Evaluating the Travel Demand using E-Bike on Campus

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Abstract: Nowadays, Malaysia is facing real problem on traffic issues such as traffic congestion, deficiency of land for parking space and increasing vehicle volume. Cycling is one of alternative approach of transportation to overcome traffic issues. This objective of this study is to forecast the travel demand using E-bike in University and comparison of carbon footprint reduces between E-bikes and motorize vehicle. UNITEN has launched a program called Electric Palled-Assisted Biked (EPAB) as topromotes the usage of E-Bikes as their main mode of transportation in UNITEN Putrajaya campus. All the travellingdata have been recording using Application Strava. The CO_2 emission and fuel cost for those particular tripshave also addressed in these studies.The result found that 107.27 daily trips were generated by E-bikes in UNITEN Putrajaya campus. The study also found that 88 percent of CO_2emission is reduced when substituting car with E-bikes. An astonishing 560.918kg of CO_2 was prevented from releasing to the atmosphere. Cycling has been proven as one of alternative option in developed countries to reduce the vehicle volume on the road. Further studies on these topic is highly recommend by increasing the number of participant in future.

Keywords: Transportations, Quality of Service, Travel Demand.

I. INTRODUCTION

Sustainable transportation is defined as transport that meets the current transport and mobility needs without compromising the ability of future generations to meet these needs [2, 15]. It has become a major factor to take into consideration for economic development, social and human development, and environment and ecological health. Most transportation mode consume depletable resources likewise energy, human and ecological habitats, atmospheric carbon loading capacity and individuals' available time that can lead to future problems.

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But when one form of energy is limited, another form of energy needs to be substituted to compensate for it [7].This only means that relaying on depletable resources will lead exhausting other resources the best solution is simply to exercise resource optimization with the current technological capability's science has to offer [9, 12]. Most the student and staff at any colleges live on campus or relatively walking distant from it. Bicycle offer riders a much faster means transport compares to walking. It also provides a positive environmental impact due to its zero-pollution emission and occupied relatively little space while also providing accessibility to those who would not be able to drive [1]. Relying on these modes of transport as your daily commute can be very beneficial. It helps protect from serious diseases, improve joint mobility, increase physical fitness and lose weight [4. 6]. Although there are many advantages adopting cycling as their main mode of transportation, people are not quick to jump to it as many of them may have already own an automobile be it motorcycle or car. With the introduction of electric bicycle (E-bike) as a superior mode compared to a traditional bicycle particularly in college campuses would help persuade more students and staff members to adopt cycling as their preferred mode when commuting around the campus [14, 20]. College campuses are a major traffic generator and are often face with the problem of increasing congestion, lack of land for parking space, and pressure to reduce traffic's impact on surrounding neighborhood [8, 19]. Proper transportation planning is essential to help mitigate these problems. Transportation planning relies on travel demand forecasting that are mostly emphasize on motorize vehicle.

The rising increase in GHG has push non-motorized transportation alternative like cycling and walking to be taken into consideration for future campus transportation planning [17]. Electric bicycle is been received as great alternative by researcher and people around the world due to its wide potential application [3, 16]. In general, the electric bicycles are not only suitable for driving on many different terrains for example hilly, flat, and mixed terrains, but also more practical in terms of price, accessibility, repairs and maintenance [11, 13]. For facility locator models, the bicycle facility is considered as the trip destination. This technique also assumes that the trips for a specified travel shed are attracted to the facility in proportion to a trip attractor/generator's size and inverse proportion to the distance of separation [18]. Though the facility locator specified in this research were not sensitive to the quality or suitability of these facilities but were sensitive to the presence or absence of the bicycle facilities [22]. Traditional four-step travel models are very similar to the sequential demand models in the third category of technique [21]. The only different is that sequential demand models deals specifically with bicycle travel. This paper presents the forecast of the travel demand using E-bikes in campus, factor influencing the preferability of E- bike compared to regular bicycle and comparison of carbon footprint reduce between E-bikes and motorize vehicle.

