

Urban Public Bus Adequacy Evaluation Analysis: A Johor Bahru, Johor, Malaysia Case Study

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Abstract: The attractiveness of public transportation to current and/ or future users is highly related upon the adequacy and reliability level of public transportation in an urban area. In order to enhance the strategy development for decision makers as well as transit agencies an evaluation of current situation of urban transportation network is needed. This study aims to evaluate and find ways to improve the performance adequacy of public bus networks in Johor Bahru, Johor state of Malaysia using GIS. Three most effective parameters, namely, drivers' punctuality, ease of accessibility, and bus schedule adherence are proposed for the evaluation of bus routes service quality and evenness. Various factors relative to the effectiveness of the bus routes are processed using geospatial analysis techniques of ArcGIS by means of real-world data. The results show that 18.75 percent of the actual running times are longer than (and thus behind) the scheduled, and 16.67 percent of those shorter than (and thus ahead of) the scheduled. However, the results are considered applicable for urban transportation planning and management in order to not only analyze the efficiency of current working buses but also improve the level of service (LOS) within a certain place of interest, thereby demonstrating that it can provide quick and accurate quality control.

Key words: GIS, Public Transportation, Urban GIS, GIS-T

Introduction

Planning and management of urban areas requires a set of precise and accurate data in a sequence of time from changes in land use plans. Monitoring of these changes is truly core material for planners and decision makers, additionally, GIS, as mentioned above, offers the essential tools in order to analyze the ground surface data that provide the framework of sustainable urban growth and development. Population density analysis, disaster management, crises analyses, land fill site selections, land management and registration, optimal route selection, transit roads network management, maintenance of Intelligent Transportation Systems (ITS), and so many others are such examples of geographic information systems applications. Arampatzis et al., (2002) presented a model by analyzing the benefits of GIS in urban transportation policies that reduced 50% of Athena traffic based on the number of travels, environmental situation, and energy indicators.

By having the need for keeping relationships and communication with other people, we humans should think to the ways which make us able to efficiently mobilize from one place to another. Undoubtedly, transportation is one of the best solutions to fulfill such needs while virtual communication (e.g., Internet, telecommunication) and mail post are the others. By the term of transportation we may remember the process in which we can physically travel from our origins to destinations. Mobility enables us to separate home from work and visit friends and family, as well as to allow us to do business across a wider region (Gohari, 2011).

In thinking about transportation, it is helpful to make a distinction between systems that focus on the movement of travelers and systems that focus on freight. Therefore, the characteristics and issues of urban transportation networks will be considered in this study.

There are several modes in the field of transportation that provide opportunities to move a traveler. Although each

mode has its own characteristics and/ or components, there are also some advantages and disadvantages for the mode will be chosen on the basis of cost, capability, routes, safety, and speed. The list below briefly summarizes possible modes of a transportation system:

1. Air
2. Rail
3. Road
4. Water
5. Other modes (e.g., pipeline, cable transport, spaceflight)

Transportation is a broad and ubiquitous field- important in a political, social, and economic sense. Everywhere you look, transportation is there. We commute. We drive to shop at the supermarket - and the goods arrived there by truck. We are impacted by the environmental consequences of transportation operations. Transportation is an integral part of our everyday life.

Socially, politically, and economically, transportation is important throughout the world. It can be a major public policy lever. The public sector often makes important public policy decisions through transportation investments. Moreover, it provides connections to other metropolitan areas, to the nation, and to the world. Urban transportation planning and development is therefore a significant activity, both for promoting the efficient movement of people and goods in an urban area as well as for providing a strong supportive role in achieving other community objectives.

Bus transportation system, is one of the most common modes of public transportation in almost all developing countries. Existence of an intercity bus transportation system by considering its accessibility and cost for the passengers could be an efficient way to handle not only the citizens' needs, but to diminish the urban issues. Every action in which we can improve the adequacy of the system is highly helpful to either passengers or reducing the environmental pollutions. Therefore, paying more attention to the part of public transportation (especially bus networks) planning and development causes reduction of the level of personal intercity travels and increasing the capabilities of transportation services.

Therefore, in order to achieve efficient development in public urban transportation management, the decision makers have to understand and implement the concept of sustainable transport. While understanding the concept is an effortless approach, adopting the sustainable transport and do materialize them is always become a problem (Mukhtar, 2009). The problem with sustainable transport in cities in the world today is that, in most cities, including Malaysian cities, the needs to use public transports are getting less and less due to a lack of managed networks. The most significant issues we can easily observe among urban public transportation users nowadays come from the value of time, fees, service frequency, safety and security, as well as traveling comfort.

There are a number of scientists have been used geographic information systems (GIS) in their studies to solve these kinds of problems (Golnarkar et al., 2009).

As Harvey and Shih-Lung Shaw, (2001) discussed geographic information systems for transportation (GIS-T) have arrived and represent one of the most important applications of GIS. GIS-T applications cover much of the broad scope of transportation. Transportation analysts and decision makers are using GIS tools in infrastructure planning, design and management, public transit planning and operations, traffic analysis and control, transportation safety analysis, environmental impact assessment, hazards mitigation, and configuring and managing complex logistics systems, just to name a few application domains. GIS-T can play a central role in the new environment for public land use and transportation decision making. By allowing a wide range of information to be integrated based on location, GIS-T fosters (but certainly does not guarantee) a holistic perspective on complex land use and transportation problems. GIS-T allows analytical and computational tools to be used in conjunction with detailed representations of the local geography, allowing analysis and problem-solving to be adapted to the local context. GIS-T can also reduce the gap between analysis and communication, allowing greater public input into analytical decisions such as choice of data, modeling, assumption and scenario development.

