自転車ネットワークのサイクラビリティ評価：宇都宮市における総合的アプローチ

Cyclability Assessment for the Bicycle Network: A Holistic Approach in Utsunomiya City, Japan

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Abstract:

While Japan's demographic crisis is affecting medium-sized towns in particular, and seems to present heavy individual vehicles as the solution to the loss of density in the territories, the environmental and climate crises are reminding us of other obligations. And while in Europe, cycling is increasingly seen as a viable and sustainable alternative to traditional forms of transport, Japan seems to be having some difficulty getting to grips with active mobility. And although a growing number of towns and cities are launching cycling development plans, the relevance and acuity of the projects sometimes seem questionable in view of a number of factors, particularly that of the network. In this study, we will look at the case of Utsunomiya City in Japan, where cycling is confined to a small portion of the population and where the cycle network is still quite underdeveloped. And while the mutual link between cause and effect seems obvious, the ways of remedying the problem are much less so. In this paper, we propose a holistic approach to the issue of the cycle network, and a way for assessing the network in term of relevance end efficiency. By doing so, we will be able to point out the weaknesses and needs of the network by focusing both on infrastructure and users' behaviour. In order to do this through a holistic approach, we will be using a number of tools relating to the assessment of cyclability, as well as data relating to residents' journeys.

Keywords: *Cyclability, Network, Efficiency, Safety, Active-mobility*

1. Introduction

(1) Background

The town of Utsunomiya, around a hundred kilometres north of Tokyo, is fairly representative of Japan's medium-sized towns and outlying major conurbations: demographic crisis, car dependency and an emerging sustainable transition. And while the city is inaugurating its first tram line, an audacious plan at first sight, to develop the use of bicycles has been published. The plan in question announces the development of more than 120km of bicycle infrastructure (BI) (50km have already been built) in less than 10 years. Nevertheless, contrasting with a bold programme, the city counts a reasonable number of regular cyclists, in line with the national norm, and a very high proportion of users (almost 50%) are secondary school students who commute to their place of study every day. At the same time, the bicycle network development plan strongly suggests a star-shaped approach to the cycle network, with prominent development of the routes towards the city-centre, with few local or

even feeder lines. Moreover, the broad outlines of the cycle network are primarily a copy of the car network. Yet, the habits of cyclists are fundamentally different from those of motorists, and some projections seem disproportionate when put in perspective with the actual use of bicycles in the city. In addition, the plan and existing infrastructure often take the form of cycle lanes or road signs. Besides the glaring lack of safety offered by these two types of infrastructure, we can also wonder about their efficiency and the impact and on the behaviour of cyclists. So, naturally comes the question of the content of the plan and how to assess the relevance of the proposed network, based on cyclists' habits, their regular journeys and their behaviour when driving.

(2) Research objective

The aim of this study is to experiment and propose an original holistic methodology for assessing the Utsunomiya-city bicycle network relevance in term of connectivity, efficiency and safety. By doing so, we will improve the cyclability assessment tool and provide a new element of reflection for a larger-scale study of Japanese cyclability.

(3) Literature review

In their research about cyclability (Caillot, A. 2017) and cyclists' conditions, (Walz, L. 2018), both of the authors are promoting a strong field-oriented approach in order to collect high-quality data for assessing cyclability. The idea of assessment, which is intrinsic to the concept of cyclability is more and more used in academia and in the public sectors for a simple reason: it's an efficient way and a clear tool to push to improve our infrastructures, ideas, and ultimately our territories and our cities. That is why we will keep cyclability at the heart of this paper. These papers however don't necessarily focus on the network as a main element to assess or at least, to use as a main factor. That is where, research focusing both on the well-being of cyclists and on network (Von Olbecke, F. 2020) are also interesting to exploit. Presenting various methods in order to evaluate not only the network but the entire "cycling system", the paper inspired some of the general methodology of this study in the sake of developing a comprehensive network. More focusing about bicycle network (Lowry, M. 2014), gives a very complete and in-depth methodology for a complete bicycle network analysis through GIS tools. It greatly inspired the network accessibility assessment part of this paper. However, the complexity of some analysis requiring specific data -in contrast with the similar topic paper and very interesting (Colette, R. 2018)- makes it difficult to apply. Also, the presence of "Bikeability" concept and the general methodology made it even generally, a source of inspiration. In the same spirit, (Rupi, F. 2019) helped developing the idea of visualising and adapting the PT data from the city of Utsunomiya to carry out a supply/demand analysis of the network. The stimulating (Szell, M. 2022) article also help to have a very accurate vision of the different challenges and issues related to network development, even though the vision there is quite conceptual and global. Some elements of the methodology will serve the construction of our indexes. Another paper (José Cabral Dias, G. 2021) had a major influence on the concept of network efficiency and inspired one of the objectives of this research: to create a hierarchy of cycle routes and eventually develop a conceptual diagram to illustrate it. In the same way, (Lanzendorf, M. 2014) has inspired the overall vision of the research (in particular the objective) carried out in this paper. Ultimately, the Utsunomiya city bicycle network development plan (City of Utsunomiya, 2022), was one of the main elements to study and one of the cores that leaded to the reflections in this paper.

