ISSN 2250-3153

Urban public transport accessibility for markets and wards: the case study of Mandalay City

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Abstract- Accessibility is the main parameter which contributes to the effective transport system. An effective transport system and associated urban forms will improve the economic and social opportunities. The objective of the paper is to know about the different levels of accessibility to the public transport system. The public transport accessibility level (PTAL) is identified for the selected study area with the help of an indexing system. Accessibility maps create a common language between urban planners and traffic planners, often leading to interesting insights and mutual understanding. The result of the paper would be the base for recommendations to improve the existing public transport system service.

***Index Terms*-** Accessibility, Transportation system, Public transport accessibility level, Indexing system**,**Urban planners, Traffic planners

I. Introduction

Accessibility can be related to both the qualities of the transport system like the travel speed and the qualities of land use system like density and mixes. People favor motorcycle and private cars and regard conventional public transport as a last solution. One objective of public transportation is to provide an alternative to the use of the private automobile in order to alleviate negative externalities created by automobile dependency. These negative effects include environmental degradation, equity issues (for example, the difficulty experienced by people who are unable to drive due to some physical and mental disability), and economic impacts (such as time lost due to driving congestion and lack of parking space). As one of many available alternative transportation modes, bus service must attract ridership to be competitive. In Mandalay City,the inability of conventional public transport to deter people from using motorcycle and private cars and the increase in citizen demand for private cars cause traffic problems, and infrastructure investments to eliminate these traffic problems require significant expenditures.

II. LITERATURE REVIEW

Accessibility is a term used in transport and land-use planning, and is generally “ease of reaching”. Accessibility is the suitability of the transit system in helping people get to their destinations in a reasonable amount of time. It is a function of the mobility of the individual, spatial location, opportunities relative to the starting point of the individual, and the times at which the individual is able to participate in the activity. Accessibility helps in identifying the interrelation of transport and land-use. Accessibility measures can be grouped into five categories: travel-cost approach, gravity or opportunities approach, constraints-based approach, utility-based surplus approach, composite approach. The gravity or opportunities approach summarises the contour or cumulative opportunity and gravity models. The constraint-based approach is equivalent to time-space measures, while the utility-based surplus approach uses the utility measures with a greater focus on individual behaviour and decision-making. Composite approaches attempt to combine time-space and utility indicators into a common model.

In a paper regarding Advances in public transport accessibility assessments for development control, Public Transport Accessibility Level (PTAL)is one of the criteria for evaluating the accessibility PTAL is calculated by summing a series of indices for bus, train, underground and rail services to obtain an Index Number was explained by (G Christopher and S Geoff),2008[1]. The Index Numbers are compared with a banding regime to obtain a PTAL grade. Walk distance, the number of services and their frequency, walking speed and the reliability of service are all used in the calculations. They suggested a quantitative assessment method for public transport network accessibility as an alternative to PTAL, which could be used in transport assessments to assist with planning applications. A new approach for measuring public transit accessibility was developed by A M Sha and E. L Nicholas (2008) [2] with the help of an index called Local Index of Transit Availability (LITA), The Transit Capacity and Quality of Service Manual (TCQSM) and Time-of-Day Tool. This research stays away from the methods involving software based analysis tools and considers methods that calculation procedures are straight forward and require some basic use of GIS software. Another example of GIS based accessibility measures was developed by L Wei (2009) [3] based on the GIS-based floating catchment method to assess areas with shortage of physicians. The study demonstrates the principle of the floating catchment methodology (FCM) with a simple case study in northern Illinois. FCM defines the basic unit within which to calculate this ratio as a circle of some reasonable radius centered on the census tract centroid. A case study was done by Alan T. M Rex (2010) [4] based on the methods for increasing public transport access and their likely effects. In areas in which public transport access is high, performance improvements were realized by altering the placement of stops and modifying route service. L Jonathan, G Joe, S Qing, (2010) [5] had done a work on the metropolitan accessibility. In the paper they compared transportation accessibility outcomes for 24 of the largest metropolitan regions in the United States. This study bases it accessibility metrics in the gravity model which is a powerful conceptual tool because it simultaneously accounts for both the transportation network and its surrounding land-use conditions. The paper regarding “Modelling walking accessibility to public transport terminals” by S Sony and O Piotr (2005) [6] explained about the equivalent walking distance (EWD). They developed a model called the walking access model. From the research they concluded that characteristics of walking route could be incorporated into public transport accessibility measurement. Equivalent walking distance can be a method that can measure public transport accessibility more precisely and comprehensibly. The accessibility indices are used in measuring the ease of residents going from one place to another. By analysing the accessibility indices, one can review a network system of transportation in the regions under study. There are different methods used for finding the accessibility to a particular facility. The methods are identified from the literature review.

