OPTIMIZING BICYCLE LANE NETWORKS FOR IMPROVED CYCLIST TRAVEL AND COMFORT IN THE PRESENCE OF VEHICLE TRAFFIC: A CASE STUDY IN PASIG CITY

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The COVID-19 pandemic prompted the Philippine government to establish extensive bicycle networks in major metropolitan areas, covering over 500km—a significant development to promote cycling. However, despite the infrastructure, challenges still persist in terms of connectivity, cyclist comfort, and safety, among others. This study aims to optimize bicycle networks in Pasig City, Philippines, considering factors like traffic, road geometry, and conditions. The study adopts a bi-level optimization method, conducting traffic assignment for cars and bicycles at the lower level and maximizing cycling travel distance and the Bicycle Compatibility Index (BCI) at the upper level. Employing BCI is intended to assess the comfort of cyclists along road segments affected by geometry, traffic volume, speed limits, as well as parking occupancy and land use in the surrounding area. As a proof of concept, a synthetic network was constructed to assess how the model functions. Initial results demonstrate that the network not only improves BCI but also minimizes impacts on existing traffic. The effects of imposing budget limits are also explained. Further work will be conducted to enhance the utilized optimization model.

Keywords : *Cycling network, Optimization, Traffic Assignment, Bicycle Compatibility Index*

1. INTRODUCTION

Cycling in the Philippines has recently become a trend since the COVID-19 pandemic happened in 2020 and resulted in a series of lockdowns and suspension of public transport operations in major metropolitan areas of the country. It was at that time that both local and national governments immediately recognized the importance of active transport in a time where health and sanitary protocols, including social distancing, must be met, especially in public places. In line with this, a relatively high number of relevant policies crafted and projects implemented were observed in the past few years, aiming to improve the condition of active transport, especially cycling, in the country.

While it was only during the past few years that active transport became a national priority, some local government entities had already begun initiatives to enhance walking and cycling in their areas even before the onset of the pandemic. Marikina City was one of the first cities in the Philippines to plan a 49.7-km bicycle lane network, with its feasibility study dating back to 2000[1)]. In

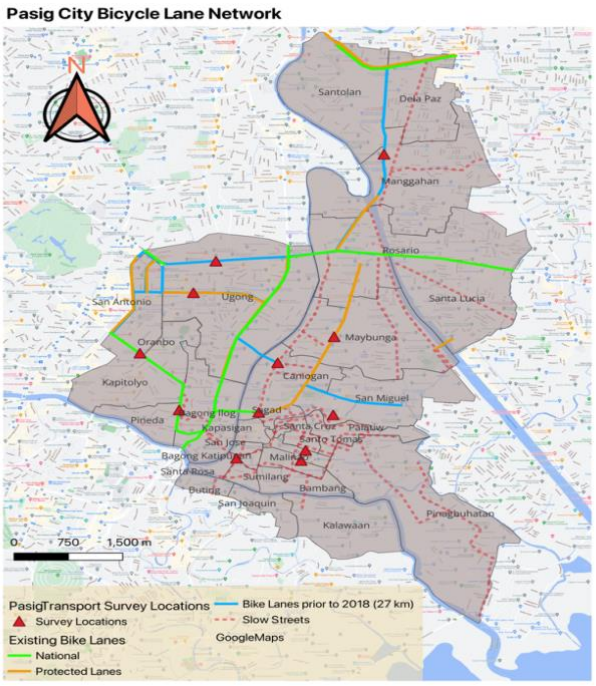


Figure 1 Pasig City Bicycle Lane Network obtained from Pasig City's City Transport Development and Management Office

Pasig City, there had also been plans of the local government in building their bicycle lane network. Said network encompasses the city's central business district connecting to the access roads from suburban areas surrounding the city. As of 2022, the existing network covers 57.5 km of visually-separated bicycle lanes, from which 18.8 km are also protected, as shown in Figure 1. The city has plans to increase bicycle lanes in the network up to 113.1km by 2024.

