -value were the infrastructure quality of the cycle track (category A) ($R^2 = 0.818$), the bike deposit (category D) ($R^2 = 0.401$), and the bike sharing (category E) ($R^2 = 0.354$). Considering an acceptable p -value < 0.05, the results also showed that the services for the cyclists (category C) were significant in the calculation of the AxI with an $R^2 = 0.321$ (p -value = 0.001), while for category B, the visibility of the area outside the railway station and the signs inside the railway stations had an $R^2 = 0.152$ (p -value = 0.025). To confirm the importance of these elements, Givoni and

Rietveld (2007) found that infrastructure provision, such as secure bike parking at stations, directly influenced the attractiveness of bike–train combinations for commuters [38]. A study by Martens (2007) emphasized the need for policies to support seamless intermodality, suggesting that while infrastructure was necessary, behavioral factors such as convenience and safety perceptions also played a pivotal role in encouraging cycling to stations [39]. Yet, this study was limited in scope, focusing on different forms of transport intermodality without a specific emphasis on bicycles.

This study expanded on previous methodologies by introducing a multilevel weighted indicator system focused on bike accessibility into railway stations, specific to bike–train intermodality improvement. Unlike traditional cost–benefit or cost-effectiveness analyses, the AxI indicator incorporated user-centered criteria, enabling a more nuanced understanding of how infrastructure investments could enhance bike–train intermodality. The AxI expanded also on the analytical hierarchy process (AHP). While the AHP allowed for structured decision-making with multiples levels of criteria, the AxI was more directly aligned with assessing cyclists' accessibility, providing a more forward, and thus less time-consuming, system for analysis. Compared with the condition-based monitoring, which was useful for detecting faults, the AxI set a step forward to a long term evaluation.

The AxI indicator may be representative of the Italian population since the sample of respondents has an average age of 50 years old, and the Italian population has an average age of 48 years old. On the other hand, the majority of respondents were frequent cyclers, and this was not totally representative of the geographical area studied. One of the criticalities of the tool was that since they need auditing in public spaces, they could be time-consuming [40]. To contrast this and make the use of the AxI more time-efficient, a guide to train surveyors will be drawn up. The guide is also a good way to engage the involved stakeholders in participating in the study and understand the importance of the application of the methodology. Moreover, the use of GIS mapping and satellite imagery could be a way to reduce the time consumed in the surveying of the single railway station.

Future research could focus on refining the AxI indicator further by integrating a validation of the weights, possibly through a virtual reality experience. The experience will include a bike simulator and relate the behavior of the cyclist with the answers to a questionnaire. The results will be compared with the actual weights of the AxI. The AxI indicator has the potential of being reproducible in other countries comparable to the Italian transportation system, population, and geographical characteristics. Future research will include exploring its application in other regions or countries with different infrastructure and policy environments. It is expected to need to adjust the AxI indicator for those railway stations that serve fewer than 100 people per day or those stations located in areas that are mostly residential and where the population is older. Older people tend, in fact, to prefer the use of private cars rather than the use of public transportation [41]. Additionally, longitudinal studies could assess the long-term impacts of infrastructure improvements on cycling and train use, providing further validation of the tool's effectiveness in promoting sustainable transportation. The study not only confirms the effectiveness of the AxI indicator in assessing the accessibility of railway stations for cyclists but also offers a roadmap for improving bike–train intermodality. By expanding on traditional methodologies and incorporating user-centered criteria, the AxI offers a more holistic evaluation tool. Its application has the potential to drive targeted investments in both large and small railway stations, with significant benefits for promoting sustainable, intermodal transportation systems.

