An Assessment of Bikeways Safety in Pedestrian Crashes Prone Areas in Marikina City

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Abstract: Marikina City's Bikeways is hailed as the first in the Philippines and Marikina is considered as a "Bicycle Friendly City". This study assessed the safety of Marikina's bikeway infrastructure by identifying the location of vehicular accidents and pedestrian crashes, evaluating its current conditions and/or design in these areas, and analysing the bikeways safety issues using the road and transport system approach framework adapted from the World Health Organization. This paper presents three factors in determining bikeways safety: (1) health hazard, the air quality of Marikina was rated from good to moderate, (2) motorist behaviour, the perspectives of cyclists and non-cyclists on the use of bicycle as alternative were discussed, and (3) bikeways infrastructure, facilities and elements that are present or are lacking in the bikeways infrastructure were examined. The study concluded that the absence of one factor can make the roads unsafe for cyclists.

Keywords: road safety, bikeways safety, pedestrian safety, road accidents, bicycle accidents

1. INTRODUCTION

The World Health Organization [WHO] (2015) states that 1.2 million lives per year were reported to road crashes injuries. In the Philippine context, 53% of road crashes are motorcyclists, 14% of road crashes are four-wheeler vehicles and 11% of road crashes are the passengers. But pedestrians, which include bicycle users are 19%, totalling to 10, 379 deaths (WHO, 2015). Based on the Philippines' Department of Public Works and Highway-Traffic Accident Recording report, there are 1, 513 deaths caused by road accidents in 2013 (Francisco, 2015). It is evident that these data identifies the issue of road safety as both a national and a global phenomenon.

In 2010, the United Nations General Assembly declared the years 2011 to 2020 as the 'Decade of Action for Road Safety'. In this resolution, road safety is generally defined as the 'methods and measures that are issued to reduce risks of injury, death and harm to drivers, passengers and pedestrians' (United Nations Road Safety, 2011). Furthermore, in 2016, the United Nations General Assembly adopted a resolution on improving global road safety, reaffirming the inclusion of road safety in the Sustainable Development Goals or SDGs. Specifically, SDG target 3 (ensure healthy lives and promote well-being for all at all ages) includes the reduction of global deaths and injuries from road traffic accidents by fifty-percent by 2020. Moreover, SDG target 11 (make cities and human settlements inclusive, safe, resilient and sustainable) includes the provision of access to "safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with

special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons' by 2030 (UN General Assembly resolution "Improving global road safety, 2016).

Road Safety Audit is used in order to assess the accident potential and safety performance of a specific design for a road or traffic scheme (Bagi, A., & Kumar, D., 2012). It may be used to analyse highway schemes covering major and minor highway improvements, traffic management and calming schemes, roundabout junctions, new or amended traffic signal junctions, priority junctions, motorway improvement, and even pedestrian and cycling schemes (Sanderson Associates, 2016).

Therefore, road safety encompasses an efficient and effective bikeways or cycling infrastructures.

In terms of transportation planning and development, the City of Vancouver, Canada sees bikeways or the bicycle network as essential components to road infrastructure and cycling as a more sustainable mode of transportation (Urban Systems, 2015). In fact, it has two major action plans namely 'The Greenest City Action Plan' and 'The City's Transportation Plan'. The Greenest City Action Plan sets 50% of all trips within the city shall be made through bicycle, on foot or by means of a public transit by 2020. On the other hand, The City's Transportation Plan aims to achieve 'zero traffic-related fatalities', to provide utmost safety for vulnerable road users, and to make cycling safe, convenient, comfortable, and fun for its residents and visitors (Urban Systems, 2015).

In the Philippine context, Marikina City's Bikeways is hailed as the first in the country and Marikina is considered as a "Bicycle Friendly City". As such, the main focus of this study is to assess the bikeways safety in pedestrian crashes prone areas in Marikina City. There have been numerous researches focusing on road safety but studies on bikeways safety in the Philippines are limited. WHO (n.d.) uses a system approach to analyse risk factors of road safety. It shows two effects of road system: the desired effect (mobility) and the undesired effect (road traffic crashes). The researchers focus on the three factors as stated in the system approach which are the human factors, vehicle factors, and road and environmental factors as guiding principles for road safety. In this study, the researchers applied WHO's system approach to bikeways safety. To examine the human factor to bikeway safety, the researchers analysed the current health hazard in Marikina City. To determine the vehicle factor to bikeway safety, the researchers identified the motorist behaviour. Lastly, to understand the road and environmental factor to bikeway safety, the researchers examined the bikeways infrastructure of Marikina City.

1.2 Research Objectives

The general objectives of this study are to determine the factors that could affect the safety of the bikeways in Marikina City.

In order to obtain it, the following objectives must be addressed by the researchers:

1. Identify the location of vehicular accidents relating to bikeways and pedestrian crashes;
2. Assess the current conditions and/or design of the bikeways in areas with records of vehicular accidents or pedestrian crashes; and
3. Identify the bikeways safety issues using the road and transport system approach framework adapted from World Health Organization and to recommend measures to improve bikeways

safety of selected areas of Marikina City.

2. RELATED LITERATURE

The degree of road safety problem is a worldwide phenomenon (University of Michigan Transportation Research Institute, 2009). Significantly, road safety has been identified as a main socioeconomic concern for most countries and a multidisciplinary multisector problem (Road Safety Audit for Road Projects). Asian Development Bank's (2016) 'Road Safety and Social Sustainability' report states accident rates in developing Asian countries are likely much higher than in advanced countries. Consequently, out of 1.18 million deaths and injuries caused by road accidents globally each year, about 60% occur in Asia and around half of those who die in road traffic crashes are pedestrians, cyclists, or users of motorized two wheelers (ADB, 2016).

2.1 Factors influencing Road Safety

2.1.1 Vehicular Accidents

Vehicular accident occurs when a vehicle crashes into another vehicle, pedestrian, animal, road debris, or any other obstruction such as a tree or pole. It may result in injury, death, or property damage. The factors contributing to vehicular accidents are speed, alcohol, driver fatigue, hand-held mobile telephones, inadequate visibility, non-use of crash helmets by two-wheeled vehicle users (Road Traffic Injury Prevention: training manual, 2006).

Vehicle accidents, particularly crash risk, are brought by the interaction between three elements called the 'three traffics safety pillars': road users, vehicles, and infrastructure. According to Singapore Road Safety Council, pedal cyclists are among the most vulnerable road users due to their small size type of transport. Moreover, the Royal Society for the Prevention of Accidents (RoSPA) (2016) states that human error is the principal factor that contributes to cyclist collisions.

2.1.2 Health Hazard

Road vehicles are major sources of air pollution and while partaking in road traffic, one tends to be exposed to one of the highest concentrations of air pollution (Knittel et al., 2016). Air pollution is a real danger. It is considered as the deadliest public health hazard apart from smoking and in various places. Hartog, Boogaard, Nijland and Hoek (2010) noted in their study that shifting the mode of transportation from vehicles to bicycle would produce positive effects to the environment and the society such as 'decreased air pollution emissions, decreased greenhouse gas emissions, and increased levels of physical activity'. However, the authors stated that higher exposure to air pollution and risk of traffic accidents may outweigh the health benefits of cyclists.

2.1.3 Motorist Behaviour

Human behaviour while driving or the 'psychology behind driving' is the most important factor in the field of transportation safety (Evans, 2004). According to Global Road Safety Partnership (2015), all forms of road users are in danger of being killed or harmed in a road traffic crash. As such, motorist behaviour is an important factor in traffic safety since it

reflects how motorists deal with vast and intense traffic mix and how motorists deal with unsafe roads (i.e. the lack of separation between slow-moving and non-motorized road users and fast-moving motorized vehicles).

2.1.4 Road Infrastructure

The road environment and infrastructure are essential components for road safety. The road network dictates how road users observe their environment (road infrastructure and road safety). Knowledge on roadway parameters may influence road safety and can help in planning, designing, building, and maintaining road infrastructure to promote a safe road environment.

2.3 Asian Countries Practice on Road Safety

In the study "Bicycling in Asia" conducted by Interface for Cycling Expertise (2008), it was stated that another component of road safety strategy is cycling safety. Bicycle has been an essential mode of transport in various Asian countries since the early 20th century. The study was initiated for establishing an improved understanding of the Asian context, to assess potential contribution of bicycles to air quality management, poverty reduction, sustainable urban development, and for better quality of life in cities. The area covered by the initial study are the countries of Asia; specifically, it focused on the non-motorized mode - bicycle, including its well-off varieties.

2.4 Case study: Vancouver, Canada's Bikeways

Urban Systems (2015), a private consultancy firm in Canada, conducted a study with the Cycling in Cities Research Program at the University of British Columbia and Simon Fraser University on the Cycling Safety of Vancouver Canada. In the study, the city of Vancouver is recognized as 'one of the most bicycle-friendly cities in North America'. Its bikeways or bicycle network plays an integral part of the city's transportation planning and development as reflected on The Greenest City Action Plan and the City's Transportation Plan. The Greenest City Action Plan sets 50% of all trips within the city shall be made through bicycle, on foot or by means of a public transit by 2020. On the other hand, The City's Transportation Plan aims to achieve 'zero traffic-related fatalities', to provide utmost safety for vulnerable road users, and to make cycling safe, convenient, comfortable, and fun for its residents and visitors. The study shows that the city's bicycle network is utilized by both residents and visitors and according to the 2011 Canadian National Household Survey, cycling trips going to work destinations within the city was about 4.4%. However, there were identified barriers that prevent some residents to do cycling. They are as follows:

BARRIERS TO CYCLING / CYCLING SAFETY CONCERNS
Uncomfortable infrastructure (presence of debris or slippery road conditions)
Lack of convenient and secure bicycle parking
Motor vehicle traffic and speeds (potential risk of injury from collisions)

Challenges in finding direct routes
Influence of weather and topography
Societal perceptions and attitudes towards cycling
Bicycle users are considered vulnerable road users along with pedestrians and motorcyclists

As a response to these barriers to cycling, the following are the recommended actions to cycling safety:

CYCLING SAFETY MEASURES
Better understanding of cycling safety hotspots and concerns
Engineering treatments such as protected bicycle lanes, buffered bicycle lanes, coloured conflict zone markings, and protected bicycle signal phases
Education and encouragement initiatives that will raise awareness among bicycle users, pedestrians, and motorists about how to safely share the road and improve the behaviour of those driving and cycling

2.5 Case Study: "Bicycle-related injuries: a local scene" (Hong Kong Journal of Emergency Medicine)

Based on Hong Kong Journal of Medicine - CP Ng, AYC Siu, & CH Chung (2001) conducted a study wherein they examined patients who experienced bicycle-related accidents and were admitted from the Accident and Emergency Department of North District Hospital. Since there is a large number of use of bicycles for leisure and other various reasons in Hong Kong, there also has been an increase in bicycle accidents. In the study, the researchers conducted a prospective survey for six (6) months in order to provide a profile of bicycle injury and other possible risk factors for severe injuries. The survey included information about the patient's' age, sex, place of accident, weather condition, purpose of cycling (work-related, transport, recreation, or sports), nature of accident (collision with a motor vehicle, other bicycles or a stationary object, fall from the bicycle or foot trapped in the wheel). They determined that they were 424 bicycle injuries, and most of the injuries were caused by fall from bicycle (276% or 65.2%), 24 (5.7%) were due to collision with motor vehicle, while the other 24 were caused by bicycle-bicycle collisions. Moreover, 43% or 10.2% were injured as passengers (e.g. feet were trapped by the wheels). And a sum of 160 patients (37.8%) had sustained head injuries (e.g. isolated injury/as part of multiple traumas).

3. METHODOLOGY

This research study employs both qualitative and quantitative research methods. It interviewed key informants or officials of local government agencies, specifically the Marikina Bikeways Office of Marikina City. This study utilized the observation method, particularly observed the areas where most pedestrian crashes were recorded by the Philippine National Police. This study also employ data on pedestrian crashes or vehicular accidents, land use, design and planning guidelines for bikeways, plans and programs regarding bikeways infrastructure, zoning ordinances, and victims' report from the Office of Public Safety and Security, the Planning Office, and the Philippine National Police (PNP). In addition, this study computed for the following data obtained from the assessment, survey and data collection: sample population and percent of bikeway infrastructure parameters. It will also use a geographic information system (GIS) to generate maps using statistical data and maps obtained from the data collection and the cyclability assessment.

To answer the research question, the researchers first identified the location of vehicular accidents related to bikeways and pedestrian crashes, with this the following are used: (1) data gathered from the Philippine National Police (PNP) on pedestrian crashes or vehicular accidents related to bikeways and other protective services; and (2) use of Geographic Information System (GIS) for spatial analysis to create maps and determine the pedestrian crashes location and patterns. Second, the researchers assess the current conditions and/or design of the bikeways in areas with records of vehicular accidents or pedestrian crashes. The researchers used the following: (1) Cyclability index survey by Clean Air Asia. The cyclability index survey provides the parameters in determining the cyclability of selected areas of Marikina city through assessing their bikeways infrastructures. (2) Document analysis on the design and guidelines for bikeways infrastructure of Marikina City given by the Marikina Bikeways Office and the Comprehensive Land Use Plan given by the Planning Office. (3) Document analysis on the air quality index to determine health hazards related to bikeways safety. (4). Survey questionnaire is utilized to determine motorists' behaviour and perception on bikeways safety.