II. METHODOLOGY

This study was carried out at compound area of Universiti TenagaNasional (UNITEN), Putrajaya.Due to increasing volume of traffic in UNITEN Putrajaya campus and mitigate the ever-rising Greenhouse gases (GHG) level. UNITEN has employed a program that promotes the usage of E-Bikes as their main mode of transportation in UNITEN Putrajaya campus. The program is called “EPAB Ambassador” where UNITEN Putrajaya campus’s student and staff were given an Electric Paddle-Assisted Bike (EPAB) to be uses for a period of fourteen week or one whole semester. In conjunction with the EPAB Ambassador program, participants were required to catalogue their daily travel base on where their trip begins and ends. Figure 1 shows the Maps of Uniten, Putrajaya and this area have been defined as Traffic Analysis Zone (TAZ).

Fig. 1 The Maps of Uniten, Putrajaya [10]

Participants were asked to submit these entries in an online Google Form. This method helps increase the efficiency and ease the workload of the data collection.As a safety measure, participants were required to download a mobile application called Strava. For accurate data collection, participant must record their trips using the application. The Strava app provides a representation of the participant’s trip travel distance and time. The recorded trip is then uploaded to the previously mention google form. Figure 2 shows the screen capture from Strava apps. From the screen capture of the strava, the trip that the participants make can be verified with all necessary data needed for this study. All the accumulated data from every participant will then be process and analysis at the end of the EPAB Ambassador program.

Besides, surveys have distributed in these studies in order to identified the influence factor for using E-bike preferable in these studies. Several characteristic have been taken in order to develop questionnaire such as the potential market for new product, rating of current product and customer’s opinions. It comprises of two main components. The first is deciding what kind of people to interview. They are often called target population. For this study, the target population should be the residents of UNITEN Putrajaya campus. The second component is determining the sample size

Bicycle trips may be expected to begin or end 3.2 to 4.8 km from either side of the bicycle facility being considered. The boundaries of the area of influence are mark on the map for use in the remainder of the analysis. Local knowledge of bicycling patterns is useful to adjust the size of the influence area. In these study also determined, the amount of carbon dioxide (CO_2) emission is reduced by substituting motorized vehicle with e-bikes. Data collected from previous objective. The trips distance for one participant can be used to calculate the CO^2 emission and fuel cost for that particular trip. The total distance travel by the participant for the given period is used to compare CO^2 emission and fuel cost of each type of vehicle The amount of CO^2 emission produced for each type of vehicle need to determine first. Based on previous studies and monitoring for CO^2 emissions the rate for each type of vehicle are shown in Table 1.

Table.1 Carbon Dioxide emission rate & Fuel Consumption rate [4]

Type of Vehicle	CO^2 emission rate (grams/kilometre)	Fuel consumption rate (litre/100km)
Petrol base car	118.5 g CO^2/km	5.6
Motorcycle	190 g CO^2/km	2.5
E-bikes	22 g CO^2/km	0

Each type vehicle then find the difference for each vehicle CO^2 emission compared to using e-bikes can be calculated using Equation 1 and the fuel cost can be calculated by the following equation 2.

$$Total\ CO2\ emission = Total\ Distance\ Travel \times CO2\ emission\ rate \quad (1)$$

$$\text{Fuel cost} = (\text{Fuel consumption rate})/100\text{km} \times \text{Total distance travel} \times \text{fuel price} \quad (2)$$

III. RESULT AND ANALYSIS

All the data collected from the participants of the EPAB Ambassador Program was sorted and tabulated. The travel trips make by the participant was analysed to give an insight on what the travel pattern of the participants. An E-bikes trip distribution map was develop using the collected data. The map shows the trip distribution of a transportation analysis zone (TAZ) on the study area for this research. The red line on the map indicates the boundaries of the study area. While the black line represents trips from one TAZ to another.

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The TAZ are named and mark with white dots. Figure 2 shows the summary of the number of trip made by participant.