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Institutional Review Board Statement: Ethics approval was not sought for the present study. The survey is conducted as anonymous from the beginning, there is no possibility to return to the respondent, and identify him or her. No name, last name, email, or other information that can be linked to a single specific person is collected. Also, no data that could lead to individuation, inference or correlability has been collected. In this case, there is no necessity to apply the privacy of personal data, and the European regulation 2016/679 is respected.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Section A of the indicator.

| Indicator Number | Indicators | Description of Indicator |
|------------------|--|---|
| A1 | The existence and proximity of the cycle path | The assessment includes whether there is a cycle path direct to one of the four cardinal points (north, south, east, and west) and the contiguity of it to the railway station. This aligns with regional laws (5 June 2017, n.10) aiming to improve daily commuting by promoting cyclability. A feasible cycle path is vital for encouraging active mobility [42]. If the cycle track is within a maximum distance of 500 m from the node of interest, it gets a score of "1", otherwise, "0" for absent. The distance that has been considered acceptable for the cycle path is 500 m as it corresponds to a 5 min walk. |
| A2 | The cycle path distance from the railway station | The assessment is in the vicinity of the cycle path to the railway station. If it is located within 75 m, the score assigned is (1); if the cycle path is more than 75 m away, it gets a rating of (0), indicating it is farther and less convenient for cyclists [8]. |
| A3 | The pavement material | The prevailing pavement is rated based on the materials with a score of (2) for asphalt, (1) for self-locking pavement, and (0) for natural earth. |
| A4 | The pavement quality | Factors include how well the pavement holds up and if there are any potential hazards like plant roots. The pavement quality is assessed as (2) for good, (1) for average, and (0) for poor. |
| A5 | The number of lanes and the direction | Emilia-Romagna regional guidelines suggest that a two-way cycle path in an urban area is less safe than a one-way single-lane cycle track. One-way cycle paths get a score of (2), a two-way reserved for bicycle cycle path is given a score of (1), and a two-way cycle path receives a score of (0). |
| A6 | The vertical separation from motor vehicle traffic | A raised cycle path is a bicycle facility that is paired with a furnishing zone between the cycle track and a motor vehicle travel lane and/or pedestrian area. A raised cycle track gets a score of (2) as it keeps motorists from entering the cycle track; a non-raised cycle track gets a score of (1); and in cases where there is no cycle track, the score is (0) [43]. |
| A7 | The type | A one- or two-way reserved, raised-level cycle track is assigned a rate of (6); a one- or two-way reserved, raised-level cycle track, separated from pedestrians by a painted line, is assigned a rate of (5); a one- or two-way unsegregated cycle track shared with pedestrians is assigned a rate of (4); a one- or two-way reserved, ground-level cycle track separated by motor vehicles with a painted line is assigned a rate of (3); a one-way reserved cycle track, opposite to the 30 km/h speed limit motor vehicle traffic flow, separated by motor vehicles with a painted line, is assigned a rate of (2); a one- or two-way unsegregated cycle track at ground level is assigned a rate of (1); and having no track is assigned a rate of (0). |
| A8 | The geometrical standards | The Nuovo Codice della Strada defines a minimum width of 1.5 m for one-way paths and a minimum width of 1.25 m for two-way cycle tracks [44]. The adequacy of average geometric standards is marked as (1), while non-adequacy is marked as (0). |
| A9 | The slope | The slope of the cycle path is crucial for user engagement and safety. A slope lower than 5% is rated as (1), and it is rated (0) in cases where the slope of the cycle path exceeds 5%. |
| A10 | Punctual obstacles | Consideration is given to potential obstacles along the path, as associated to near misses. The assessment of punctual obstacles or standard reduction is rated as (2) when absent, (1) when rare, and (0) when frequent. |
| A11 | Side conflicts | The presence of shops or driveways that could cause interference with cyclists on the cycle track are evaluated as (2) absent, (1) light, and (0) severe. |
| A12 | Interference with pedestrians | The near-miss collisions with pedestrians are evaluated as absent (2), low (1), and high (0). |
| A13 | Interference with motor vehicles | The near-miss collisions with motor vehicles are evaluated as absent (2), low (1), and high (0). |