Lastly, the researchers identified the bikeways safety issues using the road and transport system approach framework adapted from World Health Organization and recommendation of measures to improve bikeways safety of Marikina city, the researcher will use the system approach framework and the formulated conceptual framework to make a comparative analysis of the results of the data gathered based on the cyclability index survey, air quality, and survey questionnaire. This is done to recommend measures to improve bikeways safety of Marikina city.

3.1 Theoretical framework

This study used a system approach adopted by the World Health Organization (WHO) to analyse risk factor of road safety - The Road and transport system approach framework. The framework illustrates how road users, vehicles, and road and environment infrastructure are factors for mobility, road traffic crashes and other consequences of transport. It shows two effects, the desired and undesired output. The desired output focuses on the mobility, as to, work, school, leisure, shopping, and others. But mobility is also an area for safety concerns. The undesired outputs are road traffic crashes and other consequences of transport. Road traffic crashes have three factors: (1) human factors; (2) vehicle factors; and (3) road and environmental factors. The link between the outputs and the system is road safety. The framework was used by the researchers as a guiding principle including the three factors for the

factors of road safety. With this together with other related literatures, the researchers have formulated its own conceptual framework for bikeways road infrastructure safety.

3.2 Conceptual Framework

This conceptual framework formulated by the researchers shows the factors that have been identified for the bikers' safety in using the bikeways infrastructure. Some of the identified factors were based on the different studies that were used in the review of related literature.

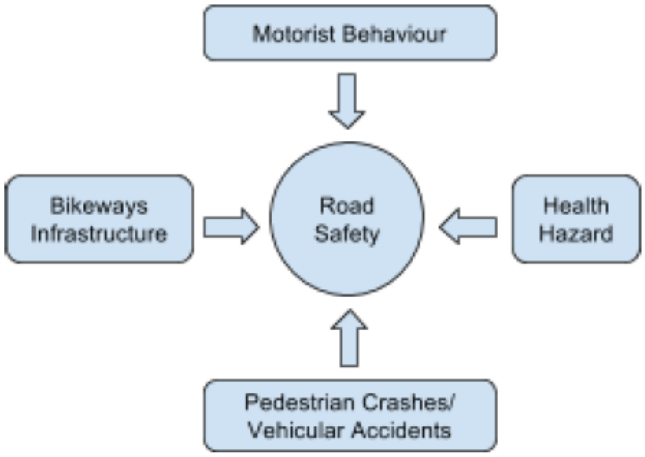


Figure 1. Conceptual Framework for Road Safety

The four factors and data needed to consider for road safety are health hazard, motorist behaviour, bikeways infrastructure, and vehicular or pedestrian crashes. Health hazard focuses on the effect of air pollution with the health of the bikers and examines if the level of pollution is still acceptable for cycling. Motorist behaviour looks at the perception of the residents and bikeways users on the safety, security, and usage of the bikeways infrastructure. On the other hand, bikeways infrastructure focuses on the design and structure of the infrastructure. And lastly, the vehicular or pedestrian crashes analysed at the areas wherein most accidents and pedestrian crashes usually occurs provides the base information for survey and analysis of the bikeway infrastructure safety.

3.3 Data Source and Research Instruments

The researchers chose three key informant interviewees. This is done to understand the role of bikeways, the infrastructure design and guidelines, the project and plans to further develop the infrastructure, vehicular accidents or pedestrian crashes and its relation to bikeways safety. The three informant interviewees are the head of the planning department, Marikina Bikeways Office, and the Chief of the Traffic Management Office. They are chosen to be the key informant interviewee of the research because of their expertise in planning and monitoring the bikeways infrastructure and facilities, as well as monitoring the safety of the users. Interviews were done in the Office of the Public Safety and Security, City Environmental Management Office, and Philippine National Police.

The respondents of the research are the residents of Marikina City. It uses random sampling, since bikeways are open to all the residents of Marikina. The researchers used the Slovin's formula in order to get the sample size for the research. The researchers have used the standard survey level of confidence that is 95% with a 5% margin of error to calculate the

sample size.

The research strategy employed in this proposal started through conceptualization. The researchers explored related studies and key issues of their current research interests. Upon reviewing literatures, the researchers looked at the gaps in knowledge and formulated questions through an empirical way. The unit and level of analysis were identified, research problem and questions were drafted and upon careful examination, a theoretical framework was chosen. Since the proposed study is basically positivist in orientation, the research design includes quantitative and qualitative methods and analysis and survey research. The research process for the proposal follows a linear form that includes identifying a theory followed by formulating a hypothesis, then establishing research objectives, and lastly, identifying the appropriate research method. Stretching the research process for the whole study includes observing, data collecting, sampling, analysing, coming up with findings and lastly, validating.

The analytical framework (Figure 2) below shows the flow of the entire process that the researchers have done in order to achieve its objectives and conclusion. First, the researchers gathered information on the topic of the study by looking at different related literature that have guided the research to the conduct of their study. Once the researchers have gathered enough information, the researchers were able to formulate survey questionnaires, identify key informant interviews, interview questions, and cyclability index survey for the assessment of the bikeway infrastructure.

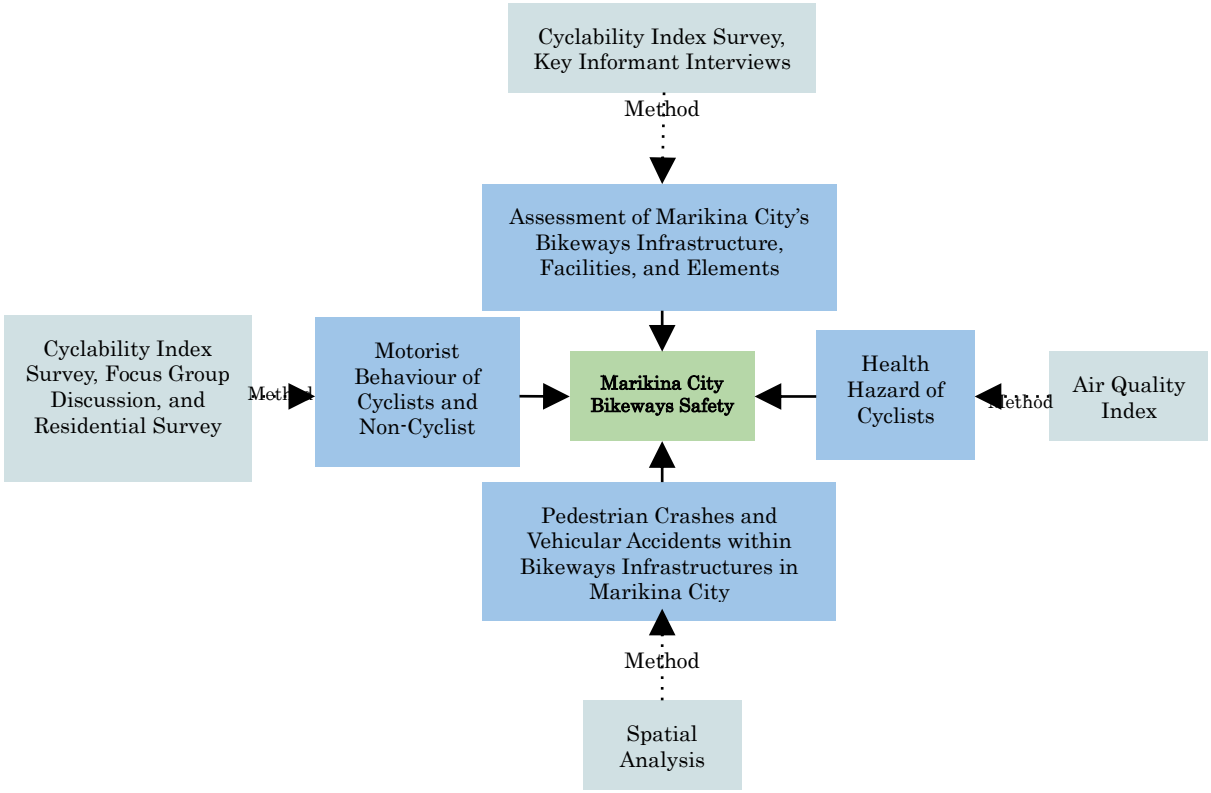


Figure 2. Analytical Framework

Based on the conceptual framework, Marikina City bikeways safety encompasses four elements which are: (1) an assessment of bikeways infrastructure, facilities, and elements; (2) health hazard of cyclist; (3) motorist behaviour of non-cyclist and cyclists; and lastly, (4) pedestrian crashes and vehicular accidents within bikeways infrastructure in Marikina City. These elements are determined through cyclability index survey, residential survey, key

informant interviews, focus group discussion, spatial analysis, and air quality index.

There are four (4) main steps in the data gathering process. First, the researchers identified the location of the pedestrian crashes or accidents relating to bikeways infrastructure and usage in Marikina City through data gathered from the PNP, and using GIS as a tool to create hotspots and points for the accidents. Second, the researchers assess the bikeways infrastructure through the cyclability index survey, a checklist that have 16 parameters that should be considered to conclude that the bikeways are syllable and safe. The researchers did two analyses on this part: (a) street wide analysis, the researcher analyse the findings and the ratings in roads where vehicular accident or pedestrian crashes have occurred through the use of GIS and data from PNP; and (b) the researchers used the cyclability index survey to determine the availability of the parameter in accident prone areas to determine the parameters that needed to be addressed. Third, the researchers also did a survey questionnaire for the motorist behaviour. This includes question for the residents' perception regarding the safeness and how effective are the bikeways in Marikina City. Lastly, the researchers gathered data regarding the air quality index of the city through interview and data gathering with the CEMO. Document analysis is done in this part. Determining the air quality index means analysing whether Marikina City and its bikeways infrastructures adheres to the standardized air quality.

4. RESULTS AND DISCUSSION

4.1 Location of pedestrian crashes involving bicycle users

Marikina city's traffic management chief (2016) said that accidents involving bikeways users are relatively small compared with other accidents. Furthermore, he said that these accidents mostly happen at intersections. The researchers looked at the police accident data given to the researcher from the PNP office. It includes the narrative and location of the most accidents actually happened at intersection. There are four (4) main offense done namely; (1) consummated physical injury; (2) consummated malicious mischief; (3) consummated robbery with violence against or intimidation of person; and (4) consummated theft. 73.9% of the total recorded pedestrian crashes are related to consummate physical injury (reckless imprudence resulting). Meaning that most of the accidents happened in the said areas have caused victims into some injuries but with no damage to vehicle or property. While only 15.2% of the total recorded pedestrian crashes are related to consummated malicious mischief (RIR to damage to property). This means that there are injuries as well as damages to property. Lastly, a small percent lies for robbery and theft regarding bicycle and or the usage of bicycle as means for robbery or theft. Though most of the accidents and crashes happened at intersections, there are other incidence at some location. And most of these accidents are near the periphery of the intersections. This can be said that the bikeways infrastructure in these area are not safe.

4.2 Assessment of the Bikeways Infrastructures

This section assesses the bikeways infrastructure of Marikina City by using the PNP data on the location of accidents to determine the areas for assessment. In order to further understand on why certain roads in Marikina City are pedestrian crashes/accident prone especially to cyclists, there is a need to assess the bikeways infrastructure. The researchers used the cyclability survey index, a tool that assesses the facilities of the bikeways on whether or not they promote safe cycling roads. It consists of 16 parameters, namely: (1) Conflict with other vehicles; (2) availability of cycle tracks; (3) Behaviour of motorists; (4) lighting; (5) quality of

riding surface; (6) crossing points; (7) availability of cycle parking; (8) shaded lanes; (9) exposure to air pollution; (10) traffic calming measures; (11) connectivity of street network; (12) Signboards and markings; (13) connectivity with other modes; (14) Presence of service shops; (15) Priority at junctions; (16) Perception of security. The researchers did not include in the survey parameters exposure to air pollution and perception of security. These two parameters were analysed through data analysis and survey questionnaire. Furthermore, the researchers, used a scale of 1 to 5, 1 being the most important infrastructure and 5 as the least important.

Table 1. Rating and scale of the assessment

Rate	Scale	Verbal Interpretation
5	4.50-5.49	Least Important
4	3.50-4.49	Somehow Important
3	2.50-3.49	Important
2	1.50-2.49	Very Important
1	1.0-1.49	Most Important

Table 1 shows the rating and scale of the assessment according to which is the most and least important infrastructure that is needed to be addressed. The rate of 1 means that it is the most important infrastructure that is not present in the current city bikeway infrastructure. Below is the summary of the parameters.