Geographic Information System (GIS) is a powerful tool that provides the simultaneous access and usage of a computerized system. GIS can generate a variety of thematic maps by overlaying a number of data layers to analyze

the area which is in interest. These systems are able to perform different spatial and non-spatial operations as well as data management and manipulation. This kind of characteristics made GIS to be known as a handy tool in which increase the decision making ability. Nowadays, GIS assists humanity in technological, industrial, environmental, economic, social, and thousands of disciplines. By having GIS in hand, people, especially managers and decision makers, can save their money and time.

GIS maps are interactive. On the computer screen, map users can scan a GIS map in any direction, zoom in or out, and change the nature of the information contained in the map. They can choose whether to see the roads, how many roads to see, and how roads should be depicted. Then they can select what other items they wish to view alongside these roads such as storm drains, gas lines, rare plants, or hospitals. Some GIS programs are designed to perform sophisticated calculations for tracking storms or predicting erosion patterns. GIS applications can be embedded into common activities such as verifying an address (Getis, 2008).

Problem and Methodology

Land transport such as road and rail transport is the main mode of transportation in Malaysia. To coordinate all activities, the Land Division of The Ministry of Transportation plays a crucial role as a generator and driving the development and implementation for National Transport Policy throughout the country.

To meet the general requirements, the land division designed a various public transport policies to ensure that public land transport sector remains as safe and efficient as possible based on current needs. According to the Road Transport Act and the Railways Act 1991, the enforcement and regulatory duties are under the roles and responsibilities of agencies such as the Road Transport Department (JPJ), Department of Railways, Railway Assets Corporation (RAC), Road Safety Department (RSD) and the Institute of Road Safety Research (MIROS). All of these agencies are regulated by a set of units such as Unit LRT, KTM Unit, Roads Transport Unit and NTTCC Unit directly.

Johor Bahru, with approximately 900,000 in the city population, and nearly 2 million in the metropolitan area, is the second largest urban area in Malaysia after Kuala Lumpur. The rapid urbanization causes Johor Bahru, like many Asians cities, to face increased demand in efficient urban public bus transportation.

In general, there are about 600 buses in Johor Bahru operating on 117 routes which owned and managed by 6 bus companies in order to serve its citizens' intercity mobility needs. Even though the current public transport is accessible to a large number of the city population, but a modal split ratio- the process of separating person trips by the mode of travel usually expressed as a fraction, ratio, or percentage - at 30:70 is not in favors of public transport to private vehicles (Mukhtarah, 2009). Based on the current modal split it can be said that the most trips in Malaysian cities has shifted towards the private automobiles.

Based on the researches conducted by Mukhtarah, 2009 on the automobile dependency of Johor Bahru citizens, and Annamalai, 2008 on the public bus data management in Johor Bahru, there are a number of evidences that severely convey the necessity of considering the current situation of public transportation (especially bus network) in the study area.

Annamalai, 2008 denoted that there is still a kind of conventional methods in the field of data management taking place among six public bus operators. The study has been carried out by the author was to depict the data management condition in Johor Bahru public bus transportation system in terms of the data collection methods and frequency, records keeping, purpose of data collection, use of collected data, analyzing methods, and so on. As an example, only one operator (i.e., Handal Indah) collects the data about its buses punctuality and seat condition which are very important factors for public transportation users. While four operators (i.e., Maju, Handal Indah, S & S, and Triton) have their own department for data management, yet there are only two bus operators which store and analyze their collected data using computer software. Moreover, there is no idea among these six bus operators to assist maps in order to present their analysis results.

Another study conducted by Mukhtarah, in 2009 as to determine whether Malaysian cities are indeed automobile dependent based on several parameters. Johor Bahru and two other cities (Muar and Batu Pahat) were the study areas in which a number of factors that play roles in urban automobile dependency were surveyed. Among those factors, mode of travel, vehicle ownership, satisfaction by public transportation, waiting time, and safety are most

related things that can be used to recognize the citizens' issues facing to choose public transportation as their traveling mode.

The followings are some responds of the 134 Malaysians and non-Malaysians who live in Johor Bahru and were asked during the data gathering of study:

- Only 18.1 percent of citizens prefer to use public transports (either taxi or bus).
- 81.9 percent of them owned at least one car.
- 75 percent severely feel disadvantaged by public transports - they believe that public transports limit their ability to move.
- 67.1 percent go to job by their private cars.
- 69 percent walk more than 400 meters to reach the nearest available transit service.
- 42.6 percent claimed the frequency of public transportations is "good" while 13.4 percent said that it does not cover their area and it is "very poor".
- 47.9 percent respond that waiting time condition and also convenience of public transports is "poor", whereas the same numbers of people believe its safety is "very poor".

