Spatial Analysis of Road Transportation Network in Thanlyin Town

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ABSTRACT

Developed and efficient transportation network in urban areas is just like blood flowing through veins in blood. It is a basic infrastructural requirement to meet the need of the increasing population and growing economy. The study was taken up to provide road and railway network information to city dwellers which help them to choose appropriate route for increasing the transport network system efficiency.

The study area of Thanlyin Town is located in Thanlyin Township, southern part of Yangon Region. It is located in the southern part of Yangon Region. Thanlyin Town lies between 16º 45' north and 16º 47' north Latitude, and also between 96º 13' east and 96º 16' east longitude. The town has an area of (7.93) square miles. It is composed of (17) wards. Among them, Myoma (South) and Myo Houng (East) are densely populated area. In the town area, main transportation routes is Kyaik Khauk Pagoda Road (Bago-Thanatpin-Khayan- Thonegwa- Kyauktan), and Bogyoke Nay Win Road is secondary road.

In this project, I present the spatial analysis of transportation network in Thanlyin Town. The Arc GIS 10 is used to perform the extraction of region of interest from primary data and for Road Generalization, like selection, merging, elimination, symbolization etc. Total Road length and total area is calculated using the Arc Map software, using these data and population data, a Population Density and Road Density is calculated.

Network dataset is created in Arc Catalog 10 which provides the number of Transport Lines and number of Junctions. It is used to calculate the Network Connectivity Indices. An Alpha Index, Beta Index, Gamma Index are calculated for Transportation Analysis. This provides the spatial relationship between the transportation and Town planning of Thanlyin. We present the land cover classification of study area by Remote Sensing, Population Density, Road Density, Buffer analysis and Network analysis by Geographic Information System.

Index Terms — Alpha Index, Beta Index, Eta Index, Gamma Index, GIS, Network Indices, Road density, Transportation Network Analysis.

INTRODUCTION

The transportation system is critical component of urban infrastructural development and economical growth of the city. It displays region's condition as well as planner's dedication for their region. An Geographic Information System (GIS) is more useful in management functions and decision support systems which are more helpful in the planning process of urbanization. According to that when the spatial entity is associated with the non-spatial attributes. This is a key factor for applying GIS platform, the database of transportation network is normally extended by integrated with attribute and spatial data. As roads are the only means of transport available to the urban settlements, it plays an important role in the comprehensive development of a society. It acts as the lifeline of the urban economy and society.

The factors mentioned in the above statement include purpose of journey mode of transport route if a number of routes are available type of vehicle, etc. The elements, transportation literally means to carry something from one place to another. It can be executed by means such as through roads, rails, airways, waterways pipelines etc. Roads and its network only are considered in this paper. The study area lies between 16º 45' north and 16º 47' north latitude and 96º 13' east and 96º 16' east longitude, which is an area of 7.93 square kilometers.

The development of a region partly depends on transportation road. GIS can be used to monitor transport network, conditions of a network facilities, shortest or best route to reach destination and new service area. The Transportation System is a critical component of urban infrastructure growth of that region. It also displays region's economic condition as well as planners' decision for their region. An efficient route planning and accessibility facilitate sustainable development. This paper introduces the current pattern of the transportation Network system in Thanlyin Town.

Road transportation of Thanlyin Town had rapidly developed after two bridges (Thanlyin bridges and Kalawel Bridge) had been built. Transportation network analysis plays an important role to make commodities flow and better decisions for socio-economic development. The benefit of GIS is not only user-friendly access and display, but provides spatial analysis. This spatial analysis can be used to identify more data to discover new relationships. These analyzed data can be displayed in the form of maps, graphs or summary statistics.

The Implementation provides GIS functionalities like, extraction of features, Network Analysis. Designing thematic maps, access to several layers of data at a time. The existing database of the Thanlyin Town does have the option to manipulate, access, and query the database but it is limited to textual queries only. It is not possible to make relationship between the crossing attribute data with respect to the topological and spatial relationship. To identify the spatial link between Transport Network and Town Planning as an existing database is useful.

A mode of transport is a solution that makes use of a particular type of vehicle, infrastructure and operation. The transportation of a person or of cargo may involve one mode or several modes, with the latter case being called intermodal or multimodal transport. Transport systems are among the various factors affecting the quality of life and safety in a city. The study area has two means of transport i.e. railways and roads. The Present analysis of the road and railway transport network analysis was carried out because the city is the convergence point of all type of inland transport network of main road and secondary and others road.

The main concerns of this type of studies are the observation of development of the road transport network which creates level of connectivity and accessibility between settlements. This study was based on remote sensing data and processing using the GIS Technique the study on road network analysis of Thanlyin Town using high resolution satellite data and GIS. Also studied on road network analysis using Geo-informatics Technique.

Key Term: Connectivity Indices (Alpha Index, Beta Index and Gamma Index) to know the level of connectivity in the study area.

Aims and Objective-

Aim

-to observe the network connectivity of Thanlyin Town area and spatial distribution of transportation pattern and bus stop points

Objectives

-to understand the current pattern of transportation routes in Thanlyin Town
-to analyze the road network of the town area
-to examines the access the Connectivity of Network Analysis

TRANSPORTATION NETWORK

Transportation represents one of the most important human activities worldwide. It is an indispensable component of the economy and plays a major role in spatial relations between geographic nodes. Its importance is manifested through several points of view, such as historical, social, political, environmental, economic and geographic. Moreover, the transport sector influences all people and affects their environment. When transport systems are not efficient, they can be a source of frustrations as well as being detrimental to welfare, mobility, economics, etc. However, when transport systems are efficient, they provide economic and social opportunities and benefits. Transport also carries an important social and environmental load, which cannot be neglected (Rodrigue, 2006).

The transport network with complex mathematical models is the basis for transport analysis and urban growth. The network is a representation of major routes within that area. This transportation network is the input to the transport analysis and to identify urban growth, which contains Vertexes (Node /Point / Junction) and Edges (Arc / Line / Link). This is used to identify the starting point and ending points of any routes. Every Vertexes (V) and Edges (E) is a record that is used to represent the characteristics of roads for transportation network.

The GIS & RS technology applies to development of urbanization, the transportation information system and management can provide a very strong solution. Information related to transportation network is used in the efficient planning, designing, construction, maintenance and management of the transport system. In the study area ofThanlyin Town's transportation network consist a main road (Bago- Tha Nut Pin- Khayan- Thone Gwa- Kyauk Tan Road) and Secondary Road (Bogyoke Nay Win Road) shown in Figure (1.1).

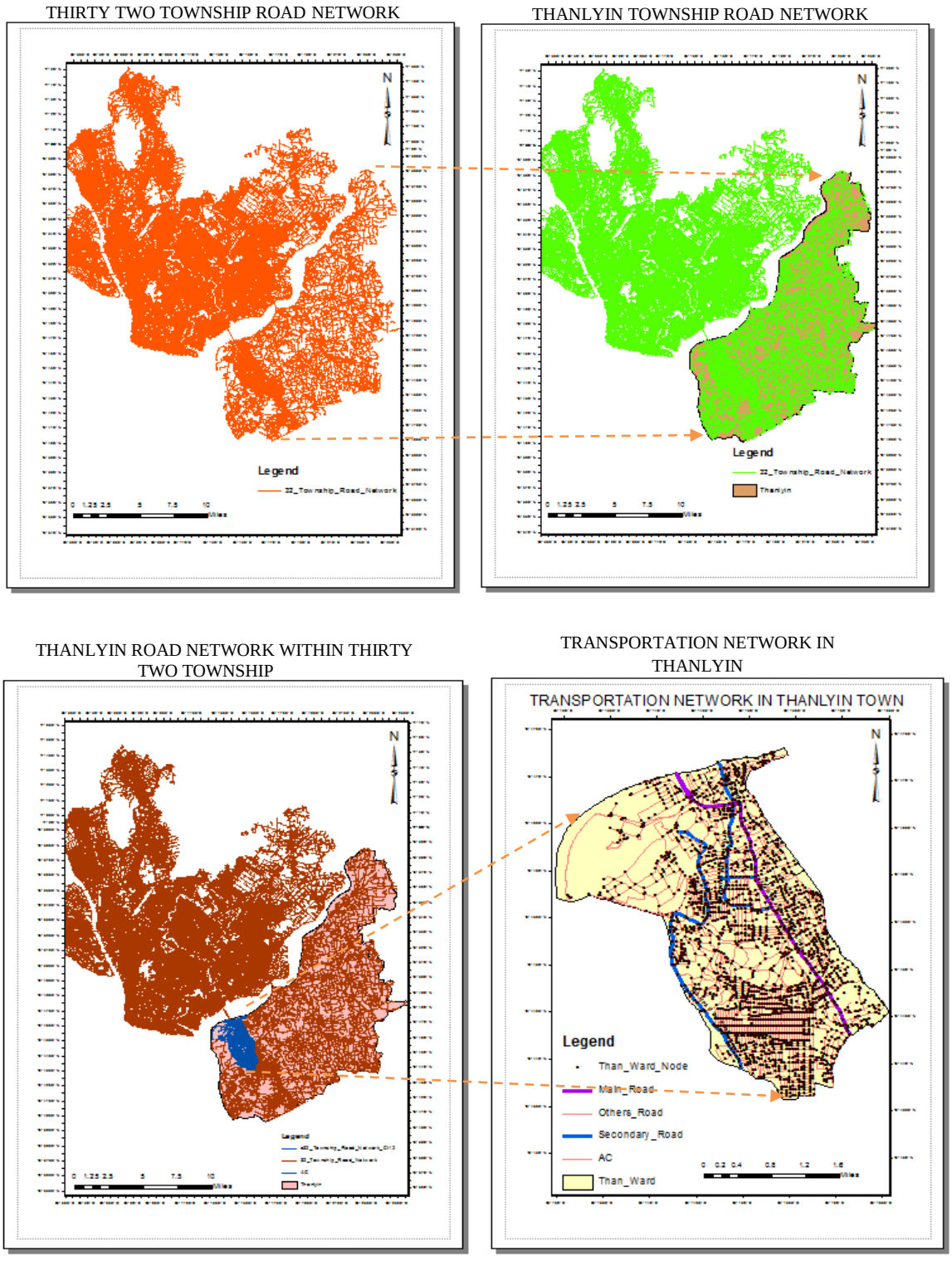


Figure: (1.1) Network Pattern in Thanlyin Town
Sources: Google Earth Image in 2014 and UTM

1. BACKGROUND OF STUDY AREA

Thanlyin is a capital town of Thanlyin Township and located Southern Yangon Region. It is located at the corner where the Bago River and the Yangon River meet. Latitudinally, Thanlyin Town lies between 16º 45' north and 16º 47' north latitude and 96º 13' east and 96º 16' east longitude.