Table A1. *Cont.*

| Indicator Number | Indicators | Description of Indicator |
|------------------|--------------------------------------|--|
| A14 | The surface color of the cycle track | A distinctive coloration of dedicated lanes makes the infrastructure more attractive and safer [45]. A colored cycle track can score (2) for bright new coloring, (1) for color that needs maintenance, and (0) for no coloring. |
| A15 | The horizontal signs | Horizontal signs on the cycle path play a crucial role in guiding cyclists and ensuring their safety. The assessment focuses on the presence of them: (1) present and (0) absent. The visibility of the edges of the cycle path is taken into consideration to ensure that cyclists have a clear understanding of the path boundaries to further enhance safety. Reflective border markings along the edges of the cycle path can contribute to improved visibility, especially during night and low-light conditions. |
| A16 | The vertical signs | The assessment focuses on the presence and visibility of signs dedicated to cyclists, in relation to the cycle path [46]. The Nuovo Codice Della Strada states that the sign indicating the cycle path has to be present at the beginning of the cycle path and has to be repeated after every interruption. The rate of (2) is assigned to complete, (1) to averagely complete, and (0) to uncomplete. |
| A17 | Address signs | This aspect focuses on the presence and quality of address signs directing cyclists toward significant landmarks or points of interest in the city. The address signs, recognizable by the brown color, are placed to allow the user to not consult a map while riding [47]. A rating of (2) is given when address signs are present and visible, a rating of (1) suggests that there is only a city map in the proximity of the railway stations, and a rating of (0) indicates the absence of any address signs. |
| A18 | Lighting of the cycle path | The presence and quality of night lighting along the cycle path are crucial for ensuring safety and visibility, especially during low-light conditions. A rating of (2) denotes good lighting, a rating of (1) suggests average lighting, and a rating of (0) indicates the absence of any night lighting on the cycle path, which could pose significant safety risks, especially during nighttime cycling. |
| A19 | Source of lighting | This criterion considers the source and type of lighting along the cycle path. A rating of (2) implies proper lighting designed specifically for the runway or zone 30, ensuring optimal visibility and safety for cyclists. A rating of (1) suggests that the lighting is sourced from public roads, and a rating of (0) indicates that lighting is sourced from private billboards. |

Table A2. Section B of the indicator.

| Indicator Number | Indicators | Description of Indicator |
|------------------|--|--|
| B1 | Vertical signs toward cycle path | These signs are important to guide the cyclist from the platform to the cycle path or the bike parking racks. A rate of (2) is given for the presence of signs, a rate of (1) is given for distant and not visible signs, and (0) is assigned when there are no signs. |
| B2 | Lighting of the area outside the railway station | The assessment of lighting around the railway station focuses on the presence and adequacy of lighting in the vicinity. This rating underlines the importance of addressing any lighting deficiencies to create a safer environment for commuters accessing and traversing the railway station. (1) is given for adequate lighting present, and (0) is given for lack of light. |
| B3 | Vertical signs inside the railway station | These signs refer to the directions to lifts, exits, and platforms with bikes on hand. The rate of (2) is given for clear directions to lifts and exits, aiding navigation effectively; (1) is given for only signs directing to lifts; and (0) is given for the absence of vertical signs. Vertical signs complying with regulatory standards may include clear symbols, color-coded information, and standardized text, enhancing overall effectiveness. Assessment extends to signs within the railway station premises, aiming to guide cyclists effectively. These signs may include directions to bike parking areas, cycle-friendly routes, and other relevant information. |
| B4 | The visibility of bicycle parking slots | The visibility of bicycle parking slots is essential for facilitating convenient access for cyclists. Easily visible parking slots from the entrance of the railway station ensure that cyclists can quickly locate and utilize designated parking areas. Poor visibility can lead to frustration and inconvenience for cyclists, potentially discouraging the use of bicycles as a mode of transportation. The rating (1) is given for parking slots are easily visible from the entrance, and the rating (0) is given for parking slots not visible from the entrance. |
| B5 | The presence of "P" signage for bicycle parking | Clear signage helps cyclists to navigate the railway station premises and a secure parking facility. The rate of (1) is given for the presence of the bicycle parking area sign, and (0) is given for the absence of signage. |
| B6 | The presence of signs directing to parking racks | These signs are important to guide the cyclist from the platform to the bike parking racks [48]. The rate (2) is given for signs that are present and very clear; (1) is given for signs that are present and not complete, while (0) is given for the absence of signs. |

