TRIP DESIGNATION FOR E-TRIKES AT ROBINSONS PLACE MANILA: DETERMINING OPTIMAL ROUTE ALONG ERMITA AND MALATE USING FOUR STEP MODEL

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Abstract

The E-Trike operating system of Robinsons Place Manila functions as a point-to-point transportation system identical to private vehicle service. This results in lesser people being transported while occupying road space, a slower operating system, and lower accommodation for travel demand. The study conducted to establish an exclusive route along Ermita and Malate for the said E-trikes to transport more passengers and have an increase in accommodation towards the travel demand around the areas of Ermita and Malate. The study conducted a Household Interview Survey among the residents of Ermita and Malate, having a total of 399 respondents. The study utilized the obtained data such as socio-economic and demographic data, origin and destination locations, and mode preference, and conducted the four-step model. After conducting the procedures of the four-step model, the study generated trip generation models which determine trip forecasts after 10 years. Furthermore, the study found that there is 53.38% of patronage for E-Trikes as a mode of transportation. Lastly, the study was able to construct an exclusive E-Trike route following the principle of the Shortest Path Method which resulted in a cumulative distance of 10 kilometers with the use of Google Maps and DPWH GIS.

Keywords: E-Trike, Household Interview Survey, Four-Step Model, Trip Assignment

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1. Introduction

The traffic congestion in Manila, Philippines, with a congestion level of 53%, ranked fourth among the 416 cities surveyed worldwide with the worst traffic congestion (TomTom, 2020). With this congestion level causing additional travel time, road users (i.e., drivers and commuters) struggle to go to their destinations, especially during rush hours in the city. Considering the yearly increase of motor vehicles in Metro Manila, roads and infrastructures are becoming incapable of accommodating such an increase.

The country's land transportation current status is evidently dependent on private vehicles rather than public transportation. A total of 1.1 million private cars were registered in the country in 2020 (Statista Research Department, 2021), and this massive number of private vehicles mostly occupy public roads compared to public transportation. Due to the road occupation of private vehicles, the design of roads and infrastructures, and the traffic management focused on faster travel for private vehicles, often neglecting road safety and air quality, resulting in adverse effects to the commuters and traffic congestion (Siy, R., 2020).

In June 2021, it was stated that 50% of the 8,681 respondents of a survey conducted in the Philippines were likely to use public transportation in the next six months, while 34% were not likely to use it and 16% abstained (Statista Research Department, 2021). The likelihood of patronage for public transportation should be accommodated with reliable public transportation vehicles in order to encourage people to use them. The Philippine government continuously plan to implement solutions on how to eliminate traffic congestion by improving existing public transportation system and providing alternative services, such as electric vehicles, extension of rail transit system, construction of subway, etc.

Non-government organizations have partnered up with the Philippine government in developing cleaner and quieter public transit electric vehicles (EV) to replace motor vehicles which emit CO2 gases (Pandika, M., 2014). An example of this electric vehicle is the E-trike, which is a three-wheeled electric vehicle used as an additional mode of public transport and an alternative for traditional tricycles in the country. Before the pandemic, wherein social distancing was not yet implemented, E-trikes had a maximum passenger capacity of eight to ten people, while the traditional tricycle can only load three to four passengers (Balaria, F. et al., 2017). Therefore, E-trikes aid drivers in earning more due to the increase of passenger capacity compared to traditional trikes while also being environmentally friendly.

The E-trike project was first launched in April 2017 by the Estrada administration in Manila City, having the pilot site taken place in District 3, with the aim of mitigating air pollution and providing livelihood for tricycle drivers who need financial support (Araneta, S., 2017). The current E-trike service as a public transportation vehicle is still in operation in Manila and various places around the country. However, some of the E-trikes travel with no specific route and transit passengers to any point, resulting in an increase in road vehicle occupancy as it functions indifferent than a cab or a private vehicle. The operation of E-trikes situated at Robinsons Place Manila began around the first month of the year 2021 with a maximum capacity of six passengers functioning as a “to any point” system. It's also referred to as a “special trip” wherein passengers will pay for the maximum capacity of the vehicle to travel. The E trikes currently run in the same manner while having a maximum passenger capacity of ten people.

The mall is near Taft Avenue and Roxas Boulevard, which are one of the most traffic-congested areas in the city (Grecia L., 2019), along with other universities and government facilities. With the operation being “to any point”, the vehicles are not utilizing its passenger capacity, occupies road and parking space due to lack of exclusive route. The E-trikes of Robinsons Place Manila operate similar to a private vehicle. However, private vehicles, and number of motor vehicles significantly contribute to the severity of traffic congestion around Metro Manila (Regidor J., 2021). It is in this light that this study was conducted with the aim of establishing an optimal e-trike route based on transportation engineering principles, that operates to travel roundabouts around the area to accommodate the travel demand.