The town is bounded by the Bago River on the north, Nyaung Thone Pin village tract on the east, Phayar Gone village on the south, Bogyoke village on the southwest and the Yangon River on the west. It has an area of 7.93 square kilometers. It composed with 17 wards. The northwest- southeast axis is slightly longer than east-west axis at the widest places (Fig.1.2).

Bago River (before joining Yangon River) running from north to south is crossing the western part of the town. Main roads (Kyaik Khauk pagoda routes) are trended from northwest to southeast on the undulating lateritic ridge. Elevation ranges are from 50′ (15 meters) to 100′ (30meters) above mean sea level.

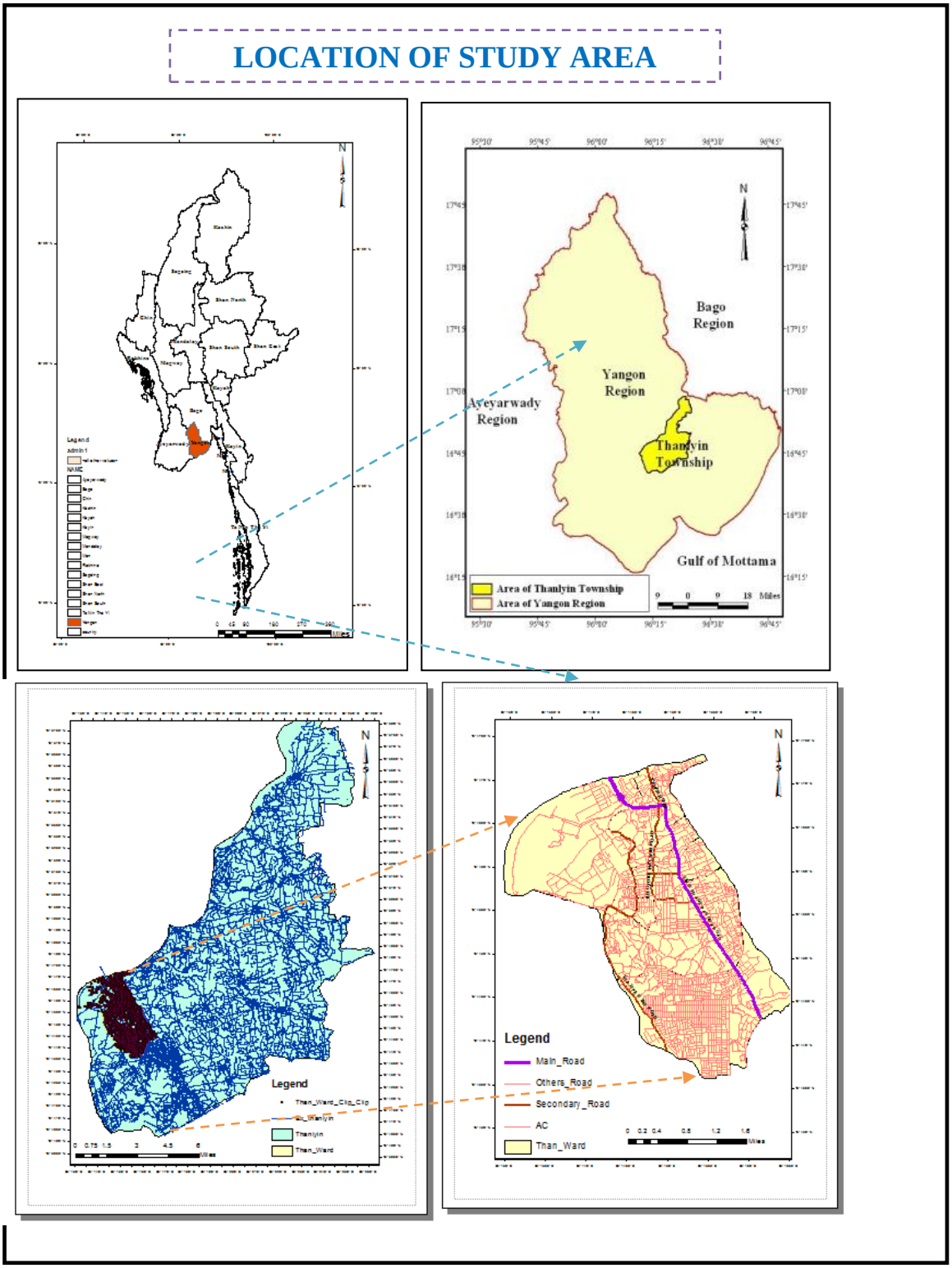


Figure (1.2) Location Map of Thanlyin Town Area, Yangon Region
Source: Survey Department in Yangon, Google Earth Image in 2014 and UTM

2. MATERIALS AND SOURCES OF DATA

In this paper, UTM map (1:50000)(Survey Department) and Google Earth image (2014) are used for application of GIS. Geo-database, digitize features, network analysis, and buffer analysis are made step by step. The necessary facts and data are acquired from the local offices, field surveys and interviews with the local people.

The Geographic Coordinate System of these images is GCS_WGS_1984 and Projection is Transverse Mercator. Also a primary data of Thanlyin Town boundary (limit) was provided by the Town Administrative Office, The secondary data of population was taken from the Immigration and Manpower Department in Thanlyin Town.

Field Collected Data**:** Field data has been collected through walks by mobile mapper GPS-Data collector.

Official Data: This data has been used for road network structure, classification of Public- Facilities, Commercial and Governmental Units.

GIS Data: Due to the cross disciplinary nature of the methodology, a diverse variety of data sources were accessed. A brief description datasets is given herein.

Road Network Dataset: With the help of Official/field collected data and basic imagery

POI (Point of Interest): POIs also collected from same resources. Network Dataset: Network dataset has been created with the help of network data and its attributes in Arc Catalog.

UTILIZATION OF SOFTWARE

The study has been implemented using Arc GIS software. Digitization, calculations, attribute, removal of topological errors, modeling of digitized data, building of network dataset and network analysis of the data have been done with the help of Arc GIS software and its useful resources. The software used in the study is as follows:

-Arc GIS 10.1-Used for creating Geo-database, topology and network analysis of the data.

-MS Excel 2007- Used for making of attribute table of data collection through primary data and secondary data.

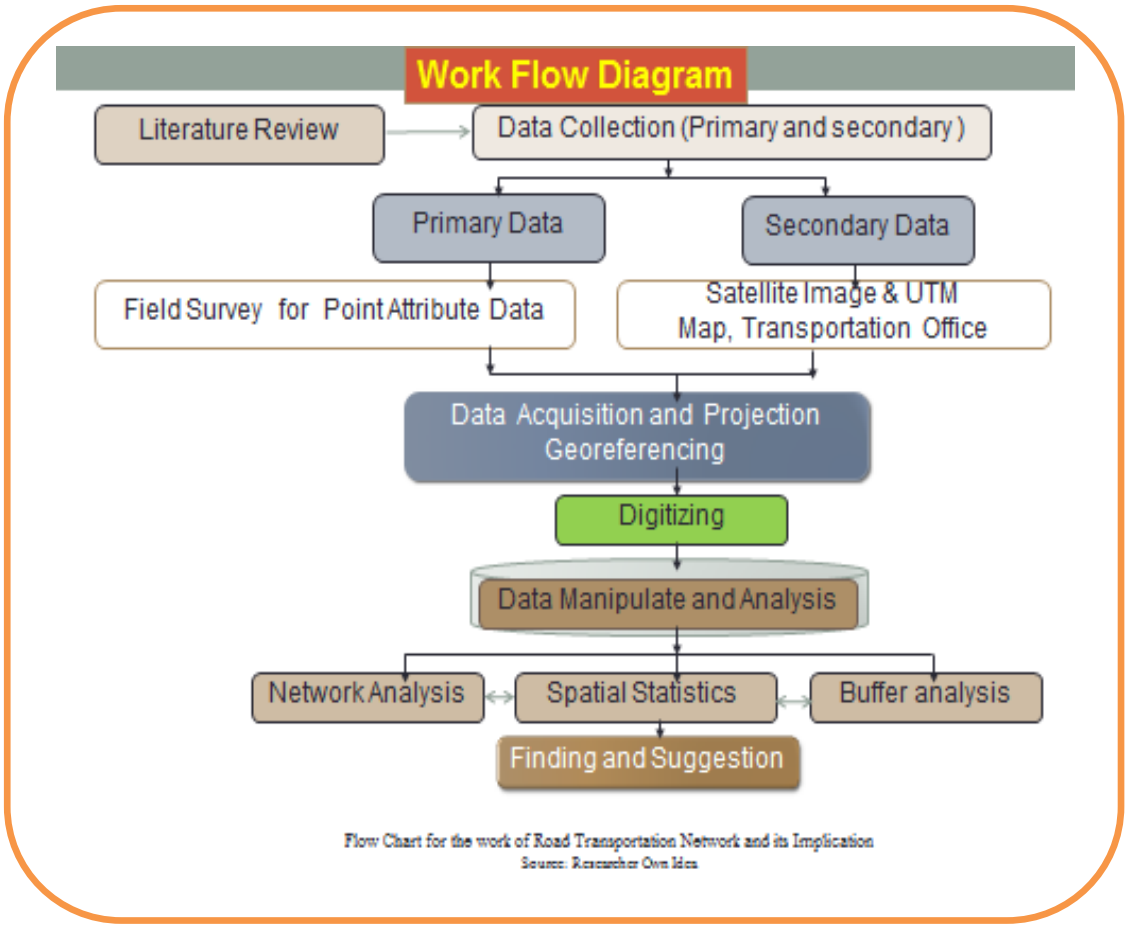
-MS word 2007- Used for write up of the Paper.