(4) Novelty of this research

The originality of this paper stands into 4 distinct points. First, we enhance the cyclability as an indicator by bringing an original analysis of a cycle network by focusing on its relevance. Second, this focus will be made possible by bringing new elements into the network assessment as the networks' influence on cyclists' behaviour. Third, by experimenting this kind of user-centered approach, we also bring a new way to evaluate the efficiency of the network. Fourth, the geographic background of this study tries to bring new reflections about the Japanese cyclability and its related issues.

2. Methodology

(1) PT data usage

The first part in the methodology consists in using the Utsunomiya PT (Person trip) data for simulating the journeys realised by bicycle and collect the maximum information about cyclists'

profiles. With the highest level of precision (the city is divided into 569 districts) we will accurately simulate the length of journeys by creating a centroid for each area, simulating all the possible journey combinations with Open Route Service. We will then associate each route with its corresponding combination in the PT data, so as to obtain a distance in km for each sample (13,512 samples in total). Secondly, in order to provide a clear picture of the dominant trends in cycling for visualisation process, we have reduced the number of territorial divisions to 78 and repeated the analysis. These new divisions will be called "sub-areas". Finally, we will repeat the operation one last time, this time dividing the city into just 9 territorial divisions (Fig. 1). These 9 divisions will be called "areas". This last operation will enable us to gather essential information on cyclists' movements for each area, as it is on this scale that we will carry out part of the evaluation of the cycle network. A matrix gathering all the journeys with the total of arrival and departure for each area will also be created.

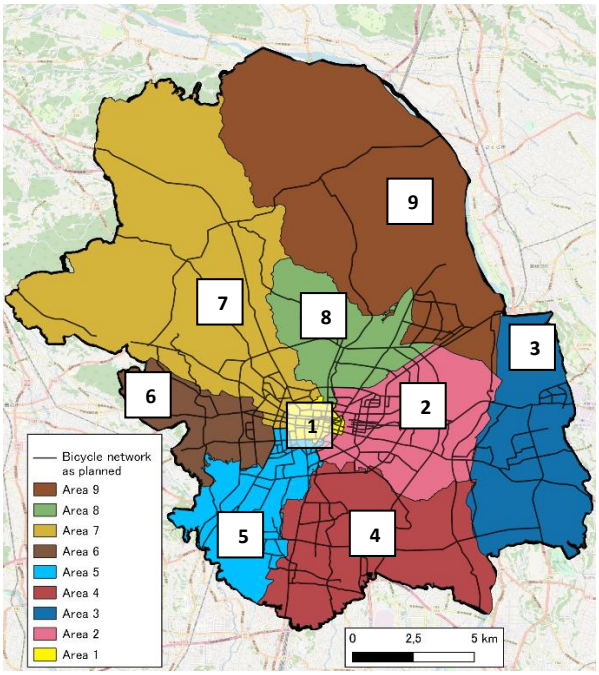


Fig. 1 Utsunomiya 9 areas and the bicycle network as planned

(2) Street and network classification

In order to classify the network depending on cycling situations, we will categorise the different types of roads and bicycle infrastructures as follow:

- Shared sidewalk: considered as "shared" following the (City of Utsunomiya, 2022).
- Sidewalk: any pavement infrastructure.
- Narrow street (or *"road"*): street without physical sidewalk, generally under 5,5m large.
- Bicycle signs: bicycle signs placed at regular intervals on the road tarmac.
- Bicycle lane: signs + blue lane completely or partially covering the trace of the signs.
- Tracks: Fully dedicated bicycle path.
- Riverside: Path only usable by active mobility users along the river.