Given the plans for bicycle networks in the aforementioned cities within Metro Manila, the country's major metropolitan area, cycling is not the primary means of mobility for the majority. In a 2015 study conducted by the Japan International Cooperation Agency (JICA) for the Greater Manila area[2], trips mainly consisted of walking (30.7%), followed by jeepneys (19%) and tricycles (16%), both public transport modes. Private modes like motorcycles (8.3%) and cars (8.2%) came next. The report did not specify the share of bicycle trips, grouping them with 'other private modes,' accounting for only 2.3% of all trips in the area.

Despite a low percentage share of cycling in the transport mode, a recent survey report by the Social Weather Station (SWS) in 2023 found that 24% of Filipino households own a bicycle, while 36% uses a bicycle in performing tasks such as running errands and going to groceries or work, among others[3]. This highlights the potential of cycling and underscores the need for the establishment of bicycle networks that will improve safety and comfort of cyclists. However, building a bicycle network on roads usually congested with numerous modes of transport may further worsen existing traffic conditions if the network design problem does not properly consider these conditions.

In view thereof, this study aims to look closely into the existing network of Pasig City aiming to optimize cyclist's travel and comfort while taking into account the existing vehicle traffic within the area. The following sections of this paper will discuss review of related studies and literature, methodology, initial results, and succeeding actions that will further improve this ongoing research.

2. REVIEW OF RELATED STUDIES AND LITERATURE

2.1 Bicycle networks in the context of the study area – policies, projects and programs, and issues

Policies crafted in relation to promotion of active transport have become more proactive since the occurrence of the COVID-19 pandemic. The Philippine Government Republic Act (RA) No. 11494 or "*Bayanihan to Heal as One Act*" was enacted during the height of the COVID-19 pandemic, thereby allotting funds for promotion of active transport and implementation of projects and programs thereof[4]. In line with this, a Joint Administrative Order was established among government agencies, including the Department of Health (DOH), Department of Transportation (DOTr), Department of the Interior and Local Government (DILG), and the Department of Public Works and Highways (DPWH). This order provides implementing guidelines, and delineates the roles and responsibilities of each agency for promoting active transport during and after the pandemic[5]. Furthermore, the DPWH issued Department Order (DO) No. 88, which contains guidelines that classify types of bicycle lanes/paths and outlines the corresponding criteria for determining the appropriate type to be installed on national roads[6], as shown in Table 1.

Table 1. Bikeway Types According to DPWH DO No. 88 (National Government)

Bicycle Facility	**Criteria**	
	Motor Vehicle Operating Speed	Motor Vehicle Volume
Class 1 – Shared Use Path or Bike Path	Speed ≥ 50 kph	Annual Average Daily Traffic (AADT) > 6000
Class 2 – Separated Bike Lane using Pavement Markings or Physical Separation	40 kph ≤ Speed < 50 kph	3000 < AADT ≤ 6000
Class 3- Shared Roadway	Speed < 40 kph	AADT ≤ 3000

In the local context of the study area, the Pasig City Government (PCG) also issued relevant policies which further classifies road segments. Executive Order (EO) No. PCG-27 s. 2020 lists down complementary traffic engineering and infrastructure solutions that may be applicable on a particular road segment in the city's planned bicycle lane network[7]. A summary of said solutions are shown in Table 2.

Table 2. Bikeway Types According to PCG EO No. 27 (Local Government)

Complementary Solution	**Speed limit**
Shared use path or dedicated bike lane	30 kph
Slow streets	20 kph
People's streets (no motorized vehicles permitted)	N/A

Both local and national government policies were

observed to have similar parameters/criteria, particularly motor vehicle speed, to determine the appropriate bikeway type to be installed in a particular road segment. It is also important to note that coverage of national government policies is limited to national roads while the local government pertains only to roads that exist within their area of jurisdiction.

These existing guidelines served as the foundation for an unprecedented increase in bicycle facilities and infrastructures, primarily driven by the pandemic. Currently, 564km of bike lanes have already been built in major metropolitan areas of Manila, Cebu and Davao and there are plans to construct more bicycle infrastructure, aiming to reach up to 2,400km of bike lanes by 2028[8].