Regarding to these issues, there is a need to design and develop the public bus transportation network in Johor Bahru due to not only shift from using private cars to public transport, but to improve the existing services quality. These problems can make the use of public transport systems less satisfying and leads to more serious overcrowding issues. If we, as urban managers, are unable to overcome the problem of public transport in Johor Bahru, the roads would become too congested and will affect the productivity of surrounding major cities, quality of life and overall ability to boost cities in Malaysia as world status cities. Taking note of this problem, and given that transport is an important factor in achieving better employment, health services, education and social services, the improving of current public bus transportation network in Johor Bahru is a subject to attention.

As a matter of fact, reduction the capability of public transportation system in Johor Bahru and managing its performance using Geographic Information System (GIS) can handle most various problems that users may face like inefficient services (high delay and cancellation rates), limited service network, lack of continuity of public transport modes, as well as serious congestion issues.

The key points in this research are to assess the overall performance of the buses working on four sampled routes and also find the percentage of residential land-use that lies inside a certain buffer zone from a given distance to the bus stops in MPJB and MJBST Regions. The following steps and approaches were needed to achieve this goal:

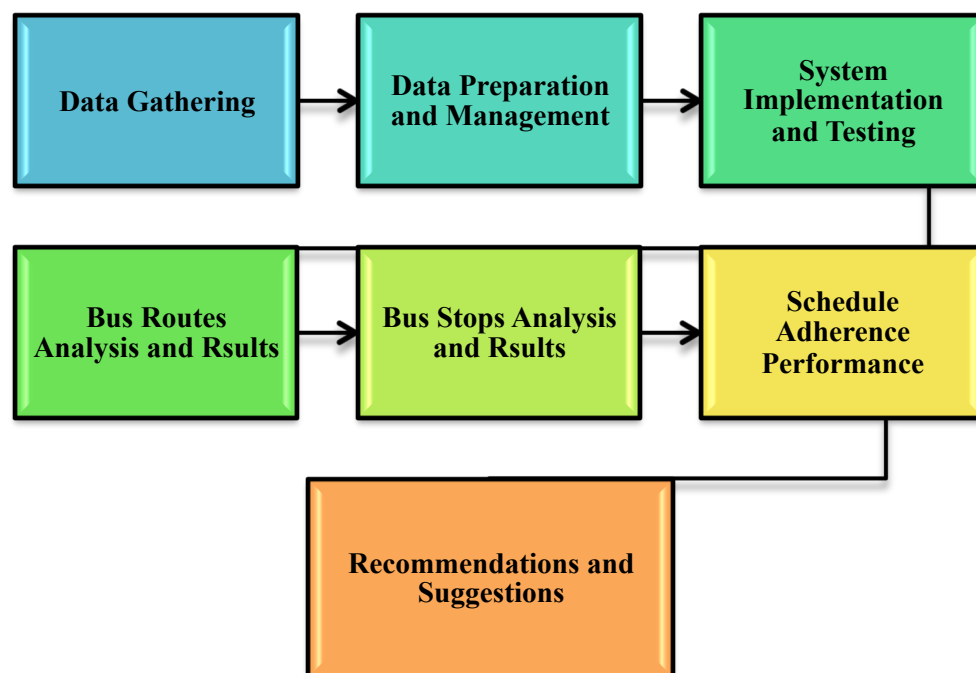


Figure 1: Research Work Flow

Transit Service Coverage and Effectiveness of the Bus Routes: Analysis and Results

Transit service coverage or, in other words, the service area of each bus route which serve citizens of a particular part of city plays a key role on entire quality and also tendency to use of the urban transport systems. One may not choose to walk for a round half kilometer, especially if it is too hot or rainy, in order to reach the nearest bus stop or any other public transport facilities. The various number of interchanges between modes due to lack of straight stops at the desired destinations could be another factor in this regard. In Johor Bahru, from users' opinions surveyed by Mukhtarah (2009), the condition of public transport services is not at a good level (refer to Figure 2 and Figure 3).