The number of motor vehicles in Metro Manila has been growing each year, it being the main cause of traffic in the city and costing the country at least 3 billion a day (Navarrete, P., 2015). Aside from the money wasted each day, the traffic situation in the Metro also costs people time and energy. The area of Ermita and Malate, surrounded by universities and government facilities such as the Manila City Hall, Manila Central Post Office, National Library of the Philippines, National Museum, and Rizal Park, is one of the busy roads within Metro Manila.

Some E-trike units have been operating all over the country with no well-defined routes, functioning as point-to-point transportation to transit passengers to their destination. Robinsons Place Manila, located at

Ermita, has been allowed by the City Government to deploy E-trike services with the same operation system. However, this system occupies road space while only transporting few people than it can, not utilizing its vehicle occupancy. Given the traffic situation in the country that the Philippine government is still trying to solve, point-to-point system of E-trikes would be an added influence on the traffic.

The study aimed to study the locale, utilized the roads, and provided an optimal route for the E-trikes situated at Malate and Ermita and having Robinsons Place Manila as their terminal. Using Four-Step Method to assign an exclusive route, and also aimed to promote clean and green alternative mode of transportation.

2. Objectives of the Study:

The main objective of this study is to designate an exclusive route for E-trikes stationed at Robinsons Place Manila within areas of Ermita and Malate using the Four Step model.

1. To determine the trip attraction and trip production by analyzing the data collected from the survey questionnaires.
2. To determine the likelihood of people to travel using E-trikes as an alternative to other modes of transportation through Multinomial Logit Model of the Four Step Model.
3. To develop an exclusive optimal route for E-trikes at Robinsons Place Manila within Ermita and Malate.

3. Methodology:

Figure 1 shows the conceptual framework of the study which illustrates the flow of activities and procedures that were followed in achieving the objectives of this study.

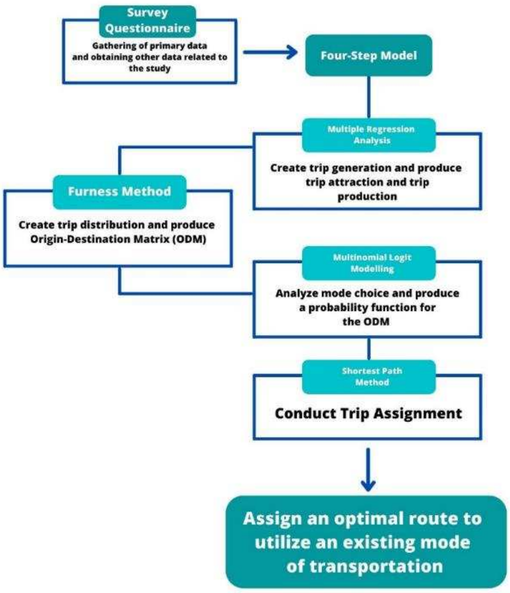

Figure 1: Conceptual Framework for Trip Designtion for E-trikes at Robinsons Place Manila

3.1 Multiple Regression Analysis:

Multiple Regression Analysis, also known as Multiple Linear Regression (MLR), is a statistical technique that is greatly used in analyzing relationship between a single dependent variable and several independent variables, with an aim to apply independent variables with known values to predict the value of the single dependent, wherein predicted value is weighed and are indicated as relative contribution to the overall prediction (Moore, et. al., 2006).

In this study, MLR was used in predicting outcome of a response variable (Hayes, 2021) which was used in developing trip generation which helped in producing trip production and trip attraction by using the formula:

$$\mathbf{Y} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1} \boldsymbol{x_{i1}} + \boldsymbol{\beta_2} \boldsymbol{x_{i2}} + \cdots + \boldsymbol{\beta_p} \boldsymbol{x_{ip}} + \boldsymbol{\epsilon} \quad \text{(Eq III – 1)}$$

where,
Y = dependent variable
$\boldsymbol{\beta_0}$ = y-intercept (constant term)
$\mathbf{x_i}$ = explanatory variables
$\boldsymbol{\beta_p}$ = slope coefficients for each explanatory variable
ε = model's error term or residuals

3.2 Furness Method:

In this study, Furness Method was used in the development of trip distribution that will help in producing the output of Origin-Destination Matrix. The Furness method was invented by K.P. Furness in 1965 which requires the forecast trips origin and destination for each zone to make the present trip matrix similar to the forecasted trip origins and destinations alternatively until both terms are satisfied (nptelhrd, 2012).