Table A3. Section C of the indicator.

| Indicator Number | Indicators | Description of Indicator |
|------------------|--|--|
| C1 | The presence of bike parking racks | A designated and secure area to park bikes has to be present in the railway station. A rating of (1) is given in cases where there are bike parking racks, and (0) is given in cases where there are none. |
| C2 | The type of parking rack | Two distinct types of bike racks are evaluated. The first one, with a rate of (1), allows both the wheel and frame to be securely tied; the second type allows one to secure only the wheel and is assigned to a rate of (0). |
| C3 | The availability of bike parking slots | Sufficient parking space ensures that users are able to secure the bicycle. The rate of (1) is given for the correct sizing of bike parking slots, and (0) is rated in cases where the bike parking spots are insufficient. As bike bicycle parking capacity is a dissatisfier of users, it is a need that must be fulfilled [49]. Indicator C3 is evaluated based on the comparison between the amount of bike racks present during the survey at the railway station and the amount of bike racks that should be present following the correct dimensioning. The recommendations on cycle parking spots developed by USTRA show that at the railway stations, the number of bike spots should be from one to four for every ten passengers [33]. For the calculation of indicator C3, it has been considered as one bike spot for every ten travelers. |

Table A3. *Cont.*

| Indicator Number | Indicators | Description of Indicator |
|------------------|--|---|
| C4 | The bike repair kit | A pump column or tools for rapid adjustments are useful to cyclists in cases of minor repairs. The rate of (2) is given for the presence of the bike repair kit, (1) is given for a bike repair kit that does not work properly or is missing some tools, and (0) is selected in cases where there is not a bike repair column. |
| C5 | Accessibility through lifts or ramps | The minimum dimension for a lift to fit a bicycle is 1.4 m depth and 1.10 m width. In cases where the lifts are absent or have a smaller dimension, ramps must be present. (1) is given for the presence of lifts and/or ramps, and (0) is given in cases of the absence of both facilities. |
| C6 | The accessibility of the ticket office | Ramps or lifts that can facilitate the access of ticket boxes with the bike on hand are evaluated. In cases where it is accessible, the rate is (1); in cases where it is not accessible, the rate is (0). |
| C7 | The presence of restrooms | Access to basic facilities is evaluated. A rating of (1) is given in cases where restrooms are present, and (0) is given in cases where restrooms are not present. |

Table A4. Section D of the indicator.