This further emphasizes the need for a comprehensive network of bicycle lanes that looks upon the existing issues which can be addressed in its planning and design stages. As an example, improving cyclist safety can not only reduce number of bicycle accidents but also encourage other people to use cycling. A study by Cruz (2017) mentioned that women do not cycle primarily due to safety, the image of cyclists as "deviants", and "compliance to the definition of femininity"[9]. A survey report by the Institute for Climate and Sustainable Cities (ICSC) noted the extremely high disparity of users between male and female cyclists during their survey in , with more than 90% of cyclists being male[10]. On the other hand, Gaspay, et al. (2022) noted a high number of new cyclists who do not have a car and/or motorcycle and resort to cycling as their primary mode during the pandemic[11]. This complements the previously mentioned SWS Survey Report that the largest percentage of people are cycling due to its affordability compared to other transport modes.

Cycling trips, however, are becoming more difficult as cars return to roads and trips are going back to normal. In addition, some bicycle lanes are being reconsidered for removal to ease the traffic in heavily congested areas, such as the bicycle lanes found in Metro Manila cities of San Juan[12] and Makati[13].

There are several international efforts which resulted in complex yet efficient bicycle networks. In the United States, the National Association of City Transportation Officials (NACTO) released in 2014 the Urban Bikeway Design Guide, enumerating types of bicycle facilities and infrastructures and the corresponding standards and criteria, e.g. lane widths, presence of pavement markings and traffic signs, etc.[14] .Similarly, the Institute of Transportation Engineers published the Protected Bikeways Practitioners Guide which further explains what a protected bikeway is and its advantages, and how to maintain and implement such bicycle facility[15]. The City of Vancouver in Canada also has its 10 general rules in building bicycle lanes that will improve comfort and safety of cyclists, also taking into consideration lighting, smoothness of road and slope[16].

These reports, among many others, that have been published, further pointed out the many factors affecting cycling use, and what it takes to improve a bicycle network and to encourage bicycling that is inclusive to everyone, breaking gender disparities and differences in social status.

2.2 Existing studies on bicycle network optimization

A number of studies were found to be relevant in this particular research, which Liaw and Lin (2022) classify as part of the network design problem stream[17]. This research stream of bikeway network development focuses on maximizing the performance of bicycle networks in various specific aspects and measurements. Similar studies employ bi-level or multi-level objective optimization methods, among others. The bi-level optimization approach simultaneously solves two optimization problems, with the solution of one problem impacting the outcome of the other—a concept similar to the Stackelberg model, with a leader making decisions followed by the followers[18]. Multi-objective optimization, on the other hand, solves a problem with conflicting objectives, i.e., improving one objective worsens the other, usually resulting in a Pareto solution[19].

Applications of said methods in bicycle networks involve maximizing factors including, but not limited to, accessibility or service coverage, cyclists' comfort, travel time, route length and bikeway suitability, and simultaneously taking into consideration constraints such as budget, network connectivity and existing traffic among others. This establishes a more realistic network reflecting the conditions and context of the study area.

Table 3 presents studies which use the aforementioned methods while selecting the appropriate objectives and constraints based on the study area and their target respondents. In their 2019 study conducted in Singapore, Zhu, S. and Zhu, F. concentrated on commuter cyclists, a group highly sensitive to travel time, and incorporated an objective aimed at minimizing the number of intersections when designing their network[20]. On the other hand, Lin and Liao (2014) established their network that aims to maximize the number of destinations for better recreational cycling experience[21]. In Australia, Mesbah, et al. (2012) takes into consideration mobility of cars and other modes of transport as the network being designed aims to not only improve cyclist's travel but also minimize impacts of the established bicycle network

to the existing traffic[22].

Another research stream in bikeway network development mentioned by Liaw and Lin (2022) involves evaluation of how bikeable a particular location/road segment/zone is. In this research, the Bicycle Compatibility Index (BCI), which is used as a tool to evaluate bikeability of road segments, will be employed and integrated in the optimization framework. The BCI was developed by researchers from the University of North Carolina Highway Safety Research Center for the US Federal Highway Association to assess the comfort of adult bicyclists when riding under different circumstances, particularly in geometry and operation conditions of the road[23]. This formulated equation was a result of the survey conducted in 3 regions in the USA; however, this has been widely accepted and used by bicycle coordinators, transportation planners, traffic engineers, and researchers in several parts of the globe, including Japan[24] and Norway[25], in evaluating the capability of specific roadways to accommodate both motorists and bicyclists.