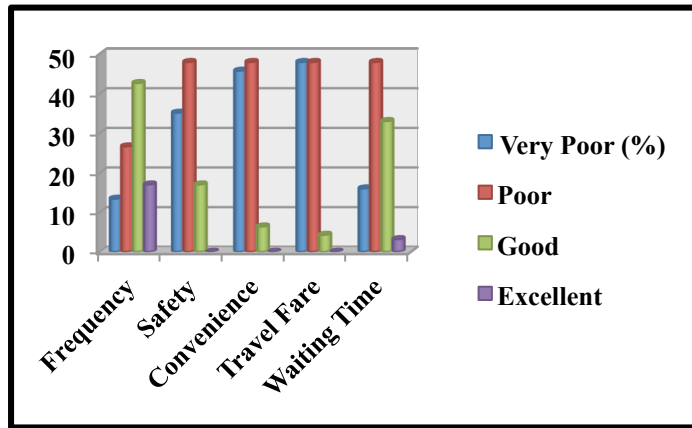


Figure 2: Quality of Public Transport Services in Johor Bahru

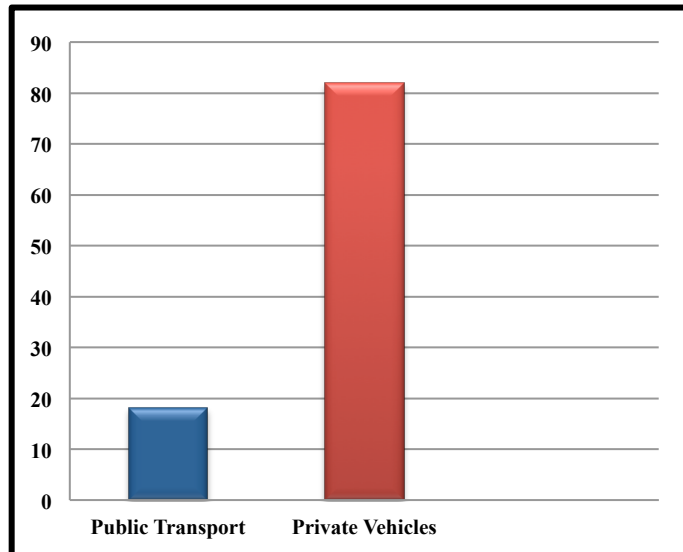


Figure 3: Current Travel Mode in Johor Bahru

As a result, 69 percent of the citizens claimed that they have to travel from home to the nearest available transit service for more than 400 meters. Based on Cervero (1998), for transit oriented development to work, the substantial distance between transit service and neighborhood area is within 400 meters.

The situation in Johor Bahru implies that current public bus transport service does not consider the significant walking distance (i.e., 400 meters) that may applicable to transit users. Therefore, this is a vital point to study whether they are attracted to cars and how they view the current level of service offered by local public transport.

Assumptions of the Research:

This research has the following assumptions:

1. It is assumed that bus routes in the Johor Bahru region are adequate if 80 percent or more of the residential or the commercial land-use are located inside a buffer zone of 400 meters from all routes.
2. It is assumed that bus stops in the Birkenhead region are adequate if 80 percent or more of the residential land-use or the commercial are located within a buffer zone of 400 meters from all bus stops.

These two assumptions are based on the author's observations and judgment which will allow a normal person to walk about eight-to-ten minutes to catch a bus provided he can walk 40 meters per minute.

JB- Taman Universiti Bus Route

There are 33 bus stops through an approximately thirty-seven kilometers bus route in JB- Taman Universiti area collected in this study. Nine bus stops out of thirty three are known as peak-hour bus stops in which the bus stops only at them during the morning and evening peak-hour (5 am to 9 am and 5 pm to 8 pm).

Figure 4 shows 33 bus stops alongside the road from Johor Bahru town to Taman Universiti. A buffer zone with a buffer distance of 400 meters was drawn around the existing bus stops using ArcGIS spatial analysis functions.

The resulted buffer zone then superimposed onto the base map layer which includes residential areas as well as urban features. Basically, the aim of this analysis is to depict the areas covered by these 400 buffer zones which have been known as transit service distance or walking distance.