Table 2. Summary of the Parameters

Statement	Weighted Mean	Scale	Verbal Interpretation
Conflict with other vehicles	2.529	3	Important
Availability of Cycle Tracks	2.706	3	Important
Behaviour of motorists	3.294	3	Important
Lighting	2.176	2	Very Important
Quality of Riding surface	3.875	4	Somehow Important
Crossing points	1.625	2	Very Important
Availability of cycle parking	1.118	1	Most Important
Shaded lanes	1.588	2	Very Important
Traffic calming measures	1.000	1	Most Important
Connectivity of street network	3.529	4	Somehow Important
Sign boards and marking	1.765	2	Very Important
Connectivity with other modes	2.529	3	Important
Presence of service shops	1.471	2	Very Important
Priority at junctions	1.000	1	Most Important

The parameters above is determined by assessing the road infrastructure in the pedestrian crash prone areas. The researchers computed for the weighted average mean and analysed it through the scoring system. It can be said that the main concern and the reason for the pedestrian crash or the accident is that there is no traffic calming measure present in the infrastructure. Secondly, shaded lanes, lighting, crossing points, and signboards and markings are also significant concerns. The quality of riding surface and connectivity of street network are only somehow important and these parameters may need additional improvement. Significantly, the availability of the cycle parking is another vital infrastructure facility that is

lacking. It can be traced back from the PNP accident report that a number of offenses are committed from robbery and theft.

4.2.1 Conflict with other road users

According to the assessment of the bikeways infrastructure of Marikina city, bikeways are prone to crashes since 58.8% are in conflict with fast moving vehicles making difficult for cycling. It was observed that the presence of fast moving vehicles were evident mostly on major roads which can put cyclists into danger. While 29.4% of the total roads assessed have lesser extent of conflict due to slower vehicle speed since some of the roads have stop lights making the trip safer for cyclists (see figure 1). However, there is only a small percentage of 11.8% for low level of conflict with other non-motorized transport and slow moving vehicles. It was identified by the researchers that the chances of accidents that may lead to serious injuries still remain as hindrance to the safety of cyclists.

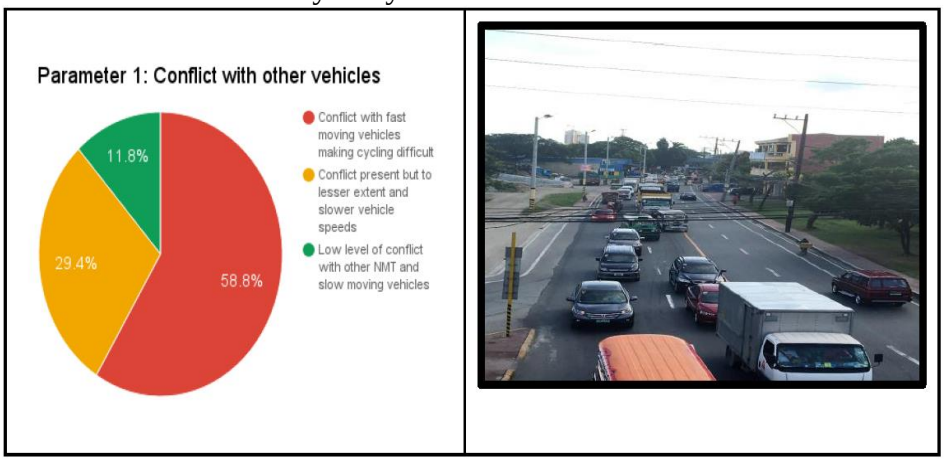


Figure 1. Conflict with other road vehicles

Furthermore, there is a 52.9% available cycle tracks, this tracks are available but with minimal or temporary obstructions such as cars parked along the bikeways. As one of the narratives of the incidents from the PNP report, pedestrian crashes that happen in bikeways are the presence of obstruction such as cars. In addition, the pedestrian crashes prone area also has 35.3% non-cycle cycle tracks. It can be said that unavailability or poor condition of the cycle tracks creates opportunities for pedestrian crashes or accidents.

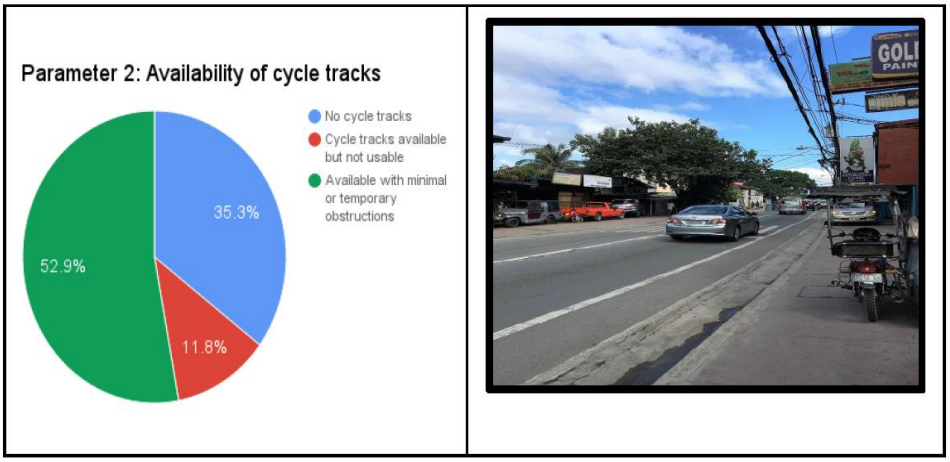


Figure 2. Availability of cycle tracks

Aside from the availability of the cycle track, a result of 52.9% said that motorists sometimes yield to cyclist. The design and non-division of the bikeways with the road makes it difficult for both cyclists and the motorized vehicles to control and maintain their speed, and attitude. Because of this, some motorist still uses the bikeways to avoid traffic congestion without thinking that the bikeways are lanes allocated for cyclist at any time. According to the Balara, QC bikers group, the problem with the motorists is that they don't obey traffic regulations mainly the designated lanes, this is whether or not the bikeways are narrow or wide.

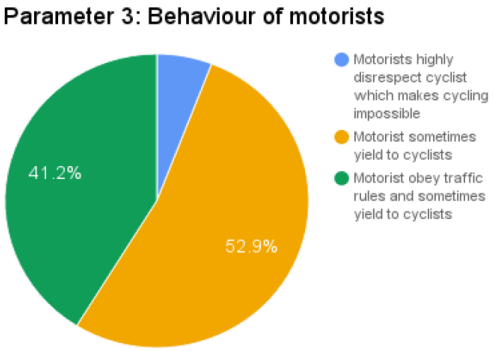


Figure 3. Behaviour of motorists

Lastly and the most important as computed by the average weighted mean, is the absence of traffic calming measures. Traffic calming measures reduce the speed of the motorized vehicles in order to prevent pedestrian crashes or vehicular accidents. The researchers observed and assessed that there are no traffic calming measures present in the area making it more difficult for road users to maintain their speed and to be conscious with the pedestrian.

Based on the results of the assessment according to the conflict with other road users, it can be said that traffic calming measures play an important role to control the behaviour of motorist towards the use of proper lanes and in reducing speed to prevent pedestrian crashes and vehicular accidents. Furthermore, the bikeways in Marikina city failed to include traffic calming measures resulting from the assessment that 100% of the bikeways in the pedestrian crashes prone areas have no traffic calming measures.

4.2.2 Visibility

Most of the bikeways have a sharing lighting with other vehicles or with street lights. Based on the assessment, 82.4% are said to have lighting but are in poor condition. Meaning that the lighting in a certain point or area in the road is not enough or that the streetlights are not working anymore. Lighting is very important in one's safety not only for cyclist but also for motorized vehicles. This is mainly used for visibility purposes of the bikers to avoid crashes during night. Based on the observation and assessment of the researchers, it can be said that lighting are limited and that some of the light post are not working, and in some the light from the streetlights may be working but because of obstructions (i.e. trees and shades) the light from the street lights becomes limited.

Lighting is a very important parameter as it gives visibility at night. On the other hand, shades are very useful parameters especially during daytime. For cyclists, shades make cycling more comfortable and less tiring. The assessment shows that 52.9% of the bikeways are exposed to the sun and there are no shades that can serve as protection for cyclist.

Based on the assessment, visibility is an important factor in the bikeways facilities. Since bicycles do not have powerful lights, street lights and shades are important for they do not

only provide visibility for the other road user, but more importantly they provide visibility and security for cyclists. The bikeways of Marikina City generally have poor visibility that makes cycling prone to pedestrian crashes.

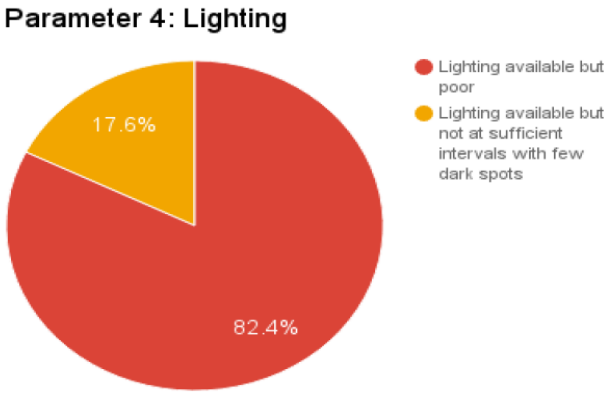


Figure 4. Lighting

4.2.3 Intersections

According to the Philippine National Police (PNP) report, most of the accidents happened at intersections. In relation with conflict with other road users, these accidents may have happened because the roads have limited or no traffic calming measures present. Another reason is the poor visibility of the cyclists during day and night. In order to assess the safety of the bikeways at intersection, there are three main facilities or elements needed to be observed: (1) crossing points or specific area for crossing of the cyclist (i.e. crossing lanes); (2) signboards and markings; and lastly (3) traffic signals.

First is crossing points. Marikina city's traffic management chief said that the cyclists are expected to follow the traffic lights and regulations as motorized vehicles are. Based on the PNP accident report, intersection is the area in which most accidents happen but it is not clear on the reason of how these accidents have happened. According to the Clean Air Asia (2013), "Crossing points should be wide enough to accommodate many cyclists and keep them safe at the medians." This means that there should be a designated lane for cyclist for crossing points. 75% of the roads do not have a crossing or median for the cyclist. While some of the roads 12.5% have crossing points but are not well defined and the median width is too small to accommodate cyclists.

Second are signboards and markings. Signboards and markings are defined by Clean Air Asia as "Road sign boards and pavement marking help road users to clearly delineate the cycling paths or tracks and provide information to all". According to the Marikina Bikeways Guidebook (2008), there are three functions of signboards, (1) determine and regulate the facilities in the road; (2) warning signage's for potential hazards in the road; (3) assist the road users in finding their way around the roads and street network. In addition with the guidelines, it is said that the signages should follow the international regulations such as the design and size. As observed by the researchers, there are signboards and markings but are in very poor condition. Some are even erased already due to the usage and depletion of the material (Figure 18). In addition, the presence of the sign boards can only be seen mostly on major roads. According to the assessment, 64.7% of the roads have signboards and markings but are not sufficient. Based on the Marikina bikeways guidelines, the signboards and markings complies with it in terms of the size and design but it can really be seen that these facilities due to the poor maintenance are not in good quality anymore. In contrast with DPWH road safety manual (2012) that signboards and markings should use Filipino language rather than the international

standards. The use of Filipino language signboards and markings may help all the people especially the people who have poor knowledge on the English language.

Lastly, traffic signals. This facility or element is very important for bikeways infrastructure. This gives priority for cyclists at junctions since they are given their own traffic signals. Based on the assessment, 100% of the roads have no separated signals for the cyclists. Instead they have a sharing system of signals with the motorized vehicles, placing them at a situation of high possibility of crash.

Based on the assessment, observations, and interviews, the three facilities and elements are very important in the safety and effectiveness of the bikeways in Marikina City. The unavailability of one of these facilities may result in accidents. Specifically, crossing points provide the cyclists a sense of security for their crossing time. And for a given place (i.e. areas in which there is a present traffic signals - Sumulong Highway) there may be a clustering of cyclists at some time, and the absence crossing lanes and priority, cyclists will find their own way to cross the lanes together with fast moving motorized vehicles. Thus, the absence of crossing points promotes accidents. Consequently, bicycle signboards and markings provide good vision for cyclists and motor vehicle users. The assessment shows that there are present signboards and markings but are not properly placed and maintained.

