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Danica Shine Q. Sagnip
Engineering Programs, School of Advanced Studies, Saint Louis University,
sagnipdanicashine@gmail.com

Mark P. De Guzman
Civil Engineering Department, Saint Louis University, mpdeguzman@slu.edu.ph

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ASSESSING THE BIKING SUITABILITY IN NATIONAL HIGHWAYS
The Case of Palayan City, Nueva Ecija, Philippines

DANICA SHINE Q. SAGNIP *(corresponding author)*
Engineering Programs, School of Advanced Studies
Saint Louis University
Baguio City, Philippines
sagnipdanicashine@gmail.com

MARK P. DE GUZMAN
Civil Engineering Department
Saint Louis University
Baguio City, Philippines
mpdeguzman@slu.edu.ph

ABSTRACT

The conundrum of the Philippines' public transportation has been a long-standing issue. With this, the Philippine government has been moving toward more sustainable public transportation systems such as cycling. Culturally and traditionally, cycling has never been mainstreamed or fostered in the country's public transportation system. However, bicycles were considered an alternate means of transportation in the new normal. Thus, this study assessed if biking would be suitable on national highways, particularly in Palayan City, Nueva Ecija. Several factors can influence the use of cycling, such as physical and environmental factors, level of service, and width of inner and outer lanes of national highways. In this study, considering the physical and environmental criteria, the four selected barangays (Atate, Singalat, Caimito, and Santolan) are suitable for bike lane development as they cover 0.85 to 6.0% of the total land area and are densely located on flat to

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gently sloping areas. These barangays are also mostly covered with cultivated area. Furthermore, as for data collected from the vehicle count survey in 2021 versus 2022, the level of service (LOS) as calculated is LOS B against all the peak hour traffic, where reasonably free flow speed is maintained. However, compared to the 2021 vehicle count survey, there is an increase in passenger car units (pcu) in 2022 as COVID-19 ends. In consideration of the road width, the outermost lane has a width of 3.05 m, which corresponds to the DPWH-prescribed minimum measurement of 2.44 m. With these results, developing bike lanes on national highways is suitable.

KEYWORDS

biking suitability; cycling; bike lane; level of service; vehicle count survey

TRANSPORTATION SYSTEM IN THE PHILIPPINES

It is undeniable that the most basic function of the transportation system is to connect places and people, integrating the social, economic, and environmental systems with globalization and urbanization (Wang, Xue, Zhao, & Wang, 2018). In the Philippines, one of the government's goals is to improve the quality of life through accessible transportation to strengthen the investment climate and enhance economic growth. Thus, the government has developed the National Environmentally Sustainable Transport (NEST) Strategy to promote sustainability. Its main goal was to make the Philippines' transportation policies more people and environment-friendly and contribute to achieving Sustainable Development Goals (Bellen, 2017). However, while the government has taken steps to improve the transportation situation, the problem with public transportation remains unsolved. In the Philippine Development Plan (2017–2022), the National Economic Development Authority (NEDA, 2017) also recognizes that in comparison to the growing demand for transportation, current progress in the expanding transportation systems is pitiful.

CYCLING IN THE PHILIPPINES

Cycling is seen as a viable alternative that can counter the trend of using private cars for short and medium-distance trips in urban areas to address climate change goals, enhance the livability of cities, and reduce pressure on public transportation (Wysling & Purves, 2022). When designing urban cycling networks, cycling infrastructure must be integrated into the existing road network in a comprehensive and strategic manner. There are four fundamental types of cycling infrastructure: (1) stand-alone paths, which are found in parks and sometimes shared with pedestrians; (2) cycling lanes that physically separate bicycles from motorized traffic using markings; (3) cycling lanes designated on roads which do not physically separate cyclists from motorized traffic; and (4) roads where cyclists ride in mixed traffic where speed limits and traffic volumes are low (Pucher & Buehler, 2017).

In the Philippines, the government has been moving toward a more sustainable public transportation system. Several policy documents, including Administrative Orders and Senate and House Bills were proposed that emphasized the importance of low-cost alternative modes of transport, such as cycling. There have been some attempts in the political realm to improve cycling. Among the laws proposed are the development of bicycle infrastructures (bike lanes, proper bike parking, etc.) (Bakker, Guillen, Nanthachatchavankul, Zuidgeest, Pardo, & van Maarseveen, 2018). Although the planning and implementation of infrastructure improvements are part of an ongoing political process, there is clear evidence that effective cycling infrastructure may develop a cycling culture and have a beneficial impact on the number of people using bicycles. It assumes that bicycle facilities should be provided on each street and take into account factors like speed limits, traffic volumes, and road width (Wysling & Purves, 2022).

Some of the cities in the country (such as Marikina City, Pasig City, and Iloilo City) have advanced and forwarded initiatives to promote sustainable transportation and mobility. Pedestrianization, walkability and green spacing, mass transportation and other alternative modes of transportation, and institutional policies are among the initiatives (Bellen, 2017).

Last 2020, the Department of Public Works and Highways (DPWH) prescribes a standard bike lane design for future projects. Through Department Order No. 88, series of 2020, new national road and bridge construction or future expansion

of projects must have a bicycle facility, which must be no less than 2.44 meters of bicycle path width depending on road and traffic conditions (DPWH, 2020). Furthermore, the future bicycle lane projects will have three classifications: Class 1, a designated protected path that is completely separated from the motor-vehicle roadway by an open space with a sidewalk (for moderate to high speed and high traffic volume); Class 2, a portion of a roadway designated for the exclusive use of bicycles and is separated from the motor-vehicle roadway through pavement marking or physical separation (for low speed to low to moderate traffic volume); and Class 3, which is part of a roadway that has been officially designated and marked as bicycle route but can also be used by motor vehicles due to limited carriageway width (for lowest speed and traffic volume).

During the COVID-19 pandemic in the country, cycling and walking have also been promoted as essential and safer modes of transportation. The National Transport Policy of the National Economic and Development Authority (NEDA) encourages LGUs to prioritize the development of bicycle lanes to promote active transportation that provides safe and direct access to priority services (DILG, 2020).

As per DILG Memorandum Circular (M.C.) No. 2020-100, LGUs must review their existing transportation plans, including their local public transport route plan (LPTRP) and comprehensive land use plan (CLUP). LGUs should prioritize establishing bike lanes and walking paths when updating their LPTRP. The criteria for identified road types are shown in Table 1.

Although cycling is known as a sustainable mode of transportation, Filipinos have not yet fully adopted it into their daily lives. Previous studies investigate individual factors and built environmental characteristics that influence the likelihood to use bicycles, as well as to develop a bike lane. For individual factors, attitudinal characteristics were found to influence bicycle use (Heinen, Maat, & Van Wee, 2011). Since attitude significantly influences cycling behavior, attitude-based interventions should be addressed to promote active travel. Other than individual factors, cycling is also influenced by the physical conditions of the roadways, streets, paths, and other structural elements. Similarly, there is empirical evidence that population, land use, and urban design also affect cycling levels. Natural environmental factors are also considered significant. For instance, the effects of weather may increase or decrease the probability of cycling (Gao, Kamphuis, Dijst, & Helbich, 2018).

Road Type	Lanes	Separation	Speed Limit	Traffic Calming
Type 1	Local roads with four (4) or more lanes	Physical separation by object	30 kph	With traffic calming design interventions
Type 2	Local roads with four (4) or less	Paint/other markings	10 kph	With traffic calming design interventions
Type 3	Any street/open space	Paint/other markings	Motorized transport is not allowed Access is limited to residents, business loading/ unloading, and emergency vehicles only with a 10kph speed limit.	With traffic calming design interventions

Table 1: Criteria for Identified Road Types. Note: Adapted from DILG Memorandum Circular No. 2020-100.