Table 1 Bicycle signs (left) and bicycle lane (right)



(3) Network relevance index: connectivity & accessibility

The accessibility and connectivity index will be used at the 9 areas scale, then the average of each area weighted by its population will give us the final index for the city. The construction of this index requires data relating to the cycle network (share of intra-area and inter-area roads), data previously obtained from the PT data (share of inter-area and intra-area journeys) for evaluating the connectivity, as well as the number of people within 1 minute's cycling distance of the cycle routes for each area for evaluating the quick accessibility. This dataset was created using Valhalla (QGIS plugin) with the following parameters: Bicycle; isochrones bicycle; 1 min commuting; shortest route; Hybrid bicycle; 12Km/h. The isochrones are formed from points located at 94m intervals on the lines forming the developing cycle network. The index will be calculated as:

$$D_i = \frac{(\sigma_1 + \sigma_2 + \cdots \sigma_9)}{9}$$

$$I_i = \frac{D_i}{\sqrt{P_i}}$$

Where:

$\boldsymbol{D_i}$ is the average of the calculated standard deviation for $\boldsymbol{i}$ area.
$\boldsymbol{\sigma_n}$ will be calculated for every intersection of *trip to* "***t***" and *line to* "***l***" values for the same $\boldsymbol{n}$ area.
$\boldsymbol{P_i}$ is the share of the population in area $\boldsymbol{i}$ within 1

minute's cycling distance of one or more cycle routes.
$\boldsymbol{I_i}$ is the index of bicycle network relevance for one area.
$\boldsymbol{I}$ is the average of $\boldsymbol{I_i}$ and gives the final city index

(4) Network efficiency & impact data collection

Big data and other databases, even if they are based on GPS tracking of users, do not allow us to know precisely whether a user is driving on a pavement or a track, under what conditions, the cause of his stops, his violations of the highway code, etc... In order to carry out our study of the cycle network and its impact, we have a crucial need for these different variables. For this reason, data collection in the field is required. The first part of this fieldwork therefore consists of collecting data by following cyclists on their daily journeys. On the one hand, GPS recording (with a margin of error of -/+2 metres) allows us to collect precise data relating to speed (moving or average), journey time and gradient. On the other hand, the camera (or audio note recording when filming was impossible for safety reasons), enabled us to record details relating to the profile, the behaviour, as well as the specifics of the route (passage over such and such an infrastructure, etc...).

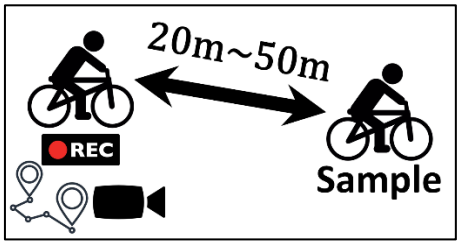


Fig. 2 Basics for data collection

The samples are chosen randomly. Most often, as soon as a cyclist passes nearby, the researcher begins to follow him/her and activates GPS tracking and note-taking as soon as his speed has stabilized at that of the sample. If a sample does not exceed 200m (except for specific case study) it is deleted because considered not revealing enough. A total of 102 valid samples were created. The second part of the field study is much more traditional, as it consists of counting cyclists passing or not passing on an infrastructure when there is one. 14 surveys were created for three distinct types of infrastructure: cycle lanes, signs and shared sidewalks.