A book entitled *"Introduction to Transportation Engineering"* by Tom V Mathew and KV Krishna Rao (2007), explained the Doubly Constrained Growth Model, also referred to as the Furness method in carrying out Trip Distribution for the trip table or OD matrix. The method is applicable if there is available information about growth rate for trip origins and trip destinations are available for each zone-to-zone travel. This is used for distributing the forecasted values of trip origins and destinations of each zone to each cell of the trip table. This method is a process of iteration wherein growth factors of trip origins and destinations are alternatively applied until convergence is reached.

$$\mathbf{T_{ij}} = \mathbf{t_{ij}} \times \mathbf{O_i} \times \mathbf{D_j} \qquad \text{(Eq III – 2)}$$

Where, O_i and D_j are balancing factors

3.3 Origin-Destination Matrix (ODM):

As described by Ekowicaksono et al. (2016), Origin-Destination Matrix describes the movement of people within certain areas. In estimating ODM, the following assumptions are used: (1) forces between two different zones are related to some existing parameters such as population, social-economic condition, etc., and (2) the movement of the people are influenced by accessibility from origin to destination, which is affected by distance, time, and/or cost.

In this study, ODM was produced by tallying the number of responses that traverse to each zone-to-zone travel. Furthermore, in carrying out trip distribution and went through the Furness Method as a requirement in achieving the objective of the study of planning a transportation route and coming up at the traffic pattern between various points.

3.4 Multinomial Logit Modelling:

Great Learning Team (2021) describes Multinomial logit modelling/Multinomial logistic regression as a "use to predict the probabilities of categorically dependent variable, which has two or more possible outcome classes." A Transportation Engineering lecture from IOWA University (2015) discusses Logit Modelling as it considers the utility of each mode based on different modal attributes (e.g., time, cost,) and estimating regression models that would follow the logistic distribution.

$$\mathbf{U_m = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n} \quad \text{(Eq III –2)}$$

Where:
Um = Utility of Mode β = Coefficient for attribute
n = number of attributes
X_i = attribute value (time, cost, etc.)

The logistic distribution would follow the probability distribution which determines the probability of a person choosing a mode over others. Furthermore, the lecture discusses that if Auto or Transit modes are considered the probability of a person to choose auto would be expressed as:

$$\mathbf{P_A = \frac{e^{U_A}}{e^{U_A} + e^{U_T}}} \quad \text{(Eq III - 3)}$$

Where:
P_A = is probability of Auto
A = Auto
T = Transit

Multinomial logit modelling was used in this study for carrying out the step Mode Choice as it determined the probability of the passengers choosing to travel by E-trike over any other mode.

3.5 Shorted Path Method:

The shortest path problem aims to determine the path between two nodes with minimized weights on its constituent edges (Zhang Z. et al., 2010). The shortest path method was utilized in this study to determine the optimal path to designate the route for the E-trikes with least cumulative distance.

3.6 Phase 1: Conducting the Study

In conducting the study, it is important to determine information considering research specifications that was qualified to the research design. In this method, a Household Interview Survey was formulated and primary data (i.e., vehicle ownership, income, occupation, etc.) needed in order to proceed to the following methods.

The questionnaire was designed using descriptive formulation that aided in better understanding of the respondents' answers. The data collected consisted of socio-economic data, modes of transportation used by the respondents to travel within the area of study, as well as the originating locations and designating locations of travel. These essential data aided the researcher in conducting the four-step model. Manila's Comprehensive Land Use Plan and Zoning (MCLUPZO 2005-2020) (Fig 2) was used as basis of zoning to organize and gather the origin and designation locations of the respondents. Furthermore, it was also utilized in constructing the Origin and Destination Matrix in conducting the Four-Step Model.

3.7 Phase 2: Four-Step Model:

In this phase, the Four-Step Method is followed with different steps and analysis which was conducted after collecting the data from the survey. The 4 steps are significant processes namely, Trip Generation, Trip Distribution, Mode Choice, and Trip Assignment which are the procedures of in achieving the goals of the study as it outputs an established route for the said E-trikes of the study.

Step 1: Trip Generation

The use of multilinear regression models and analysis was conducted for the first step of the four-step method. Total existing trips generated from a certain area (zone) acted as the dependent variable of the regression model, while the independent variables are the demographic and socio-economic data projected 10 years into the future which are obtained from the HIS, these are income and vehicle ownership after 10 years for trip production, and number of students and workers after 10 years for trip attraction. The main output of this step were the multilinear regression models of trip production and trip attraction with the independent data with the use of Microsoft Excel. The generated models in carrying out this step was used for the next step Trip Distribution in distributing the forecasted trips. The forecasted trips were determined by inputting the forecasted values of the independent variables of the trip production and trip attraction models.

Table 1. Growth rates of independent variables after 10 years (from PSA, 2017)

Variable	Growth Rate
Income	5.6%
Vehicle Ownership	9.18%
Workers per zone	0.67%
Students per zone	1.06%

Step 2: Trip Distribution

The construction of OD matrix and its zones came from the MCLUPZO 2005-2020 and from the survey responses organizing common origins and destinations of the respondents. The matrix went through the process of Furness Method also referred to as Doubly Constrained Growth Model, which used the gathered existing number of trips per zone and the forecasted trips origins and destinations per zone (calculated by trip production and trip attraction models) in determining the growth factors. The quotient of the forecasted trips (production and attraction) divided by the total existing trips (origin and destination) indicated the growth factor of each zone. The growth factors of trip production (origin) were used in adding up the values of trips per zone-to-zone travel, then was followed up by adjusting the trip values with the growth factors of trip attraction (destination) repeating the same process done for the growth factors of trip production. The process of iteration repeated up until the values of the total trips have an error ranging from 0 to 0.05 is reached.