SIGNIFICANCE OF THE STUDY

There has been a critical need to transition to sustainable transportation systems for the past years. As such, studies relevant to sustainable transportation are significant. It contributes to a better awareness of current transportation issues, potential solutions, and roadblocks to change (Moody, 2012). Thus, this study could contribute to the existing literature regarding the acceptability of sustainable transportation in the Philippines.

It is also necessary to adapt governmental and planning measures to provide comfort and safety for users. These conditions must be considered when planning new bicycle networks or modifying the existing road network to include cycling mobility (Santos, Passos, Gonçalves, & Matias, 2022).

This study seeks to assess the biking suitability of Nueva Ecija-Aurora Road along Palayan City with the following objectives:

1. Evaluate certain areas in the city if they are suitable for bike lane development

2. Identify the capacity and level of service (LOS) of Nueva Ecija-Aurora Road

3. Compare Nueva Ecija-Aurora Road width vs. DPWH Standard Guidelines

The findings of this study can be utilized by the city government of Palayan or other LGUs to determine what transportation programs and policies need to be re-oriented. If there is an existing transportation plan, LGUs can also use this study to review and realign it, if possible.

The study will also be a guide to support the LGUs in engaging various stakeholders when planning and developing biking infrastructure. The results of the study may influence the decision-making processes of the stakeholders. Decision support tools to assist LGUs and stakeholders in cycling network planning are essential to promote sustainable mobility practices and increase the bicycle-use on daily trips (Santos et al., 2022).

It will serve as a reference for the community to provide them with a more explicit version of the current situation of the transportation management system in Palayan City. Through this study, community engagement would be possible.

This study will also be a basis to consider cycling as an alternative mode of transportation in Palayan City. The city government of Palayan can use this study as a guide when developing bike lanes. It will also raise awareness among the city government and community on the importance of cycling.

RESEARCH SETTING

Palayan City was chosen as the locale of the study. It is a landlocked area situated at the center of the province of Nueva Ecija in the plains of northern Luzon, which is the biggest island of the Philippines. It is located near Cabanatuan City and the municipalities of Bongabon and Laur. Potentially, it can also serve as an alternative link leading to the province of Aurora. The city has a total land area of 101.40 square kilometers (km^2) constituting 1.76% of Nueva Ecija's total area.

As of November 2015, the City of Palayan's concreted road network is 164,032 meters (m) consisting of (a) national roads: 15,600 m; (b) city roads: 28,890 m; and (c) barangay roads: 118,542 m. For many years, Palayan City has consciously cultivated the image of a "Green City." As the capital city of Nueva Ecija, it is also the center of the provincial government and positioned to be the "Business Hub" of the province. Considerations of what the city can best contribute to the development of the province and the wider region are not only a valid concern but also an imperative (City Government of Palayan, 2016).

The City of Palayan is located in the southeastern-central portion of Nueva Ecija. It serves as the capital and seat of the Provincial Government of Nueva Ecija. Palayan City has a total land area of 13,413.79 hectares that are politically subdivided into 19 barangays. Palayan City has grouped the barangays into five clusters defined based on their location and the key roles they play within the city. Cluster I aims to protect Agrarian Reform areas and the Special Planning Zone for the Government Center, host industrial sites, and serve as a location for housing and institutional areas. This cluster is comprised of the following barangays: Atate, Imelda Valley, Marcos Village, Sapang Buho, and Singalat. It is in Barangay Singalat that the major institutions are located such as the provincial capitol of Nueva Ecija, the city hall of Palayan City, and the Palayan City Business Hub. Cluster II is the Poblacion area that serves as the urban core of the city. It is where major commercial areas are located. This includes the following barangays: Caballero, Caimito, Ganaderia, Malate, and Santolan. The remaining three clusters are for agro-production areas and agro-industrial centers.

Figure 1: Palayan City, Along Nueva Ecija-Aurora Road

SCOPE AND LIMITATIONS

This study aims to find out if biking would be suitable on national highways along Palayan City. In this study, Nueva Ecija-Aurora Road was the chosen national road as shown in Figure 2, as it serves as the city's primary link to and from Cabanatuan City.

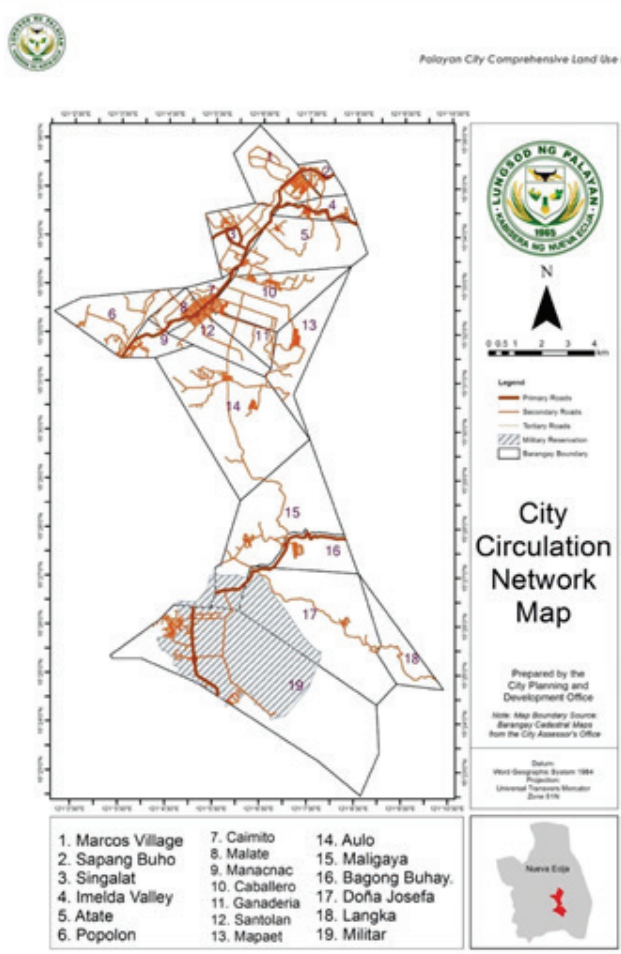

Figure 2: City Circulation Network. Note: Adapted from Comprehensive Land Use Plan 2019-2027 (City Government of Palayan, 2019).

Figure 3 shows the five clusters of Palayan City. To evaluate the suitability of certain barangays for the bike lane development, two out of 19 barangays (Brgy.) from each of Clusters I and II were selected based on their key roles. Brgy. Atate and Brgy. Singalat were chosen from Cluster I, where government and economic hubs were mainly located. On the other hand, Brgy. Caimito and Brgy. Santolan from Cluster II (Poblacion) were selected as these barangays cater to a majority of the commercial areas. The study focused only on two criteria—physical and

environmental—as factors to be considered for the development of bike lanes. Thus, this study utilized the Geographic Information System (GIS) software.