(5) Network efficiency index: speed & behaviour

With the previously collected data (average movement speed, kin and share of BI used, differences in average speed) a second index named I_e will be created to evaluate the network efficiency based on the differences in speed observed and then weighted according to the availability and frequency of use of the different bicycle infrastructures. In this index, the BI are grouped into 2 categories where $\boldsymbol{l}$ refers to the lanes and signs and $\boldsymbol{s}$ refers to the shared-sidewalks and tracks. The index will be calculated as:

$$Q_l = (S_l * U_l)$$

$$Q_s = (S_s * U_s)$$

$$I_e = \frac{\big((V * Q_l) + (V * Q_s)\big)}{V}$$

Where:

$\boldsymbol{Q}$ is the efficiency coefficient for the measured infrastructure.
$\boldsymbol{S}$ is the share of deployment for the measured infrastructure in the cycle network.
$\boldsymbol{U}$ is the rate of use of the measured infrastructure.
$\boldsymbol{V}$ is the arithmetic mean of the speed differences observed for each age category.
$\boldsymbol{I_e}$ is the index of bicycle network efficiency for the city.
In this index, $\boldsymbol{I_e}$ is heavily influenced by the value of $\boldsymbol{Q}$ because we work on the assumption that even if bicycle infrastructure has a positive influence on the efficiency of the network, the rate of use is even more important, and the deployment of infrastructure is an even more important value.

(6) Network user's feedbacks

Table 2 Questionnaire content

90 usable samples
February to March 2023
45 questions in 5 distinct parts dealing with cyclability fundamental issues: Conflict Safety Comfort (& efficiency) Parking Policies (democracy)

In order to gain a comprehensive view of the network, clarify results of previously presented analysis, and to perfect the "user-centred" approach, a questionnaire on cyclability will be used for a complementary descriptive analysis.

3. Results

(1) Network relevance: the local trips are prominent

By summarising the data from the PT file and dividing up the results for the 9 areas to be analysed, there seems to be no doubt that cycling in Utsunomiya is mainly used for very local journeys (Table 3). As well as having fairly short average journey lengths, the vast majority of journeys are still made within the same area.

Table 3 Arrival/Departure per Area

Area	1	2	3	4	5	6	7	8	9
1	35%	10%	3%	6%	10%	13%	12%	11%	6%
2	18%	70%	15%	12%	4%	2%	7%	20%	4%
3	1%	2%	71%	1%	0%	0%	1%	1%	1%
4	3%	4%	1%	59%	8%	1%	1%	2%	1%
5	14%	3%	1%	17%	66%	13%	6%	3%	0%
6	4%	1%	1%	1%	4%	45%	7%	1%	0%
7	16%	5%	4%	3%	6%	24%	62%	12%	4%
8	6%	6%	2%	2%	1%	1%	5%	45%	9%
9	2%	1%	2%	0%	0%	0%	1%	5%	75%

(2) Visualisation of the results (sub-area scale)

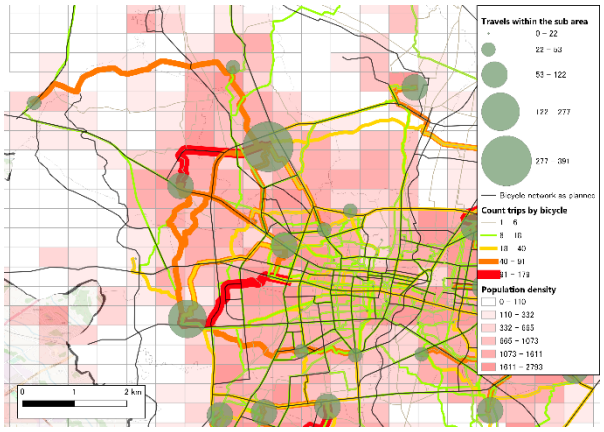


Fig. 3 Visualization of the network demand/offer

As seen on the (Fig. 3), and although the density of journeys is logically higher in the city centre, we can constate a very high demand characterized by a quite high number of inter-areas and intra-area bicycle trips. On the other hand, the bicycle network in the visualised areas (6 and 7 mainly) is almost only limited to the long passing-through lines going straight to the city centre. Adding these observations with the results showed on the (Table 3) make the star-shaped network very questionable. Another dubious point is that of developing long crossing inter-city network in the north and the south of the city, where demand is low or even non-existent. An investment in infrastructure that seems completely disproportionate.