3. METHODOLOGY

In Arc GIS 10.1, it is possible to extract the region of interest (ROI). This ROI consist three types of features the first one is polygon feature and second one is line feature and final one is point features. The polygon feature represents the Thanlyin Town boundary, from this Boundary was extracted.

The line feature represents the Transport Network of Thanlyin Town. By using the Town boundary, the road transportation line feature were clipped and saved with a different name, so it shows only the Road Network which comes within the Thanlyin boundary and point feature is used for the location of bus stop shown in Figure (3.1).

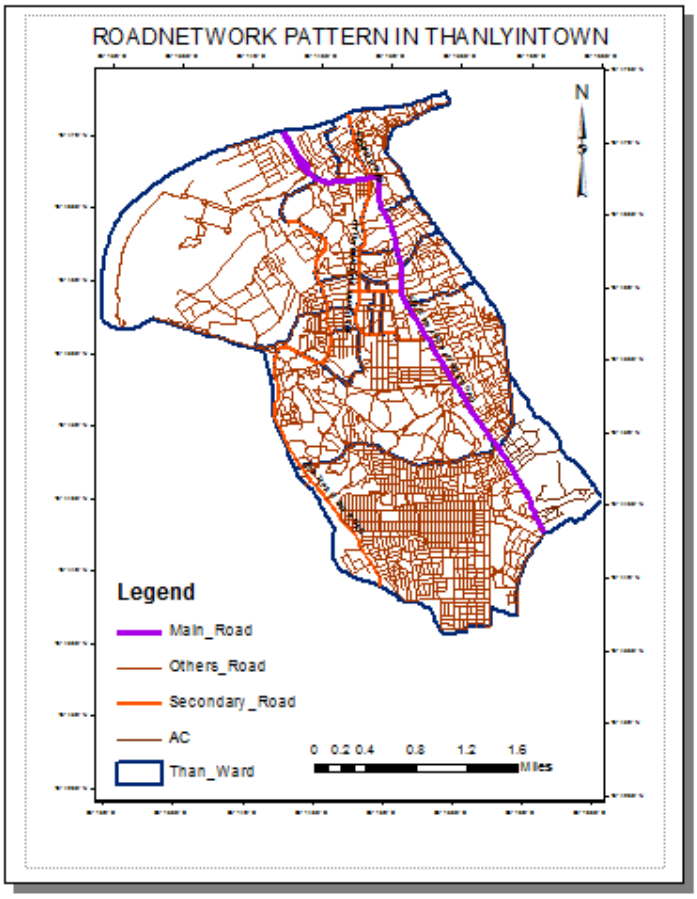
3.1 Work Flow Diagram



Flow Chart for the work of Road Transportation Network and its Implication
Source: Researcher Own Idea

3.2 Road Network Pattern in Thanlyin Town

The road conditions are involved selection, merge, symbolization, elimination etc. The road Transportation Network data having a category Road Type, like Main Road, Secondary Road, and Others Roads. By using this classification the selection process was performed Figure (3.1).



3.3 Create Feature Class

Feature Class for Geo-database is which helps to store and manipulate geographical data. Geo-database is a combination of two data sets. The single uses database is also known as Personal Geo-databases. A Personal Geo-database is a Microsoft Access database that can store, query and manage both spatial and non-spatial data.

The Geo-database is based on coverage and shapes file of road data structure. It supports user defined relationship among feature classes and personal geo-database. In addition to generic feature, such as points, lines and polygons, it can create custom features such as transformer, Pipes and parcels. These custom features can have special behavior to better represent real work objected. It supports a topology in a Geo-database, so it allows representing shared geometry between same features within a feature class and between different feature classes. In personal geo-database the following type's dataset can be created in Arc Catalog such as feature dataset, feature class, spatial data, and toolboxes.

The groups of related features are within feature datasets. Within feature datasets, like all feature classes have a same coordinate system. Also it is possible to create topology for each feature class of nodes patterns. Feature classes can be a part of geometric network dataset within feature datasets .It is possible to add new datasets like as Feature class, network datasets and road topologies structure**.**

After created the feature classes, the lines and polygons features were joined to get the attribute values by points got from field verification and another sources from UTM and Google Earth Image sources in 2014, by using spatial join tool in Arc Map.

3.4 Topology in Arc GIS

Topology is a collection of rules that, coupled with a set of editing tools and techniques, enables the geo-database to more accurately geometric relationships. It is the arrangement for how point, line, and polygon features share geometry. So it helps to validate and maintain better features.

Also topologies can be used for modeling spatial relationships between features. Using this technique it discovery easy for analytical operation such as checking the connected feature, A topology is stored in a geo-database as one or more relationships that define how the features in one or more feature classes.Topological data model manages the spatial relationships by representing the spatial objects like point, line, and polygon. The topology errors can be find outs and it is possible to fix or solves this error in Arc Map.

4. TRANSPORTATION NETWORK PATTERN

The transportation network is a realization of spatial network, describing a structure which permits either vehicular movement or flow of some commodity (Rodriguez, 2006). Examples are network of roads, streets, railways and, pipes, aqueducts, and power lines. One can distinguished land, sea and air transportation network.

Therefore, Transportation network also carries an important role as social & economical, environmental and commodities which cannot be neglected for Thanlyin Township. In Thanlyin, transportation networks are not improved for Aung Chanthar Ward than other areas within Thanlyin Town for studied period in 2017.

4.1 Road Generalization

4.1.1 Main Road

This road was subdivided into two parts. The study area passed through by two local Highways namely Yangon- Thanlyin-Kauktan and Yangon- Thanlyin-Thone Gwa and Khayan Road. Thanlyin-Kauktan road was first construction in 1926-27. Thanlyin Kyaik khauk Pagoda Metalled Road is 4 miles long and 14 feet in wide. It was also built since 1900, this road trend north south alignment, connecting with Kyauktan -Phayargon Road. It passes through the southern part of Thanlyin Town area and Phayargon village of Thanlyin Township It was built on lateritic ridge. In 1958-59 this road was one of the best metalled roads in Myanmar. YBS Bus route of No.31, 32,33,34,70 and 76 are operating on this road.

4.1.2 Secondary Road

There is two Secondary Road in the study area which passes through the center of the city. These are Bogyoke Nay Win Road and Thatipahtan Road. Total length of these Road is ( ) kilometer.

There are five major roads in Thanlyin Township. There are as follows- 1. Thanlyin Kyauktan Road - 12 miles

2. Thanlyin Thonegwa Road - 13 miles
3. Thanlyin Thilawa Terminal Road - 6 miles

4. Thanlyin Thilawa lower Road - 2 miles

5. Thantay kwin Pagandaung Road - 18 miles

After the completion of Yangon Thanlyin Bridge in 1993, there were some newly developed roads connecting Thanlyin with Yangon City. Various public transport service buses, private vehicles and office vehicles use the Bridge for the trip between Yangon and Thanlyin. These Roads are tar, bituminous, metalled, earth roads and motorable in all seasons. The renovation, improvement and works maintenance works for roads were also carried out yearly as in the case construction.

Within Thanlyin Town municipal area, up to 2004-2005 nearly 40 miles of roads were constructed of these, there were 13 miles of tar roads, 5.5 furlongs of metalled roads, 9 miles and 5 furlongs of gravel roads and 16 miles and 5 furlongs of earth roads. The total number of roads is 163 roads. Roads also general maintenance and improve by Township councils, Town committees and municipalities and ward committees, with the public on self-reliance basis and on individual basis every year.

Similarly Thanlyin township municipalities, Village committee with the public on self-reliance have been extensively carryout construction activities in every village within Thanlyin Township. The total lengths of roads in village tracts area are 34 miles and 8.20 furlongs with the total number of 23 roads. These are 6.3 furlongs of the road, 1 mile and 6.3 furlongs of metalled roads, 2 miles and 0.9 furlongs of gravel and 30 miles and 1.65 furlongs of earth road.

The construction of new roads, the extension of the existing, upgrading, repairing and maintenance of the existing roads are being undertaken on above mentioned roads by Public works under the Ministry of Construction annually. Timely maintenance works carrying outs as the following:

. Patching up the old road holes with mixed coal tar

. Cutting out the grasses the beside of the roads

. Digging up the gutters for the good drain, of the roads

. Extension in width of some road

. Upgrading from the roads to metalled of some road.