Table 3. Relevant Studies on Bicycle Lane Network Optimization

	Liaw, A., Lin, J.J. (2022)	**Zhu, S., Zhu, F. (2019)**	**Lin, J.J., Liao, R.Y. (2014)**	**Mesbah, M., Thompson, R., Moridpour S. (2012)**
Study Area	Da-an District, Taipei, Taiwan	Jurong District, Singapore, Singapore (Urban Area)	North Coast & Guanyinshan National Scenic Area (Taiwan)	South East Queensland, Australia
Beneficiary	Utilitarian and recreational cyclists	Commuter cyclists	Recreational bicycling	Urban cyclists
Methodology	multi-objective integer linear programming model; epsilon-constraint method	multi-objective integer linear programming model; augmented epsilon-constraint method, weighted-sum method	multi-objective integer linear programming model; epsilon-constraint method	Bi-level optimization; genetic algorithm using crossover and mutation techniques
Objectives	Maximize **accessibility** and **comfort**, minimizing **risks** and **impacts**	minimize **inaccessibility**, **number of intersections and total construction cost,** maximize **bicycle level of service (BLOS**)	maximize **bikeway service coverage, service station service coverage, and bikeway suitability**, minimizing **cyclist risk**	Upper level: **maximize bike travel – performance of car;** Lower level: **traffic assignment**
Constraints	budget, connectivity among links and nodes, bikeway capacity, and flow conservation of nodes	space–time constraint, monetary budget, bikeway type, flow balance, bike-way construction	network connectivity, bikeway type, monetary budget, location relationships between bikeways and service stations	Upper level: costs, bike lane type, connectivity; lower level: conservation of flow, relationship of paths to links
Results	Out of 9 alternatives, 7 maximized accessibility objective, 2 maximized cyclist's comfort, 1 minimized risks, 1 minimized traffic impact; trade-offs between objectives	All 5 generated solutions superior than the existing network; trade-offs between the objectives	4 out of 6 solutions are found to be superior than the existing network; all 6 maximize bikeway service coverage, only 2 maximize service coverage of service stations, only 1 minimized risks, 3 maximized bikeway suitability	Numerical example results show that links near the destination satisfy the objective functions.
Major highlights/ key differences	Provides scenario analysis on budget constraints and demand	Used concept of time budget between each OD pair, BLOS based on attributes including road geometry and material (i.e., paved), use of road space (i.e., parking), vehicle traffic volume, vehicle speeds	Bikeway suitability includes shade trees, scenic spots and landscapes, environmental impacts, and distance from bus stops/parking lot as criteria	Existing traffic is considered; effects of genetic algorithms provide optimum values through increasing probabilities of crossover and mutation but with longer calculation time

3 METHODOLOGY

3.1 Bi-level Optimization

The paper conducts a bi-level optimization following the aforementioned study by Mesbah, et al. (2012), particularly its lower objective of conducting traffic assignment for cars, which shall be taken into consideration given the existing traffic condition of Metro Manila. The upper objective is to maximize the improvement in Bicycle Compatibility Index of potential roads where bicycle lanes will be built. This approach helps identify the roads with the least impact on existing traffic after bike lanes are introduced. Notations used in formulating the optimization model are shown in Table 4.