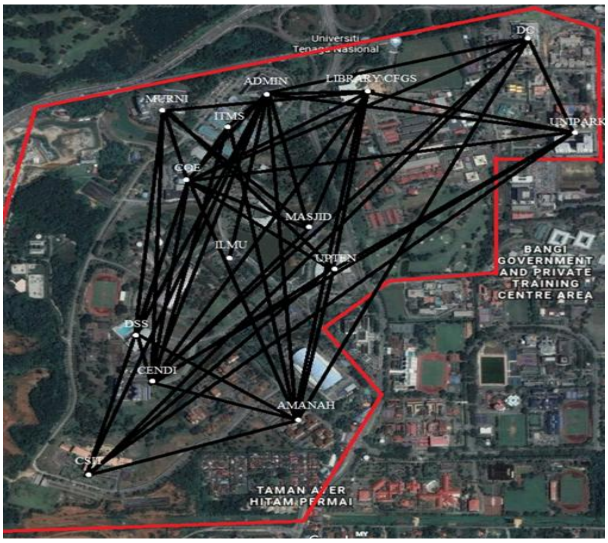

Fig. 2 Trip Distribution Map in Uniten

Figure 3 shows the graph of number of trips form starting location. A large portion of the trip generated from the study area is from Cendikiawan residences (234). The large number of trips originated from CENDI is most likely because many of the participant reside there. Another significant trip generator is the College of Engineering (COE) with 185 trips originated from there. As most of the participant are students of UNITEN, is not a surprise that COE has a large number of trips started there as this where most the UNITEN students attend their class during the day. The total number of trips made was 825 with an average trip for each of the defined TAZ is calculated to be around 63.5 trips over a period of one semester or 14 week.

Figure 4 shows the graph of the number of trips based on end points. All the trip-ends made by the participant are represented in the chart. It shows that CENDI and COE have the highest number of trip-ends of 214 and 195 respectively. These results are similar to the previous chart as it is from the same participants with a slight variation on certain areas. As expected, CENDI and COE is the main trip generator as a large sum of the participant live and attend lecture there. The total number of trip-ends is 815 with an average of 62.7 trips ended at all the TAZ.