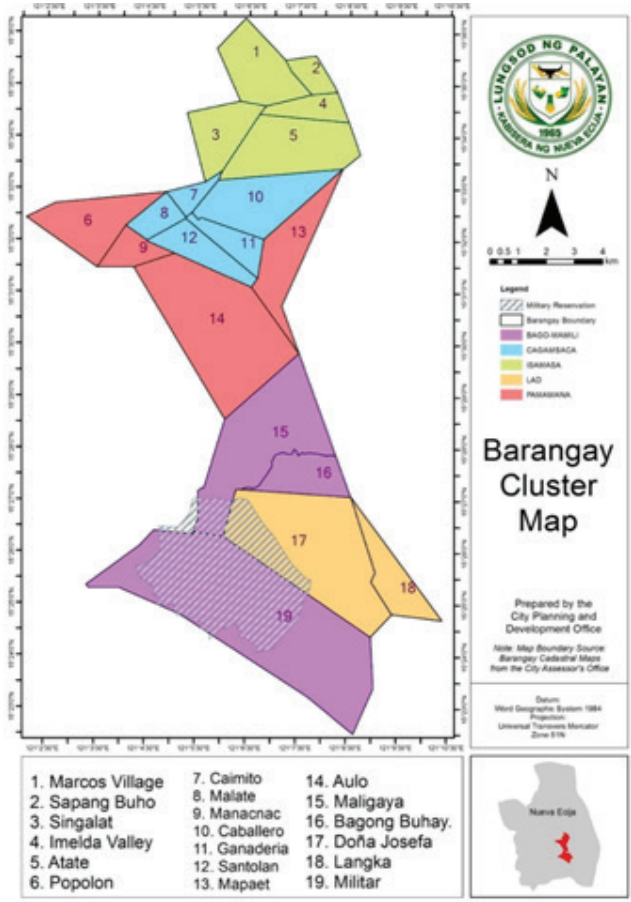

Figure 3: Barangay Cluster Map. Note: Adapted from Comprehensive Land Use Plan 2019-2027 (City Government of Palayan, 2019).

Meanwhile, in terms of the capacity and LOS of Nueva Ecija-Aurora Road, the 2021 vehicle count survey of Palayan City (City Government of Palayan, 2021) was utilized to compute the Design Hour Volume (DHV) and Volume/Capacity (V/C) ratio. To assess the changes, an updated vehicle count survey for 2022 was also conducted in this study.

Furthermore, the D.O. No. 88 Series of 2020 of DPWH was used to determine if the Nueva Ecija-Aurora Road width corresponds with the standard guidelines (DPWH, 2020).

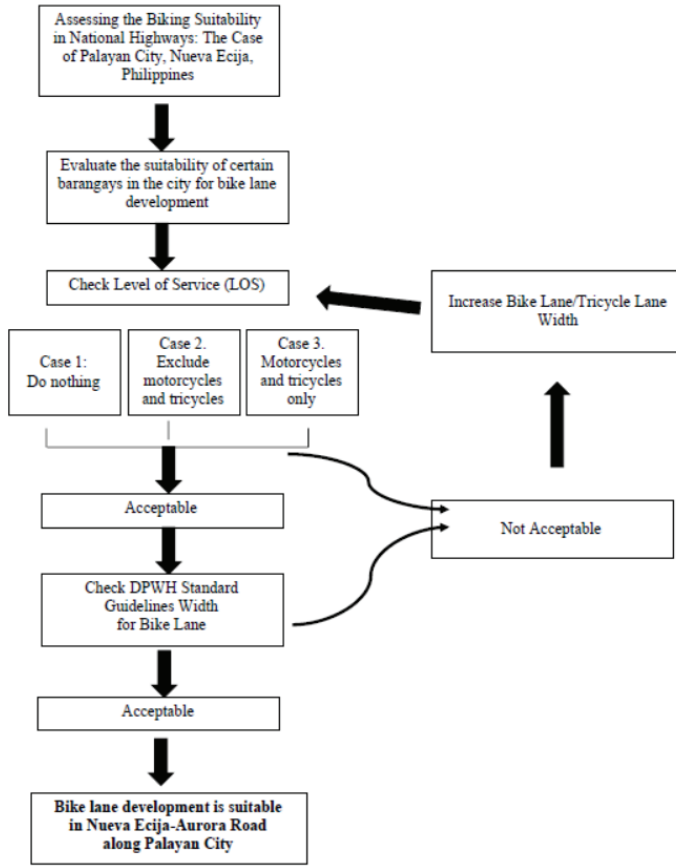

Figure 4: Decision Framework for the Study

METHODOLOGY

To answer the research objectives, Figure 4 shows the framework of the study. Finding out whether biking is suitable in Nueva Ecija-Aurora Road along Palayan City was the main objective of the study. With this, the physical and environmental criteria were identified in evaluating the biking suitability of the four selected barangays, where the GIS, specifically QGIS 3.10 was used. Afterward, it was also

necessary to determine the capacity and LOS of Nueva Ecija-Aurora Road, a primary road in Palayan City. Thus, a vehicle count survey was utilized in determining the existing conditions of the said primary road. It is also required to check the roadway measurements of Nueva Ecija-Aurora Road, whether it corresponds with the DPWH Standard Guidelines (DPWH, 2020). Once accepted, the development of bicycle lanes is now suitable on Nueva Ecija-Aurora Road, along Palayan City.

In this study, the following data were utilized to evaluate whether certain areas would be suitable for bike lane development:

Criteria for the Development of a Bicycle Lane

Several factors including economy, population, land use, travel distance and time, and environmental and physical factors may influence the bicycle-use and development of a bike lane (Santos et al., 2022). In this study, the physical and environmental conditions of certain barangays were evaluated to determine if a bike lane would be suitable in an area. The physical criteria determine how the physical characteristics of the road will affect the model while the environmental criteria determine the effect of the number of users, variation in usage types, connection of the route with the existing transportation system, and the traffic density of the model (Olgun, 2020). In this study, the physical criteria include land area and slope factor while land cover, population, and hierarchy of settlements are for the environmental criteria. These parameters would also be utilized to ensure the safety of the inhabitants who will use bicycles for commuting.

Geographic Information System (GIS)

The GIS is commonly used for planning and developing bicycle lanes. Thus, studies like determining the most suitable routes for bikes and estimating the demand for bike lanes can be evaluated in this context (Rybarczyk & Wu, 2010). In this study, GIS software, specifically QGIS 3.10, was utilized. For verification, Google Maps Street View was also used. It is a travel tool kit designed to identify different destinations. Google Maps Street View offers aerial photography, street maps, 360° panoramic views of the street, etc. It also provides a route planner that enables users and/or drivers to easily locate accessible directions through driving, taking public transportation, walking, or biking (Antony, 2021).

Capacity and Level of Service (LOS) of Nueva Ecija-Aurora Road

The capacity of a highway facility is a measure of its ability to accommodate vehicular traffic. This ability is influenced by the road's physical characteristics as well as traffic demand and vehicle interactions (Drew & Keese, 1965).

To measure the effectiveness or the capacity of the traffic flow on a particular stretch of road, the LOS is worth considering. LOS refers to the quality of the driving conditions afforded to a motorist by a particular facility. Factors that are involved in the level of service include speed and travel time, traffic interruption, freedom to maneuver, safety, driving comfort and convenience, and vehicular operational costs (Drew & Keese, 1965). As shown in Table 2, six LOS are defined for each type of facility with letters designating each level from A to F.

Level of Service	Description
A	Highest quality of service with free-flow conditions (free traffic flow with low volumes). Little or no restriction on maneuverability or speed.
B	Reasonably/ stable traffic flow, speed becoming slightly restricted. Low restriction on maneuverability.
C	Stable traffic flow, but less freedom to select the speed or to change lanes.
D	Approaching unstable flow. Speeds are tolerable but subject to sudden and considerable variation. Less maneuverability and driver comfort.
E	Unstable traffic flow and rapidly fluctuating speeds and flow rates. Low maneuverability and low driver comfort.
F	Forced traffic flow. Speed and flow may drop to zero.