(3) Network relevance index

Table 4 Calculation and Relevance Index result

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
/ 1	40%	8%	5%	9%	8%	13%	14%	11%	14%
/ 2	9%	39%	23%	18%	6%	9%	8%	22%	9%
/ 3	2%	10%	50%	3%	2%	9%	3%	0%	0%
/ 4	7%	12%	5%	27%	12%	9%	3%	11%	9%
/ 5	9%	6%	5%	18%	41%	17%	14%	15%	9%
/ 6	7%	4%	9%	6%	8%	13%	17%	4%	0%
/ 7	12%	6%	5%	3%	10%	26%	31%	11%	5%
/ 8	7%	12%	0%	9%	8%	4%	8%	7%	23%
/ 9	7%	4%	0%	6%	4%	0%	3%	19%	32%
t 1	35%	10%	3%	6%	10%	13%	12%	11%	6%
t 2	18%	70%	15%	12%	4%	2%	7%	20%	4%
t 3	1%	2%	71%	1%	0%	0%	1%	1%	1%
t 4	3%	4%	1%	59%	8%	1%	1%	2%	1%
t 5	14%	3%	1%	17%	66%	13%	6%	3%	0%
t 6	4%	1%	1%	1%	4%	45%	7%	1%	0%
t 7	16%	5%	4%	3%	6%	24%	62%	12%	4%
t 8	6%	6%	2%	2%	1%	1%	5%	45%	9%
t 9	2%	1%	2%	0%	0%	0%	1%	5%	75%
Avσ	0.0199	0.0366	0.0279	0.0351	0.0302	0.0354	0.0345	0.0438	0.048
P	61%	32%	26%	26%	44%	25%	19%	18%	32%
I_i	0.025	0.065	0.055	0.069	0.045	0.070	0.080	0.104	0.086
I	0.0669								

Particularly suited to scenarios such as those of outlying Japanese medium-sized towns (low population density, underdeveloped cycle network, dependence on the car, etc.), our index provides a rough but clear picture of the network situation by only focusing on grid priority issues (accessibility and connectivity). For this index, we will judge that a score inferior to 0.05 is good. On the other hand, a score superior to 0.07 will then be considered as bad. In our case, the areas 6, 7, 8 and 9 clearly suffer from the lack of local or feeder routes. On the other hand, areas 1 and 5, which have a more developed network and, above all, one that is better adapted to demand, come out of this with very respectable scores. The final city score is then fairly modest.

(4) Network impact

a) Efficiency

The data collected in the field covering the behaviour and driving habits of cyclists according to the type of infrastructure used has enabled us to refine our understanding of the cycle network. In the following analysis, lanes, signs and shared sidewalks are all included in the "BI" category. The "riverside" category includes bicycle infrastructure

along rivers. The first observation about the network efficiency is then clear and positive: the difference in average speed of cyclists when riding pavements, roads or bicycle infrastructures is considerable (Fig. 4).



Fig. 4 Average cyclist's speed

A correlation analysis, using as input the proportion of journeys made on each type of infrastructure and the average speeds observed, enables us to confirm and refine the results set out above (Fig. 5). Thus, the correlation coefficients are r = -.365 when driving on pavements, r = -.185 when driving on roads, r =.485 when driving on BI, and r=.272 when driving on riverside.

Correlations

		Gender	Age	Sidewalk_prctg	Road_prctg	Lane_prctg	River_prctg	Infra
Gender	Pearson Correlation	1	-,031	,207*	-,269**	-,045	,105	-,
	Sig. (2-tailed)		,758	,037	,006	,651	,292	
	N	102	102	102	102	102	102	
Age	Pearson Correlation	-,031	1	-,026	,132	-,090	-,022	
	Sig. (2-tailed)	,758		,799	,186	,367	,828	
	N	102	102	102	102	102	102	
Sidewalk use share	Pearson Correlation	,207*	-,026	1	-,523**	-,510**	-,265**	
	Sig. (2-tailed)	,037	,799		<,001	<,001	,007	
	N	102	102	102	102	102	102	
Road use share	Pearson Correlation	-,269**	,132	-,523**	1	-,273**	-,177	
	Sig. (2-tailed)	,006	,186	<,001		,006	,075	
	N	102	102	102	102	102	102	
Lane use share	Pearson Correlation	-,045	-,090	-,510**	-,273**	1	-,149	
	Sig. (2-tailed)	,651	,367	<,001	,006		,135	
	N	102	102	102	102	102	102	
River use share	Pearson Correlation	,105	-,022	-,265**	-,177	-,149	1	
	Sig. (2-tailed)	,292	,828	,007	,075	,135		
	N	102	102	102	102	102	102	
Infraction	Pearson Correlation	-,265**	-,022	-,075	,183	-,040	-,085	
	Sig. (2-tailed)	,007	,829	,451	,065	,689	,393	
	N	102	102	102	102	102	102	
Average speed in movement	Pearson Correlation	,001	-,374**	-,365**	-,185	,458**	,272**	
	Sig. (2-tailed)	,989	<,001	<,001	,062	<,001	,006	
	N	102	102	102	102	102	102	