Railway- Rail transport between Thanlyin and Yangon first started in 1993.Itis connected with one way to Yangon and another side separate into two branches.

4.2 Transport Network Planning

Generally Transportation Planning consists of various transportation networks. These networks can be road type (width of road), pavement management, traffic management and accident related data. The transport network structure should be redesigned for infrastructure improvements. These improvements may be creating to provide road width, lengths and parking areas (multi parking).

A network is a system of interconnected elements such as lines (Edges) and connecting junctions (Vertexes or points) which represent every possible route from one Junction to another Junction. From a feature class a network dataset is created but it is restricted that only one feature class can create only one Network Dataset Figure (4.3).

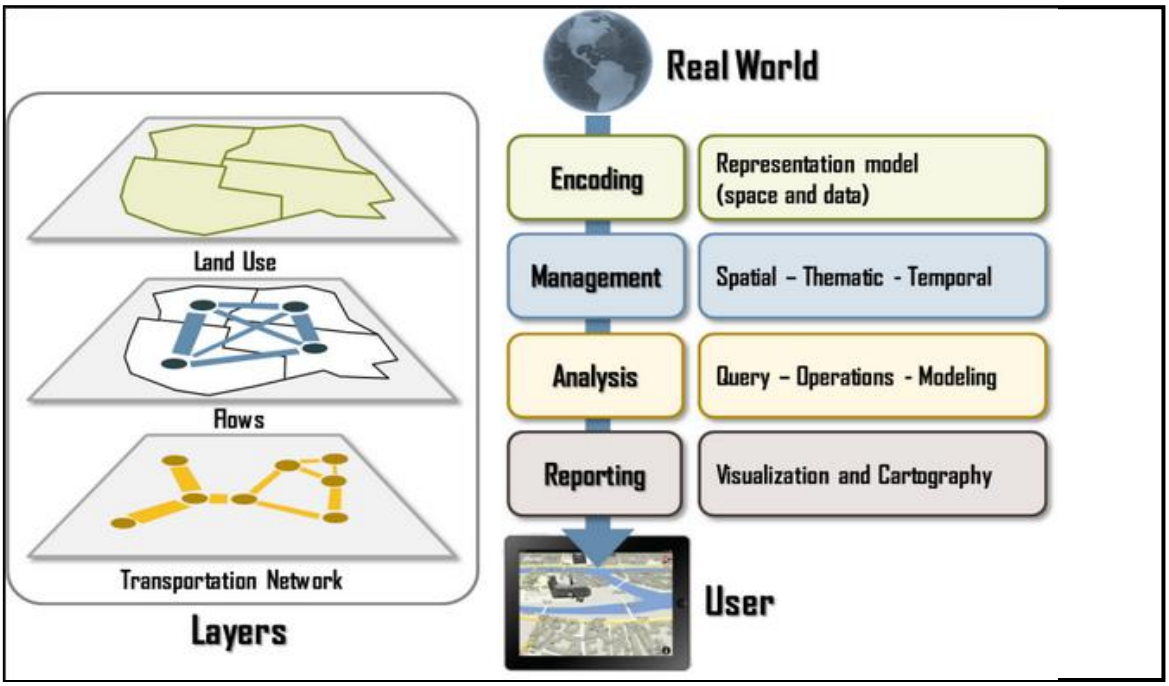
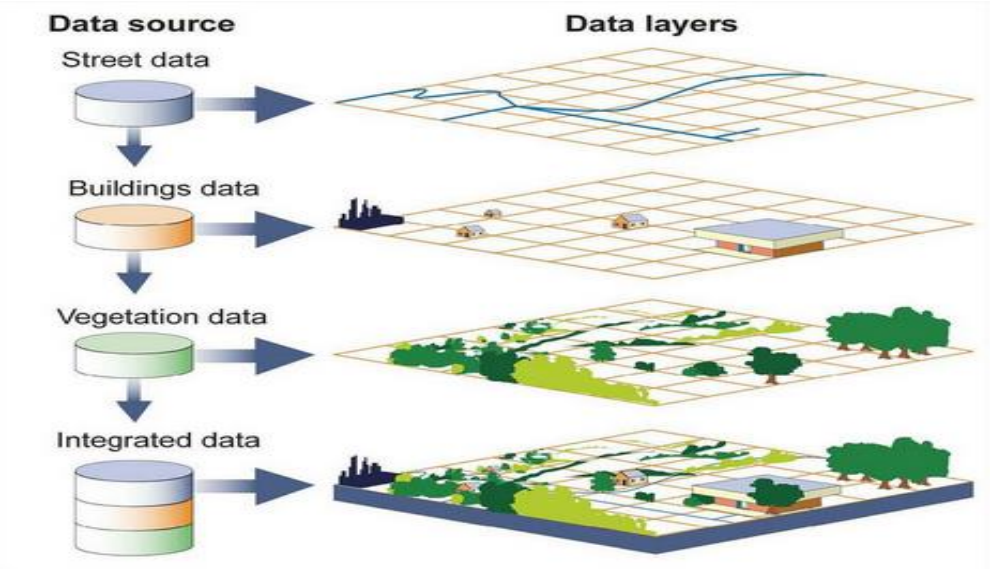


Figure (4.1) Model Building of Transportation Network
Source: GIS Reference Book

DATA STRUCTURE



GIS FOR ROAD NETWORKING

GIS Technology using for Road Networking comprehensively, also It could be identified through Transport Infrastructure Life Cycle.

Figure (4.2) Data Structure and Transport Infrastructure Life Circle
Source: GIS Reference Book

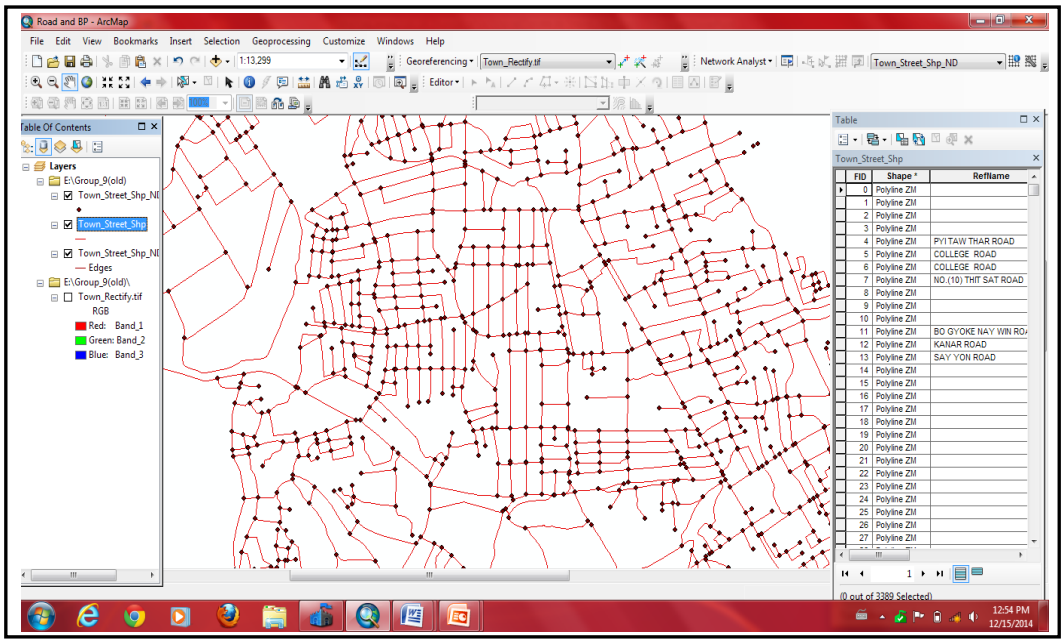


Figure (4.3) Building of Network Dataset
Source: Google Image 2016

4.3 Rationale for the Study Area

Transportation is one of the most important for human activities, transportations and commodities and it is a basic system of infrastructures. It plays a major role to spatial relations. Its importance factors for historical, social, political, cultural, economical, environmental and all spatial factors. It affects their environment as well as being detrimental to welfare, mobility, and socio-economic factors when transport systems are efficient, they provide economic and social, opportunities and benefits for all living society. When transport systems are efficient, they provide economic and social, opportunities and benefits for all living society (Rodriguez, 2006)

Therefore, Transportation network also carries an important role as social & economical and environmental load, which cannot be neglected for Thanlyin Township. In Thanlyin, Transportation networks are not improvement except Aung Chanthar Ward.

4.4 Network Pattern Analysis

The Arc GIS Network Analysis extension allows wanting the platform of network analysis. Then select to Network Dataset. Once the Network Dataset has been created then open Arc Map to perform Network Analysis After creating a Network Dataset will get a Total number of Lines and Total number of Junction (Nodes) shows a total number of Edges and total number of Vertex. A transport network is used for transport analysis to determine the flow of vehicles (or people) through it within the public transport services. It may combine different modes of transport services of vehicles and commodities flow.

A network is a system of interconnected elements such as lines (Edge) and connecting junction (better or points) which represent ever possible route from one junction to another junction form a feature class a network dataset is create but it is restricted that form only one feature class can create only one Network Dataset. The Arc GIS network analyst extension allows building a network dataset and performing analysis on a network dataset.

Generally Transportation Planning consists of various transportaton networks. These transportation networks can be road type (width of road), pavement management, traffic management and accidents for related data.