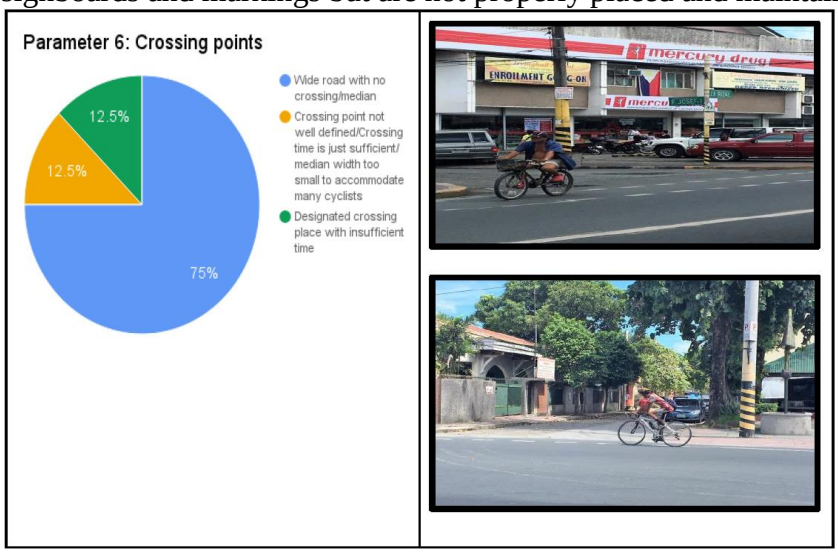


Figure 5. Crossing Points

4.2.4 Quality of riding surface

Clean Air Asia (2013) states that “Quality of riding surface directly impacts the quality and comfort of the ride. Ideally asphalt or concrete surface are more suitable than tile as they do not have frequent joints and undulations. The surface should be free from cracks, gaps, undulations”. Based on the assessment, 87.5% of the bike lanes are in good condition but are slightly uneven with few cracks and ruts. While only 12.5% of the bike lanes have large cracks and significant pothole making the ride bumpy. Based on the assessment, this concern can make cycle trips uncomfortable and more difficult to bicycle users which can also result to minor accidents such as having scratches (cyclists to be out of balance).

It is important for the cyclists to be provided with a smooth surface during their trip so that they are free from any unconstrained or slippery materials since bicycles are easily deflected even by small deformities. Also, during at night it would be hard for the cyclists to see the cracks so it is important that the cycle paths are properly maintained to avoid such threats. And since bicycle users are vulnerable, slippery surfaces can cause them bad crashes and

injuries.

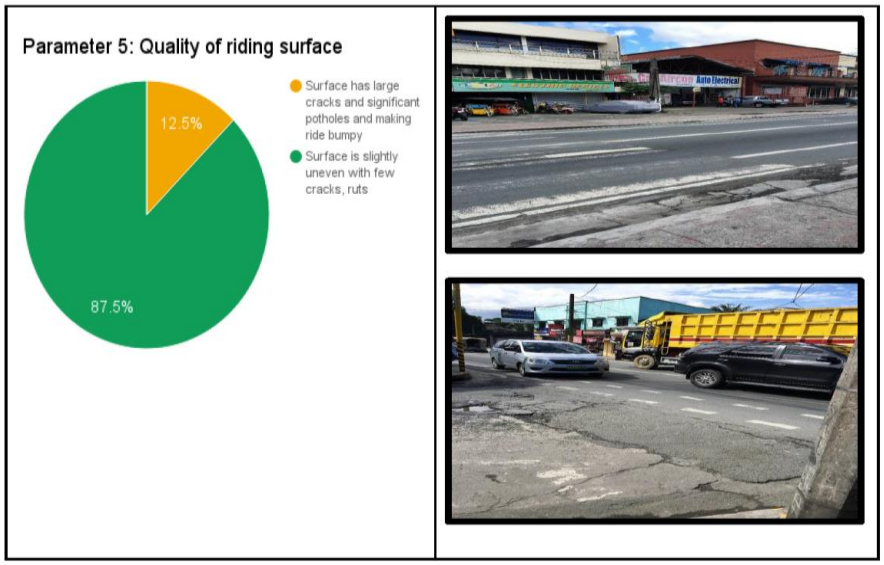


Figure 6. Quality of riding surface

4.2.5 Transportation and street network

Transportation and street network are very much related with each other especially when it comes to cycling. Just like any private motorized vehicles, the safety of its property and the easy access of other modes of transportation is very much needed. According to Marikina Bikeways Office head, Engr. Rommel Felipe one of the upcoming plans of the Marikina Bikeways Office is to establish an area in public transportation terminal (i.e. LRTA and jeepney terminal) wherein the cyclists have the assurance of the safety of their bicycles and that this facility shall include a shower room for the cyclists. Coming from the head of MBPO, one thing that discourages some employed individuals are the lack of assurance of safety of the bicycles and that the comfort after cycling is an important factor. With this it can be said that in order to have an effective transportation and street network, the following should be considered: (1) safeness of the bicycles at bicycle parking or the availability of bicycle parking; (2) location of the bicycle parking; and lastly (3) how these bicycle parking are present in areas with other modes of transportation.

Most of the parking or racks provided by the City of Marikina for bicycle users either do not have locks or cover. Based on the assessment, about 88.2% do not have secure parking while 11.8% have available parking but are in poor condition. It is important that there must be sufficient cycle parking for bicycle users because this does not only encourage bike users but also those non-users to use bike as an alternative mode of transportation. It is essential that there is a convenient and secure location near them so that they can automatically use their bicycles for any local journeys to shops and/or other amenities.

Moreover, there must also be a sufficient space for people and/or residents in order for them to approach and leave the cycle parking easily if there are instances that they want to access public transportation. Based on the assessment regarding the connection of bikeways to other modes especially to public transport, 64.7% of connectivity and access to other modes are manageable but difficult. However, 23.5% of connectivity and access to other modes remains difficult while 11.8% have no connectivity with other modes. It was perceived that the access to public transport in Marikina is sufficient but what makes it hard for cyclists is the lack of parking racks. They cannot leave their bicycles safely in order to ride public transport that discourages cyclists to use bicycles.

Furthermore, some bicycle users do not like to cycle in areas where there is traffic so they tend to bike only on the local streets and/or routes in which they are familiar with. Based on the assessment, the highest point is 76.5% wherein the connectivity of street network is present but can be better. While 11.8% has very poor connectivity or unusable connection because some of the streets are very far from places such as the main road, school, mall, and offices. It was also notable that a small percentage proceeds to no connectivity of streets and poor connectivity. It was perceived by the researchers that the connectivity of street network in Marikina City is useful for bicycle users and they can have an easy and shorter trip.

These parameters are important to be considered because an enticing, inclusive cycle network, and a better quality of cycle parking can be a way of encouraging people to shift into non-motorized transport and/or use bicycles and people would not need to buy a car.

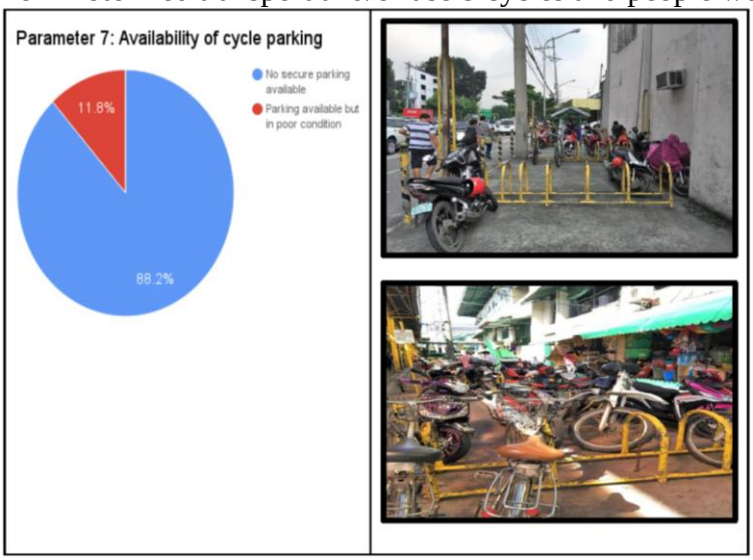


Figure 7. Availability of cycle parking

4.2.6 Presence of service shops

Presence of service shops in Marikina is insufficient. Based on the assessment, no service shops are available and this comprises 58.8% of the respondents agreeing with this. While very few service shops are available and not open at all-time and this comprise 35.3% of the respondents agreeing with this. A small percentage of service shops are few and far apart. It can be said that if there are any instances that a bicycle owner will need some help in his/her bicycle, he/she might have hard time to look for service shops in the city.

Presence of service shops and/or local bike shops are important in order for cyclists to maintain and repair their bicycles if needed. In this way, the exposure of bicycle users to such accident will be lessen because bicycle users are able to track and take care of their bicycles. Also, for those who use their bicycles often, cyclists would seek for high-quality materials for their bicycles and look for trained bicycle mechanics. Construction of many bike shops in the city can help to grow the number of people cycling.

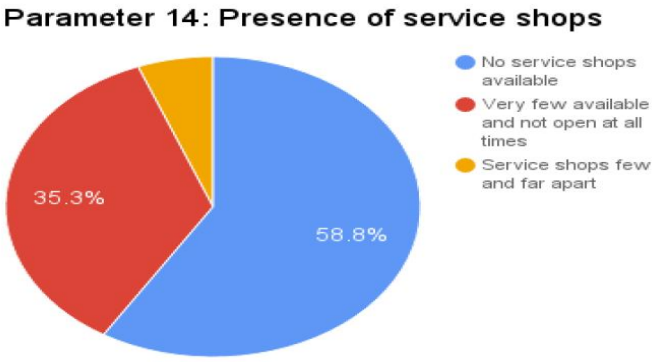


Figure 24. Presence of service shops

4.3 Air quality of Marikina City and its effect on health hazard

Health hazard are measured by Air Quality Index (AQI). According to Environmental Protection Agency (EPA), "The AQI is an index for reporting daily air quality. It tells you how clean or unhealthy your air is, and what associated health effects might be a concern. The AQI focuses on health affects you may experience within a few hours or days after breathing unhealthy air. The AQI is calculated for four major air pollutants regulated by the Clean Air Act: ground level ozone, particle pollution, carbon monoxide, and sulfur dioxide. For each of these pollutants, EPA has established national air quality standards to protect public health."

According to Clean Air Asia (2013), exposure to air pollution have different health effects. High level of pollution is expressed in Parameter 9: Exposure to air pollution description which states that "High levels of pollution can be a factor on the reason why cyclists are discourage to cycle, since cyclists are exposed to pollutants. Cyclists tend to inhale at a higher rate than motorists or pedestrians".

According to the cyclability survey index, exposure to air pollution is categorized as: (1) very high levels of exposure to pollution making cycling risky; (2) significant levels of pollution exposure; (3) not significant but still high exposure to pollution; (4) low levels of pollution only at certain times; (5) no pollution and air is clean making cycling a pleasure. The researchers used data from the CEMO for the AQI instead of conducting an air quality monitoring per location of accident as to apply for cyclability survey index.

AQI is a standardized value that determines whether the air content is good, moderate, and unhealthy for sensitive groups, unhealthy, very unhealthy, and hazardous. The higher the AQI value, the greater level of air pollution is present, therefore the greater the health hazard or concern. An AQI value of 0-50 is considered as satisfactory and the air pollution poses little to no risk. While an AQI with 300+ value is considered hazardous and have a health alert meaning that the surrounding may experience a serious health effects. According to EPA, an AQI value of 0 to 100 are considered as the air quality standard for the pollutant to protect public health. This study analyses the data gathered from the CEMO through interpreting the AQI values in the past years. The data consist of figures and tables of AQI values for Particulate Matter (PM10) and Total suspended particulates (TSP) in Marikina City as well as AQI value of the entire city for 8:00 AM, 12:00 NN, and 5:00 PM. Below is table 3 that shows PM10 concentration for 24-hour averaging time in ng/Ncm in Marikina City.

Table 3. PM10 Concentration in Marikina City

Year	PM10 (ng/Ncm)	Source
2011	69	EMB-NCR
2012	74	EMB-NCR
2013	61	EMB-NCR
2014	47	EMB-NCR
2015	67	EMB-NCR

According to the Air Quality standards of the Philippines, PM10 National Ambient Air Quality Guideline Value: for 1 year averaging id 60mg/Nm^3). Therefore, table 4 shows the Air pollution index and its equivalent concentration range in ng/Ncm for PM10.

Table 4. Air Pollution Index Concentration Range in ng/Ncm

Air Pollution Index	Concentration Range in ng/Ncm
Good	0 - 54
Fair	55 - 154
Unhealthy	155 - 254
Very Unhealthy	255 - 354
Acutely Unhealthy	355 - 454

From the tables 3 and 4, it can be said that Marikina City in terms with PM10 have a fair air quality from years 2011 to 2015, making it safe for cyclist. Another pollutant, TSP, was examined.

TSP is also determined in Marikina City from the years 2009 to 2015, generally it ranges from 89 - 128. This means that TSP is under a Fair air pollution index, giving fair air quality for cyclists. To further analyse the air quality of Marikina, the CEMO also provided the researchers data about the AQI of the entire city from time hours of 8:00 AM, 12:00 NN, and 5:00 PM. Below are the details of the AQI value range in the Philippines.

Table 5. Air quality for PM10

Time	Air Quality Index (AQI)
8:00 AM	Moderate
12:00 NN	Moderate
5:00 PM	Good

Table 5 shows the air quality in Marikina throughout the day ranges from good to moderate, meaning that the air pollution in the city is not harmful, giving the cyclist a good air quality conditions.