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Fig. 5 Correlation table - efficiency

b) Behaviour

Another correlation analysis highlights the impact and attractiveness of certain types of infrastructure on cyclists (Fig. 6). We can for example observe that while sidewalks seem to be preferred by women (r = .207), roads as well as narrow streets seem to be more to the taste of men (r = -.269). On the other hand, bicycle infrastructures seem to be to the taste of all users, regardless of age or gender. It's also worth noting that adult men seem to be much more likely to break the highway code (r = -.265). Unsurprisingly, alleyways and narrow streets seem to be the riskiest areas for behaviour impacting.

Correlations

		Gender	Age	Sidewalk_prctg	Road_prctg	Lane_prctg	Rive
Gender	Pearson Correlation	1	-,031	,207*	-,269**	-,045	
	Sig. (2-tailed)		,758	,037	,006	,651	
	N	102	102	102	102	102	
Age	Pearson Correlation	-,031	1	-,026	,132	-,090	
	Sig. (2-tailed)	,758		,799	,186	,367	
	N	102	102	102	102	102	
Sidewalk_prctg	Pearson Correlation	,207*	-,026	1	-,523**	-,510**	
	Sig. (2-tailed)	,037	,799		<,001	<,001	
	N	102	102	102	102	102	
Road_prctg	Pearson Correlation	-,269**	,132	-,523**	1	-,273**	
	Sig. (2-tailed)	,006	,186	<,001		,006	
	N	102	102	102	102	102	
Lane_prctg	Pearson Correlation	-,045	-,090	-,510**	-,273**	1	
	Sig. (2-tailed)	,651	,367	<,001	,006		
	N	102	102	102	102	102	
River_prctg	Pearson Correlation	,105	-,022	-,265**	-,177	-,149	
	Sig. (2-tailed)	,292	,828	,007	,075	,135	
	N	102	102	102	102	102	
Stop	Pearson Correlation	-,085	-,108	,296**	,006	-,219*	
	Sig. (2-tailed)	,393	,280	,003	,955	,027	
	N	102	102	102	102	102	
Infraction	Pearson Correlation	-,265**	-,022	-,075	,183	-,040	
	Sig. (2-tailed)	,007	,829	,451	,065	,689	
	N	102	102	102	102	102	
Time_lost	Pearson Correlation	,020	-,260**	,314**	-,060	-,251*	
	Sig. (2-tailed)	,839	,008	,001	,548	,011	
	N	102	102	102	102	102	
Speed_Average_Mov	Pearson Correlation	,001	-,374**	-,365**	-,185	,458**	
	Sig. (2-tailed)	,989	<,001	<,001	,062	<,001	
	N	102	102	102	102	102	

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Fig. 6 Correlation table - behaviour impact

c) Perception

After a series of 14 counting points to observe the attractiveness of the various BI, the findings are clear: both lanes (BI profile = 2) and signs (BI profile = 1) are used very little. By contrast, shared sidewalk (BI profile = 3) seems to be extremely popular with cyclists, with a usage rate of around 90% (Table 5).

Table 5 Counting of BI using

% on BI	Lane profile	Sidewalk profile	Total count
14.89%	**1**	1	47
25.71%	**1**	1	35
3.45%	**1**	2	29
85.29%	**3**	2	34
5.56%	**2**	1	36
33.33%	**1**	1	36
13.89%	**2**	3	36
17.07%	**1**	1	41
12.50%	**2**	3	64
13.89%	**2**	2	36
18.18%	**2**	2	44
90.20%	**3**	2	51
88.64%	**3**	2	44
20.83%	**1**	1	24

The only three times the usage rate of signs or lane exceeds 20% is when the pavement is narrow (Sidewalk profile = 1) (less than 3m wide) and then logically offers few spaces in case of coming across any other Active Mobility User.