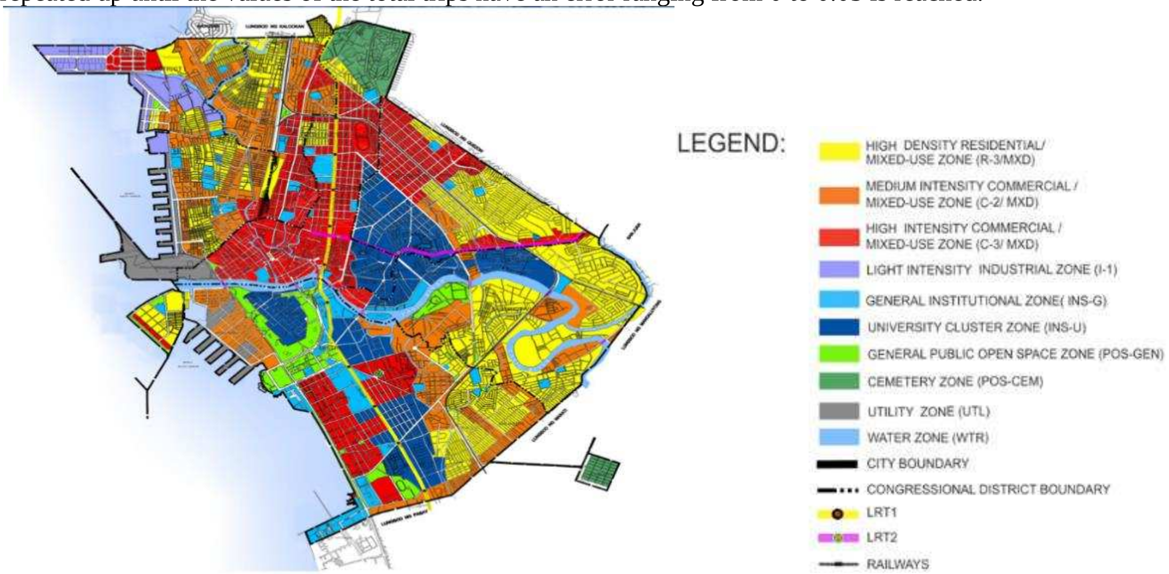

Figure 2. MCLUPZO 2005-2020 (Clemente, S., n.d.)

Step 3: Mode Choice

Data from the survey was used in this study and determined the likelihood of people choosing to travel by E-trike through the process of Multinomial Logit Modelling (MLM). This began by constructing a travel cost and travel time matrix with different modes of transportation per zone-to-zone travel, followed by generating a utility function for each mode having travel cost and travel time, which will be gathered from the survey, as the independent variables. A utility matrix was constructed and used to determine the probability of people choosing a mode of transportation over other modes. Lastly, the modal share was calculated by getting the product of probability of each mode with the number of forecasted trips from trip distribution, this determined the number of forecasted trips generated on zone-to-zone by a mode of transportation.

Step 4: Trip Assignment

Shortest path method was utilized in this study in determining and establishing the optimal route for the E-trikes situated at Robinsons Place Manila. The paths from this method were determined by using Google Maps and Road Information from DPWH to link the path to high demand areas as well as minimizing the travel time and distance and utilizing available roads. The generated route focused only on accommodating high demand areas of the research locale, a looping route starting from the mall and making its way back to it. Other parameters such as the need for additional terminal location, charging station locations, and unloading areas were not considered in designing the route.

An estimated maximum route length that loops around Ermita and Malate was constructed linking known landmarks and locations with the aid of Google Maps. A total of 7.4-kilometer route was computed for the looping route around the area of Ermita (Fig. 3) and 5.9 kilometers for the area of Malate (Fig. 4). For Figures 3 and 4, the points on the figures are only features in projecting and connecting line paths on the Google Maps application and do not represent specific locations or stations in the route.