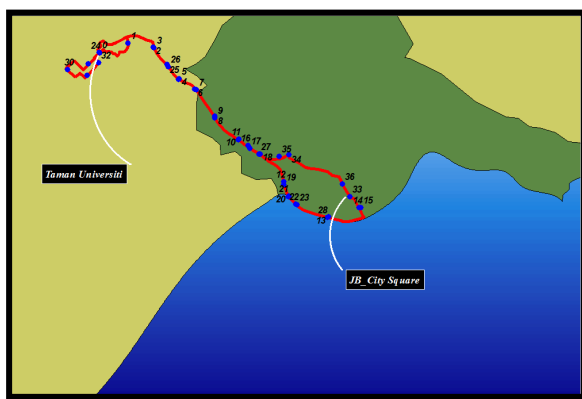


Figure 4: JB-Taman U Bus Route and Bus Stops

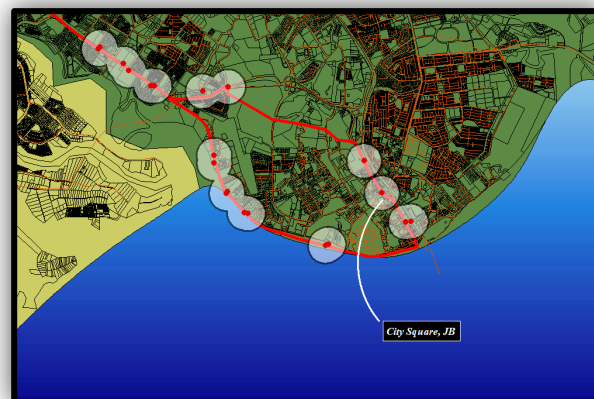


Figure 5: Buffer Zone of 400 meters around Existing JB-Taman U Bus Stops

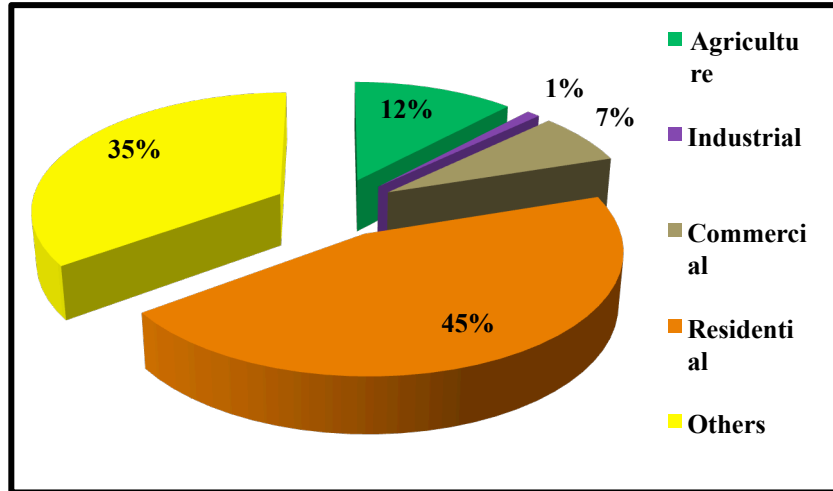


Figure 6: Landuse Types Covered in JB-Taman U

Based on Figure 5, there is a quite long distance (approximately 4 kilometers) over the bus route which does not covered by any bus stop. Looking its nearby features on the base map layer we can say that this roughly 4,000-meter distance between two adjacent bus stops is reasonable due to the current land-use condition.

It is fairly obvious that the above-mentioned residential and commercial coverage area, at 45 and 7 percent in turn, are not far below the level of adequacy for bus stops. In order to make it better, it is thought of increasing the bus stops where needed. By adding these new bus stops, the result of the overlay is much better than the existing condition but still lower than the desired level.

The result showed that 50 percent of the residential areas in Johor Bahru- Taman Universiti region were inside the buffer zone of all bus stops while only 13 percent of commercial and 2 percent of industrial zones were covered. In the case of agriculture area, 8 percent were inside all the thirty-eight bus stops (33 existing and 5 suggested) buffer zone (Figure 7).

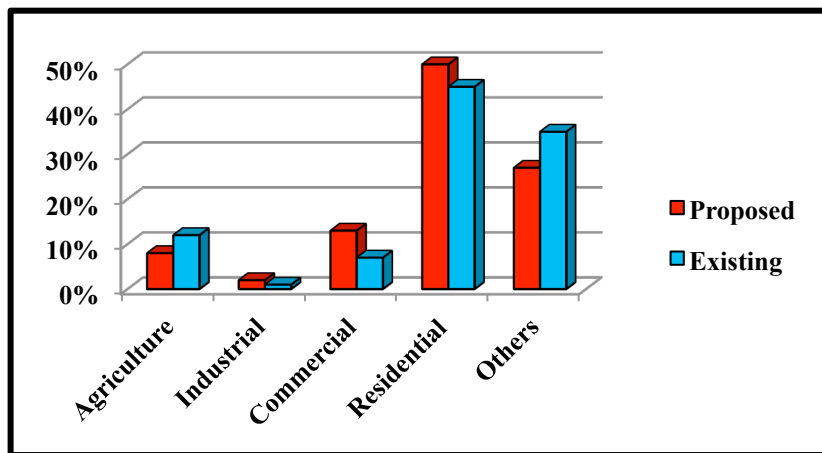


Figure 7: Bus Stops Transit Coverage -Existing vs. Proposed-

JB- Taman Kempas Bus Route

A total number of 36 bus stops have been collected throughout the JB- Taman Kempas bus route which is about 23 kilometers in length. Twenty two bus stops out of 36 are known as peak-hour.

Figure 8 shows 36 the bus routes and bus stops alongside the road from Johor Bahru town to Taman Kempas.

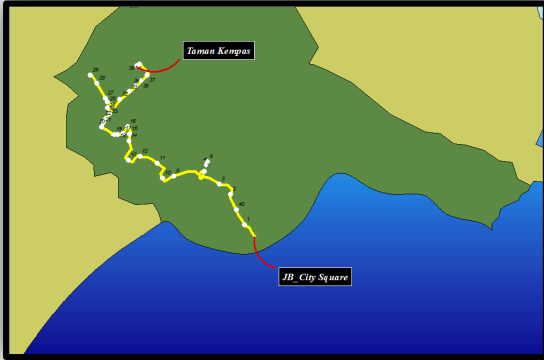


Figure 8: JB-Taman U Bus Route and Bus Stops



Figure 9: Buffer Zone of 400 meters around Existing JB-Taman U Bus Stops

The output of the buffer analysis then superimposed over the base map layer which includes residential, industrial, agriculture, and other urban areas. Figures 9 and 10 show the service area coverage of bus stops along the bus route from Johor Bahru town to Taman Kempas.

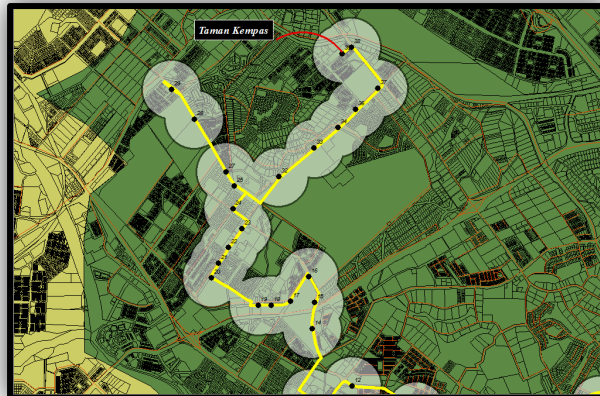


Figure 10: Buffer Zone of 400 meters around Existing JB-Taman U Bus Stops

Based on Figure 11, Residential at 42 percent is the most covered landuse type in JB- Taman Kempas bus route. Agriculture type of landuse with a percentage of 27 is at the second stage. Others type of landuse (i.e., vacant lands, green spaces, water bodies, etc.) with a percentage of 16 is at the third stage. Correspondingly, Commercial, and Industrial regions at 13 and 2 percent out of total area of the city are in the lower levels of landuse coverage by bus stops. So, there is no doubt that in this specific area we do need to not only add some more bus stops to cover wider

residential places but also review the bus route or even redesign it for making the public transport facilities easier to access.