1. Transit service indicator
2. The Land Use and Public Transport Accessibility Indexing Model (LUPTAI)
3. Accessibility index from (database extracted directly from the satellite imagery and the highway network
4. The transit level-of-service (TLOS)
5. The Local Index of Transit Availability (LITA)
6. Public Transport Accessibility Levels (PTALS)

The present paper deals with the application of PTAL for evaluating the accessibility in the selected study region. The method provides a detailed and accurate measure of the accessibility to the public transportation opportunities.

III. STUDY AREA

Located on the east bank of the Irrawaddy River is Mandalay, Myanmar's second largest city. It is considered the country's cultural hub because it maintained the cultural legacy of the ancient Burmese kingdoms. The study area consists of 93 wards. Fig 1 shows ward map for the site selected for the study.

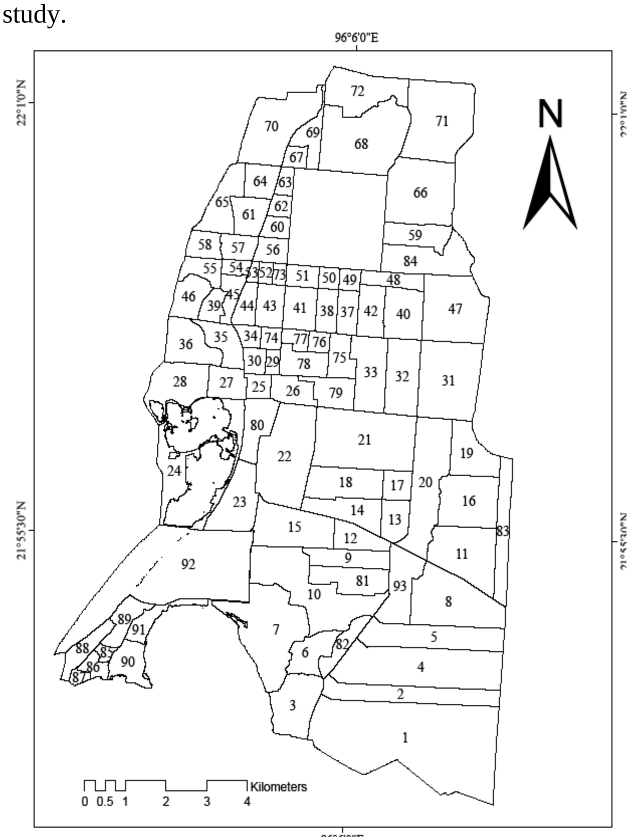

Figure 1. Ward map for the site selected for the study area

The software ArcGIS10.1 has been used as a GIS platform of this study. The current bus teams, number of bus frequency per day, the average number of buses per day and the daily transportable number of passengers are obtained from Bus Line Control Committee, Mandalay Division.