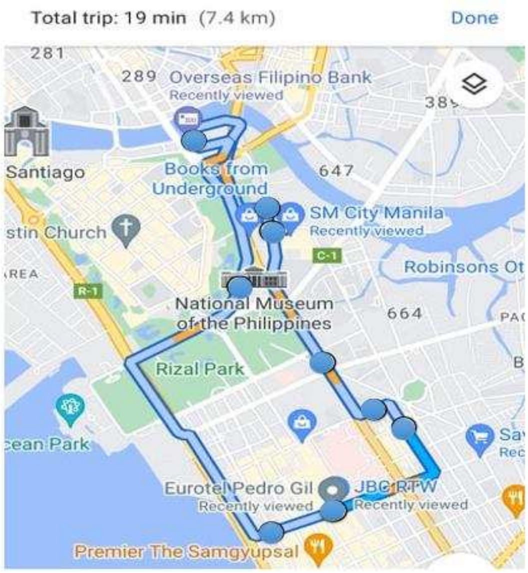

Fig. 3 Estimated Maximum Route for Ermita

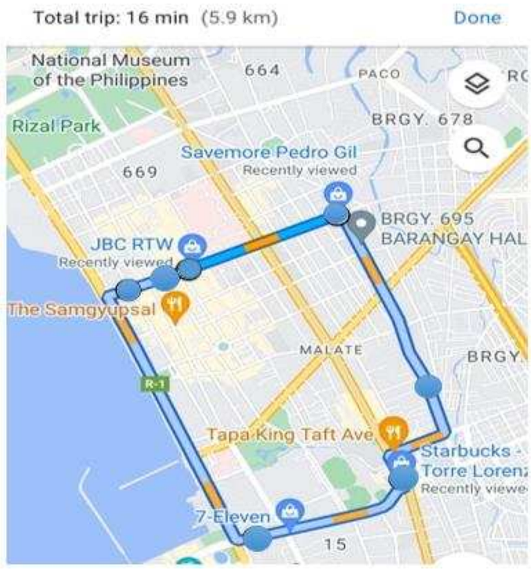

Fig.4 Estimated Maximum Route for Malate

4. Results and Discussion:

The data of originating and designating locations obtained from the study was gathered and organized to zones present in the MCLUPZO. The MCLUPZO divided the area of Manila basing on its land use (See Figure 2). The study focused on the research locale, utilizing MCLUPZO and was able to construct thirteen (13) zones in total (See Figure 5).

Zone	Land Use
1	General Institution Zone & General Public Open Space
2	University Cluster Zone & Medium Intensity Commercial/Mixed Use
3	General Institution Zone & General Public Open Space & Medium Intensity Commercial/Mixed Use
4	General Institution Zone
5	High Intensity Commercial/Mixed Use & General Public Open Space
6	University Cluster Zone
7	General Institution Zone
8	General Public Open Space
9	Medium Intensity Commercial/Mixed Use
10	General Institution Zone
11	High Intensity Commercial
12	High Intensity Commercial/Mixed Use
13	Medium Intensity Commercial/Mixed Use

Figure 5: Gathered Zoning and Land Use Classification

5.1: Trip Generation:

Trip Generation yielded regression models for Trip Production and Trip Attraction which both determine the forecasted number of trips originating and trips designating ten years from now. Trip productions are the number of trips that originate from a zone, the inputted variables used to generate its model are socio-economic data of a household, such as household income, and vehicle ownership, after ten years. Table 2 presents the forecasted values after applying the given growth rates from PSA (2017).

Table 2. Existing and Forecasted (After 10 years) Income and Car Ownership

Zone	Present		After 10 yrs	
	Household Income	Vehicle Ownership	Household Income	Vehicle Ownership
1	52500	1	90531.24343	2.406749552
2	49062.5	4	84603.60249	9.626998209
3	0	0	0	0
4	0	0	0	0
5	56235.29412	48	96972.40193	115.5239785
6	49166.66667	82	84783.22798	197.3534633
7	40714.28571	2	70207.90307	4.813499105
8	0	0	0	0
9	42976.19048	37	74108.34213	89.04973343
10	0	0	0	0
11	51190.47619	10	88273.0945	24.06749552
12	80000	0	137952.3709	0
13	52105.26316	16	89850.55739	38.50799284

On the other hand, trip attractions are number of trips that designate to a zone. The input variables used are also forecasted number of students and number of workers (Table 3).

Table 3 Existing and Forecasted (After 10 years) number of students and workers per zone

Zone	Present		After 10 yrs	
	Worker	Student	Worker	Student
1	9	2	10.00082	2.138113
2	35	23	38.89206	24.5883
3	0	0	0	0
4	0	0	0	0
5	204	98	226.6852	104.7675
6	422	155	468.9272	165.7038
7	19	4	21.11283	4.276226
8	0	0	0	0
9	86	51	95.56336	54.52188
10	0	0	0	0
11	62	21	68.89451	22.45019
12	2	3	2.222404	3.20717
13	34	13	37.78086	13.89774

The resulting forecasted values were the X1 and X2 variables for Trip Production and Trip Attraction, respectively, and the Y input were the existing trips originating and designating per zone which utilized assumed factors that the researcher adopted from the study of Ahmed Bayes (2012) which utilized the Four Step Model to construct a transport network in Dhaka City, Bangladesh. The existing trips for Trip Production was determined by utilizing the family class, indicated from the surveyed household income responses of each respondent present in a zone and having them represent the whole population of a zone. This was determined by calculating the percentage of each family class among the respondents and was then multiplied to the actual population of a zone, followed by multiplying assumed factors, adopted from Ahmed Bayes study in 2012, for each family class which would result to the number of trips. The researcher utilized Microsoft Excel in generating the regression equations.