Table 2: Level of Service. Note: Adapted from the (1) Highway Capacity Manual, 2016 and (2) DPWH Department Order No. 22, Series of 2013 (DPWH, 2013).

City Circulation Network

There are two major roads traversing through Palayan City: (1) Nueva Ecija-Aurora Road, which runs across the northern portion of the city; and (2) Santa Rosa-Fort Magsaysay Road, which traverses the southern portion of the city. Furthermore, the existing road network of the city is shown in Table 3.

Road Types	Description
1. Primary Roads	- These are the arterial roads that link directly to Maharlika Highway or the Pan-Philippine Highway Network (Asian Highway Network No. 26 or Route No. AH26) at Cabanatuan City and the Municipality of Sta. Rosa. - It includes Nueva Ecija-Aurora Road and Sta. Rosa-Fort Magsaysay Road.
2. Secondary Roads	- These roads are considered the collector roads which terminate at the Primary Road. - City roads and Inter-Barangay Roads are considered under this classification.
3. Tertiary Roads	- These are roads within each barangay, serving as access to residential settlements and other land parcels. They are connected to the collector roads.

Table 3: Types of Roads and their Description. Note: Adapted from Comprehensive Land Use Plan 2017-2022, Palayan City.

Vehicle Composition and Count Survey of Palayan City

In the City of Palayan, the Traffic Management and Public Safety Division (TMPSD) is the agency responsible for supervising and monitoring ordinances, policies, and programs relating to transport and traffic management, under the Office of the City Mayor. In May 2021, TMPSD conducted a two-day (Tuesday & Saturday) vehicle count survey along Nueva Ecija-Aurora Road, particularly in Poblacion areas. The 2-day vehicle count survey of TMPSD was utilized in this study to analyze the capacity and LOS of Nueva Ecija-Aurora Road along Palayan City. With this, the following were computed:

Design Hour Volume (DHV) and Annual Average Daily Traffic (AADT). In actuality, DHV is often derived from AADT. It is calculated using the American Association of State Highway and Transportation Official's (AASHTO's) factor method.

This method uses permanent count stations to calculate daily and monthly factors, and normally, each permanent count station is connected to a group of short-term count locations (Keehan, 2017)

DHV = AADT x K (for 2-lane or 3-lane, 2 highways) (1)

or

DDHV = AADT x K x D (for multilane highways) (2)

where:

DHV – design hourly volume

DDHV – directional design hourly volume

AADT – annual average daily traffic

K – the proportion of daily traffic occurring during peak hour, expressed as a decimal

D – the proportion of peak-hour traffic traveling in the peak direction, expressed as a decimal

Road Type	Carriage width, m	Roadside friction	Basic hourly capacity in pcu in both directions
Highway	≥ 4.0	None or light	600
	4.1 – 5.0	None or light	1,200
	5.1 – 5.5	None or light	1,800
	5.6 – 6.1	None or light	1,900
	6.2 – 6.5	None or light	2,000
	6.6 – 7.3	None or light	2,400
	2 x 7.0	None or light	7,200 (expressway)
Urban Street	~6.0	Heavy	1,200
	6.1 – 6.5	Heavy	1,600
	6.6 – 7.3	Heavy	1,800
	2 x 7.0	Heavy	6.700

Table 4: Basic capacities for highways and urban streets. Note: Adapted from the Ministry of Public Works and Highways (1982).

Volume/Capacity (V/C) Ratio. After solving the DHV, it is necessary to determine the capacity of roads. Ideally, volume capacity compares roadway demand

(vehicle volumes) with roadway supply (carrying capacity). Volume refers to the number of vehicles utilized during peak hours, while capacity is the road's ability to accommodate that volume based on its design and number of lanes (King County Government, 2008). Table 4 shows the basic capacities for roads.

Level of Service. Through DHV and V/C Ratio, the LOS will be determined. As abovementioned, LOS is a measure of the quality of the capacity of the traffic flow in a section of the road. LOS is also measured during peak hours. LOS can be determined by the scale intervals of the V/C ratio as shown in Table 5.

Level of Service	Volume-capacity ratio
A	Less than 0.20
B	0.21 – 0.50
C	0.51 – 0.70
D	0.71 – 0.85
E	0.86 – 1.00
F	Greater than 1.0

Table 5: LOS and V/C Ratio. Note: Adapted from the DPWH Department Order No. 22, Series of 2013 (DPWH, 2013).

RESULTS AND DISCUSSION

The present study was an attempt to assess the biking suitability of the primary roads in Palayan City. This chapter presents a synthesis and discussion of information and data gathered from different procedures used for each objective of the study. For better understanding, the results were divided and presented into three sections: (a) Areas suitable for bike lane development; (b) Capacity and LOS of existing roadways, and (c) Compliance with DPWH Standard Guidelines.

Areas Suitable for Bike Lane Development

To evaluate the suitability of certain barangays for bike lane development, it has been identified that consideration of physical and environmental criteria was crucial in the planning and development of bicycle lanes to provide inhabitants with a more comfortable and safe journey.

Physical criteria. Physical factors such as land area and slope condition may influence an individual's choice to use bicycles. These factors are considered important determinants for bicycle lane development. Accordingly, it is expected that the use of bicycles tends to increase when certain physical conditions are suitable for cycling.

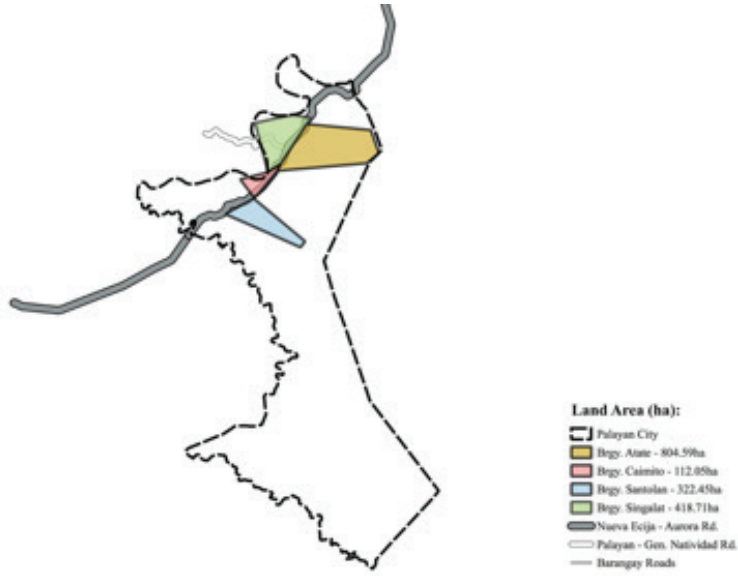

Figure 5: Physical Criteria (Land Area) for Bike Lane Development

The City of Palayan covers a total land area of 13,413.79 hectares that is politically subdivided into 19 barangays. In Cluster I, Brgy. Atate covers 804.59 ha (5.99%) and Brgy. Singalat covers 418.71 ha (3.12%) of the total land area. However, Brgy. Santolan covers 322.45 ha (2.40%) and Brgy. Caimito 112.05 ha (0.83%) for Cluster II as shown in Figure 5.