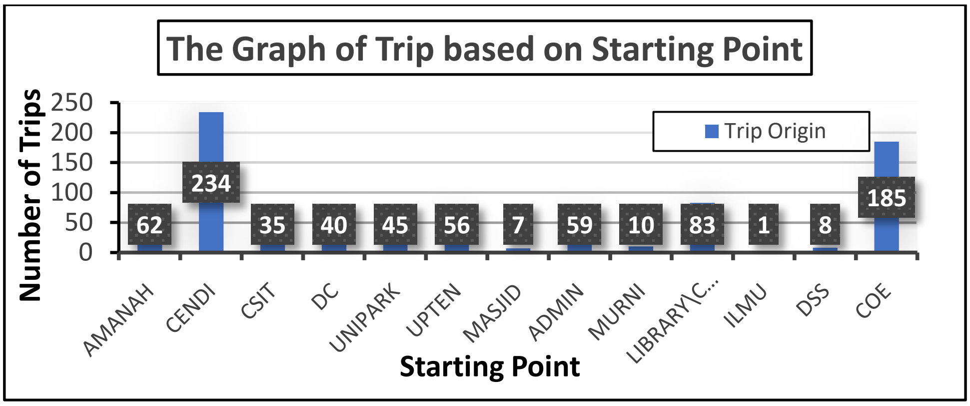

Fig. 3 The number of trip from starting point

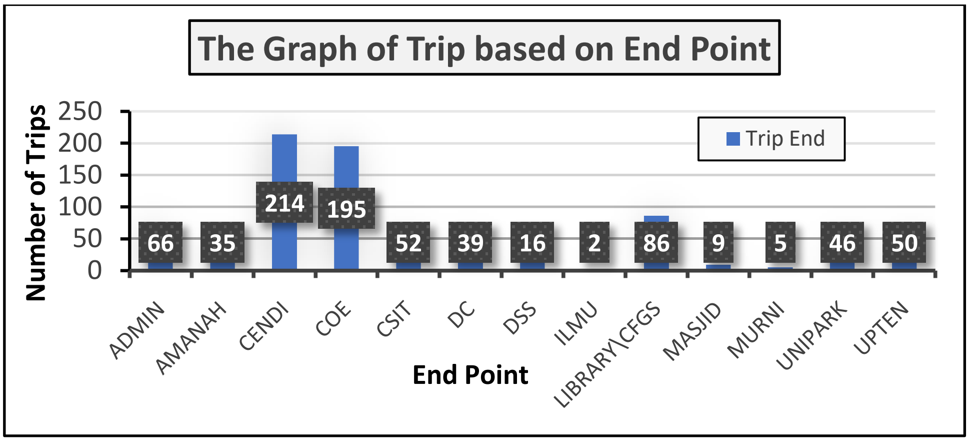

Fig. 4 The number of trip based on end point

There was a short survey have been conducted to all the participant of the EPAB Ambassador program to determine the influence factor of E-bikes preferability. the survey was about the preferability of E-bikes. As discussed in Chapter 2, the factors influencing the preferability of E-bikes over regular bicycle was determined. The questionnaire was design based on these factors. Figure 4.2.7 shows that more than half of the E-bikes users are satisfied with their E-bikes. A very low percentage of the E-bike users are dissatisfied. These bar charts represent the respondent's opinion on whether the mentioned factors affect their preferability of E-bikes over regular bikes. The number below the chart represents how strongly the factors affect them being 1-Strongly Disagree, 2-Disagree, 3-Nuetral, 4-Agree and 5-Strongly Agree. A ranking matrix was developed from the data of the entire respondent to determine the top influence factor of E-bikes preferability as show in Figure 5. From the ranking matrix, Safety and Security (4.28) was determined to be the top influence factor followed by Time Travel Flexibility (4.26), Parking (4.26) and Weather Condition (4.26).

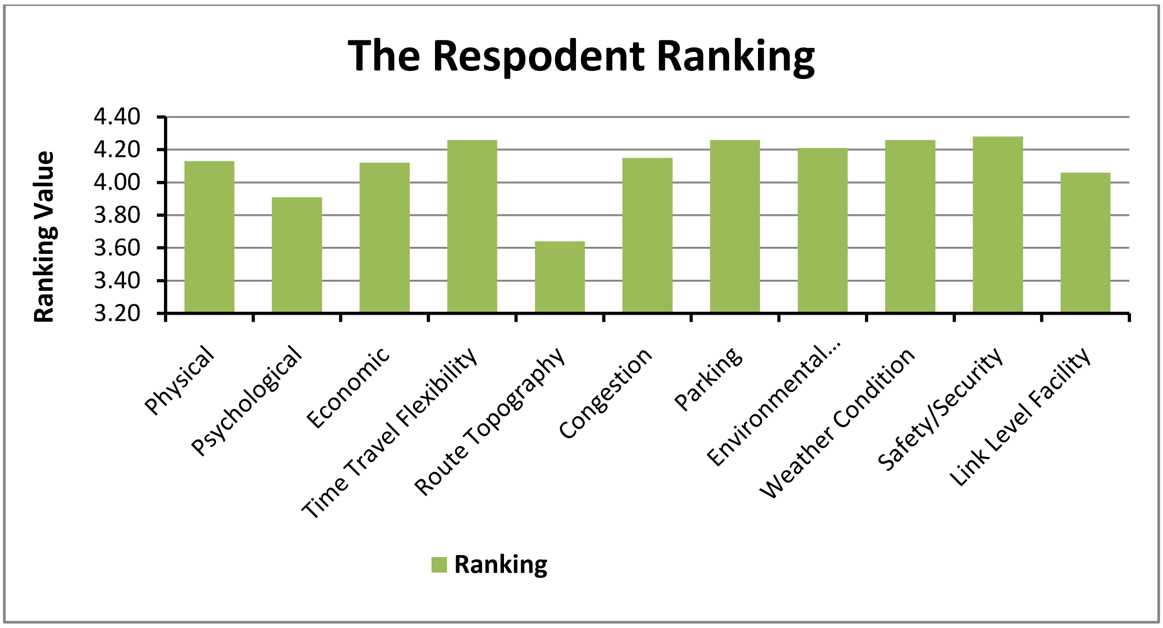

Fig. 5 Influence Factor Ranking Matrix

The amount of Carbon Dioxide (CO^2) emissions have been identified based on the data collected. The amount of Carbon Dioxide (CO^2) emission have been substituting common motorized vehicle used by the participant such as cars and motorcycle with the E-bikes provided by UNITEN. Following the methods that has been discussed in the previous chapter, the collected data from the EPAB Ambassador program that show the distance travelled by every participant was used to calculate the CO^2 emission and fuel cost for each student. Table 2 shows the Carbon Dioxide Emission for selected participation.