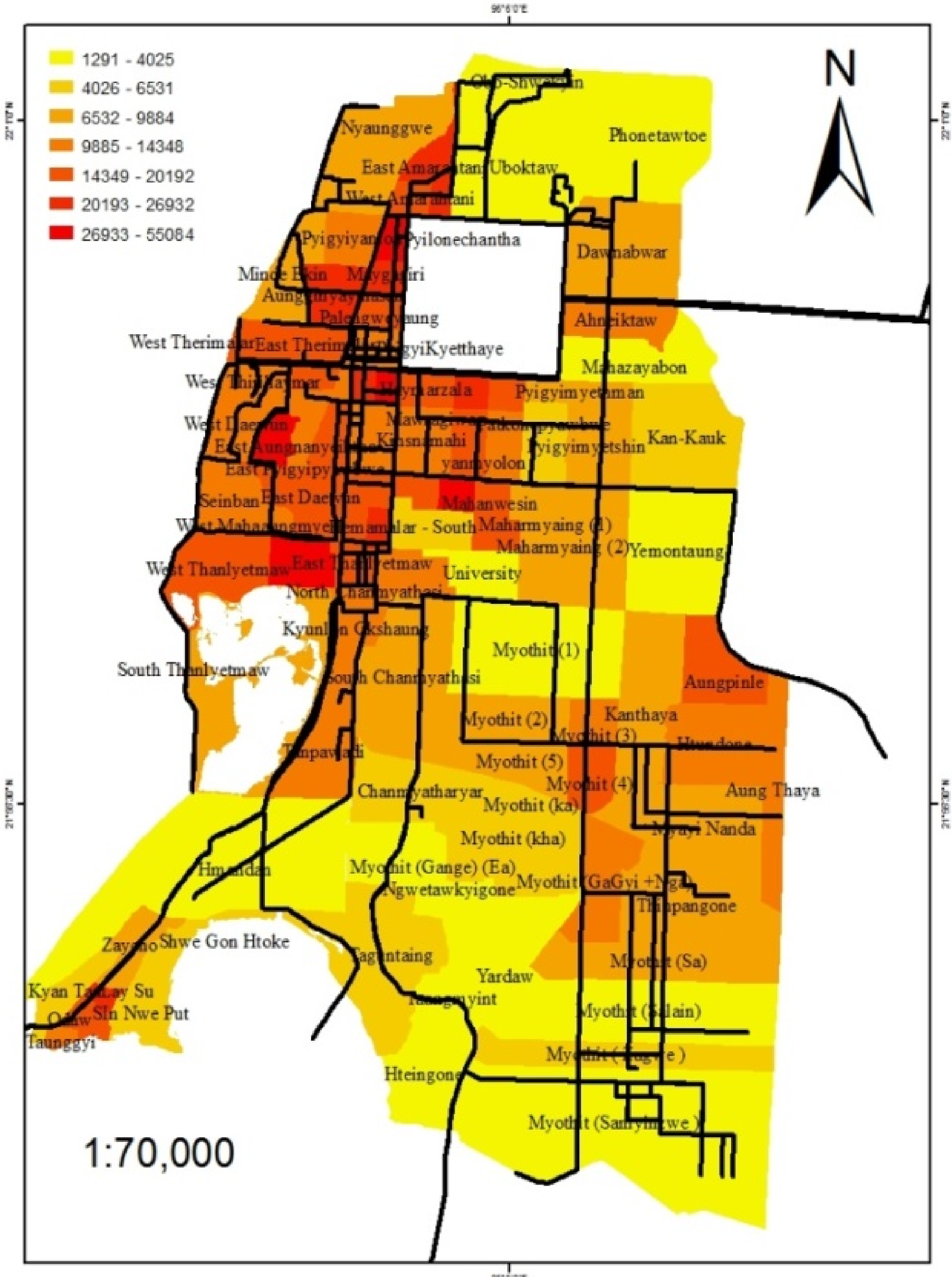

Figure 2. Population density and bus network map in Mandalay city

Land use and population density map,as shown in figure 2 and 3, is taken from department of remote sensing, Mandalay Technological University. Various data types are needed to collect from different sources. Most of data involved two-pronged spatial and attribute data, which included maps of the study area, and locations of bus routes as spatial data. On the other hand, the attribute data included population; bus routes in terms of statistics and geographic information. After collecting data, the next step is building the geo-database of the study. And then, public transport accessibility index for each ward is calculated by using PTAL method.