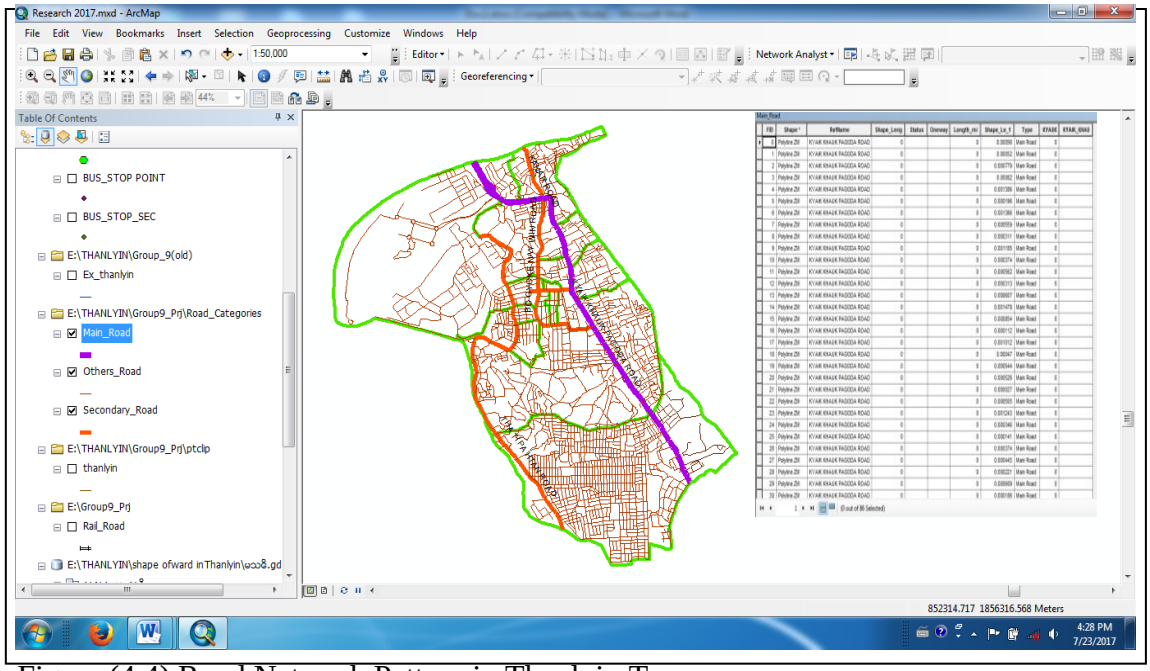


Figure (4.4) Road Network Pattern in Thanlyin Town
Source: Digitizing from Base Map (UTM)

The use of GIS& RS technologies in development of urbanization, transportation system and management for urban planning can provide a very strong solution. The topology structures are related to transportation network is used to the efficient planning, designing, construction, maintenance and management of the transport system. In the study area, Thanlyin Town Transportation Network consist a Main Road (Bago- Tha Nut Pin- Khayan- Thone Gwa- Kyauk Tan Road), Secondary Road (Bogyoke Nay Win Road) shown in Figure (4.5).

Transport Network plays a vital role in the growth of urban center and economic development of a region. It is also found that there is a positive relationship between urbanization and good transport network. The study area has Main Road, Secondary Road and Other Roads on the road pattern model of private creation from the base of Google image and UTM map.

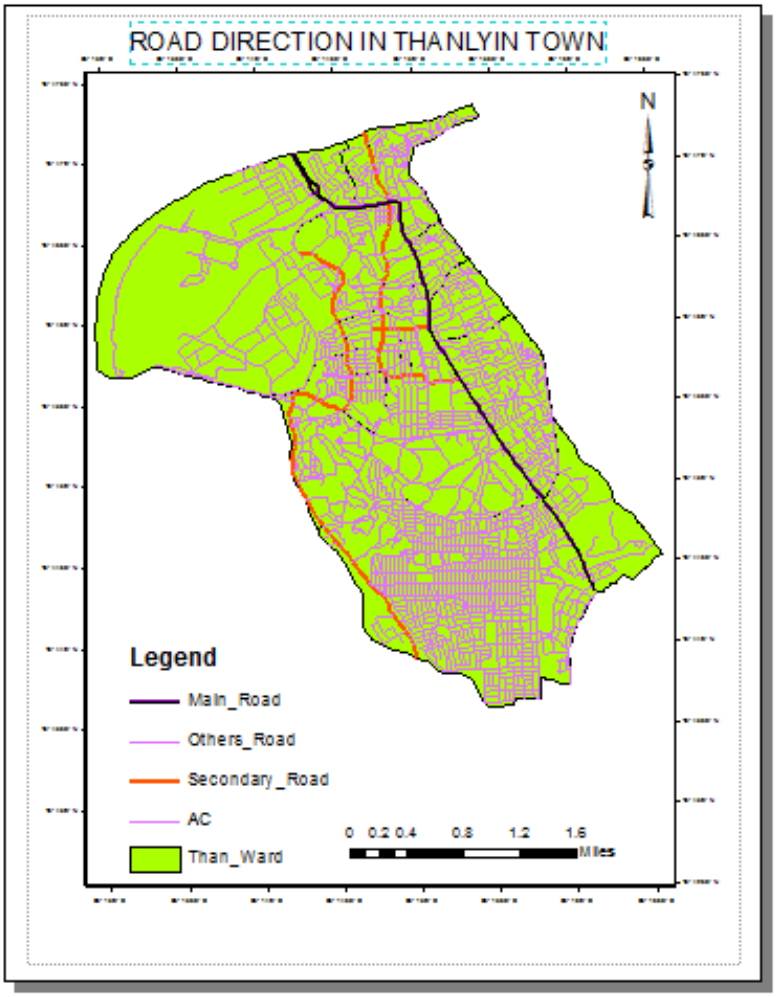


Figure (4.5) Road Direction in Thanlyin Town
Source: Private Creation from

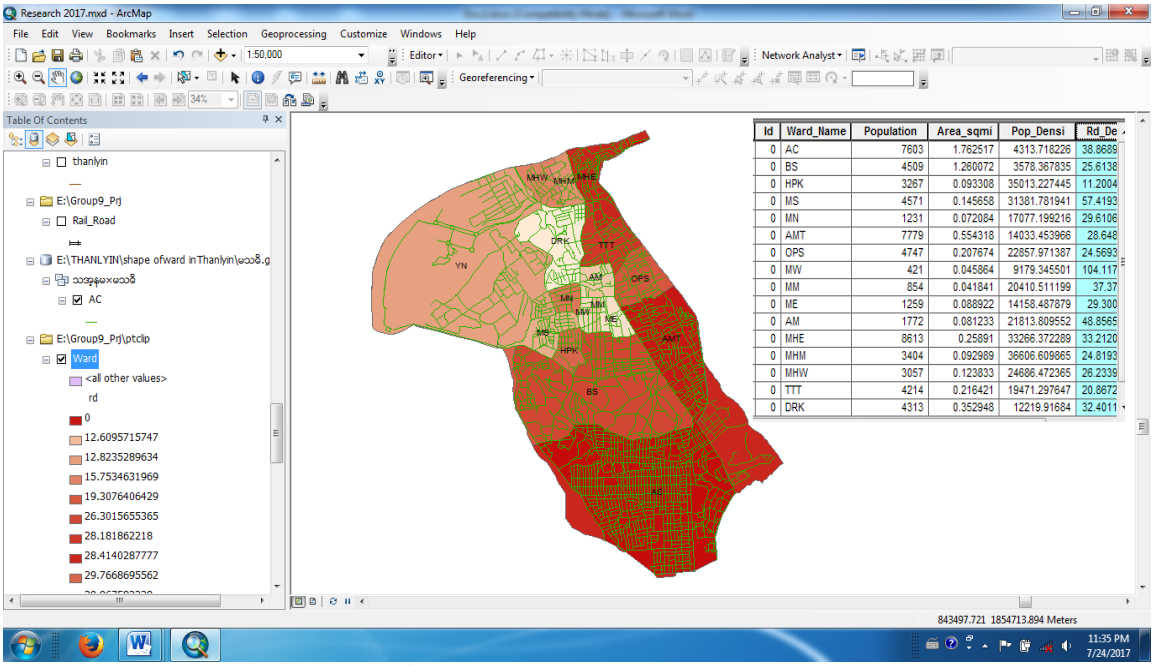


Figure (4.6) Road Density Analysis in Thanlyin
Source: Base from Google Earth Image (2014)

4.5 Road Density

A network is a system of interconnected elements such as lines (Edge) and connecting junction (points) which represent ever possible route from one junction to another junction form a feature class a network dataset is create but it is restricted that form only one feature class can create only one Network Dataset.

The Arc GIS network analyst extension allows building a network dataset and performing analysis on a network dataset. Firstly, in this paper summarization of Ward length and then the calculation of road density focus on for the (17) Wards. By the calculation, the highest Road Density Ward is Myothit West and Yae Nan Ward is lowest road density. Myoma Ward is located in the central part of the study area and also the center of economics activities. In this method, the highest density of road is overlapping in the central part of the town, especially found in the Myoma Ward area.

The Road Network density is used to measure s the Network Development. So, another way of road density is represented by mathematically as Equation

(RD = L / A), where (L= total length a network, A = total area of network), 9.712 Km / 20.54Sq Km = o.4728m / sq. km.

This index value shows good condition of Transport Network. The study area of Thanlyin Town has (17) Ward, the area and total road length of this Zone is calculated in GIS, and Road density is shown in the Table (4.1).