Furthermore, the city is endowed with a generally flat topography. Overall, approximately 72.17% of the total land area ranges from flat (0–3%) to gently sloping and moderately undulating and gently rolling trains (5–18%). As shown in Figure 6, the three barangays (Singalat, Caimito, and Santolan) have a slope that varies from 0 to 8%. Typically, these areas are suitable for industrial development and urban growth. Meanwhile, Brgy. Atate having 0 to 30% slope are generally grasslands that can be utilized for cultivation and urban purposes. In general, the ideal slope for conventional bicycle-use should be the lowest possible, preferably less than 3%. It

can also be used in moderate slopes up to 5% while slopes greater than 8% should be avoided (Santos, et al., 2022).

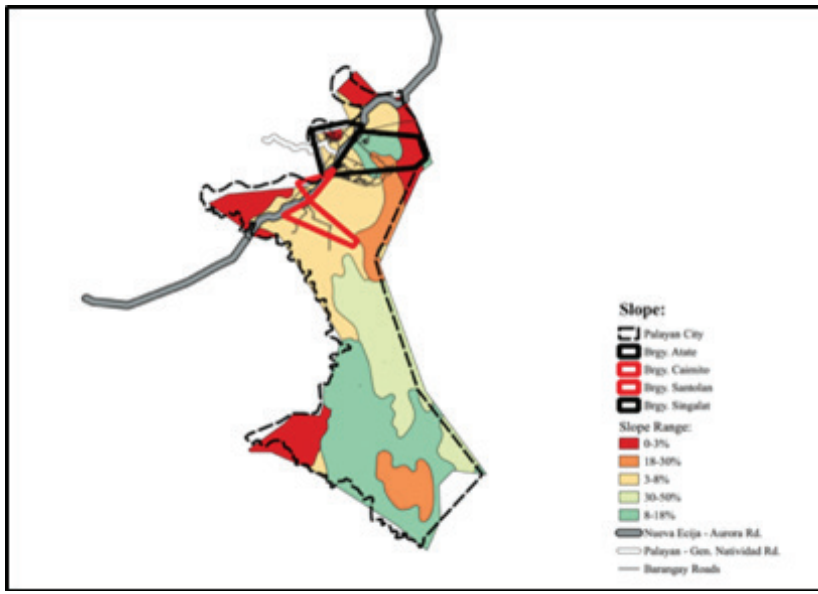

Figure 6: Physical Criteria (Slope) for Bike Lane Development

For better comparison, a summary is shown in Table 6 for the analysis of physical criteria for bike lane development in Palayan City.

Cluster	Barangay	Land Area (ha)	Slope
I	Atate	804.59	0–30%
	Singalat	418.71	0–8%
II	Caimito	112.05	3–8%
	Santolan	322.45	3–8%

Table 6. Analysis of Physical Criteria for Bike Lane Development

Environmental criteria. In determining the most suitable areas for bike lane development, environmental factors must also be taken into consideration. Environmental criteria include the different land cover classes, the expected number of users, and urban settlement growth.

Based on the temporal and spatial data acquired, six land cover classes were identified in Palayan City: Grassland, Cultivated Areas, Inland Water, Built-Up Areas, Open Areas, and Tree Plantation as shown in Figure 7. The four selected barangays are mostly covered with cultivated areas. Crop production and livestock raising are feasible in these barangays due to the comparatively gently undulating and rolling land slopes. For the roadways sector, one of the city's priority projects is to identify new routes and circulation loops for network efficiency and support future land uses to assure linkage to various barangays within the city and improvement of existing egress and ingress networks.

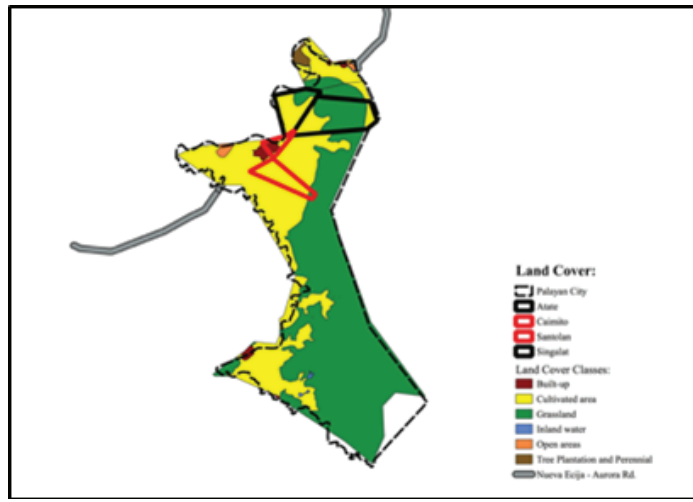

Figure 7: Environmental Criteria (Land Cover) for Bike Lane Development

Environmental criteria also include the impact of the anticipated number of users (Olgun, 2020). Thus, the population and hierarchy of settlements were also factors that need to be considered. Furthermore, there is an increase in the population of the four selected barangays in the 2020 Census compared to the 2015 Census as shown in Table 7. Cluster I (Brgy. Atate and Santolan) significantly increased (approximately 23%). In terms of the hierarchy of settlements, it falls on second-order central places (Figure 8). These barangays will serve as catchment areas for future urban expansion projects. They are booming due to the business hubs and economic centers. However, as these areas remain mostly residential, retail and trading operations still exist along with other commercial areas but within low to moderate concentrations.

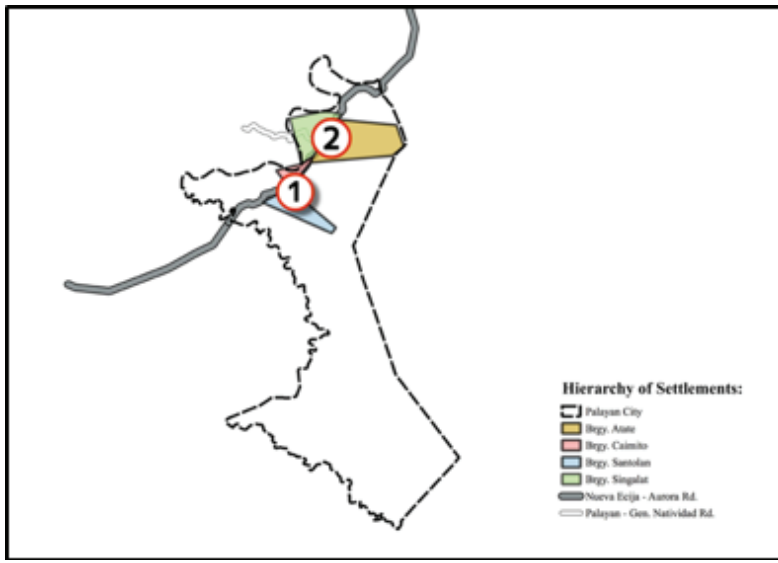

Figure 8: Environmental Criteria (Hierarchy of Settlements) for Bike Lane Development

Contrariwise, the Poblacion area (Cluster II), which includes Brgy. Caimito and Santolan, barely increased in terms of population but still rank at the first-order central place (Figure 8). However, it continues to lead in terms of economic activity. At present, it is bustling with commercial activity but in low to moderate conditions.

Cluster	Barangay	Population (2015)	Population (2020)	Annual Population Growth Rate	Change (2015-2020)
I	Atate	3,210	3,942	4.42%	22.80%
	Singalat	2,093	2,568	4.40%	22.69%
II	Caimito	2,359	2,553	1.68%	8.22%
	Santolan	1,985	1,996	0.12%	0.55%

Table 7: Population Growth Rate in the Four Selected Barangays

A summary is shown in Table 8 for the analysis of environmental criteria for bike lane development in Palayan City.