4.4 Motorist behaviour and their perception of safety

Motorist behaviour is one of the factors that affects the perception of safety of pedestrians. According to Evans (2014), traffic safety and the way vehicles are driven are the base parameter for determining the safety of the road. In order to understand the perception of safety of pedestrians and cyclists, the researchers conducted a survey with 400 respondents in pedestrian crashes prone areas (based on the hotspots analysis). Among the respondents, 51.54% answered that they are using bicycles as a means of transportation. 65% of the total cyclist respondents were males. It reflects that males are more active in cycling than females. No further reason was accumulated from the respondents why women are not involving fully

involved in cycling. Moreover, cyclist respondents are mostly students which are about 52.1%, and only 32.5% are working/employee - bicycle users. In addition, 29% of the respondents are at the age group of 14-19 years old. This strengthens that most of the bicycle users are students which means that may have used cycling as a means of transportation to school, entertainment or leisure, recreation or for doing errand work.

Based on the survey most of the cyclists are students but only 23% show that bicycles are used as a transportation going to school. 32.8% of the cyclist respondents ranging from 10 to 24 years old use bicycles for leisure or entertainment.

Based on the survey, most of the cyclists use bicycle as an entertainment. According to the respondents, cycling is used as an exercise and for quality time with friends and family. As for the biker groups, cycling for them is a method that encourages people to use non-motorized vehicles (bicycles) as a means of transportation for it is more sustainable and it helps in lessening air pollution. Generally, cycling is deemed to have provided health benefits. The survey results show that cycling for most people is used for leisure. But a growing number of cyclist (i.e. bikers group) relates cycling to sustainable transportation.

Furthermore, the following data strengthens the finding that cycling is mostly used for entertainment or leisure. As such, the survey result shows that the travel time include 40.7% of bicycle users travelling to their destinations within a 15-30 minute time frame. It is assumed that only in a certain area or park that these cyclists namely, students and individuals ranging from 10-24 years old use bicycles. But 27.8% of bicycle users show that about 30-60 minutes are utilized as their travel time to their destinations. It can be assumed that these individuals may have use cycling in to go to places outside the city. Moreover, 16.2% of bicycle users show that less than 15 minutes are utilized as their travel time to their destinations and about 7.9% of bicycle users show that less than 90 minutes are utilized as their travel time to their destinations. The following assumptions are based on the respondent's own experience and the biker's group knowledge.

Aside from the travel time, the frequency of the cycling includes 29.1% of bicycle users stating that they use bicycles from Monday to Friday while 27% of bicycle users said that they use bicycles from Saturday and Sunday. Moreover, 19.6% of bicycle users said that they use bicycles only sometimes or not every week and about 13.5% of bicycle users said that they use bicycles sometimes on Saturday and Sunday. Around 10.9% of bicycle users said that they use bicycles sometimes from Monday to Sunday. It can be seen that cycling in Marikina City does not have a permanent cycling pattern. Cycling is generally done for leisure, as a means of transportation for students and workers and in doing errands.

The previous paragraphs show the profile of the cyclists. 48.45% of the total respondents said that they do not use bicycle as a mode of transportation. Around 31.3% of these individuals still prefer to use and/or buy motorcycles because of their high performance compared to bicycles. Moreover, 29.1% own private vehicles which can be one of the reasons why they lose interest in using bicycles. Consequently, about 26.9% of non-bike users still ride jeepneys as these are considered as one of the fast modes of and low-cost transportations. Other results obtained from the survey include a small portion of non-bikers stating that they prefer walking, riding tricycles, and PUJs.

The reasons that discourages biking in Marikina City despite the existence of the city's bikeways. The concerns of the respondents that do not use bicycles have four general reasons: (1) bicycle is an accident prone transportation due to bad conditions of road infrastructures; (2) non-cyclists do not have enough knowledge on how to use bicycle; (3) there is no enough bicycles to be used; and lastly (4) the environment namely the quality of air, undisciplined motorist behaviour, and road infrastructure are not good.

The respondents said that bicycle is an accident prone transportation and that there is

always a possibility of having an accident. Bicycles alone do not cause accidents but also low-quality or bad condition of the road infrastructure. With this it can be said that the main issue and concern of the respondents is that the road infrastructure is inefficient since it promotes accidents and almost all respondents are discouraged from using bicycle as a mode of transportation. Another reason that were raised by the bikers groups is that "Jeepneys do not use jeepney lanes…. Bike lanes are of low quality since they have narrow width." The inefficiency of the facilities of the bikeways, especially in addressing the safety of the users is a major concern among bikers. Generally, the construction of the bikeways is limited to the idea of promoting biking but lacks on ensuring the safety of the users. With this a huge population is still inclined with using other modes of transportation such as Jeepneys, private vehicles, etc.

By contrast with the non-bikers, the bikers have a more positive idea of cycling. The reasons that encourages biking in Marikina City with the existence of the city's bikeways. The reasons of the respondents that use bicycles have four general reasons: (1) cycling has health benefits; (2) cycling is an alternative mode of transportation that is fast, it avoids traffic, and is cost saving; (3) the environment also benefits from cycling (i.e. less pollution); and lastly (4) cycling is a good venue or activity for recreational activities with family and friends. Half of the respondents have a negative view on the use of bicycle. As stated above, cycling is deemed as accident prone and that the bikeways are insufficient and not safe. But for cyclist they have viewed the bikeways and cycling itself as a positive attitude towards a more liveable and sustainable city. According to some of the respondents and the biker groups, the presence of the bikeways encourages the community to use cycling as a mode of transportation. But they also have stated that there are also some concerning issue that are needed to be addressed.

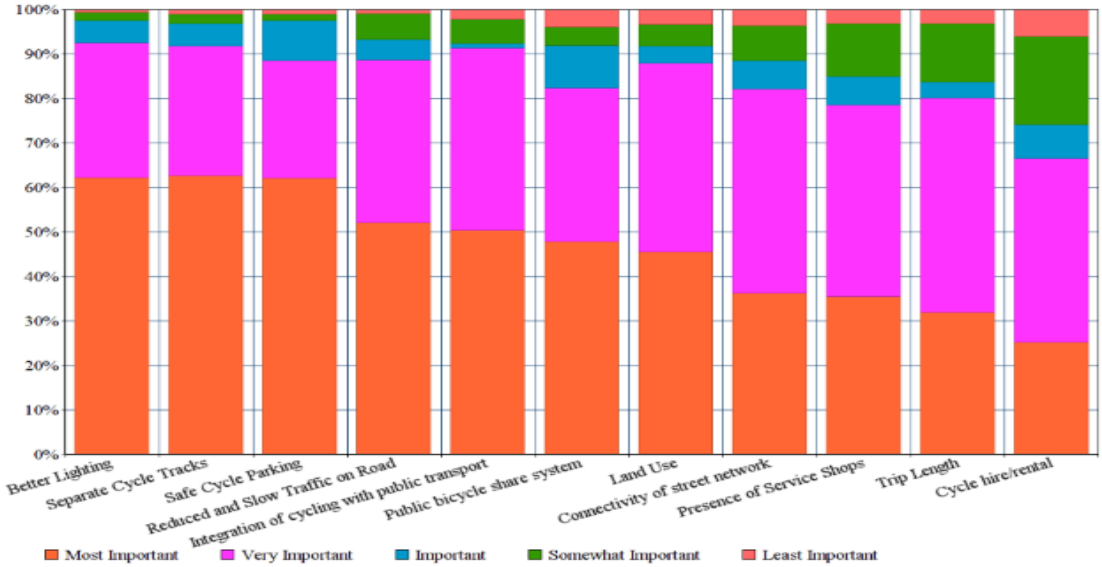


Figure 3. Parameters adopted from the study of Cyclability Index by Clean Air Asia

The researchers have asked both the cyclist and non-cyclist to rate the following facilities, elements and methods based on what is the most important to least important. Figure 3 above shows the respondents view on the facilities, elements and methods that may be present or lacking in the city's bikeways infrastructure. This is done to know what are the facilities, elements, and methods that the respondents wanted to be improved or added in the existing bikeways infrastructure. As can be seen in the diagram, there are top three elements that the respondents said are most important and these are: (1) better lighting; (2) separate cycle tracks; and (3) safe cycle parking.

Table 6. Rating system

Parameters	Scale	Rate	Verbal Interpretation
Separate cycle tracks	1.495	1	Most Important
Public bicycle share system	1.815	2	Very Important
Safe cycle parking	1.528	2	Very Important
Better lighting	1.483	1	Most Important
Reduced and slow traffic on road	1.668	2	Very Important
Cycle hire/rental	2.401	2	Very Important
Presence of service shops	2.042	2	Very Important
Connectivity of street network	1.965	2	Very Important
Trip length	2.074	2	Very Important
Land use	1.779	2	Very Important
Integration of cycling with public transport	1.678	2	Very Important

As shown in table 6, in comparison with the rating system, the most important element, facility, and method are better lighting and separate cycle tracks. This can mean that the available cycle tracks provided by Marikina city are insufficient and they can somehow discourage people on using the bikeways since they have a narrow width. Also, they give importance to the visibility of the cyclist through better lighting. Most of the respondents described better lighting as "Better lightning at night so it will be easier to bike and to see the road clearly. It will be safer." For cyclists, they rate each parameter according to what they think are needed to have a more efficient bikeway. As for the non-cyclist, they have rated the parameters according to what they think are needed for them to engage in cycling. Consequently, the two parameters that are very important and are also the needed facility for improvement are availability of cycle tracks and lighting. Both will give good visibility and safer use of bikeways with other road users.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Summary of findings

This research study about the bikeways safety of Marikina city has three objectives: (1) identification of the location of vehicular accidents related to bikeways and pedestrian crashes; (2) assessment of the current conditions and/or design of the bikeways in areas with records of vehicular accidents or pedestrian crashes; and (3) an analysis of the bikeways safety issues using the road and transport system approach framework adapted from the World Health Organization and recommendation of measures to improve bikeways safety of Marikina City.

To answer the study's first objective, the researchers were able to identify the location of vehicular accidents related to bikeways and pedestrian crashes. According to the reports gathered from PNP Marikina, the researchers were able to point out where accidents occurred in the city as well as the likelihood of their occurrence. The researchers, then, created a hotspot map to illustrate the points of accidents. The hotspot map helped in plotting the areas that needs to be assessed. The accidents were observed to be found at these areas: Calumpang, San Roque, Santa Elena, Tanong, Santo Nino, Malanday, Concepcion Uno, Marikina Heights, Parang, and Nangka.

To answer the second objective, the researchers assessed the current conditions and/or

design of the bikeways in areas with records of vehicular accidents or pedestrian crashes through the cyclability survey index by Clean Air Asia (2013). There are sixteen (16) parameters considered in the Cyclability Index Survey. The rating system for each parameter is 1-5, with 1 being the most important facility that is needed to be addressed. With this tool, the researchers were able to evaluate/rate and identify parts of the existing bikeways infrastructure that needs to be altered and/or improved.

The researchers computed for the weighted average mean and analysed it through the scoring system. From the results, there are three (3) parameters that are the most important facilities that are needed to be addressed. These are availability of cycle parking, traffic calming measures, and priority at junctions. These three parameters are clearly shown through the PNP report. They state that most of the offenses done to the cyclist are physical injury due to fast moving vehicles, low visibility, or the presence of obstructions. Furthermore, one of the offenses that was also committed is robbery/theft of the bicycles. Therefore, availability of cycle parking is clearly important to secure one's belonging. Traffic calming measures and priority at junctions are equally important to secure one's safety. Aside from these, numerous facilities are also needed to be addressed such as shaded lanes and lighting to improve visibility; and crossing points, signboards and markings to alert other road users of the right usage of the lanes.

In addition, the researchers, through data analysis, have found that the air quality of Marikina city varies from good to moderate. It reflects that its air quality is not detrimental to the health of the city.

To answer the third objective, the researchers were able to identify and analysed the bikeways safety issues using the road and transport system approach framework adapted from World Health Organization and they provided recommendations on how to improve bikeways safety of Marikina city. The main research methods utilized by the researchers to obtain results for objective 3 were: (1) cyclability survey index which was used to identify the issues of the bikeways infrastructure; (2) data analysis on the air quality of Marikina City; and lastly (3) survey questionnaires. The survey questionnaires serves as the tool to identify the perception of safety of the city and the motorist behaviour on their choice on choosing to cycle or not.

In terms of the respondents of the survey, the ratio of cyclist and non-cyclist respondents is 1 is to 1 or 50% if the respondents are cyclists and the other 50% are non-cyclists. The reasons why non-cyclists do not engage in cycling are the following: first, cycling activity is accident prone; second, non-cyclists do not know how use bicycles; third, non-cyclists respondents claim that there is no enough bicycle available for the public; and lastly, non-cyclists stated that the quality of the bikeways in Marikina city are not in good condition. On the contrary, cyclists provided the positive effects of cycling which include the following: cycling activity can have health benefits; cycling activity is good for the environment (it creates less pollution); cycling is a fast source of transportation; and cycling is a good recreational activity for family and friends. Overall, the perception of cyclists and non-cyclists varies. Nonetheless, both respondents agree or have identified the necessary facility, elements, and methods that are needed to be improved or implemented so that the bikeways will be more efficient and safe. On top of those necessities are the creation of separate cycle tracks and the use better lighting.