$$\text{Trip Production} = \mathbf{345.6913 + 0.16898(\mathit{X1}) + 1805(\mathit{X2})} \qquad \text{(Eq V – 1)}$$

Where:

X1 = Household Income

X2 = Vehicle Ownership

5.2. Trip Distribution:

The procedures and computation of the step, trip distribution yielded a 10-year forecast of zone-to-zone travels within Ermita and Malate of all considered public transportation vehicles. The O-D matrix (Table 5.9) presents the tallied origin and destination locations into the created 13 zone matrix. Trip distribution utilized the Furness method in distributing the growth factors, which was determined by the quotient of future and surveyed trips production and trips attraction.

Before conducting the Furness method, the study adopted the procedure of Trip Distribution in the study of Ahmed Bayes (2012) where, “trips attraction and trips destination must be equal”, an adjustment factor was applied wherein the sum of Future Trips Production was divided by the sum of Future Trips Attraction and was multiplied to the Future Trips Attraction/Designation, this made the sum of future trips production and attraction equal (Table 4). The Furness method alternatively applied the growth factors of Trips production and attraction until the matrix reaches unity or an error of 0.05%. Applying the adjustment factor aided the researcher to fully accomplish conducting Trip Distribution by the means of Furness Method, as it made the matrix capable of reaching unity.

Table 4: Origin-Destination (O-D) Matrix

OD Matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	Σ Trips Production	Future Trips Production
1					3					1				4	19989
2	1	2		3	8		1						1	16	32024
3														0	346
4														0	346
5	6	9	6	5	26	13	15			2		2	1	85	225317
6	16	32	7	15	71	27	24	1	1	1	4		5	204	371005
7		1			2	2				2				7	20901
8														0	346
9	2	2	2	1	12	16	3		1		3			42	173653
10														0	346
11	1				5	8	3		2		2			21	58717
12					1									1	23657
13		1	1	2	4	6	1						4	19	85057
Σ Trips Designation	26	47	16	26	132	72	47	1	4	6	9	2	11		
Future Trips Designation	641.7	33436.7	129.8	130	120082	150082.1	753.27	130	70625.3	129.8	18514	5501	13264		

Table 5: Adjusted Future Trip Designation O-D Matrix

OD Matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	Σ Trips Production	Future Trips Production
1					3					1				4	19989
2	1	2		3	8		1						1	16	32024
3														0	346
4														0	346
5	6	9	6	5	26	13	15			2		2	1	85	225317
6	16	32	7	15	71	27	24	1	1	1	4		5	204	371005
7		1			2	2				2				7	20901
8														0	346
9	2	2	2	1	12	16	3		1		3			42	173653
10														0	346
11	1				5	8	3		2		2			21	58717
12					1									1	23657
13		1	1	2	4	6	1						4	19	85057
Σ Trips Designation	26	47	16	26	132	72	47	1	4	6	9	2	11		=
Future Trips Designation	1570	81825	318	318	293860	367274	1843	318	172831	318	45307	13462	32460	=	1011704

5.3. Mode Choice:

Mode Choice utilized the Utility Function of each mode of transportation to determine high demand areas and the probability of choosing a public mode of transportation over different modes of transportation. Utility of each public transportation vehicle. The researcher utilized Google Maps to gather the estimated zone-to-zone travel time of each mode of transportation during peak hours of the day which would serve as the estimated travel time. Google Maps utilizes real time traffic data which aided the researcher to gather approximate results of travel time of public transportation vehicles at peak hours. The estimated travel cost of each mode of transportation was determined by inputting its base fare/minimum fare and its adding fare per succeeding kilometer. Travel cost and travel time served to be the X variables of the utility equation, while its Y input was the number of survey responses for each mode of transportation.

U_{Jeep} = 2.76555 -0.160018 (TT) (Eq. V – 2)

$U_{E\text{-}Trike}$ = 0.042085 (TC) - .028169 (TT) (Eq. V – 3)

U_{Trike} = 3.075 - 0.133405(TC) + 0.26667 (TT) (Eq. V – 4)

U_{Bus} = 0.02255 (TC) - 013161 (TT) (Eq. V – 5)

U_{FX} = 0.0053 (TC) - 0.00382 (TT) (Eq. V – 6)

$U_{\text{Private vehicle service}}$ = -0.022371 + 0.00082 (TC) - 0.008071 (TT) (Eq. V – 7)

U_{LRT} = 0.01622 + 0.017089 (TC) – 0.02576 (TT) (Eq. V – 8)

The utility matrix for E-trike was then constructed representing its utility per zone-to-zone travel. Using multinomial logistic modelling, the study was able to determine the probability of e-trike patronage within the matrix by using the utility values of all modes of transportation per zone-to-zone travel (Table 6).