Cluster	Barangay	Land Cover	Population (as of 2020)	Hierarchy of Settlements
I	Atate	Grassland Cultivated area	3,942	1
	Singalat	Grassland Cultivated area	2,568	1
II	Caimito	Built up area Cultivated area	2,553	2
	Santolan	Built up area Cultivated area	1,996	2

Table 8: Analysis of Environmental Criteria for Bike Lane Development

Bicycle lane proposal map. According to the results of the analyses in this study, the land structure of Palayan City does not have a high degree of slope and the hierarchy of settlements is not quite high. With this, developing a bicycle lane is suitable in Nueva Ecija-Aurora Road along Palayan City. A bicycle lane proposal map is shown in Figure 9, which can serve as a basis for the Palayan City government in bicycle lane development.

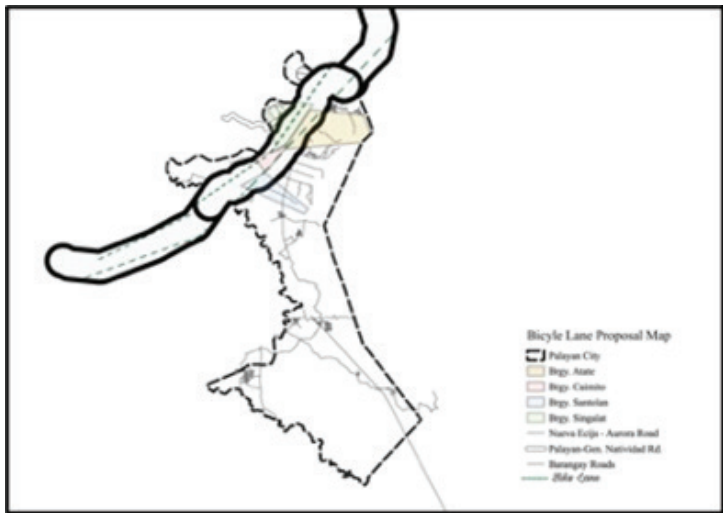

Figure 9: Bike Lane Proposal Map (using QGIS 3.10)

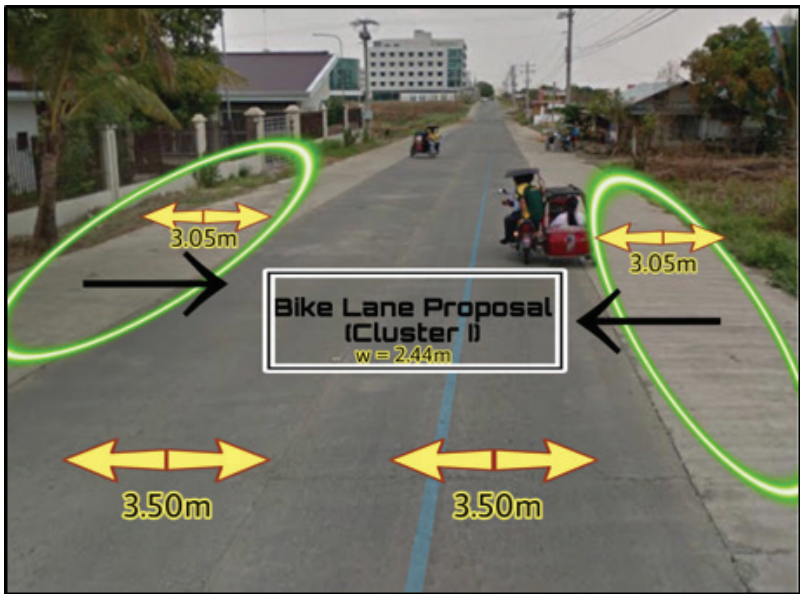

Figure 10: Bike Lane Proposal Map (Cluster I)

Furthermore, Google Maps Street View was used to verify the precise location of the proposed bicycle lane along Nueva Ecija-Aurora Road in Palayan City. As shown in Figure 10, a bicycle lane can be developed between government centers

and economic hubs in Cluster I. Meanwhile, it can be proposed along the churches and commercial buildings of Cluster II, as shown in Figure 11.

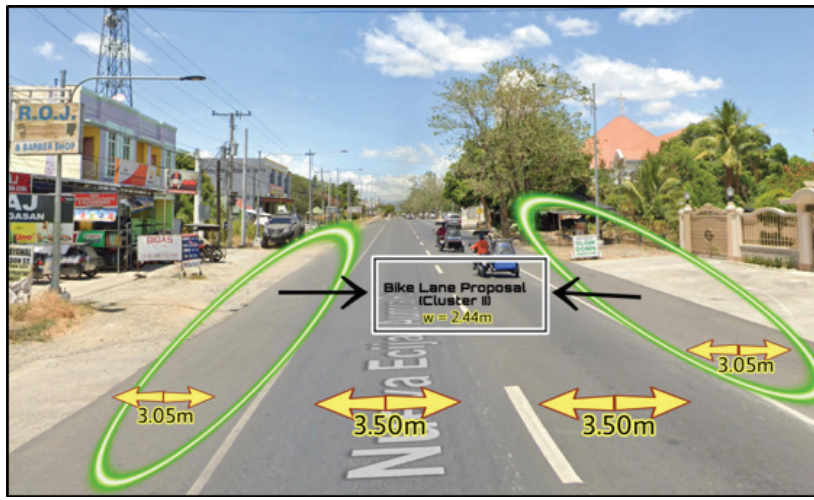

Figure 11: Bike Lane Proposal Map (Cluster II)

Capacity Level of Service of Existing Roadways

In this study, it is also necessary to determine the capacity of the traffic flow and LOS in Nueva Ecija-Aurora Road along Palayan City. For the determination of the LOS, the DHV and V/C ratio were considered.

In Palayan City, vehicle count surveys were conducted by TMPSD. The latest vehicle count survey was conducted last May 2021 for two days on the Nueva Ecija-Aurora Road along Brgy. Caimito and Brgy. Santolan. In this study, DHV, V/C Ratio, and LOS were computed, considering three cases: (1) do nothing; (2) exclude motorcycles and tricycles in the inner lane; and (3) motorcycles and tricycles only in the outer lane. A summary is shown in Table 9.

Case Level	Date	AADT (pcu/ day)	Carriage width (m)	Basic hourly capacity in both directions	DHV (pcu/hr)	V/C Ratio	LOS
1. Do nothing (inner lane)	May 25, 2021	14,739	7.0	2,400	1,326.51	0.55	C
	May 29, 2021	12,710	7.0	2,400	1,143.9	0.48	B
2. Exclude motorcycles and tricycles (inner lane)	May 25, 2021	6,473	7.0	2,400	582.57	0.24	B
	May 29, 2021	5,830	7.0	2,400	524.70	0.22	B
3. Motorcycles and tricycles only (outer lane)	May 25, 2021	8,266	6.10	1,900	743.94	0.39	B
	May 29, 2021	6,880	6.10	1,900	619.20	0.33	B

Table 9. Level of Service of Nueva Ecija-Aurora Road along Palayan City (as of 2021)

The Nueva Ecija-Aurora Road along Palayan City can be considered a single carriageway, as it is located in a small area with a limited population and low trip generation. Based on the result, the single carriageway (Case 1) typically operates in LOS C, which offers stable traffic flow but less control over lane changes and speed. However, several factors including speed and travel time, flexibility to travel at a preferred speed, traffic restrictions, driver comfort and convenience, and vehicle operating costs may have an impact on the current level of service (Uwitonze, 2014). Any road obstructions may result in modifications to the level of service. Meanwhile, significant traffic reduction efforts contribute to maintaining the level of service and extending the span of the road service. Contrariwise, Cases 2 and 3 operate in LOS B, where reasonably free flow speed is maintained. The freedom to select desired speeds is relatively unaffected. Thus, drivers have a high level of physical and psychological comfort, and limited impact from minor accidents (Penny, 2021). In

rapidly developing areas like Palayan City, LOS B is desirable and a minimum of LOS C is acceptable given the expectation of drivers. Furthermore, the existing roadways might not be feasible to provide a high LOS, therefore, a well-designed balance of lane numbers around the existing number of lanes must be achieved (Queensland Government - Department of Main Roads Road Planning and Design, 2005).