5.2 Conclusion

Based on the assessment, the current condition and design of the bikeways in Marikina city both have positive and negative results. On health hazard, the air quality of Marikina city is

rated from good to moderate. On bikeways infrastructure: (1) Cyclability survey index showed that the bikeways of Marikina City are not safe for cyclists, (2) there are three important parameters were identified in relation to the safety of the bikeways: availability of cycle parking, traffic calming measures, and priority at junctions, (3) separate cycle tracks and better lighting are the main concerns for both cyclist and non-cyclists

On motorist behaviour the perceptions of road users on cycling are: (1)cycling activity is accident prone, (2) motorists and other vehicle users often use the bike lanes, (3) non-cyclists do not know how use bicycles, (4) non-cyclists respondents claim that there is no enough bicycle available for the public, (5) non-cyclists stated that the quality of the bikeways in Marikina city are not in good condition, (6), cyclists are not discouraged to do cycling despite the poor quality of the bikeways rather they tend to look at the benefits of cycling (i.e. health benefits, recreation)

The conceptual framework on bikeways safety include three factors: health hazard, motorist behaviour, and bikeways infrastructure. These three factors must always be present to ensure bikeways safety. The absence of one factor can make the roads unsafe for cyclists. The researchers analysed that a city's good air quality alone cannot determine bikeways safety. The lack of efficient bikeways infrastructure causing accidents and other offenses to cyclists by motorists and other vehicle users is also critical in ensuring bikeways safety.

On a similar manner, the presence of an efficient bikeways infrastructure that may cause a more disciplined behaviour among motorists and other vehicle users towards the proper use of lanes alone cannot totally ensure bikeways safety. A city's low air quality can discourage or prohibit cyclists to do cycling and this may affect their perception on the health benefits of cycling and may eventually discourage them from cycling.

Marikina city thrives to be a "Pedestrian and Bicycle-Friendly City". While this image advances advocacies on becoming a green city or on promoting sustainable, alternative modes of transportation, this research study assessed that the city still lacks necessary design and facility to ensure bikeways safety and the proper implementation of the rules and regulations of roads and bikeways facilities. These obstacles result to the discouragement of bicycle use by many residents, workers, and students.

5.3 Recommendations

Based on the study conducted, the researchers were able to identify facilities and elements that are needed to be addressed to ensure bikeways safety. These are determined through looking at the parameters from the cyclability index survey, survey questionnaires, observations, and interviews. The key materials that was used to improve the safety of the bikeways infrastructure was gathered from the National Association of City Transportation Officials' (NACTO) Urban Street Design Guide, the association that create manuals and workshops about street design and transportation, Department of Public Works and Highways road safety design manual (2012), and the Marikina Bikeways Guidebook (2008). Also, the researchers used Sketch Up for 3D modelling and Google Earth for maps and images. The following are the recommended measures: (1) lane development by redesigning the existing lane width, adding control speed elements, and designate jeepney lanes, (2) improve visibility by improving the lighting and shades as well as the signboards and markings, (3) addition of intersection elements such as raise intersections or midblock crosswalks, bike boxes (for intersection with traffic lights), and traffic signals for cyclist.

5.3.1 Lane Development

According to the assessment of the bikeways infrastructure of Marikina city, bikeways

are prone to crashes since 58.8% of the respondents said that cyclists are in conflict with fast moving vehicles making it difficult for cycling even with 52.9% observed that there are available cycle tracks. These tracks are available but with minimal or temporary obstructions such as cars parked along the bikeways. As one of the narratives of the incidents from the PNP report, obstruction such as cars caused most of the crashes and they happened in bikeways. Aside from the limited cycle tracks, 52.9% respondents said that motorists sometimes yield to cyclist. Though the motorist behaviour yield to cyclist, the design and non-division of the bikeways with the main road made these difficult for both cyclists and the motorized vehicle users to control and maintain their speed and attitude. In addition to the behaviour and the bikeways infrastructure, the researchers also observed that there are no traffic calming measures present in the areas making it more difficult for road users to maintain their speed and to be conscious with the pedestrian. With this, the following facilities and elements were identified to address the conflict with other vehicles, the availability of cycle tracks, the behaviour of motorist, and the need for traffic calming measures:

Lane Width

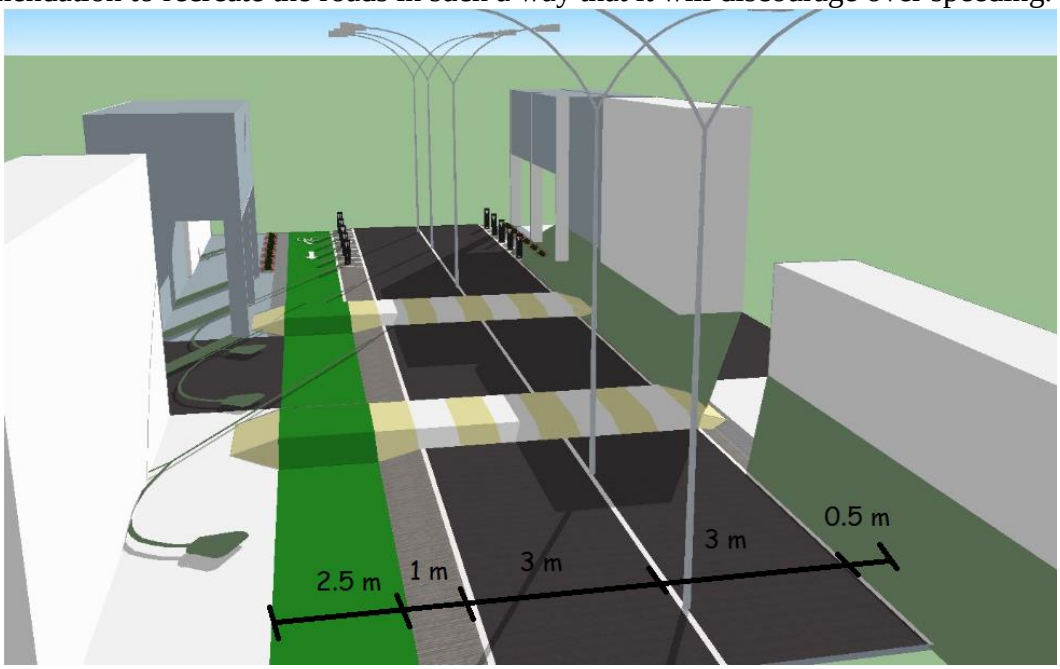
Marikina roads have a lane width of 10 meters in total. It includes bike lanes and 'one-lane two-way vehicular lanes'. In the DPWH road safety design manual (2012), there are main points to consider in planning a city or municipal roads, the following are some of it:

- The road width can be varied to provide for parking or to give emphasis to crossing points depending upon traffic flows;
- Non-motorized traffic is of equal importance to motor traffic and separate route should be provided if possible;
- Where non – motorized traffic needs to use a local distributor it should be separated from motorized traffic;
- Carriageway width can be reduced to emphasize pedestrian priority

In addition, the width of the lanes in Marikina city varies from 3.0m to 3.5m depending on the traffic volume of the roads. With this the Marikina is a compliant with the road lane width of the DPWH standards.

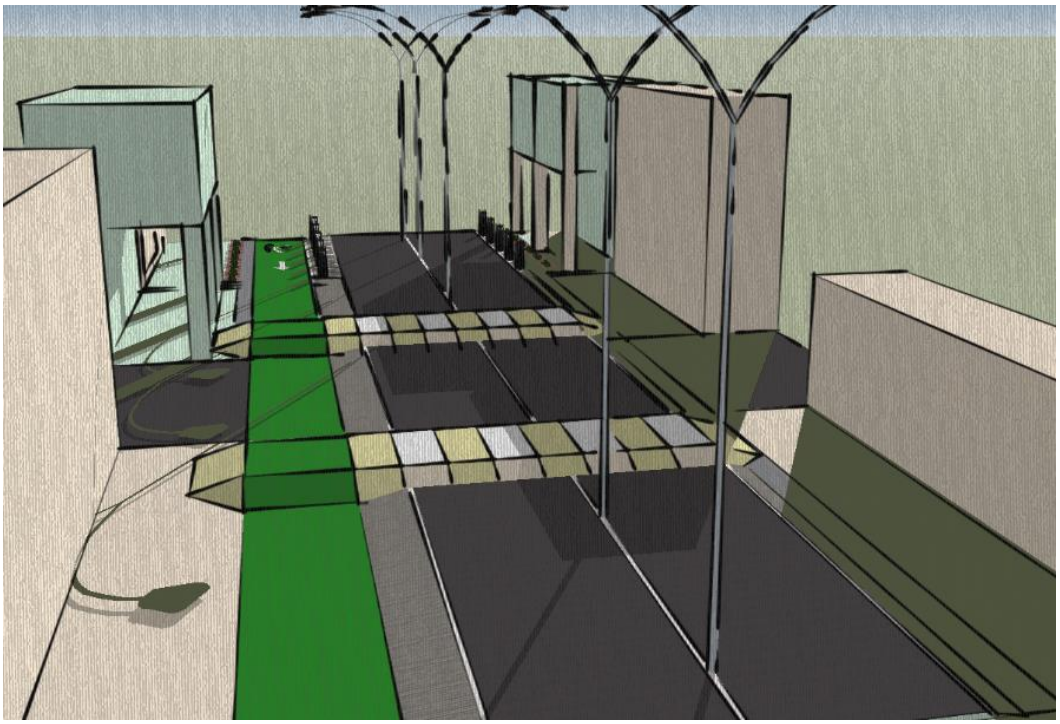
Existing Road Width Dimension

Though Marikina City is a compliant in most of the standards in DPWH road safety manual, when it comes to the allocation of road width for bikeways, Marikina City used the London Cycle Network Design Manual (1998) as a guide in constructing the Marikina Bikeways. Since the Marikina City adopted an International design manual for the construction, the researchers also recommend the use of an international guidebook, NACTO that will enhance the safety of the road users of Marikina City. According to the NACTO Urban Street Design Guideline, the width of a single lane to generally say that it is safe and to discourage speeding must be 3m. With the given guideline, the researchers come-up with the recommendation to recreate the roads in such a way that it will discourage over speeding.



Recommended width dimensions

The figure above shows the width dimensions as recommended by the researchers. Instead of providing the bikers a lane for the both sides, there will only be one lane for the bikers. But the additional buffer of 1 meter from the bikeway and the lanes for the vehicle will prohibit the other vehicles to use the bikeways. In addition, the buffer will also be a 'protected lane' to ensure that other vehicles will not use the lane. Also, the lanes will have to be re-paved and should have a different color with the other roads so that it will be visible enough during daylight and night. It will also have lane markings.



Recommended vertical speed control elements/traffic calming measures

Vertical Speed Control Elements

As indicated above, one of the main concerns of bikeways safety is the speed of the vehicles. In order to discourage speeding, vertical speed control elements or traffic calming measures should be also placed.

Existing roads in Marikina

The picture shows the existing Marikina roads. There are no traffic calming measures or vertical speed control elements present and these encourage speeding and pedestrian crashes are likely to occur. With this, the researchers recommend installing or placing a speed hump, speed table or a speed cushion to discourage speeding.

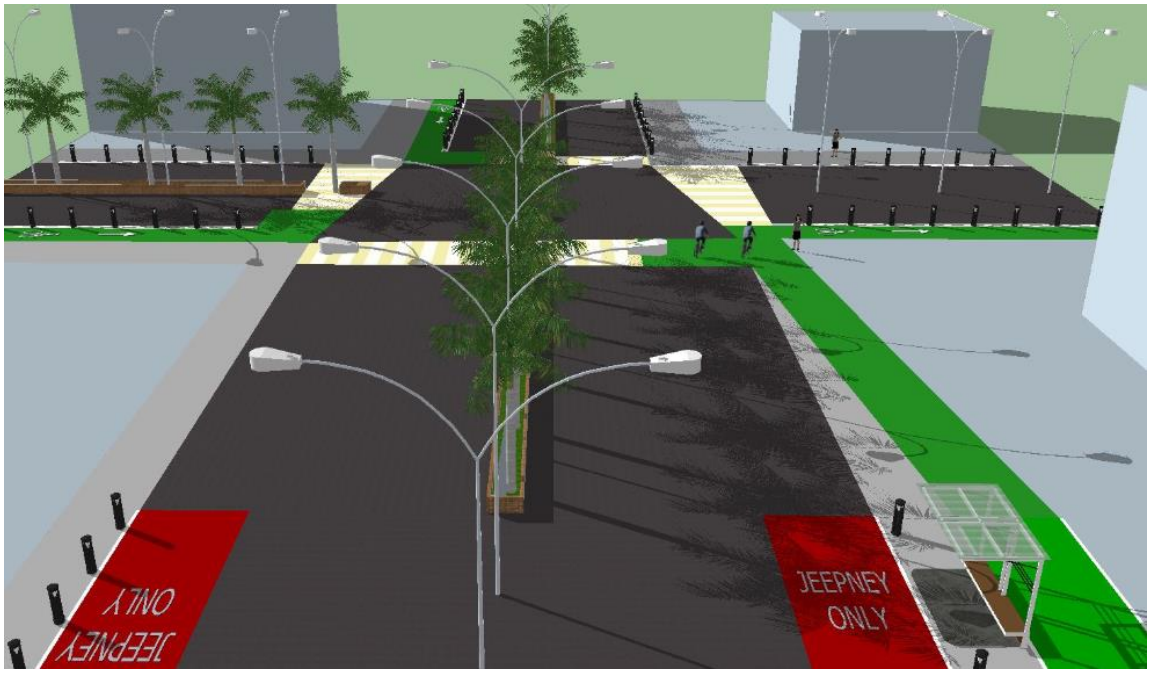
Speed tables are midblock traffic calming devices that raise the one section of the road to wheelbase of a vehicle with flat tops. These can also be describe as longer humps. These help reduce vehicular speed and they can also serve as pedestrians for most people and bikers.