The Road Density of Town given bellow;

$$RD = l / A$$

Where l = total length of network

A = Total Area of network

Table (4.1) Road Density by Ward

FID	Shape *	Id	Ward_Name	Population	Rd_Den
0	Polygon	0	AC	7603	38.868933
1	Polygon	0	BS	4509	25.613818
2	Polygon	0	HPK	3267	11.200418
3	Polygon	0	MS	4571	57.419365
4	Polygon	0	MN	1231	29.610685
5	Polygon	0	AMT	7779	28.64825
6	Polygon	0	OPS	4747	24.569309
7	Polygon	0	MW	421	104.11732
8	Polygon	0	MM	854	37.3779
9	Polygon	0	ME	1259	29.30012
10	Polygon	0	AM	1772	48.856587
11	Polygon	0	MHE	8613	33.212047
12	Polygon	0	MHM	3404	24.819388
13	Polygon	0	MHW	3057	26.233966
14	Polygon	0	TTT	4214	20.867246
15	Polygon	0	DRK	4313	32.401168
16	Polygon	0	YN	2497	10.806413

Source: Calculation with GIS Software

Transportation routes and service areas are used to solving a route of transport problems. That can mean finding the quickest, shortest, or even the most scenic route, depending on the impedance choosing to solve for events. If the effective resistance is time, then the best route is the quickest route. For example, when incidence occurs in the Myo Houng East, Myoma and Aung Chanthar, shortest path analysis are applied for the hospital and these three areas. Figure (4.7)

A network service area is a region that encompasses all accessible streets. Some streets are within specified effective resistance. For good transport network of

area, concentric service areas are needed to show how accessibility varies with effective resistance within area. Therefore, good transport site areas are choosed as a new service area for bus stop point area including of around Aung Chan Thar Ward, in Thanlyin Town. Because of Aung Chan Thar Ward is more increased of population distribution than other area and then the road patterns are systematic in Thanlyin Town. From above facts, Aung Chan Thar Ward may be a new services area as a finding. Figure (4.8)

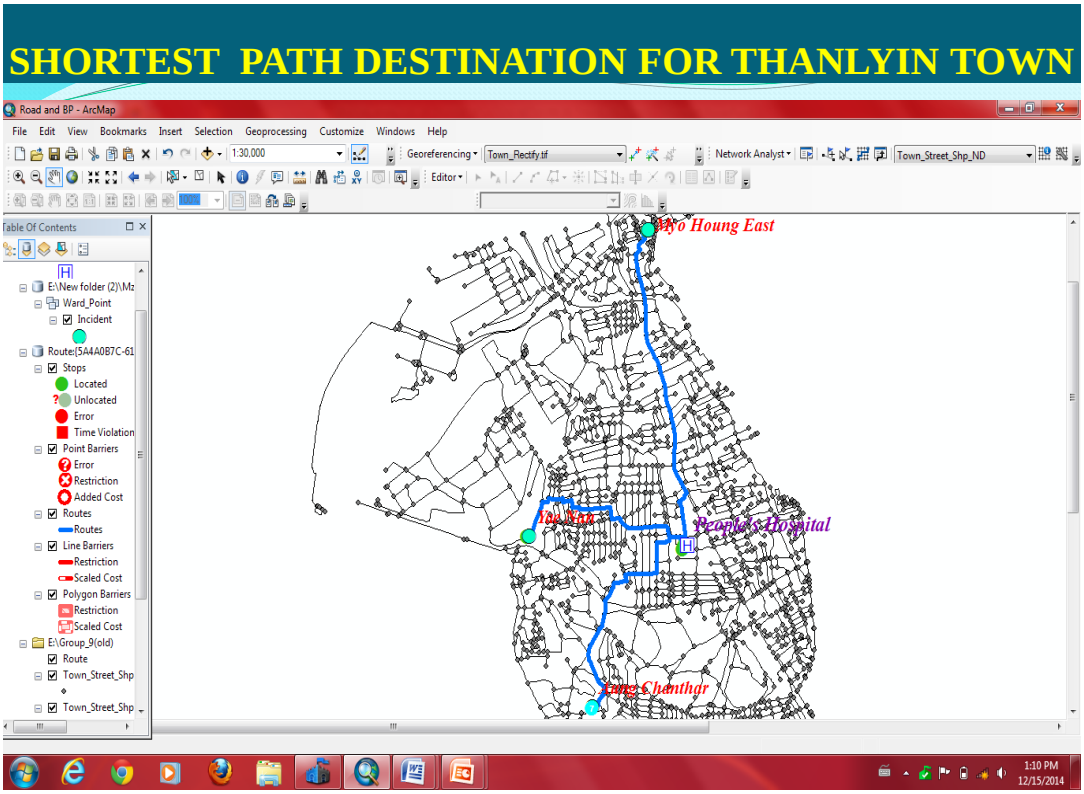


Figure (4.7) Shortest Path for Thanlyin Town
Source: Google Earth Image in 2014

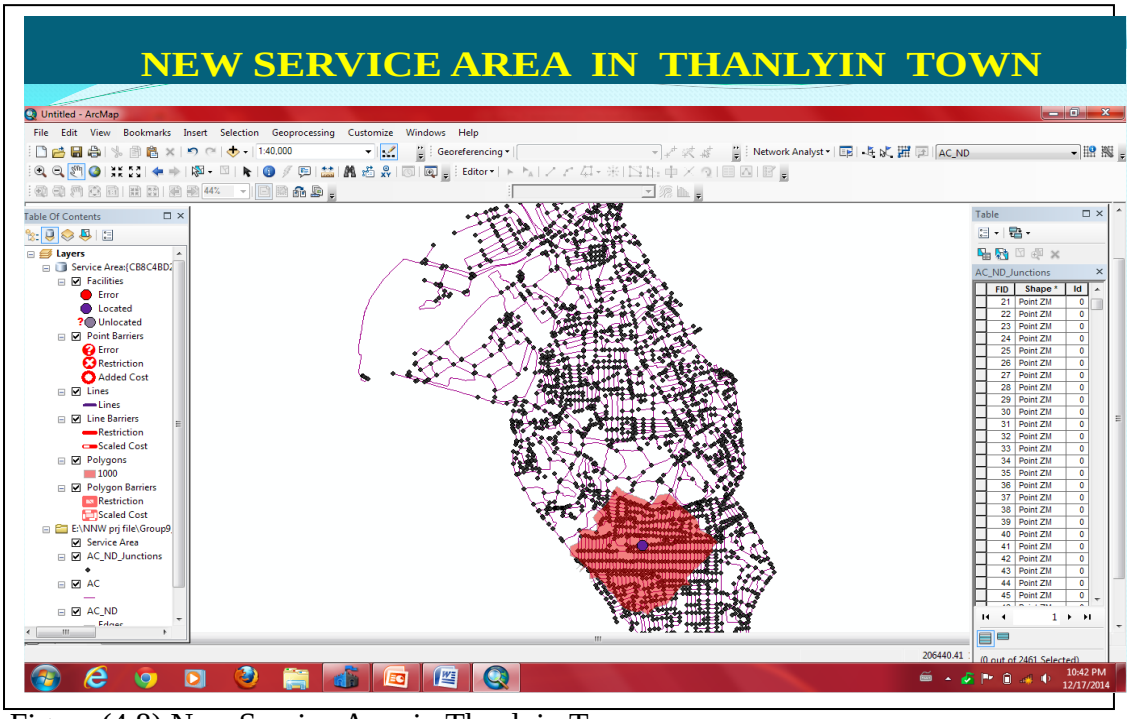


Figure (4.8) New Service Area in Thanlyin Town
Source: Own Creation by Network Analysis