| Indicator Number | Indicators | Description of Indicator |
|------------------|---|---|
| D1 | The presence of the bicycle deposit | A rating of (2) means that a bike deposit is available, (1) is given in cases where the bike deposit is not in place at the moment of survey but the project has been started, and (0) is for the absence of bicycle storage facilities. |
| D2 | The location of the depot | Determining whether the bike depot is situated within or outside the railway station impacts the convenience for the cyclist. A rate of (1) means that the depot is situated inside the railway station, while a rating of (0) suggests that the depot is located outside the railway station. |
| D3 | The distance of the deposit from the railway station | The distance of the bike depot from the railway station is assessed to gauge its accessibility for cyclists. A rating of (1) is given in cases where the deposit is located at a maximum distance of 75 m; for longer distances, the rating is (0). |
| D4 | The number of bike deposits | The services provided by a bike deposit may be differentiated and improved in cases where the number of deposits is not limited to one. A rate of (1) is assigned in cases where there is more than one deposit, and (0) is assigned in cases where there are no deposits. |
| D5 | The availability of bike parking spots inside the deposit | This rating evaluates whether the number of parking spots in the bike depot meets demand. Sufficient parking capacity ensures cyclists have ample space to store their bicycles comfortably, avoiding overcrowding and ensuring a positive experience. A rating of (1) is given for suitability, and (0) is given for incorrect dimensioning. Indicator C4 is evaluated based on the comparison between the number of bike spots present during the survey at the deposit and the number of bike spots that should be present following the correct dimensioning. The recommendations on cycle parking spots inside bike deposits developed by the regional guidelines on cyclability of Piemonte show that at the railway stations, the number of bike spots inside the deposit should be 4% of the total daily passengers [50]. |
| D6 | The cost of the service | the cost for parking the bike inside the bike deposit is evaluated. The rate is (1) for a gratuity service and (0) in cases where the service is paid. |
| D7 | The availability of services for cyclists | The indicator determines if the bike deposit offers additional user services such as lockers, changing rooms, showers, toilets, or beverage machines. The rating is (1) for the presence of some services, and the rating is (0) for no service availability. |
| D8 | The availability of services for bicycles | The indicator evaluates whether the bike depot offers services for bicycles, including repairs, inflating pumps, spare parts, accessories, or bicycle rental. The rating is (1) for the availability of services regardless of the costs and (0) in cases where no extra service is offered. |
| D9 | The average occupancy level | A rating of (2) means the occupancy rate is less than 75% full, (1) means it is between 75% and 99% full, and (0) means it is over 100% full. |
| D10 | The video surveillance system | This indicator determines if the bike deposit is equipped with video surveillance for security purposes. In cases where there is video surveillance system, the rating is (1), and in cases where it is absent, the rating is (0). |
| D11 | The possibility to book a spot | The indicator evaluates whether a cyclist can book a parking spot in advance. Offering advance booking provides convenience and assurance of space availability. In cases where it is possible to book a spot in advance, the rating is (1); if not, the rating is (0). |
| D12 | The access hours | This indicator assesses the opening hours of the bike depot. A rating of (2) is given in cases where the deposit is accessible every day of the week, 24 h per day, while in cases where the deposit is accessible only during peak hours, the rate associated is (1), and (0) suggests that the deposit is open for less than 3 h per day. |
| D13 | The type of access | The method to access to the bike depot is rated (3) when it is granted through present personnel or an app, (2) indicates access via key or badge, (1) is used in cases where a public transport pass or health insurance card can be used, and (0) implies the use of a one-time ticket to access. |

Table A5. Section E of the indicator.

| Indicator Number | Indicators | Description of Indicator |
|------------------|--|---|
| E1 | The presence of bike sharing stations | This indicator assesses the presence of bike sharing stations near the railway stations, which is linked to a rating of (1). The absence of the service is linked to a rating of (0). |
| E2 | The presence of other micromobility services | The indicator refers to the presence of other micromobility sharing stations (e.g., e-scooters). The presence of the service is rated as (1), while the absence is linked to a rating of (0). |

Table A5. Cont.

| Indicator Number | Indicators | Description of Indicator |
|------------------|---------------------------------------|--|
| E3 | The location of bike sharing stations | This indicator estimates the proximity of bike sharing stations to railway stations. A rating of (2) implies that the depot is within 75 m of the railway station, while a rating of (1) suggests it is situated between 75 to 100 m, and a rating of (0) indicates that it is located at a greater distance from the railway station. |
| E4 | The number of bikes being shared | The indicator assesses whether the number of bikes available at sharing stations meets the demand of commuters. Sufficient availability ensures that commuters have access to bikes when needed. A rating of (1) is given for suitability, and (0) is given for incorrect dimensioning. |
| E5 | Docking stations | If bike sharing is restricted to specific hubs for collection and drop-off, the rate is (0), while dockless bike share allows users the flexibility to pick up and drop off bikes at various locations (1). |

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