Transit Streets

Most of the pedestrian crashes prone areas are smaller in width and allocation for a segregated jeepney lanes are impossible or are limited. The researchers then recommend to apply the jeepney lanes to roads with bigger width such as the Sumulong highway. The application of the jeepney lanes will limit the collision of jeepneys and the bikers.

Existing Sumulong Highway in Marikina

The figure shows the existing Sumulong highway in Marikina. It shows that the road is large enough to provide lanes for jeepneys or other public transportation. With this, the researchers recommend on creating lanes for jeepneys and other public transportation vehicles.



Recommended jeepney lanes and for other PUVs

5.3.2 Sidewalks

Another problem with Marikina bikeways infrastructure is the lack of lighting and shaded lanes. Most of the bikeways have a sharing lighting with other vehicles or with street lights. Based on the assessment, 82.4% respondents said that lighting along roads exist but are in poor condition. Lighting in a certain point or area in the road is not enough and some streetlights are not working anymore. Lighting is very important in safety not only for cyclists but also for motorized vehicle users. This is mainly used for visibility purposes of the bikers to avoid crashes during night. Based on the observation and assessment of the researchers, it can be said that lighting is limited and that some of the light post are not working and in some, streetlights may be working but because of obstructions (i.e. trees, shades) street lights become limited. With this, the researchers identified the following facilities and elements for better lighting at night with no shade obstruction and for providing enough shades during the day.

Existing lighting on Marikina roads

Lighting

Lighting is important especially to the visibility of pedestrians, cyclists, and incoming vehicles. It is an element that creates safer bicycle paths and facilities (MBPO, 2008). The purpose of lighting is to provide visibility of the area and conditions. According to DPWH Road safety design manual (2012), lighting is an element that reduce accidents and as an accident prevention measure due to its illumination. Therefore, lighting provides warning to motorized vehicles and pedestrians of the presence of the cyclist. In the major roads and streets there might be an available street lights, but based on the assessment the pedestrian crashes-prone areas have lighting but in poor condition. It is suggested by the Marikina Bikeways Guidebook (2008) adapted by the London Cycle Network Design Manual (1998) for a good lighting, the lighting height should be between 3 to 4 meters and are spaced between 8 to 10 meters apart. As to the kind of bulb or lighting, it is best to not to be too bright to avoid glare or too dim that prevents cyclist from seeing the conditions and the pathway. Major intersections and pedestrians should be sufficiently lit by installing pedestrian-scaled lights in order to ensure visibility. In Pavement flashing lights are recommended in order to improve crossing visibility at night, but these should be well-maintained with markings.

Recommended lighting and shaded lanes

Shaded Lanes

According to the assessment of the bikeways infrastructure of Marikina, cyclists seem to be exposed to sun because 52.9% of the respondents said that the pavements do not have any shade that can serve as protection for the cyclists. Trees are important since these bring shades particularly to homes, businesses, and pedestrians. In order to address this problem, the researchers recommend to install street trees and/or clear zones. Street trees slow down traffic speeds when placed on a curb extension in line with on-street parking. However, requirements for tree spacing depend upon a number of key factors and should be tailored to the chosen species. Larger trees can also help in protecting pedestrians from offending vehicles. Moreover, the concept of clear zones is used in highway design process. Clear zones serve as an unobstructed, traversable area beyond the travelled way and these can be a paved or planted shoulder or a short setback on the sidewalk. These can also provide a run-off zone for fast moving vehicles that can cause roadside crashes.

5.3.3 Intersections

According to the assessment of the bikeways infrastructure of Marikina City, 75% of the respondents said that wide roads have no crossings/medians while no signals for cyclists were found and priority signals were intended for cars/motorized vehicles. It can be said that there are insufficient measures with regards to safety particularly at intersections. Cyclists and pedestrians are legally permitted to cross at desired locations, however, due to lack in design which makes them feel unsafe/unprioritized, discouragement from cycling is evident. Aside from making the pedestrian feel unsafe/unprioritized, according to the PNP reports, accidents are most likely to occur at the intersections as well.

Bagong Silang road in Marikina

The figure shows that Marikina roads have no or limited facilities and elements for pedestrians at the existing intersections. There is a lack in design and this fails to alert the high volume of motorized vehicles coming from major and minor streets/roads that intend to cross traffic. According to the road safety manual formulated by the DPWH, intersection is the junction where two roads either cross or meet. But there are also principles of good design that can reduce the likelihood of traffic accidents which include: minimize the speed of vehicles of potential collision points; separate movement and points of conflict by channelization or in some situations, control movements to reduce the possibility of conflict; and clearly define vehicle paths by use of pavement markings. In addition, it was also stated on the manual that safety at intersections are only improved by assigning clear priority to inform drivers of their responsibilities.

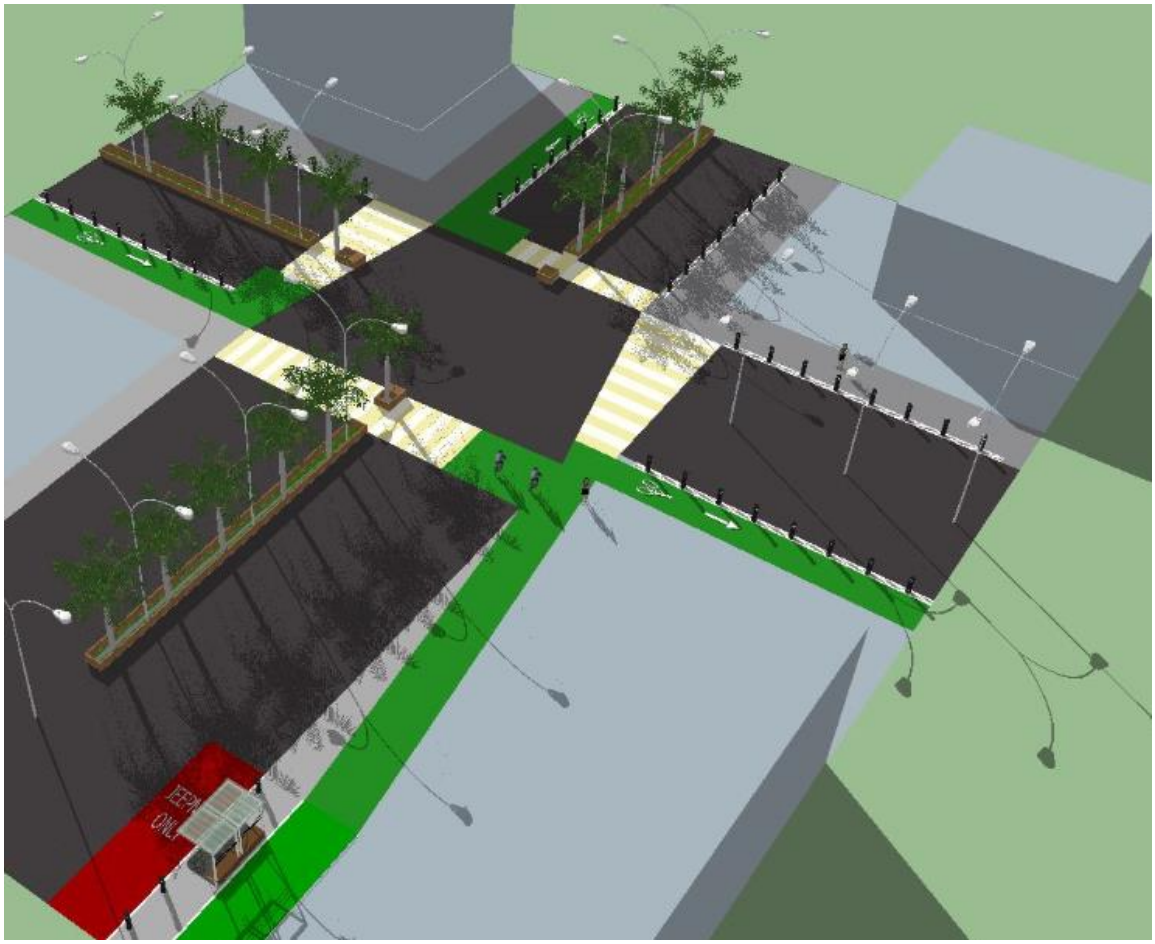
In order to address the problem, the researchers recommend to use raised crossings and curb extensions to limit turning speeds from the major to the minor street. Raised crossings can increase the visibility and potential for a vehicle to yield to a crossing pedestrian. In order to prioritize pedestrians/cyclists, a raised cycle track combined with a raised sidewalk can be carried out through an intersection. In line with this, the following facilities and elements were identified to address the safety of pedestrians and cyclists against fast moving motorized vehicles and in order to prevent or lessen road crashes/accidents:

Raised Intersection and other elements

In order to reinforce slow speeds and encourage motorists to yield to pedestrians at the crosswalk, the researchers recommend that the construction of raised intersections in intersections without traffic signals will create a safe, slow-speed crossing and public space exclusively at minor intersections. To keep fast moving motorists away from crossing into the pedestrian space, bollards along the corners should be installed so that the pedestrians are protected from errant vehicles.

Recommended raised intersection

The figure above shows the proposed intersection of the researchers. This will decrease speeding at intersection. Though it is only limited at intersection, researchers still recommend on creating or installing mid road crossing and calming measure.



Recommended installed bike boxes at intersections

In comparison with intersection without traffic signals, the figure above shows an installed bike boxes at intersections with traffic signals. A bike box is an area where bikers can wait during at signal. It provides the bikers visibility during red light. This will give enough time for the bikers at crossing, eliminating collision between fast moving vehicles and the bikers.

In addition, markings for bike lanes should not be limited on roads not within intersection but rather it should be continuous and with colour that is in accordance with the bike boxes. This will help the bikers feel safe at intersection.

Crosswalks and crossings

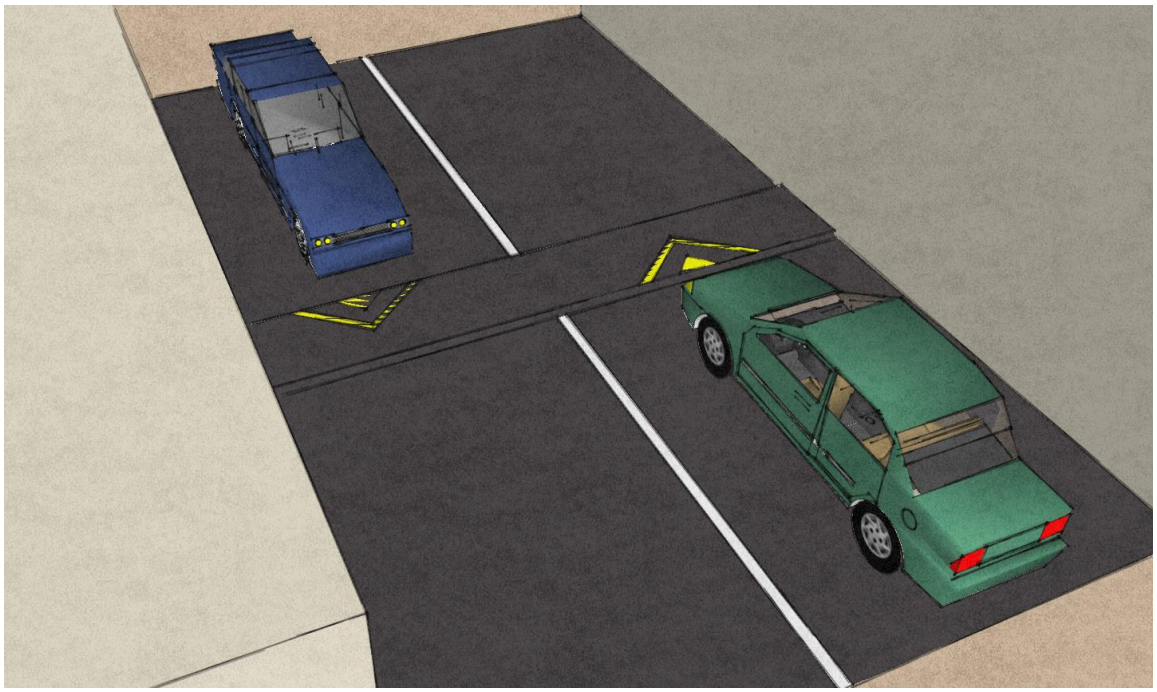
Safety concern is not limited only at intersection rather it still applies within the main road. Hence, the safety of pedestrian and bikers are compromised to give way to vehicles to have a continuous movement.