Table 4. Notations used in the model

Z	Upper-level objective
Y_c	Lower-level objective
A	Set of all links in the network
A_1	Set of links with bike lanes, $A_1 \subseteq A$
l_a	Length of link a
x_a^c	Motor vehicle flow on link a, respectively
Φ_a	Equals 1 if bike lane is introduced in link a and 0 otherwise.
e_a	Cost per length of bike lane installed in link a
B	Budget limit for building bike lanes
t_a^c	Travel time of cars on link a
$f_k^{c,rs}$	Motor vehicle flow on path k connecting origin node r to destination s
q_{rs}^c	Trip rate between r and s
$\delta_{k,a}^{rs}$	Equals 1 is link a is on path k for any origin-destination pair rs, and 0 otherwise
$t_{1,a}^c, t_{0,a}^c$	Cost function for cars (in terms of travel time) in link a installed with and without a bike lane, respectively
$t_{0,a}$	Travel time with free-flow speed in link a
m, n	Model parameters
$cap_{1,a}^c, cap_{0,a}^c$	Link capacity on link a installed with and without a bike lane, respectively
BCI	Bicycle Compatibility Index (BCI)
BLW	bike lane width
CLW	curb lane width
CLV	curb lane volume
OLV	other lane volume
SPD	legal speed limit
PKG	presence of a parking lane; equals 1 if >30% occupancy, and 0 otherwise
$AREA$	equals 1 if road is in a residential area, and 0 otherwise
AF	Additional factor; equals $f_t + f_p + f_{rt}$ where: f_t – truck volume factor* f_p – parking turnover factor* f_{rt} – right turn volume factor*

*See Appendix Table A.1. for corresponding values

Upper-Level Objective:

$$Max\ Z = \sum_{a \in A1} (BCI_{0,a} - BCI_{1,a}) \tag{1}$$

$$BCI = 3.67 - 0.966\Phi_a - 0.41BLW - 0.498CLW + 0.002CLV + 0.0004OLV + 0.022SPD + 0.506PKG - 0.264AREA + AF \tag{2}$$

Subject to:

$$\sum_{a \in A_1} l_a \left(\sum_{a \in A_1} e_a \Phi_a \right) \leq B \tag{3}$$

$$\Phi_a = 0\ or\ 1,\ \forall a \in A_1 \tag{4}$$

The upper-level objective for this optimization framework is given by Equation (1) which calculates the improvement of BCI in links before and after bike lanes are installed. This is subject to budget limits and binary constraints, i.e., a link can only be either introduced with a bike lane or not, as given by Equations (3) and (4), respectively. The BCI formula consists of parameters for road width, traffic volume (including right turn volume and percentage of trucks), speed limits, parking presence and turnover, and land use in the surrounding area, all of which provide an accurate assessment of the comfort of adult cyclists traveling along roads with existing traffic[23]. A smaller BCI value indicates a higher compatibility level. Furthermore, BCI calculation is convenient to use, as it is not affected by bicycle traffic volume.

Lower-Level Objective:

$$min\ Y_c = \sum_{a \in A} \int_0^{x_a^c} t_a^c(x)dx \tag{5}$$

Subject to:

$$\sum_k f_k^{c,rs} = q_{rs}^c,\ \forall r, s \tag{6}$$

$$f_k^{c,rs} \geq 0,\ \forall k, r, s \tag{7}$$

$$x_a^c = \sum_{rs} \sum_k f_k^{c,rs}\, \delta_{k,a}^{rs},\ \forall (i,j) \in A \tag{8}$$