Table.2 Carbon Dioxide Emission Produced

Participant	Distance (Km)	CO_2 Emission by (g)			CO_2 Emission Reduced (%)	
		Petrol Car	Motorcycle	E-bikes	Petrol car	Motorcycle
Participant 1	311.18	36874.83	59124.20	6845.96		
Participant 2	389.2	46120.20	73948.00	8562.40		
Participant 3	358.25	42452.63	68067.50	7881.50	81	88
Participant 4	223.07	26433.80	42383.30	4907.54		
Participant 5	203.35	24096.98	38636.50	4473.70		

The accumulated amount of CO2 emission produced if the participant was using car by the entire participant is calculated to be 395.647kg. For when motorcycle is used, the total CO2 produced is 634.372kg. To accurately simulate the daily travel routine of the participant when there were using motorized vehicle, the recreational trip made using E-bikes by the participants were not taken into accounted for the calculation of the total CO2emission. The amount of carbon footprint reduced when substituting motorize vehicle with E-bikes determine by comparing the total CO2 produced when using E-bikes to when using motorized vehicle. For if the participant was using petrol-based car as their mode of transport before, there is an 81 percent drop in CO2 release. Whilst for motorcycle, there's a slight bigger reduction of CO2 emission which is by 88 percent. This study also identifies the total fuel that can be saved by using E-bike. The estimated fuel consumption for each type of vehicle is based on fuel price. The fuel prices were RM 1.93/liter and RM 2.23/liter for Petrol RON 95 and Petrol RON 97 respectively as of 2th February 2019. Since E-bikes uses the manpower of the user, there's no fuel needed to power up the bike. The amount of money save can be determined as shown in Table 4. Although the amounts of money save is much, where RM 42.06 was the highest only because the participant travelled the most with a total distance of 311.28 km. This amount can accumulate over time as the longer the participant uses the E-bike.

Table. 4 Fuel cost Estimation

Participant	Distance (KM)	Fuel Consumption (L)		Fuel Cost (RM)
Participant 1	311.18	Petrol Car	17.426	33.63
		Motorcycle	7.780	15.02
Participant 2	389.2	Petrol Car	21.795	42.06
		Motorcycle	9.730	18.78
Participant 3	358.25	Petrol Car	20.062	38.72
		Motorcycle	8.956	17.29
Participant 4	223.07	Petrol Car	12.492	24.11
		Motorcycle	5.577	10.76
Participant 5	203.35	Petrol Car	11.388	21.98
		Motorcycle	5.084	9.81

IV. CONCLUSION

This study has was aimed the forecast of the travel demand using E-bikes in Malaysia and comparison of carbon footprint reduce between E-bikes and motorize. , it can be concluded that the estimated number of trips generated by E-bikes in UNITEN Putrajaya campus to be 107.27 trips per day. Even though these number does not represent the number of people cycling in UNITEN. The results are believed to still be useful in addressing the question of how many cyclists using or will use a specific facility. However, the growth of cyclists will probably be slow rather than rapid and will probably rely on the continuation of cycling environment enhancement. The findings from this study show that by substituting petrol-based car with E-bikes, there's an 81 percent CO_2 emission reduction. Whilst for motorcycle, the reduction percentage is slightly higher with an 88 percent reduction. These numbers greatly help the mitigation of rising GHG in the long run. Just from this program only, it manages to prevent an estimated 560.918kg of CO_2 release into the atmosphere within the period of 14 weeks. The significant of the studies is to analyses the advantages by using E-bike in specific area based on fuel cost, reduction of carbon footprint and to promote healthy life as well. These studies considered as a pilot studies which focusing on student at University Tenaga Nasional as only 5 samples have been actively participated in these studies by using E-bike as a main transportation even though there are more than 50 participant have participated EPAB Ambassador program. The scale is too small in order to determine the forecast of the travel demand E-bikes in Malaysia. Based to result,it suggested that the sample and participant should be added more in order to forecast the result accordingly. Selection of location would also be an important aspect to evaluating the travel demand using E-bike in urban area especially in Kuala Lumpur and Putrajaya. Further study in these areas is high recommended to identify new finding in these area.

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