These observations can be explained, among other things, by the very negative perception cyclists have of this type of infrastructure (lanes and signs). They indeed offer no protection, no assurance of safety, no separation of any kind from other road users, and are therefore very complicated to apprehend for many users. The results of question #15 of the questionnaire showing the respondent a photo of signs and a photo with a shared pavement: "On a 1 to 6 scale, how safe do you feel on that kind of infrastructure?" illustrates this poor perception very well (Table 6).

Table 6 Average perceived security scale

Bicycle signs	Cycle track
	
2.67	**5.61**

(5) Network efficiency index

Finally, we calculate the second index of this study. The value of V_i will express the difference in average speed observed for the three age categories between BI use and non-use of BI. This first value is the basis of our indicator because it is speed and the associated gains that we consider to be of primary importance in assessing efficiency. It is interesting to note that older people clearly seem to benefit from cycling infrastructure when they use it (table 7).

Table 7 Calculation of V_i

	Young	**Adult**	**Elderly**
Average speed on non-BI	14.60	13.38	12.86
Average speed on BI	19.36	16.49	16.39
Difference	**4.75**	**3.10**	**3.53**
V_i	**3.797**		

The Q values are then calculated for the two families of BI taken into account here: lanes and associated infrastructures as well as shared sidewalks and associated infrastructures. This value will temper the value of V and give us a clear final indicator, taking into account both the rate of development of BI and their rate of use by users (Table 8).

Table 8 Calculation of Q and I_e

	Lanes	**Shared-sidewalk**
Development share	0.85	0.15
Use rate	0.16	0.88
Q_l	**0.138**	
Q_s	**0.131**	
I_e	**0.270**	

The closer I_e it is to 2 the more efficient the network is considered to be. On the contrary, the closer the value is to 0, the more inefficient the network becomes. In our case, the value of I_e is quite low (0.270), reflecting the glaring mismatch between demand from cyclists (preferring shared pavements and tracks to lanes and signs), and the offer of a cycle network based mainly on lanes and signs.

4. Conclusion

After a complete analysis of the network, we were able to construct a simple methodology that nevertheless covers many of the aspects that determine the relevance of a cycle network. First of all, it should be noted that the good aspects of the network lie above all in the programme deployment: the web is wide and allows good centralisation of flows. The project is therefore generally ambitious and reflects a praiseworthy political will to improve cyclability for the general public. However, the low relevance index is a reminder of the glaring lack of local routes or feeders. So, rather than planning routes several dozen kilometres long to the north of the city, it would undoubtedly be interesting to develop second hubs around the city centre, where there are still a great many cycle journeys. Finally, the main weakness of the network lies in the mismatch between supply and demand for the type of infrastructure. Signs and lanes, which are shunned by users, should not be such an important part of development because they offer few guarantees in terms of security and are rarely used. On the contrary, the solution of a wide shared sidewalks,

of which there are some very good sections in the city, seems to suit all users and offers a guarantee of both attractiveness and efficiency. As Utsunomiya is not a densely populated city and the proportion of active mobility in daily travel is relatively low, the shared sidewalk solution seems to be a good option, as it is less prone to the conflicts and safety problems that generally accompany this type of infrastructure in a very urban environment.

5. Limitations and follow-up

The on-field studies and research are, as always, time and energy consuming. The quality of the data collected depends to a large extent on driver's ability to keep track of other users, and therefore requires practice and training. In another hand, it is the best (and maybe the unique) way to create high quality data with so many valuable variables. The methodology, compared to the previous research (Belliard, L. 2023), has improved a lot. There is, however, still some lacks in the development of ideas and the combination of the different variables in the assessment process. The index could include more variables in the future.

Next research will therefore involve improving the indicators created in this study while extending the scope of the research to new areas. The indicator should be improved by adding new variables, particularly relating to population, modal share of cycling, etc. The specific setting of medium-sized Japanese cities seems both to be a major challenge and to offer a wealth of opportunities for the development of active mobility. It is therefore vital to continue working with local authorities to offer residents a rapid and fair transition to sustainable mobility.

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