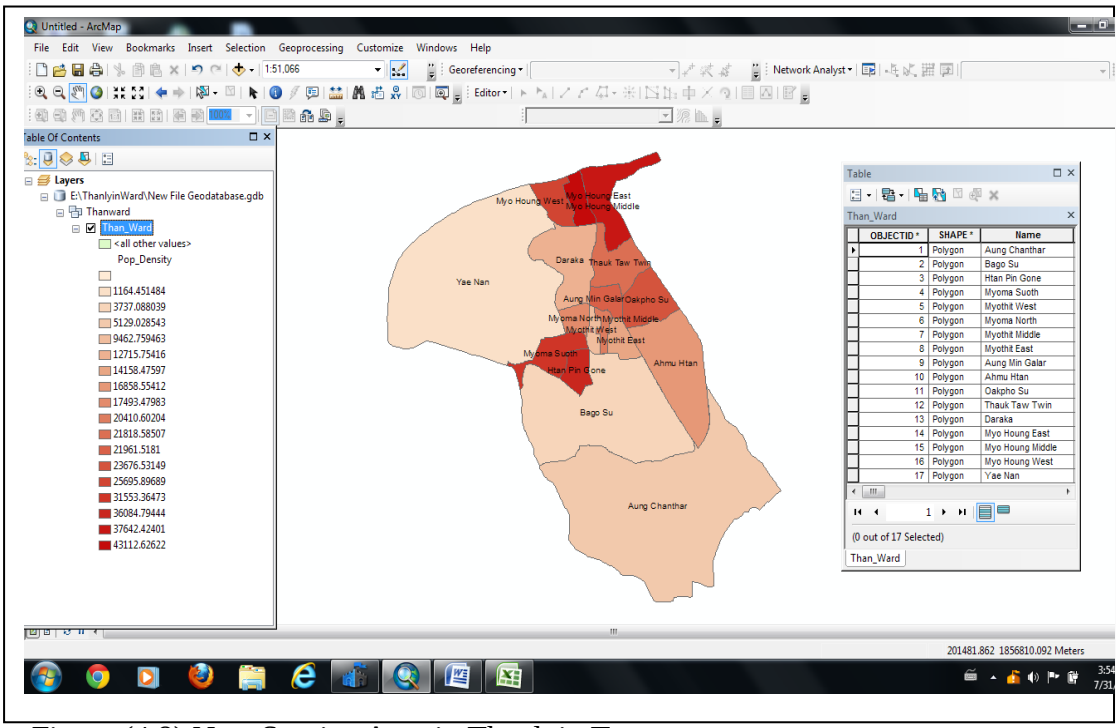
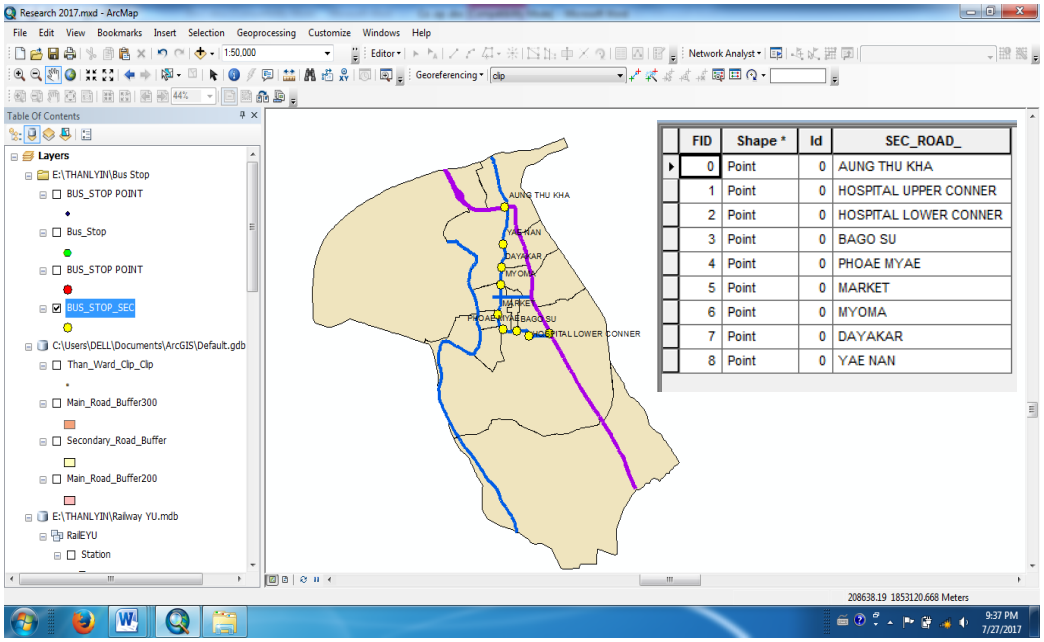


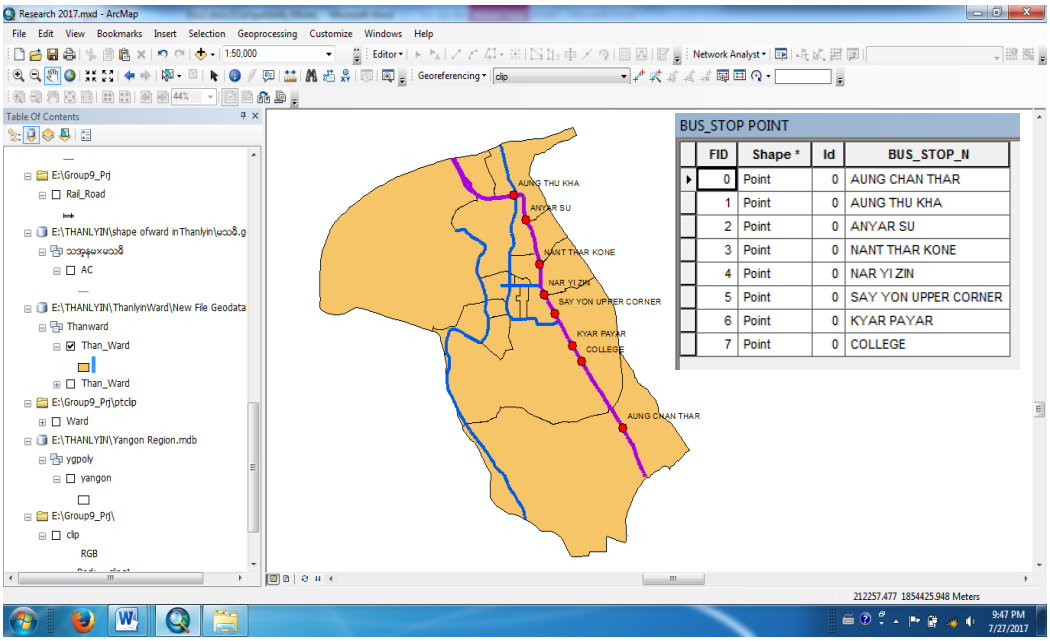
Figure (4.8) New Service Area in Thanlyin Town
Source: Own Creation by Network Analysis

4.6 Bus Stop Condition

In the study area of Thanlyin Town which can be classified into three main types of road network pattern. They are main road, secondary road and other road. Main road is alignment with the nearly north east-south west. The secondary roads are Bogyoke Nay Win Road, Thauk Taw Twin Road and Tha Ti Pa Htan Roads. Bus stop points are not on other roads within Thanlyin Town.There are (16) Bus Stops in the study area. Eight bus stops have located along the main road and other eight bus stops have situated along the Bogyoke Nay Win road (Secondary Road).Only the Bogyoke Nay Win Road used for the Public Bus Line Transportation Services. Predominantly uses of bus stops are Aung Thu Ka, Myoma and Aung Chan Thar points.



FID	Shape *	Id	SEC_ROAD_
0	Point	0	AUNG THU KHA
1	Point	0	HOSPITAL UPPER CONNER
2	Point	0	HOSPITAL LOWER CONNER
3	Point	0	BAGO SU
4	Point	0	PHOAE MYAE
5	Point	0	MARKET
6	Point	0	MYOMA
7	Point	0	DAYAKAR
8	Point	0	YAE NAN

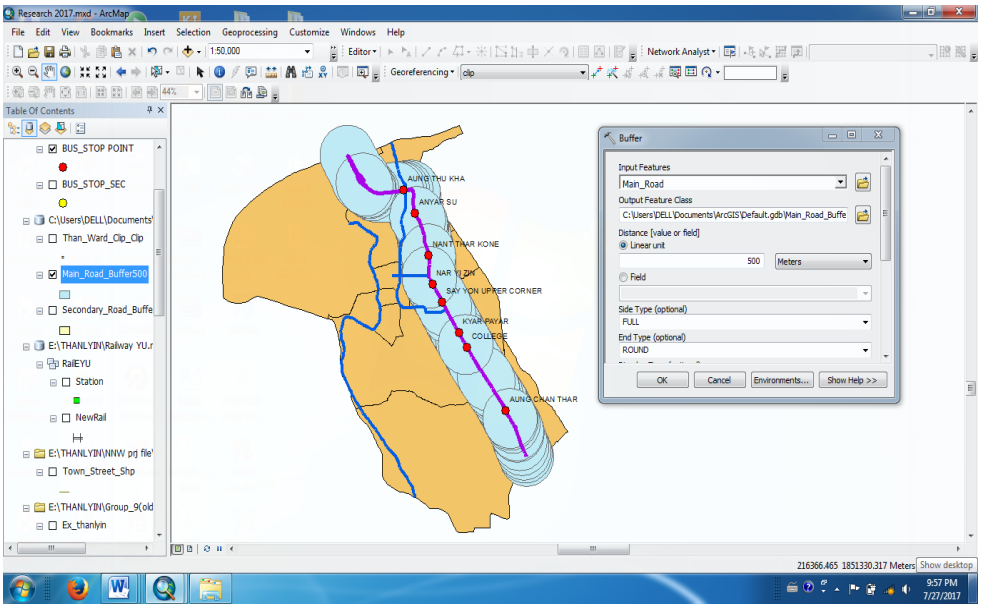


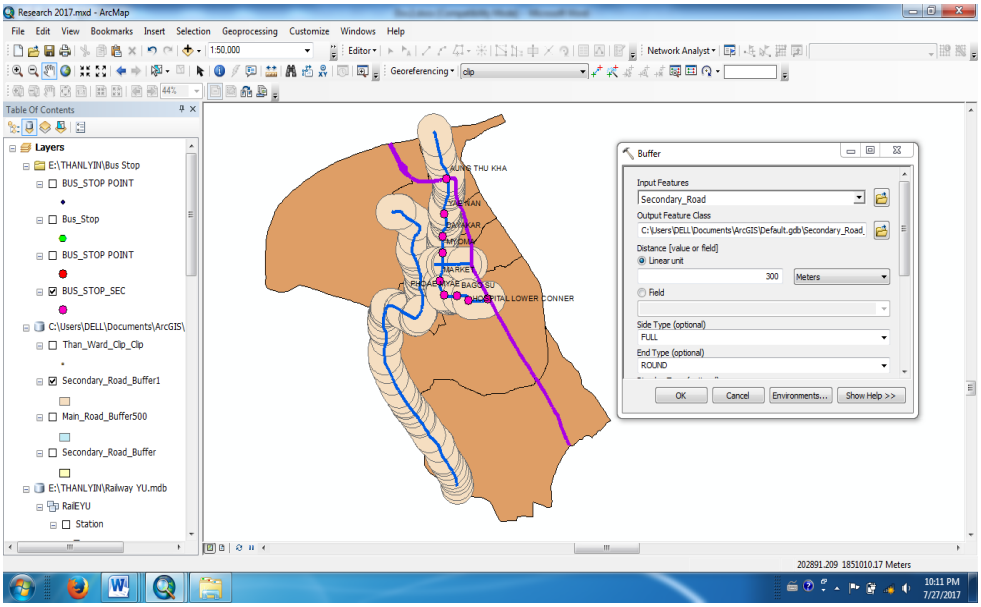
BUS_STOP POINT

FID	Shape *	Id	BUS_STOP_N
0	Point	0	AUNG CHAN THAR
1	Point	0	AUNG THU KHA
2	Point	0	ANYAR SU
3	Point	0	NANT THAR KONE
4	Point	0	NAR YI ZIN
5	Point	0	SAY YON UPPER CORNER
6	Point	0	KYAR PAYAR
7	Point	0	COLLEGE