For this study, a vehicle count survey was conducted last November 25, 2022, along the same location to assess changes from the prior year as shown in Figure 12. There were a total of 16,031 pcu passes along Nueva Ecija-Aurora Road (Palayan to Cabanatuan, and vice versa). Based on the survey, it is commonly seen that the highest number of vehicle trips occur between the hours of 7:00 and 8:00 in the morning and 4:00 and 5:00 in the afternoon, which were considered peak or rush hours along Nueva Ecija-Aurora Road as shown in Figures 13 and 14.

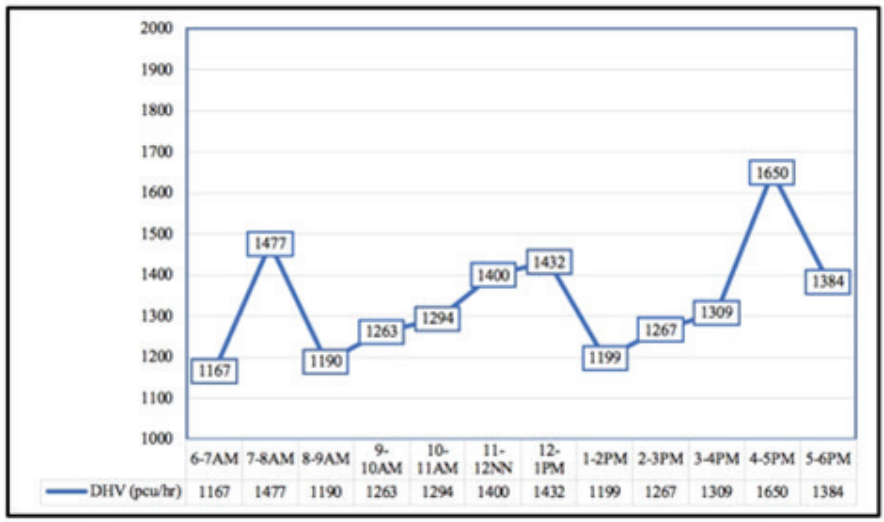

Figure 12: Vehicle Count Survey (as of 2022)

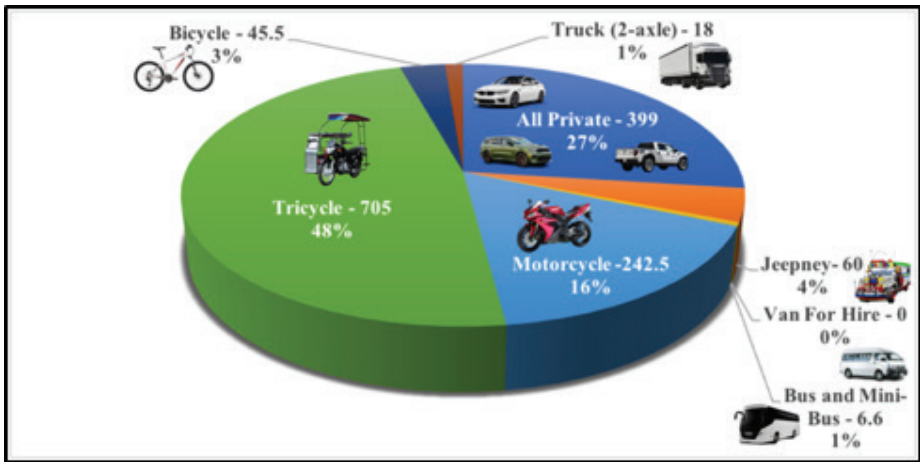

Figure 13:Vehicle Count Survey (Peak Hour: 7–8AM)

To assess changes from the prior year, the DHV and V/C Ratios (per case) were also computed to determine the LOS of existing roadways (as of 2022).

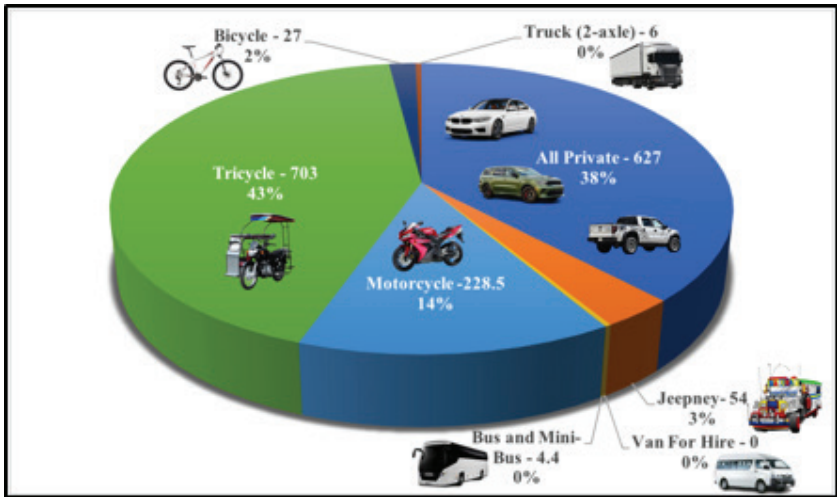

Figure 14: Vehicle Count Survey (Peak Hour: 4–5PM)

Based on the results, Nueva Ecija-Aurora Road along Palayan City still operates in LOS B as shown in Table 10. However, Ordinance No. 55 was implemented last June 2021, where all slow moving vehicles (tricycles, motorcycles, bicycles, e-bikes, tractors) are prohibited from plying and using the innermost lanes of the national roads. As a result, the vehicle count survey conducted this year reveals

that the majority of the slow-moving vehicles used the outermost lanes of the road. Additionally, the presence of bicycles and e-bikes were also noticed. Thus, it is feasible to consider the bicycle as an alternative transportation mode. As Palayan City is not particularly big in terms of square kilometers and the outlying residential areas are not far from the center, it can be traveled using a bicycle. Furthermore, cycling is a sustainable means of transportation that can improve city traffic management, and helps to reduce carbon emissions. However, to implement this, a comprehensive plan is required to create an efficient bike network. It is vital to have long-term strategies, cycle networks, safety standards, financial resources, and promotional campaigns. Once the city government of Palayan creates a cycling policy, inhabitants will perceive cycling as a viable option for daily transportation. This initiative can help to sustain its level of service.