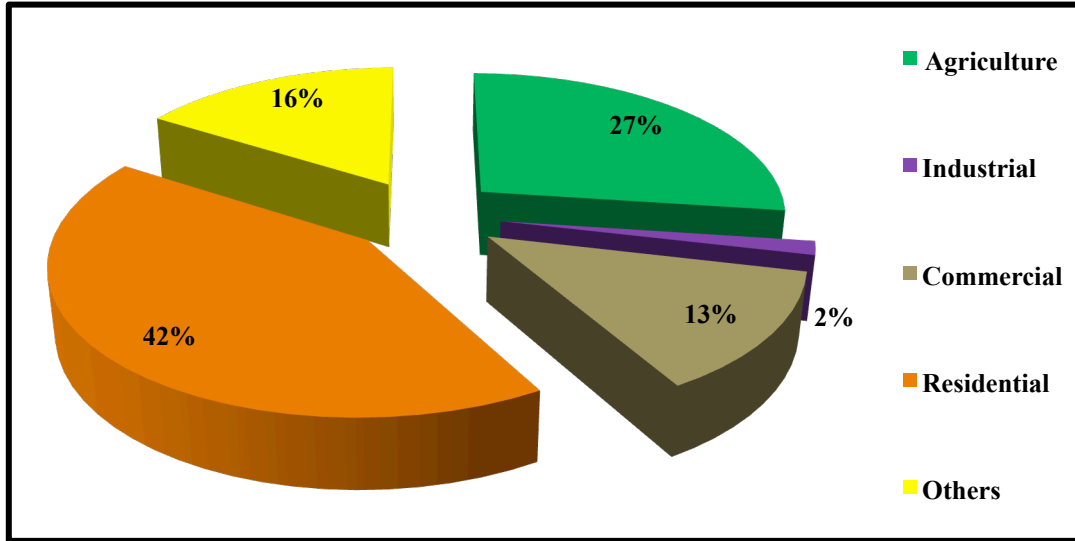


Figure 11: Landuse Types Covered in JB- Taman Kempas

Therefore, there are three suggested bus stops to increase the service area coverage of urban buses through JB-Taman Kempas route. The results showed a 16 percent enlargement in residential areas and also 7 percent decrease in agriculture coverage area as following:

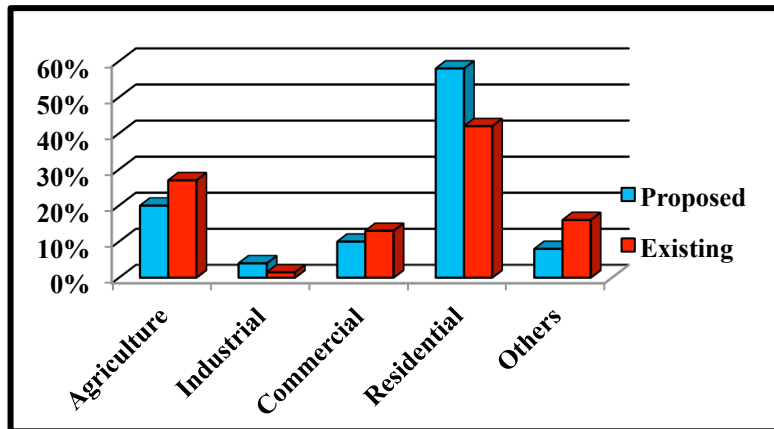
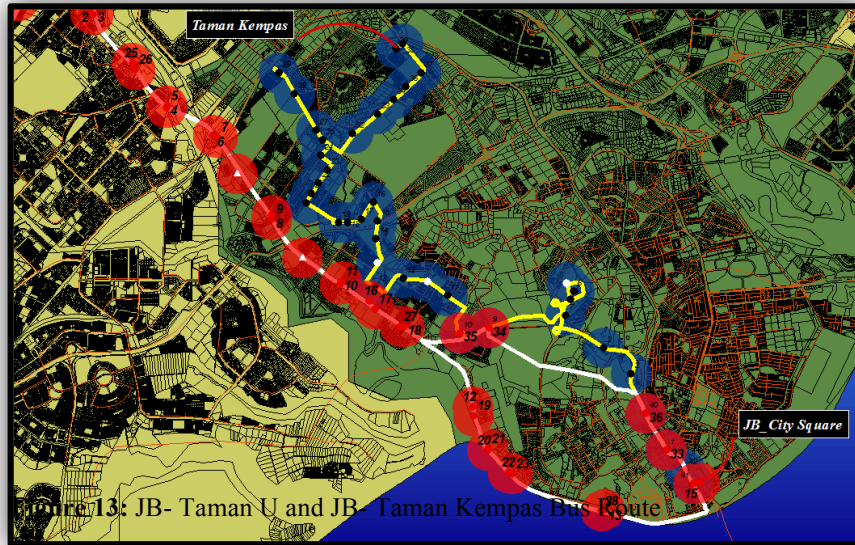


Figure 12: Bus Stops Transit Coverage -Existing vs. Proposed-

Regarding to the Figure 9, it could turn up that there is an approximately 3 kilometers gap between two adjacent bus stops at the junction and right underneath the first suggested bus stop along the bus route. Although, there is a moderately big gap between two bus stops next to each other the landuse type of the certain place is not residential,

commercial, or even industrial. In this occasion, therefore, it has been put into the no need to add new bus stop bucket.