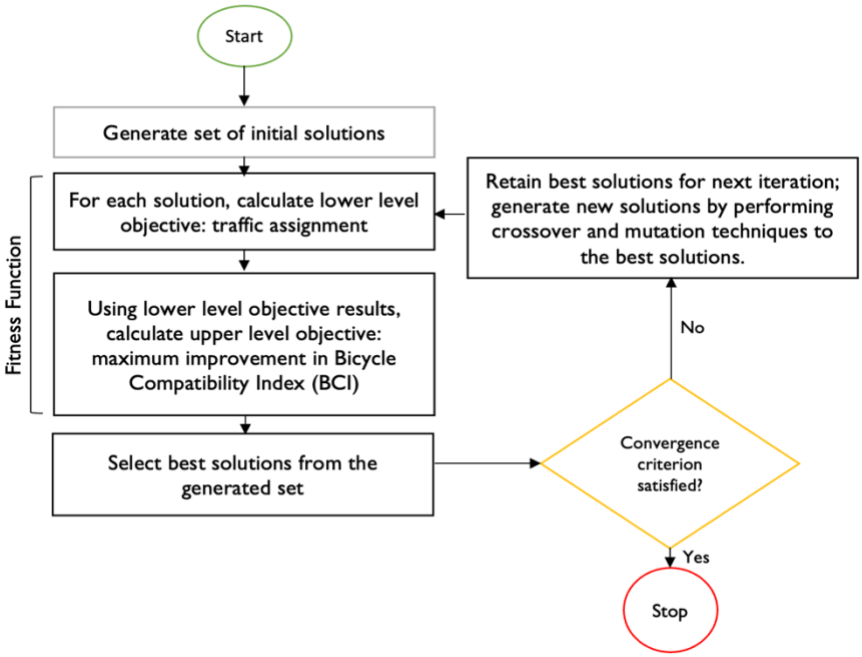


Figure 2 Genetic algorithm flowchart for this study

Inputs to calculate the upper level objective will come from the lower-level objective as shown in Equation (5) which conducts traffic assignment to cars, subject to flow conservation, non-negativity constraints, and link-path incidence, as given by Equations (6) to (8), respectively. Traffic assignment is governed by static user equilibrium, where demand is assumed to be constant over a certain period of time.

$$t_{1,a}^{c} = t_{0,a}\left(1 + m\left(\frac{x_a^c}{cap_{1,a}^{c}}\right)^{n}\right) \quad (9)$$

$$t_{0,a}^{c} = t_{0,a}\left(1 + m\left(\frac{x_a^c}{cap_{0,a}^{c}}\right)^{n}\right) \quad (10)$$

The calculation of travel time for cars along the network links follows the Bureau of Public Roads (BPR) function, as described in Equations (9) and (10). This takes into consideration traffic congestion when the links reach their capacity, whether or not bike lanes are present.

3.2 Genetic Algorithm

To solve for the formulated problem, a genetic algorithm is employed. This solution algorithm generates an initial set of solutions used to obtain values of the objective functions in the lower and upper levels. Solutions with the optimal value of the objective function will be selected and will undergo crossover and mutation techniques that will generate offspring solutions which are more likely to improve the values of the objective function. This cycle continues until the convergence criterion is satisfied, which will then identify the most optimal solution in this framework[26]. Flowchart of how genetic algorithm works is shown in Figure 2.

The R software, specifically the genalg R package, is employed to address this optimization problem. This involves utilizing a genetic algorithm to calculate the optimization model, requiring the definition of a fitness function encompassing both lower- and upper-level objectives. Furthermore, traffic assignment in the lower-level objective is carried out using the cppRouting R package.

3.3 Proof of concept

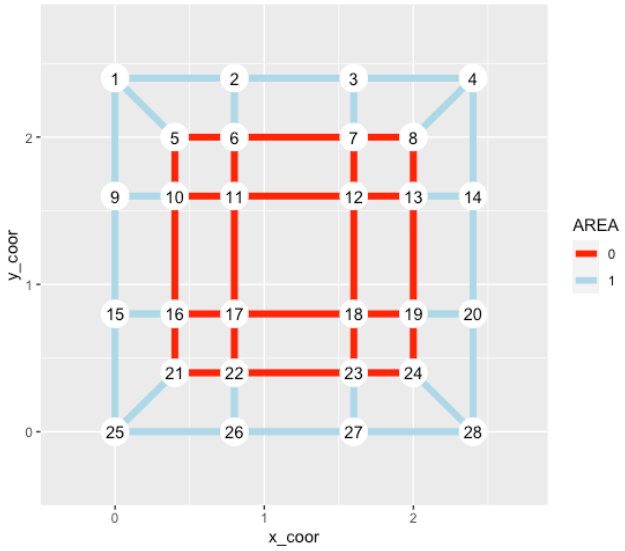


Figure 3 Synthetic Network created for the study

A synthetic network shown in Figure 3 has been created to initially check how the optimization problem works. This synthetic network has 28 nodes, 96 links (to assume a two-way traffic between the nodes). Detailed list of links are shown in Appendix Table A.2. This is designed to illustrate a city center inside (in red lines) and residential land use in the outer area (in light blue lines). In line with this, the synthetic network consists of 6 origins (nodes 1, 2, 8, 20, 27. and 28) and 2 destinations (nodes 12 and 17), generating a synthetic volume of 375 veh/hr for each OD-pair. Said OD demand depicts the travel in the morning peak hours, when movement of people will come from their homes going to their workplaces located in the city center. As for the budget constraint, only a maximum of 10 links will have bike lanes. Other necessary assumptions from Mesbah, et al. (2012), are also adopted, particularly the reduction of the road's capacity upon introduction of bike lanes from 1800 to 1500 veh/hr, and no congestion in bike lanes.