$$\textbf{Probability}_{E\text{-trike}} = \frac{E^{U_{E-Trike}}}{E^{U_{Trike}}+E^{U_{Private\ Vehicle}}+E^{U_{Bus}}+E^{U_{LRT}}+E^{U_{FX}}+E^{U_{E-Trike}}+E^{U_{Jeep}}} \quad \text{(Eq. V – 9)}$$

Table 6. Probability Matrix for E-Trike

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0.0822	0.0848	0.0998	0.0954	0.125	0.1484	0.1592	0.1825	0.1598	0.1745	0.1332	0.1855	0.1793
2	0.1025	0.094	0.0872	0.098	0.1065	0.1221	0.1324	0.1511	0.1465	0.1386	0.1064	0.1604	0.1519
3	0.0982	0.0872	0.0976	0.1081	0.1127	0.1212	0.1345	0.1505	0.1413	0.1521	0.1519	0.1675	0.1667
4	0.0984	0.093	0.0911	0.1047	0.1034	0.1165	0.1373	0.1437	0.1311	0.1356	0.1399	0.1512	0.1498
5	0.1433	0.1061	0.1357	0.1119	0.1069	0.1035	0.1136	0.1281	0.1211	0.1097	0.1211	0.1384	0.1374
6	0.1498	0.1167	0.1175	0.1101	0.0823	0.1004	0.0907	0.0946	0.0865	0.0884	0.0846	0.1112	0.0986
7	0.1427	0.1284	0.1033	0.096	0.0839	0.0898	0.0477	0.1085	0.1	0.0984	0.1	0.104	0.106
8	0.1648	0.1569	0.1652	0.1462	0.1345	0.1095	0.1011	0.0945	0.1323	0.1006	0.1084	0.1041	0.1
9	0.1618	0.1757	0.1394	0.113	0.1035	0.1019	0.1216	0.1011	0.0591	0.1188	0.0591	0.1125	0.1101
10	0.1646	0.1629	0.1619	0.1483	0.1304	0.1073	0.0982	0.0995	0.1324	0.0995	0.1324	0.1037	0.1037
11	0.161	0.1594	0.1138	0.0924	0.112	0.1069	0.1387	0.1149	0.0558	0.1159	0.062	0.1193	0.1151
12	0.1825	0.1802	0.1607	0.1331	0.1296	0.125	0.111	0.1043	0.1348	0.1042	0.1348	0.0951	0.0858
13	0.17	0.1532	0.1544	0.1435	0.1271	0.1138	0.1236	0.1002	0.1293	0.099	0.1219	0.0927	0.047

The probability values of E-trike were then multiplied to the adjusted O-D matrix to determine its modal share in each zonal travel for 10 years of serviceability (Table 7). This aided the study in determining the high demand areas for E-trike which will be used for the Trip Assignment.

Table 7. E-trike Modal Share Matrix

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0	0	0	0	2484	0	0	0	0	19.7	0	0	0
2	9.344	483.5	0	4.916	2465	0	7.443	0	0	0	0	0	536.9
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	81.23	2543	21.95	9.691	8330	10771	99.2	0	0	11.2	0	1922	503.3
6	120.9	5314	11.84	15.28	9352	11593	67.7	30.02	5339	2.409	1928	0	963.8
7	0	288.7	0	0	424.1	1213	0	0	0	8.479	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	16.73	512.4	4.114	1.071	2038	7143	11.62	0	3737	0	1035	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	2.691	0	0	0	297	1212	4.289	0	2281	0	234	0	0
12	0	0	0	0	3066	0	0	0	0	0	0	0	0
13	0	448.2	4.571	5.458	1673	6000	7.903	0	0	0	0	0	755.8

5.4. Trip Assignment:

Google maps was utilized in establishing a route for E-trikes situated in Robinsons Place Manila that would accommodate the travel demand of the residents of Ermita and Malate. The established route for E-trikes followed the Shortest Path Method to minimize travel distance while connecting high demand areas based on the E-trike Modal Share.

The route starts from Robinsons Place Manila traversing Pedro Gil Street and making a right turn towards San Marcelino Street, followed by turning left to Remedios Street, then going to Singalong Street. The route traverses Singalong Street then turning towards Estrada Street, to enter Taft Avenue, this is followed by the route entering Ocampo Street, traversing it and making a right turn to Mabini Street. The route then traverses Mabini Street making a right turn to traverse a short span of Quirino Avenue and turns left to enter Leveriza street to reach San Andres Savemore Market. The route turns right traversing the street of San Andres, right to enter and traverse Mabini Street until it reaches Kalaw Avenue. The route travels along Kalaw Avenue, making a right onto Maria Orosa Street at Luneta, turning right to Padre Burgos Avenue until reaching the City Hall underpass. The route continues traversing Padre Burgos Avenue until making a right turn onto Cecilia Muñoz Street, turning right onto Antonio Villegas Street and right onto Natividad Lopez St. The route traverses Natividad Lopez Street and making a right turn entering San Marcelino St., this is followed by making a right turn to UN Avenue, entering Taft Avenue, and making a left to Padre Faura Street, traversing it until reaching Robinsons Place P. Faura entrance.