So far we looked into two urban bus routes and analyzed their bus stops' transit service area coverage or walking distance individually. These two bus routes, JB- Taman U and JB- Taman Kempas, but, are serving the public bus users consistently. In order to demonstrate the total service area coverage of them and also to analyze whether bus stops are well positioned, we need to depict both bus routes together. Figure 13 illustrates JB- Taman U and JB- Taman Kempas in concert:



JB- Taman Johor Jaya

The 16.5 kilometers bus route in Johor Bahru- Taman Johor Jaya comprises of twenty seven bus stops in which 16 of them known as peak-hour.

Figure 14 demonstrates JB- Taman Johor Jaya bus route in a single exposure.

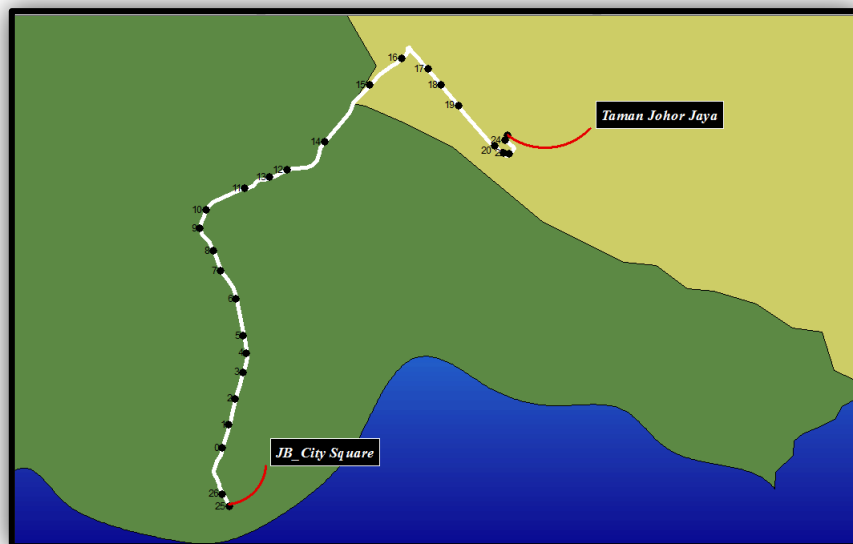


Figure 14: JB- Taman Kempas Bus Route and Bus Stops

From Figure 14, we see that the bus stops through the bus route placed in two municipality areas of JB. The area shown in darker green is MPJB and the one in olive-green hue is called MJB. Figures 15 and 16 show the buffered bus stops and landuse types covered percentage in Johor Bahru town to Taman Johor Jaya.

The results from the analysis of landuse types which located within 400 meters around bus stops are presented in the pie chart below (Figure 17). In general, it can be seen that the major landuse type covered by bus stops in JB-Taman Johor Jaya route is Residential at 59 percent. Agriculture type of landuse at 15 percent came in second and what is important in these findings from pie chart above is that only small parts of industrial and business regions (6 percent) could be accessed using public buses.



Figure 15: Buffer Zone of 400 meters around Existing JB-Taman Johor Jaya Bus Stops

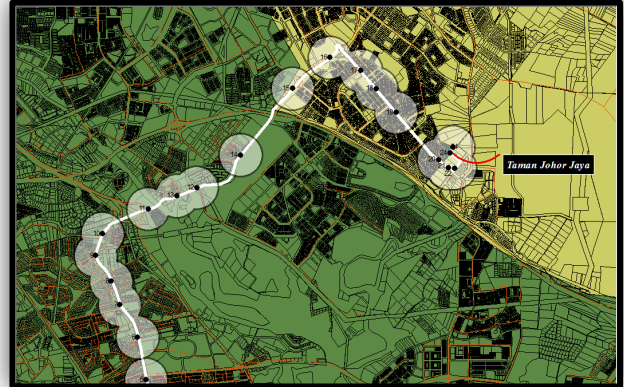


Figure 16: Buffer Zone of 400 meters around Existing JB-Taman Johor Jaya Bus Stops

As it can be seen in Figure 18, there are moderate increases in the coverage of residential regions (5 percent) and decrease in agriculture lands (3 percent). It is also important to note that the covered area of mostly vacant areas (i.e., Others) decreased by 5 percent after area calculation of suggested bus stops which means a growth in landuse coverage efficiency by public bus transportation.