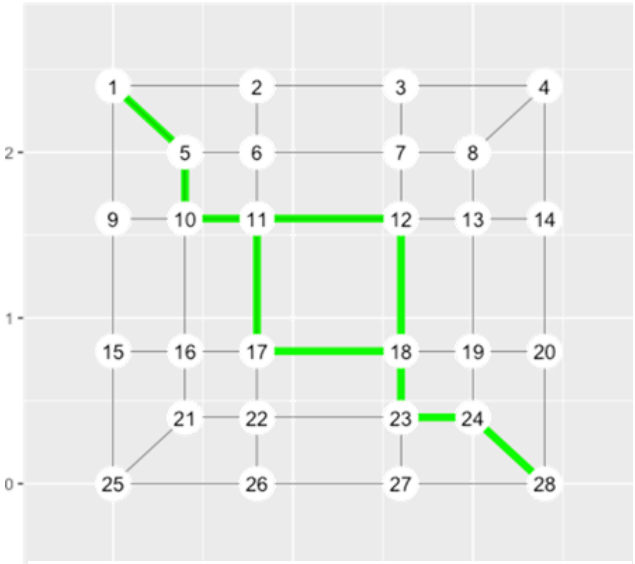


Figure 4 Solution of the optimization framework in this study using the created synthetic network.

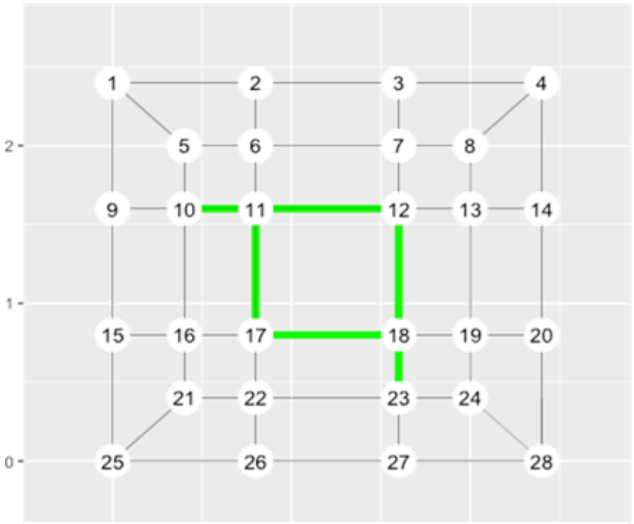


Figure 5 Solution of the optimization framework from the previous study using the created synthetic network.

Furthermore, several assumptions were made in the calculation of the BCI. 30% of the traffic volume are in the curb lane, which is 2.75m wide, and 70% are in the other Lane. Speed limit for all links is assumed to be 50kph. As shown in Figure 3, red links make up the city center, thus AREA parameter equals zero. For all links, it is assumed that PKG parameter equals zero, describing no presence of parking lanes, and the additional factor, AF, is 0.2.

4 INITIAL RESULTS

4.1 Optimized Network

Figure 4 shows the preliminary results of the optimization framework with the highlighted links that provide the greatest improvement in BCI as compared to the network's baseline existing condition. Since the optimization framework calculates the maximum improvement in BCI, the parameters that vary before and after bike lanes are introduced will yield a change in the BCI of a particular link. As a result, parameters including SPD, AREA, PKG and AF, whose values remain the same after introduction of bike lanes will not have an effect in the BCI improvement of a link. In reality, however, said parameters may have an effect, if, for example, speed limits on roads introduced with bike lanes, are to be reduced from 50kph to 30kph. In this particular example, changes in the traffic volume (CLV and OLV) affect the BCI of a particular link, aside from the presence of bicycle lanes (BL) and, subsequently, the corresponding width (BLW), both of which greatly improves BCI.