The route overall has a length of 10 kilometers looping around the study area, Ermita and Malate. From the modal share matrix of E-trike all zones have originating and designating trips, therefore the researcher designed the route that would target all zones. The study obtained the classification of road with the use of DPWH GIS, furthermore, the points shown on Figure 6 only serve to show the span of each street and road within the established route.

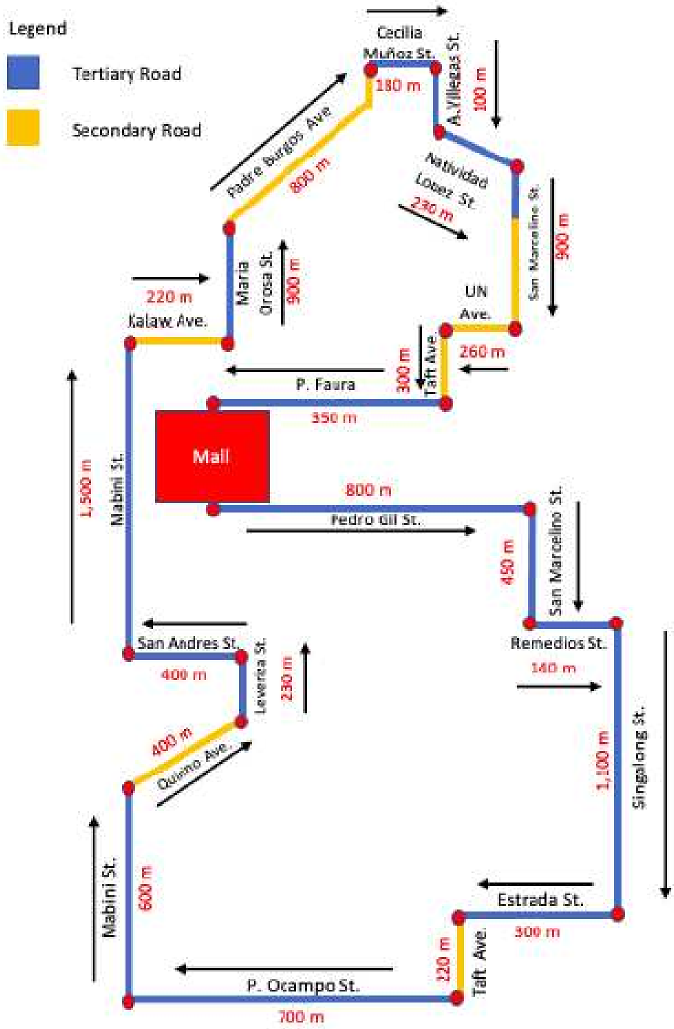

Figure 6. Assigned Robinsons Place E-Trike Route within Ermita and Malate

6. Conclusion:

The study determined the optimal route along Ermita and Malate for E-Trikes of Robinsons Place Manila by conducting the steps and procedures of the Four-Step Model with the use of the data obtained from the Household Interview Survey. Furthermore, the study establishes a route for the E-Trike operating system of the mall to adapt in order to transport more people while traversing along the streets of Ermita and Malate. The study specifically concluded the following:

Trip Generation models were generated with the use of the data obtained from Household Interview Survey, specifically, household income, vehicle ownership, number of students, and number of workers. Furthermore, trip production and attraction models forecasted the number of trips for the next ten years.

The study concludes that there is a 53.38% E-trike patronage from the respondents, which represent the amount of people that are willing to use E-trikes as a public mode of transportation. Furthermore, conducting Mode Choice: Multinomial Logistic Model determined the probability of E-Trike being chosen by the residents over other modes of public transportation. The study area of Ermita and Malate and having the respondents as its residents sets the highest demand modes of transportation which are Jeeps and Tricycles since the study area only has a short distance to travel. Furthermore, with E-trikes having a more expensive fare lead up to its lower usage around the study area and by the residents.

An exclusive route for E-trikes of Robinsons Place Manila has been assigned during Step Four: Traffic Assignment, utilizing several streets and avenues around Ermita and Malate namely, Pedro Gil Street, San Marcelino Street, Remedios Street, Singalong Street, Estrada Street, Taft Avenue, Ocampo Street, Mabini Street, Quirino Avenue, Leveriza Street, San Andres Street, Kalaw Avenue, Maria Orosa Street, Padre Burgos Avenue, Cecilia Muñoz Street, Antonio Villegas Street, Natividad Lopez Street, UN Avenue, and Padre Faura Street. The route has a cumulative distance of 10 kilometers, connecting high demand areas while utilizing the Shortest Path Method.

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