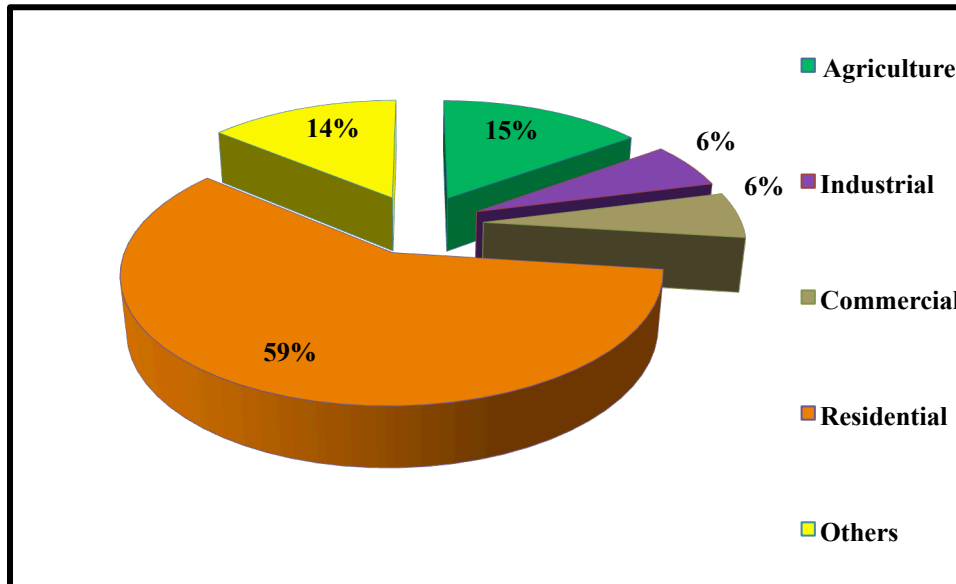


Figure 17: Landuse Types Covered in JB- Taman Johor Jaya

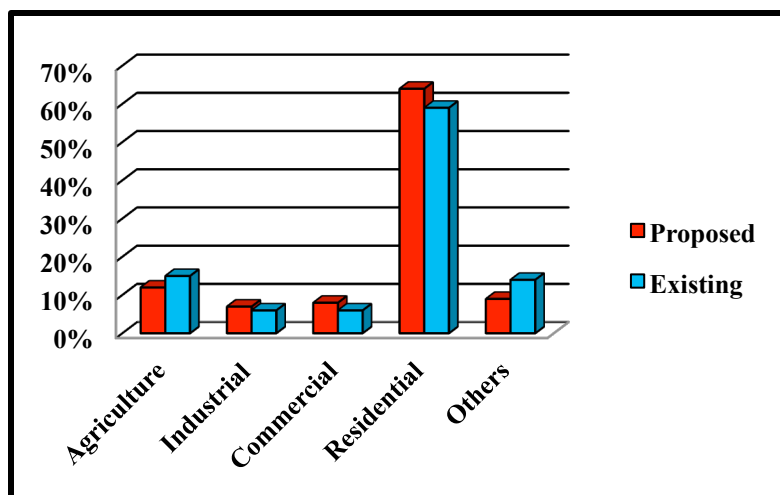


Figure 18: Bus Stops Transit Coverage -Existing vs. Proposed-

Conclusions

The use of GIS in the developed countries started in the late 1960s and early 1970s. Very few departments, however, installed them because of the prohibitive cost of the hardware and the limited capabilities of the software. Since the early 1980s, a marked increase in the installation of GIS is noticed not only in the developed countries but also in the developing countries as well; it is becoming an important component of planning support systems. GIS and state-of-the-art technologies applications in urban transportation planning have become increasingly popular in recent years. Among the many benefits in using GIS, in this field are: improved mapping, greater efficiency in retrieval of information, faster and more extensive access to the types of geographical information

important to planning, improved analysis, better communication to the public, and speedier access to information for planning application processes.

Existing service reliability on the public bus transit is not as much as enough that can make users to tend to the usage of public vehicles rather than their personals. This study revealed that the actual running time is by some means longer than the scheduled time which is important to the users and, as a result, it saw as a suffering factor for the reliability of transportation system in Johor Bahru.

As a conclusion, it is hoped that whatever information and finding of this research can contribute some meaningful information to public bus operators in Johor Bahru as well as useful for the relevant authorities especially for Road Transport Department (JPJ), Johor Bahru City Council and Commercial Vehicles License Board to design new version of transport policies and implementation for Johor Bahru city. The information in this study also can be used as a reference for future studies as explore and carry out research in depth that relates to the formulation of service quality.

The scope of this study is limited because of some factors like time, data boundary, and cost. From the results obtained, a few possible ideas are pointed out for the future studies in order to not only improve the research result but apply more information useful in decision making process.

As it mentioned earlier, this study focused on only major fixed bus routes in two specific regions of Johor Bahru City namely MPJBT and MBBJ. It is recommended that other researches be conducted on other suburbs in the city for more comparison purposes and verification of the findings of this study. Other research can also deal with the number of people using a certain bus route or stop.

Future studies could consider using more extensive data including the daily traffic conditions data to test the effects of additional contributing factors on bus service reliability, thereby offering more practical strategies to monitor and improve the quality of bus service. The conclusions of this research and the inferences drawn from them, therefore, are just uncertain. More accurate conclusions may be obtained if suggested future research can be taken into consideration.

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