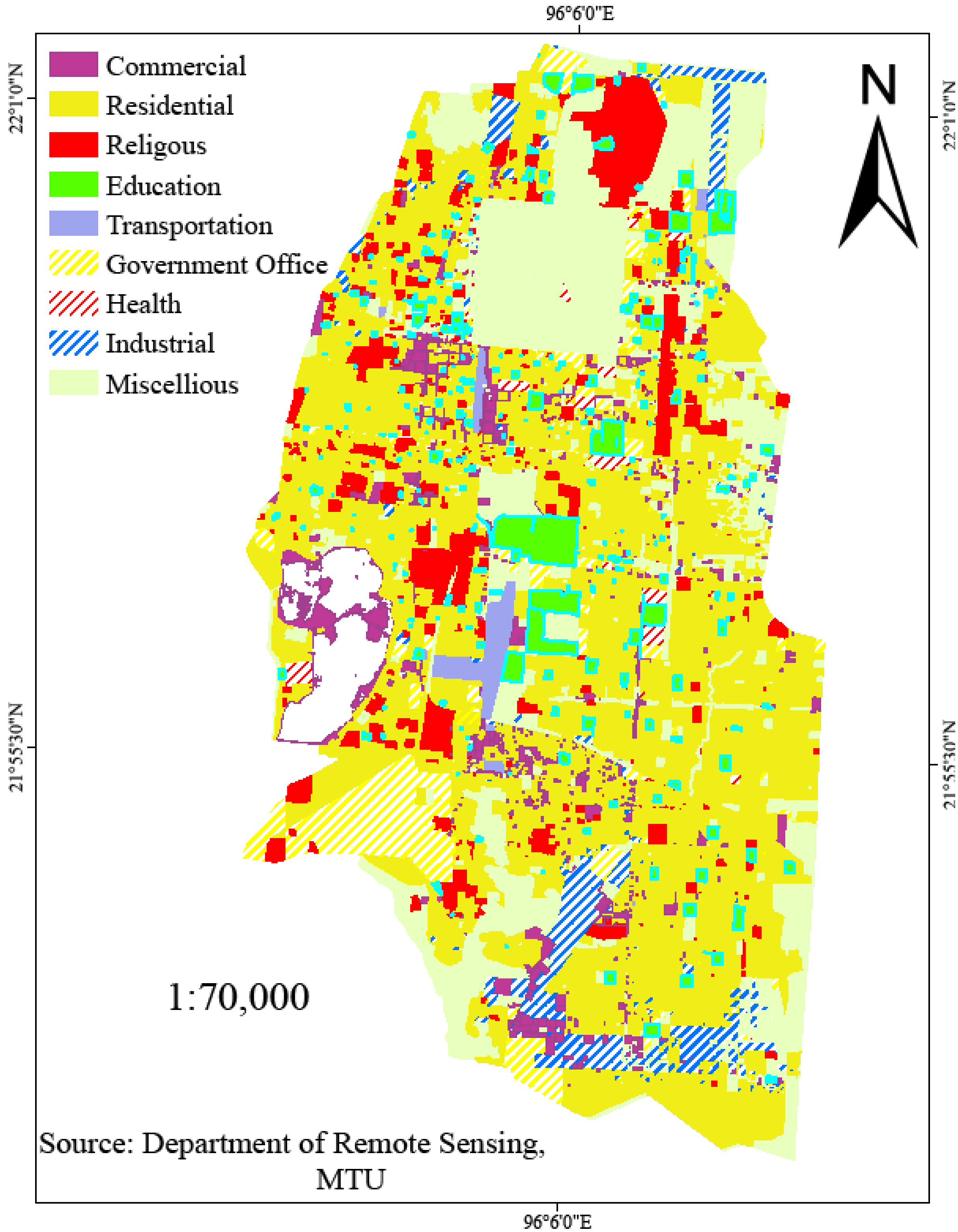

Figure 3.Land use map for the study area

IV. LONDON PTAL METHODOLOGY

PTAL is a detailed and accurate measure of the accessibility of a specific point to the public transport network, taking into account walk access time and service availability. It measures the accessibility level for a specific point (origin) considering the accessibility index (AI) for all available modes of transport from that point. The inclusion of total access time to measure the level of accessibility is an important feature of this method (Mamun and Lownes 2010). The methodology is briefly described below, broken down into key steps for calculation. For a more detailed explanation, please refer Transport for London (2010).

Step 1: Define points of interest (POI) and service access points (SAP) – POI is defined as a point for which the accessibility level is to be measured with reference to an SAP, which is a public transport stop (such as bus stop, metro station, market, zone etc.).

Step 2: Calculate walk access time from POI to SAP – The actual road network distance from POI to SAP is measured and, assuming a walk speed of 4.8 km/h, walk time (WT) is calculated. The maximum walk times for bus and metro rail are 8 and 12 minutes, respectively. Any SAPs beyond these distances are not taken into account to calculate PTAL for that particular POI.

Step 3: Identify valid routes at each SAP and calculate average waiting time (AWT) – The valid routes are bus and metro routes for the peak hour (8:15–9:15 am),1and the frequency of services on all these routes during this hour is used in the calculation of AWT. AWT is the defined as the period from when a passenger arrives at an SAP to the arrival of the desired service. In the calculation, the hourly frequency (f) is halved because the scheduled waiting time (SWT) is estimated as half the headway. For example, a 10-minute service frequency (6 buses per hour) would give an SWT of 5 minutes. In addition, to make the calculations more realistic, a "reliability factor" (K) is added to the SWT depending on the transport mode, which is assumed to be 2 minutes for buses and 0.75 minutes for rail services.

Step 4: Calculate minimum total access time (TAT) for each valid route at each SAP – This is done as shown in Equation 2 by adding times obtained in steps 2 and 3.

Step 5: Convert TAT into equivalent doorstep frequency (EDF) – This is obtained as 30 divided by TAT . The principle is to treat access time as a notional average waiting time as though the route was available at the doorstep of the selected POI.

Step 6: Obtain the accessibility index (AI) for each POI – In this step, the most dominant route, i.e., the route with the highest frequency, is assigned the weighting factor of 1.0; for all other routes, a weighting factor of 0.5 is assigned. Then, the accessibility index for a POI (AIPOI) is calculated.

Step 7: Map PTAL – The AIs obtained for each POI are allocated to eight bands of PTAL, as shown in Figure 4 (where Range of Index means AI of the POI). A POI with a value of 0 indicates no access to the public transport network within the parameters given and is not colored on the map.

PTAL	Range of Index	Map Colour	Description
1a (Low)	0.01 – 2.50		Very poor
1b	2.51 – 5.00		Very poor
2	5.01 – 10.00		Poor
3	10.01 – 15.00		Moderate
4	15.01 – 20.00		Good
5	20.01 – 25.00		Very Good
6a	25.01 – 40.00		Excellent
6b (High)	40.01 +		Excellent

Figure 4. Description of map colour for PTAL

The calculation steps in the methodology are the same as the London PTAL methodology. However, for mapping of PTALs in Mandalay, the walking distance considered in the London PTAL methodology is altered to suit the conditions of Mandalay.