Case Level	Peak hour	DHV (pcu/ hr)	Carriage Width (m)	Basic hourly capacity in both directions	V/C Ratio	LOS
1. Do nothing (inner lane; with few motorcycles and tricycles)	7–8AM	863	7.0	2,400	0.36	B
	4–5PM	1065	7.0	2,400	0.44	B
2. Motorcycles, tricycles and bicycles only (outer lane)	7–8AM	614	6.10	1,900	0.32	B
	4–5PM	585	6.10	1,900	0.31	B

Table 10. Level of Service of Nueva Ecija-Aurora Road (as of 2022)

Compliance with DPWH Standard Guidelines

The Nueva Ecija-Aurora Road is one of the two primary or major roads traversing through Palayan City. It runs across the northern portion of the city (Cluster I), including the Poblacion area (Cluster II).

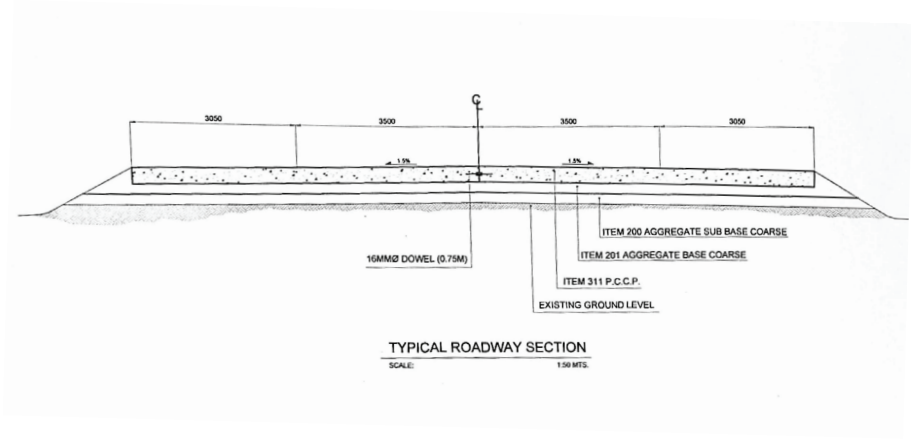

Figure 15: Nueva Ecija-Aurora Road Width (Along Palayan City). Note: Adapted from Provincial Government of Nueva Ecija - Engineering's Office (2022).

The Nueva Ecija-Aurora Road along Palayan City has a carriageway width of 7.0 m (3.50 m lane width in each direction) as shown in Figure 15. For the previous years, road widening projects were done by DPWH as the existing road width is not adequate for the demand, resulting in traffic. Road widening projects improved traffic safety, as well as its capacity. At present, the majority of Nueva Ecija-Aurora Road has shoulder pavements with a width equivalent to 1 full lane (3.05 m). These outermost lanes of Palayan City were mainly used by slow-moving vehicles (tricycles, bicycles, pedicabs, e-bikes, tractors, etc.) as the city government strictly implemented Ordinance No. 55, which bans them from plying on the innermost lanes.

The given measurements correspond with DPWH Standard Guidelines, specifically for bike lane development. The minimum width required for a bike lane is only 2.44 m, whereas the outermost lane for slow-moving vehicles has a width of 3.05 m. With these results, biking on National Highways along Palayan City is feasible.

For future bicycle lane projects, Palayan City should consider Classes II and III of the DPWH MC 2020-88. For Class II, a portion of a roadway is designated for the exclusive use of bicycles and is separated from the motor-vehicle roadway through pavement marking or physical separation. Meanwhile, Class III is a shared roadway where a part of a roadway has been officially designated and marked as a bicycle route but can also be used by motor vehicles due to limited carriageway width.

CONCLUSIONS AND RECOMMENDATIONS

In line with the determined physical criteria, the four selected barangays (Brgy. Atate, Brgy. Singalat, Brgy. Caimito, and Brgy. Santolan) cover approximately 0.85 to 6.0% of the total land area. They are densely located on flat to gently sloping areas, which are suitable for bike lane development. Meanwhile, the four barangays are mostly covered with cultivated areas as discussed in the environmental criteria. Typically, these areas are suitable for industrial development and urban growth. However, these scenarios may affect the land cover of the city, particularly in Cluster II or Poblacion areas. In this study, developing a bicycle lane is suitable in Palayan City, considering the determined physical and environmental criteria.

On the other side, the LOS as calculated for Nueva Ecija-Aurora Road is found to be at LOS B against all the peak hour traffic based on the vehicle count survey conducted last May 2021. Furthermore, the same result was found in last year's vehicle count survey where the reasonably free flow of speed is maintained. However, some changes were noticed: (1) the majority of the slow-moving vehicles utilized the outermost lane due to the enforcement of Ordinance No. 55; (2) the presence of bicycles and e-bikes was observed; and (3) there is an increase in pcu compared to the previous vehicle count survey as the COVID-19 pandemic ends.

In consideration of the road width of Nueva- Ecija Aurora Road, the development of bike lanes is also suitable. The outermost lane of the road has a width of 3.05 m which corresponds to the DPWH-prescribed minimum measurement of 2.44 m.

As Palayan City is not particularly big in terms of square kilometers (101.40 km^2 and the outlying residential areas are not far from the center, it can be traveled using a bicycle. However, to implement this, a comprehensive plan is required to create an efficient bike network. Also, developing the necessary infrastructure will encourage local officials and the public to use bicycles. Once the city government of Palayan creates a cycling policy, inhabitants will perceive cycling as a viable option for daily transportation. This initiative can help to sustain its existing level of service.

Based on the conclusions derived, the following recommendations were formulated.

For Future Researchers. Many previous studies have focused on measures to encourage bicycle use and a positive attitude towards cycling. In addition to these, it is necessary to identify and consider other measures or criteria that influence the utilization of bicycles. Also, consideration of other major or primary roads of an area, as well as its barangays, is vital to determine if they are also suitable for bike lane development. Thus, incorporating other systems or processes with GIS is needed for better analysis methods.

For the City Government of Palayan or Other Local Government Units (LGUs). The successful implementation of Ordinance No. 55 in Palayan City reveals that the majority of the slow-moving vehicles used the outermost lanes of the road. Thus, more effort from the city administrators is needed to maintain this scenario. The condition of existing roadways should also be monitored and there must be an improvement of the Inter and Intra City Circulation Network. Furthermore, it is necessary to create or adapt policies to make the areas more bike-friendly. The DILG M.C. 2020-100 can be used as a main guide for the establishment of a network of cycling lanes to support people's mobility. Identifying new bicycle routes must also be considered to promote a sustainable transportation system.

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Danica Shine Q. Sagnip is a graduating student of Master of Arts in Environmental and Habitat Planning at Saint Louis University, Baguio City. She graduated Bachelor of Science in Environmental Science, cum laude at Nueva Ecija University of Science and Technology last 2019. She also received the highest non-academic awards: Student Leader of the Year and Departmental - Leadership Gold Awardee. She is currently employed as Project Development Officer in the Planning and Development Office at the Provincial Government of Nueva Ecija. She is very passionate about the environment versus pollution. In fact, she is a devoted supporter of Ms. Gina Lopez. She is also much interested in sustainable transportation planning. Since then, she wants to become a registered and licensed Environmental Planner.

Mark P. de Guzman is a Professor at the Civil Engineering Department at Saint Louis University. His expertise includes transportation engineering, traffic engineering, road safety, traffic impact assessment (TIA), structural analysis, and design. He does TIA studies to encourage building owners to cooperate with the local government in mitigating traffic congestion that is brought about by their establishments due to trip attraction and production. He is an advocate for road safety and he looks forward to doing road safety audit projects to minimize road crash collisions and vehicle-pedestrian-related accidents.