Existing road in Concepcion Marikina

The figure shows a conventional road, no presence of traffic calming measure making the road dangerous for the pedestrians/cyclists because fast mode motorists tend to yield or drive very close to them. In order to address this issue, the researchers recommend on placing humps or midblock crosswalks.

Humps

Humps slow down traffic speeds on low volume and/or low speed roads. Its installation depends on the recommended target speed. But in general, it can reduce speeds up to 15-20 mph and may be applied on 1-way or 2-way roads.

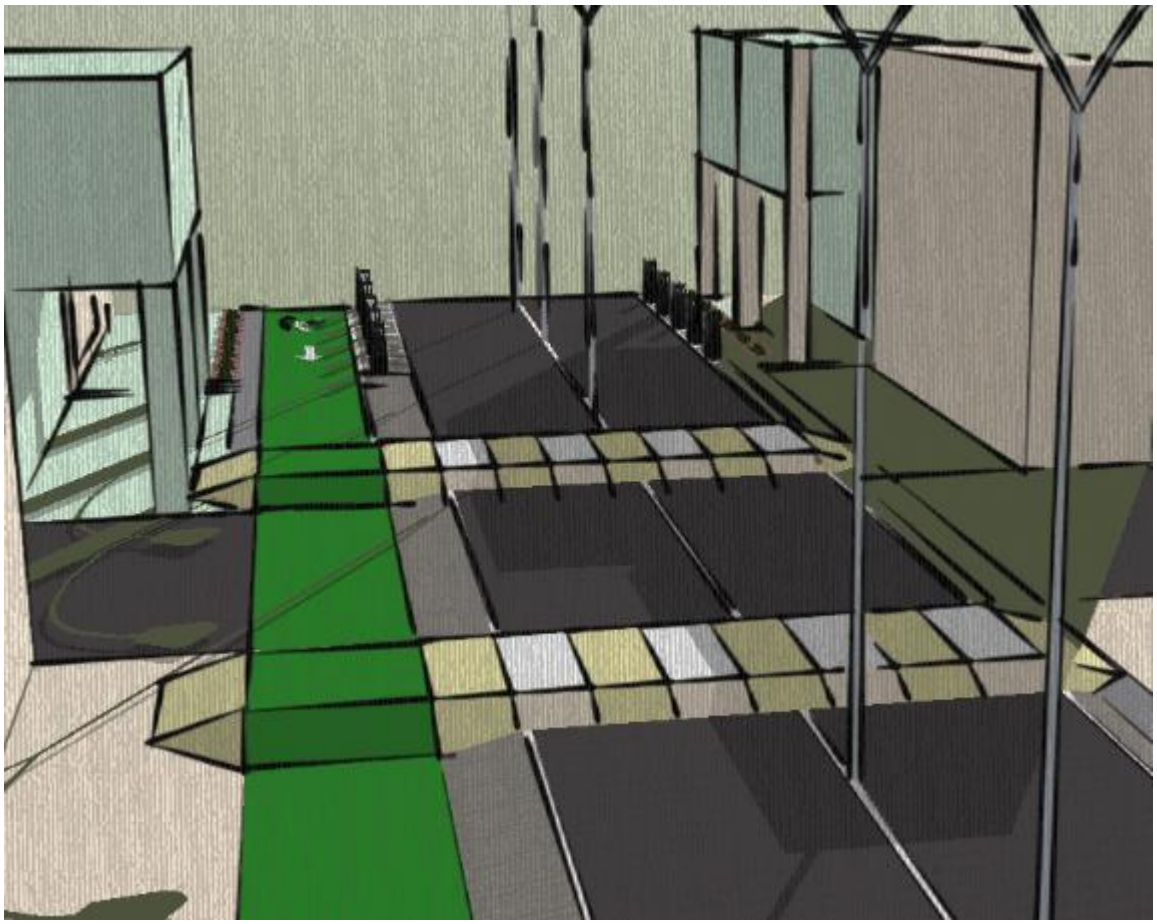


Recommended road with humps installed

The figure above is an illustration of the recommended road with the installed humps. Though it will discourage speeding for vehicles, it does not consider the crossing of pedestrian efficiently (humps are separated with pedestrian lanes) as compared to Midblock crosswalks.

Midblock crosswalks

In Marikina, the presence of conventional crosswalks can help in bring comfort and protection to pedestrians. However, there is a need to improve it. Moreover, there is an absence of built midblock crosswalks in the city. Midblock crosswalks should be provided exclusively for people who want to go to schools, parks, and other destinations in order to ensure their safety. Midblock crosswalks can also be integrated with daylighting so that pedestrians are more visible to motorists and cars but this can only be accomplished by restricting parking and/or installing a curb extension.



Recommended midblock crosswalks

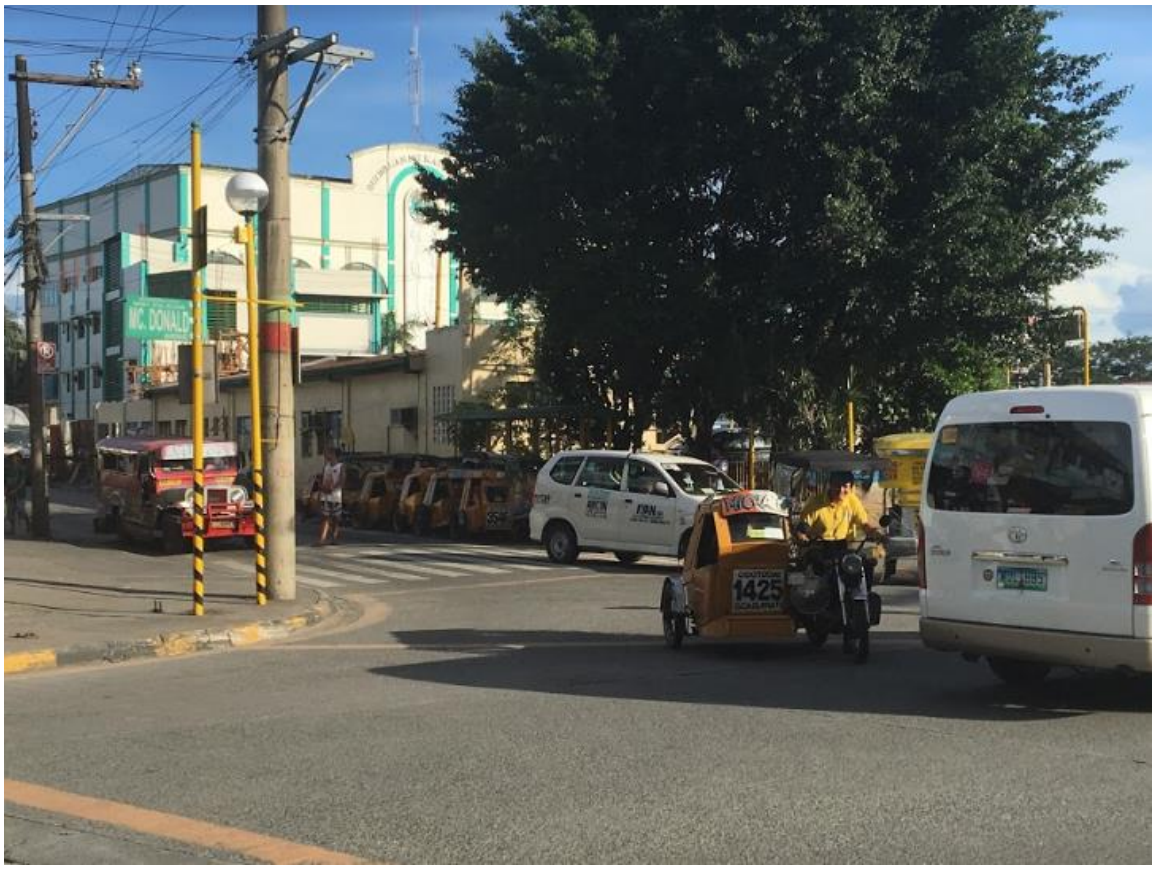
The figure shows a mid-road crosswalk, wherein both pedestrian lane and traffic calming is integrated making the motorist reduce its speed as it give way for pedestrian or bike crossing at mid road.

Recommended mid road crosswalk with pedestrian safety island

The figure shows a mid-road crosswalk with pedestrian safety island. The researchers recommend on installing these in roads with width of 17 ft. or in roads with no speed limit signals. The number of lanes are important with the pedestrians' perception of safety. According to the researcher's survey, one of the reason for some pedestrians avoiding cycling is that the area or the road is accident prone. According to the PNP report, most of the pedestrian crashes occurred at intersection. As per the researchers' assessment, it can be seen that there is an absence of priority in these roads that shall ensure the safety of the pedestrians and bike users. With these, the recommended pedestrian island may be used on both narrow or wide streets. The important part of this installation is that it will ensure the pedestrians including bikers their safety.

Traffic signals

Prioritizing cyclists over motorists at signals and/or junctions must be considered. According to the results of the assessment, it was found that no separated traffic signals were available for cyclists. More of the installed traffic signals were for cars/motorized vehicles only. Since cyclists are one of the vulnerable road users, traffic signals shall be provided to them in order to avoid accidents and to ensure their safety. And according to the DPWH Road Safety Manual, Traffic signals can also improve safety and simplify decision making. In separate vehicle movements in time, traffic signals minimizes conflicts. These can also minimize delays at intersections; it enable vehicles from a side road to cross or enter the major road; and can assist pedestrians in crossing the road.



Existing intersection road along McDonald Avenue

This figure shows the existing road with no signals at intersection and there is also no bike boxes available for the cyclists. Traffics signals are essential to the allocation of space and time and shall be in the form of street cross-sections and geometry. Space and time must be compromised because these reflect how streets operate and how well they provide mobility, public space, and especially safety. One of the useful tools is the signal timing. It is not just important for the movement of traffic but also in the safety of the environment that supports public transportation, economic vitality, walking, and bicycling.

Shorten signal cycle lengths

Traffic signal cycle lengths can also influence on the quality of the urban realm and consequently, provide opportunities for cyclists, pedestrians, and transit vehicles to operate safely along corridors. In Marikina, there are no traffic signal cycle lengths. Traffic signal cycle lengths are important especially in managing speed traffic because cycle lengths can influence the desired progression of traffic along a corridor. It can keep speed to a minimum as part of a coordinated signal timing plan. A short cycle length of 60-90 seconds is recommended particularly in urban areas because it can create consistent crossing opportunities, a more permeable network, and can even avoid discouraging pedestrians that desire to cross a street network.

Coordinated Signal Timing

Based on the assessments, signal timing exclusively for cars/motorized vehicles in Marikina is coordinated. However, the city lacks in allocating signal and time for cyclists. Coordinated signal timing must be optimized for slower speeds to create an uninterrupted flow for cyclists or low vehicle progression speeds for a pedestrian-friendly city. Coordination of

traffic signals can reduce the number of stops along a corridor and still provide a continuous flow of traffic at the target speed. Coordinated signal timing is usually installed on corridors with closely spaced intersections (¼ mile or less) and where "platooning" (seamless flow of a given street user or set progression speed) is most likely to occur. Cyclists who travel only at 12-15 mph must be provided with a green indication at successive intersections that may result in platoon of cyclists along corridors.

Bicycle Signal Heads

In order to address all the problems mentioned above concerning areas of intersections, the researchers would also like to recommend the installation of bicycle signal heads. A bicycle signal is an electrically powered traffic control device that is only used in combination with an existing conventional traffic signal or hybrid beacon. These are also used to improve identified safety or address operational problems including bicycle facilities and/or to bring guidance to cyclists at intersections who desire to cross other roads (e.g., bicycle movements, leading bicycle intervals). Bicycle signal heads can be installed at signalized intersections that indicate bicycle signal phases and other bicycle-specific timing strategies.

5.3.4 Presence of Service Shops

Based on the assessment, it was found that no service shops are available. 58.8% of the respondents stated that while very few service shops are available and are not available most of the time. A small percentage of service shops are few and far apart. Presence of service shops are essential so that if there are any instances that a bicycle owner gets involved with an accident or if some parts of his/her bicycle became broken, he/she can bring it to service shops for repair and maintenance. In order to address the problem, the researchers would like to recommend certain area for service shops where bikers can avail such services when needed.

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