V. CALCULATION OF PUBLIC TRANSPORT ACCESIBILITY INDEX

The PTAL is used as a development planning tool in London, to determine both permitted parking standards and development densities. Public Transport Accessibility Levels (PTALS) are a detailed and accurate measure of the accessibility of a point to the public transport network, taking into account walk access time and service availability. The method is essentially a way of measuring the density of the public transport network at any location within the study area.

A. Point of interest

In the study, there are two type of point of interest (POI): Wards and Markets. Public transport accessibility levels for markets are important because the commercial zones are mostly based by the bus network as shown in figure 5.

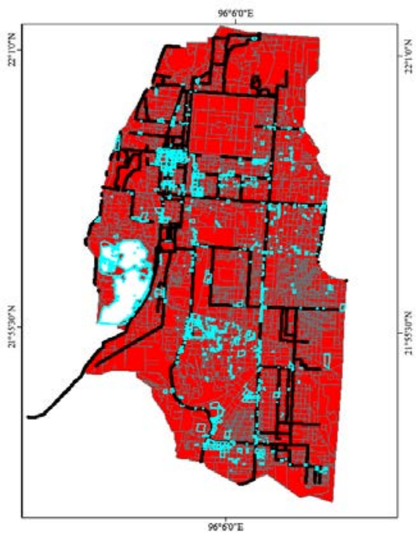

Figure 5. Commercial zones in Mandalay City

B. Walk access times

In the study, two types of the walking distance are analysed: walking distance from markets to the nearest bus stop (figure 6) and walking distance from bus routes to the bus service area in each zone (figure 7). The distances for markets are taken from using the measure tool in ArcGIS software.

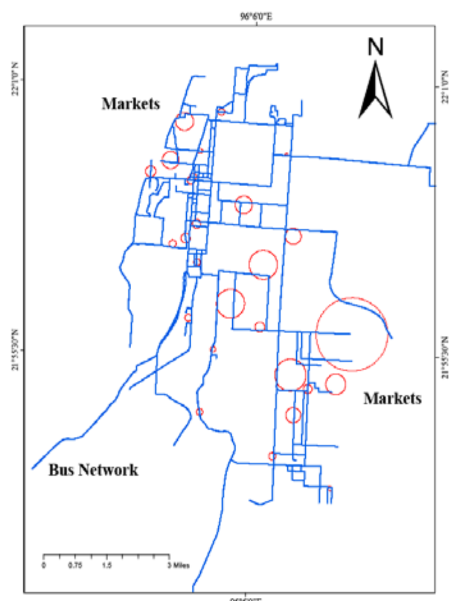

Figure 6. Walking distances form the markets to the nearest bus stops

For the latter distance, the service area is calculated by served people divided by population density. The specific radial distance based on the total supply capacity is calculated by the square root of the result of service area divided by Pi (π). Where Pi (π) represents 3.14. The specific radial distances to estimate bus service area are assumed as walking distances for wards.

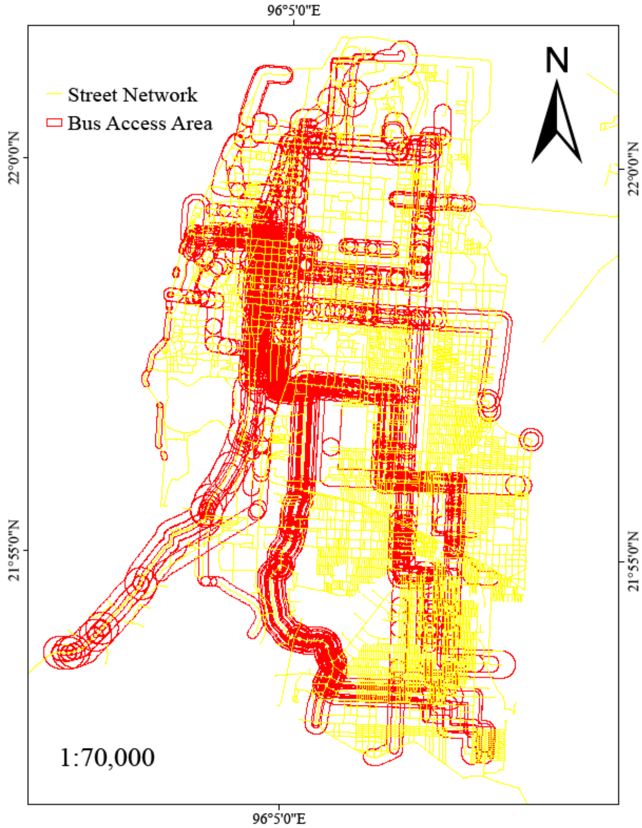

Figure 7. Walking distances from the bus routes to bus service area in each ward

The distances are converted to a measure of time using an assumed a walk speed of 4.8 kph (3 mph), which has been fractionally adjusted for crow flies optimism. Radial distances are converted to a measure of time using an assumed average walk speed of 4.8 kph.