4.2 Comparison with the previous study

As a brief explanation of the previous study's framework, the upper-level objective aims to maximize cyclists' distance traveled on bike lanes, subtracting car travel time in the network, while the lower-level objective conducts traffic assignment for both cars and bikes. Said framework is applied to the toy network mentioned in Sec. 3.3, following the applicable assumptions, including a budget limit of 10 links for bicycle lane construction. Furthermore, bicycle demand is assumed to be 10% of car demand for each aforementioned OD pair.

Results of the previous study's model, which is shown in Figure 5 reveals that the solution did not reach 10 links as the objective value did not increase beyond this set of six links. This outcome aligns with the explanation provided by the authors in the previous study. They noted that these links, which offer the optimal solution, are located close to the destination points where bicycle travel is highest.

However, when considering the previous study's upper-level objective, which aimed to maximize cyclist travel on bike lanes, this has led to certain limitations, giving less importance to the cyclists' point of origin.

This study's framework, on the other hand, reveals a network with links situated near the origin. This positioning has the potential to create bicycle routes that offer an improved cycling experience for commuting from home to work or other destinations, and vice versa.

4.3 Budget constraints

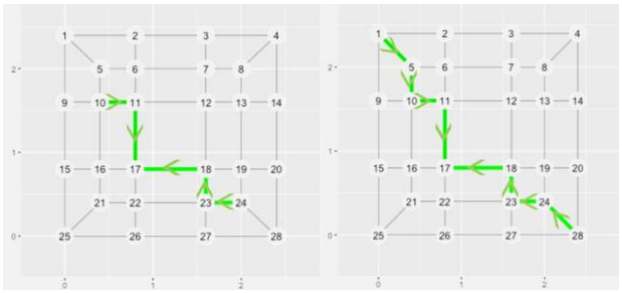


Figure 6 Network of bike lanes with a budget limit of 5 (left) and 8 (right) links.

Based on the results of this study's framework, adjusting the budget constraints is crucial in prioritizing which links should have bicycle lanes, as shown in Figure 5. This flexibility can be a valuable tool for transport planners and authorities, enabling them to implement bicycle lane networks in alignment with their specific timelines.

5 FURTHER WORK

A number of improvements can still be done moving forward in this research. Noting the parameters that make up the BCI formula, it is interesting to look how bike lane construction alongside policy changes, e.g. conversion of parking lanes to bike lanes or reduction of speed limits, may have an effect on the road's BCI.

On the other hand, to further improve the genetic algorithm, it's essential to explore its parameters. This includes defining crossover and mutation probabilities, as well as selecting the best chromosomes through elitism in each iteration. These factors play a vital role in finding the optimal solution. Currently, the genetic algorithm employs a 'death penalty' approach, where an extremely high objective function value is assigned if the solution doesn't meet all model constraints. To maintain effectiveness, mutation and crossover probabilities should be carefully chosen. Setting a high mutation probability, for instance, can lead to solutions that exceed the budget limit, preventing the attainment of an optimal value. Similarly, other solution algorithms, which may improve efficiency of running this optimization model, can be explored.

It is also important to consider types of bicycle lanes to be installed. Criteria for selection of these bikeway types, which are based on existing policies, can be incorporated in the model. This benefits transport planners and authorities, for example, in easily determining which lanes shall be protected or only have a shared roadway with existing traffic.

Another feature would be to incorporate the framework from the previous study, thereby performing a multi-level objective optimization, which may include placement of weights to multiple objectives of the model. This creates new solutions, where various objectives are considered. Similarly, different optimization functions may be explored, for example, the maximizing gross comfort of cyclists considering bicycle traffic volume/demand, and maximizing bicycle trips incorporating mode choice, among others.

Finally, with these features integrated in the model, optimizing bike lane networks in cities, such as Pasig City, can produce realistic and accurate results.

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APPENDIX

Table A.1. BCI Adjustment Factors

Hourly Curb Lane Large Truck Volume	f_t	Parking Time Limit (min)	f_p	Hourly Right-Turn Volume	f_{rt}
≥ 120	0.5	≤ 15	0.6	≥ 270	0.1
60 - 119	0.4	16 - 30	0.5	< 270	0.0
30 - 59	0.3	31 - 60	0.4		
20 - 29	0.2	61 - 120	0.3		
10 - 19	0.1	121 - 240	0.2		
< 10	0.0	241 - 480	0.1		