C. Average waiting times (AWT)

Headway data (peak period = 6am-9am)is collected from bus employee interview survey and Bus Line Control Committee.For each selected route the scheduled waiting time (SWT) is calculated. This is estimated as half the headway(H/2) (i.e. the interval between services,).To derive the average waiting time, reliability factors (RF) are applied to the SWT according to the mode of transport used. To allow for reliability additional wait times assumed are 2 minutes for buses. For example, a 10-minute service frequency (6 buses per hour) would give an SWT of 5 minutes. In addition, to make the calculations more realistic, a “reliability factor” (K) is added to the SWT depending on the transport mode, which is assumed to be 2 minutes for buses and 0.75 minutes for rail services.

$$AWT = \frac{H}{2} + RF \qquad (1)$$

D. Total access times (ATA)

Total access time is made up of a combination of factors: combining the walk time from the POI to the SAP and the time spent waiting at the SAP for the desired service to arrive.

$$TotalAccessTime = WalkTime + AWT \qquad (2)$$

E. Equivalent doorstep frequency (EDF)

The access time is converted to an Equivalent Doorstep Frequency where:

$$EDF = \frac{30}{TotalAccessTime} \qquad (3)$$

F. Accessibility index (AI)

For bus service area zones, the AI (at a single POI) can be calculated using the following formula:

$$AI_{zone} = EDF_{zone} + (0.5 \times AllOtherEDFs) \qquad (4)$$

The above calculation is done in ArcGIS software and then the calculated accessibility indices for each ward and markets are in figures 8,9,10 and 11.

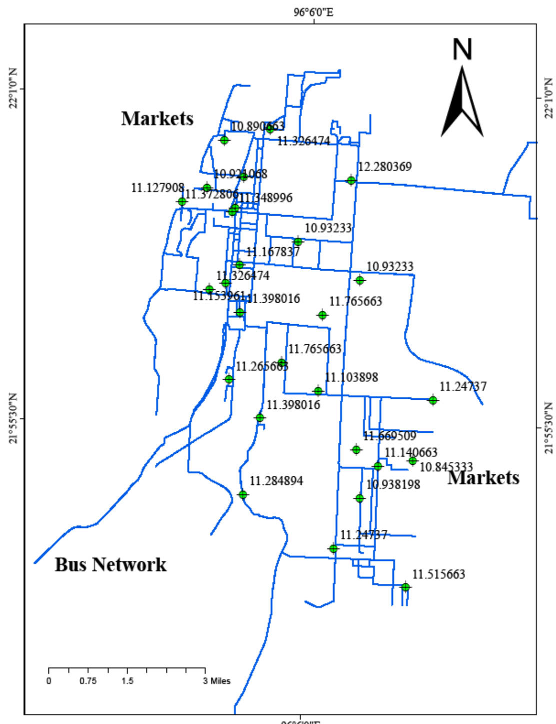

Figure 8. Accessibility index for each market with bus network in Mandalay City

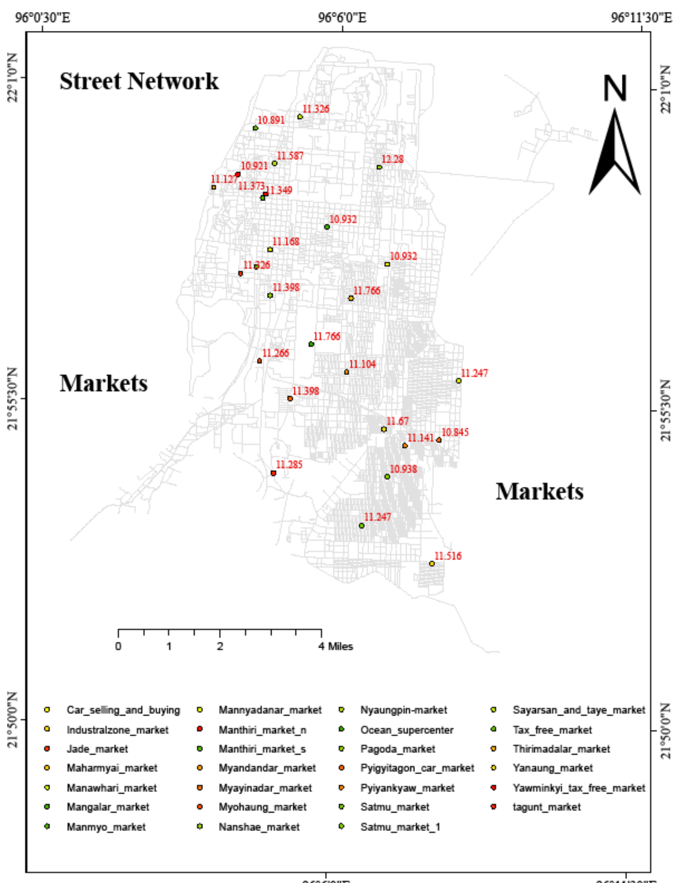

Figure 9. Accessibility index for each market with street network in Mandalay City

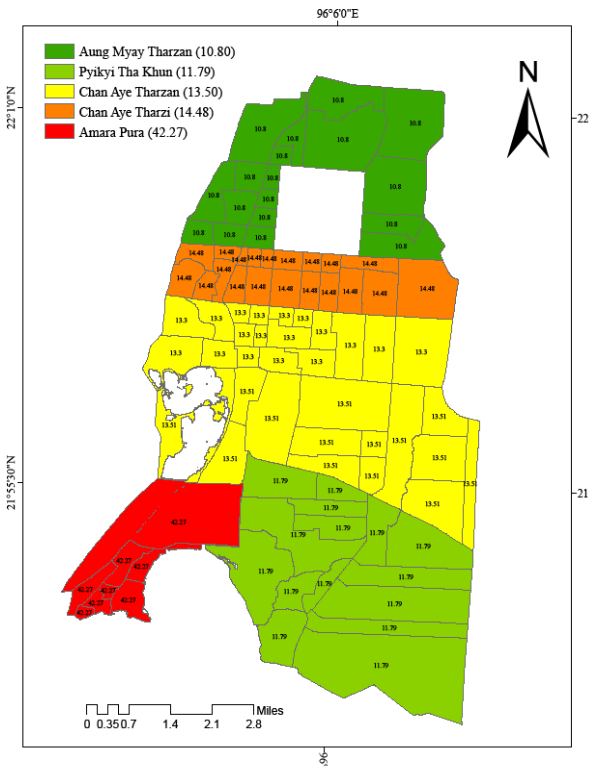

Figure 10. Accessibility index for each township in Mandalay City

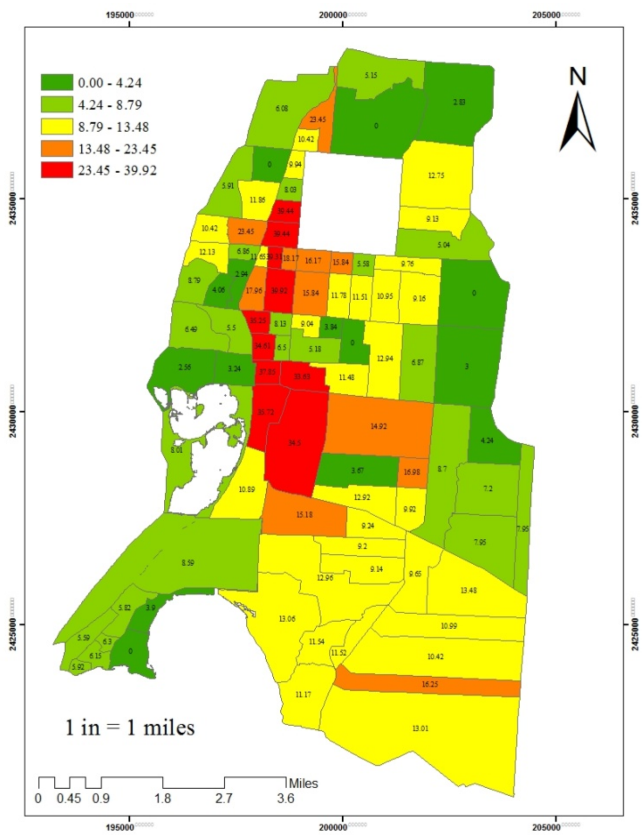

Figure 11. Accessibility index for each ward in Mandalay City

VI. RESULT AND CONCLUSION

The accessibility to public transportation in Mandalay city is determined on the basis of Transport Authority data, population density data and the PTAL method. The PTAL values for different wards are calculated using the service area calculation. From the township analysis, it is found that Amarapura has the highest accessibility to the public transport system with the value of 42.27. The township with the lowest accessibility is AungMyayTharzan with the value 10.80. From the ward analysis, four wards: East Aungnanyeiktha (ChanAyeTharzan), Palengweyaung (AungMyayThazan), Pyigyikyettaye (AungMyayThazan) and Middle Chan Aye Tharzan (ChanAyeTharzan) have the high accessibility to the public transportation with the value of 39.92, 39.44, 39.43 and 39.31. There are ninety three wards in the study area. But it can be seen that fifty wards process the lowest accessibility less than the value 10.From the market analysis, the largest one, Manthiri (Zegyo) market in Mandalay has the accessibility of 11.35. The public transport accessibility level of the Nanshae market is fair with the value of 12.28, the best service level in Mandalay city. Although the commercial zones are mostly based by the bus network, the public transport accessibility of markets are low. The result shows that the small urban area is well provided with the public transport services: however, peripheral areas are social exclusion as shown in figure 12. According to the calculation, the whole system is only 48.7% adapted to the city area, so taking the general accessibility level into account Mandalay could hardly be called even partly accessibility for people using motor cycle.

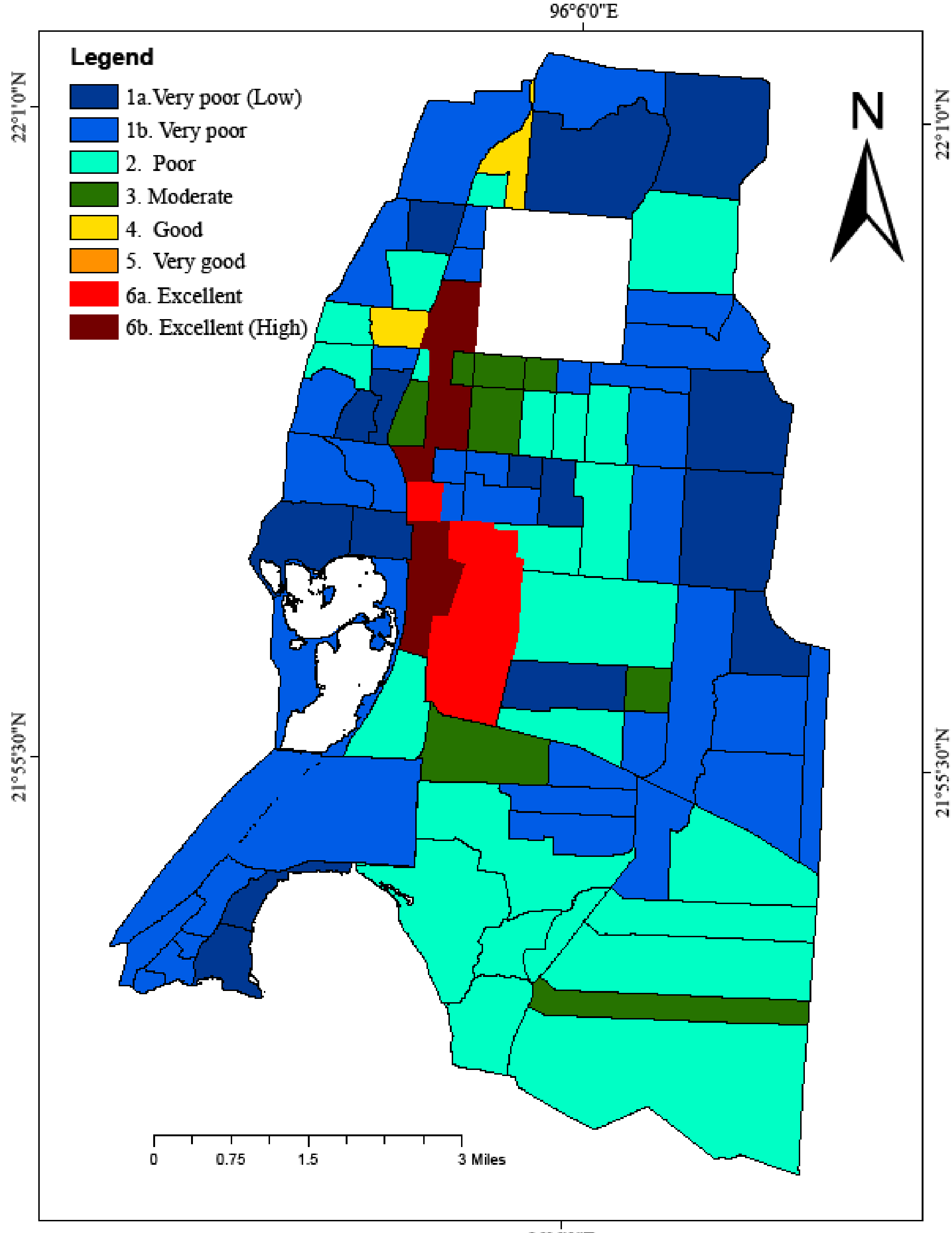

Figure 12. Public transport accessibility level for each ward in Mandalay City

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