4.7 Buffer Analysis

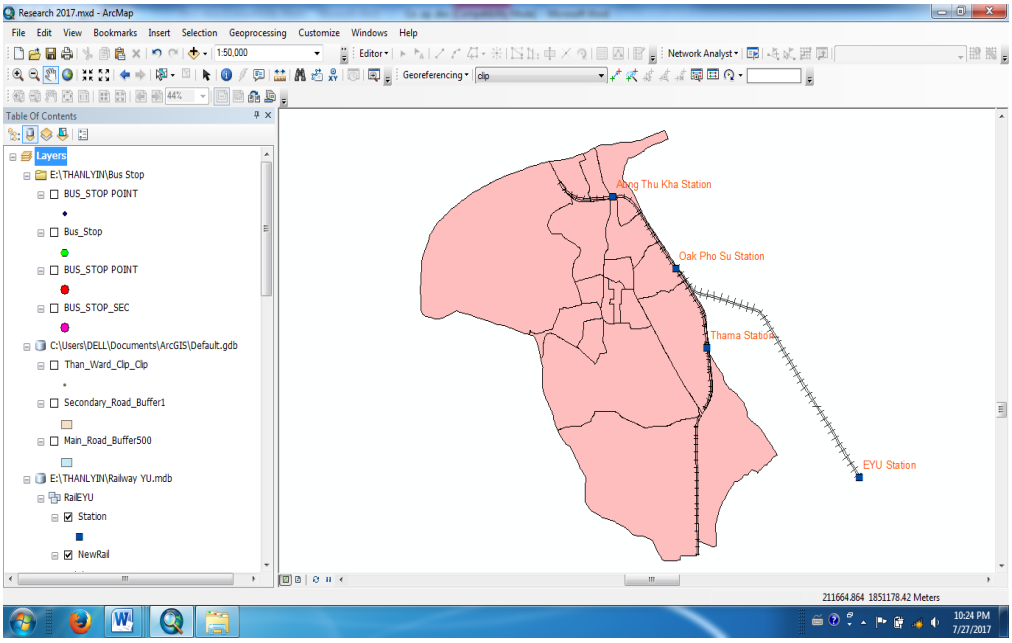
In this paper, Buffer Analysis is calculated in Thanlyin Town for main and secondary road. This main road emphasis on using with linear distance unit (500) meters of Buffer Analysis for coverage of the Bus Stop location except between Aung Chan Tha bus stop and Thama University bus stop within the Study area. And also the secondary road, emphasis on using with linear distance unit (300) meters of Buffer Analysis for coverage of the Bus Stop location.





4.8 Railway Transport

The railways station within in Thanlyin Town is connected with Toe Kyaung Lay in the Yangon Region and Thilawa port in Thanlyin Township. There is one railway by around the railways transport in Yangon Region. The lengths railways are about (3) miles within the town area.



5. Network Connectivity Analysis

5.1 Nodes and Linkages

Transportation networks can be represented by a series of nodes (Vertices) and linkages (a set of edges). Nodes may be the origins as destinations of flows and they are points as which flows in the network can change their volume, direction of movement and mode of transport. They range in size and complexity from a road junction to a major international port. Links or edges are any behind of connections between these nodes (Vertices) and linkages (a set of edges).

To analyze the road network of Thanlyin Town, every start points or end points of any routes is defined as nodes(vertices) and the roads these connect these vertices are termed as edges (linkages). According to this identification are 2460 vertices and 3744 edges in road network of Thanlyin town.

Beta Index

The Beta Index is ratio of the number of edges to the number of nodes. It is more useful for simple network where no circuits are involved. If the value is 0.0 it means there is just nodes without any arc. Its value ranges from 0.0 to 1.0 and greater, where network are well connected. The Beta Index's equation is as follows,

Equation: - $\beta = V / E$
Where
E = No. of edges (Line)
V = No .of Vertex (Node)

Alpha Index

Alpha Index is a ratio of circuits to the number of maximum possible circuits in the network its value ranges from 0.0 to 1.0. If the value is 0, then it indicates no circuits; and if the value is 100 percent then it indicates complete interconnected network.

Equation; - $\alpha = E- (v+1) / 2v - 5$

Where

E = No. of edges (Line)
V = No .of Vertexes (Node)

Gamma Index

The Gamma Index is a Ratio of actual number of edges to the Maximum possible number of edges in the network its value ranges from 0.0 – indicates no connection between nodes, to

1.0 –maximum number of connection with direct link to all nodes.

The Gamma Index's equation is as follows,

Equation: $\gamma = E / 3(v - 2)$

Where

E= No. of edges (Line)

V = No .of Vertexes (Node)

So, the calculation of the study area for each ward by the Index of Alpha, Beta and Grammar are shown in Table (5.1).

Table: (5.1) Calculation of Indices for Each Ward

CALCULATION OF INDICES FOR EACH WARD

+NO	WARD	Edge (E)	Vertices(V)	β index	α index	γ index
1	AC	1405	2460	0.5711	-0.215	0.1905
2	BS	554	474	1.1687	0.0842	0.3912
3	AMT	377	304	1.2401	0.1204	0.4161
4	YN	303	234	1.2948	0.1484	0.4353
5	MHE	180	142	1.2676	0.135	0.4285
6	DRK	163	138	1.1811	0.0902	0.3995
7	TTT	126	103	1.2233	0.1122	0.4158
8	MS	120	95	1.2637	0.1333	0.4301
9	OPS	111	91	1.2197	0.1104	0.4157
10	HPK	77	68	1.1323	0.0634	0.3888
11	ME	61	48	1.2708	0.1395	0.442
12	AM	57	47	1.2127	0.1071	0.4222
13	MHW	45	39	1.1538	0.0735	0.4034
14	MHM	43	40	1.075	0.0285	0.3771
15	MN	43	33	1.303	0.1607	0.4623
16	MW	41	30	1.3666	0.2	0.488
17	MM	39	28	1.3928	0.2173	0.5

Source: Calculation

By the showing of table (5.1), Myoma Middle Ward is the highest connectivity of Index and Aung Chanthar Ward is the lowest connectivity Index. And then The whole town of connectivity indices (β, α, γ) are shown by the calculation as follows;

Where; E = Edges, V = Vertices

Beta Index = E/V,

By the formula,

$\beta = V / E = 2460 / 3744 = 0.65710$

Alpha Index,

$$\alpha = \frac{E - (V + 1)}{2V - 5} = \frac{3744 - (2460 + 1)}{2\,(2460 - 5)} = \frac{1283}{4910} = 0.2613$$

Gamma Index,

$\gamma = E/3(V-2)$

$= 3744 / 3(2460 - 2)$

$= 3744 / 7374 = 0.5077$

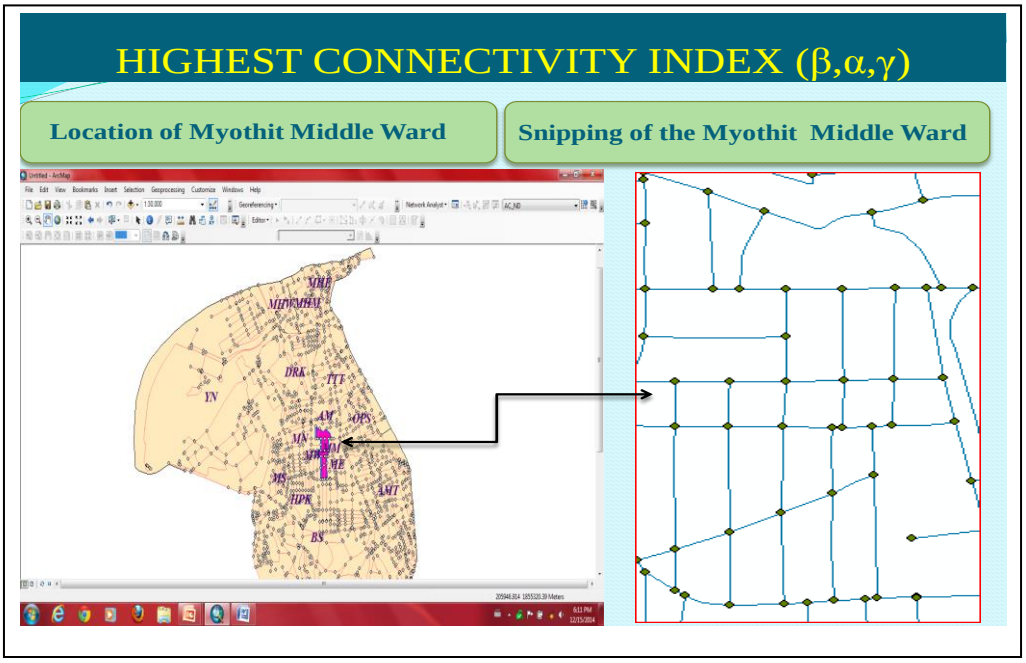


Figure: (5.1) Highest Connectivity Index of Myoma Middle Ward Snipping Tools
Source: Google Earth Image in 2014

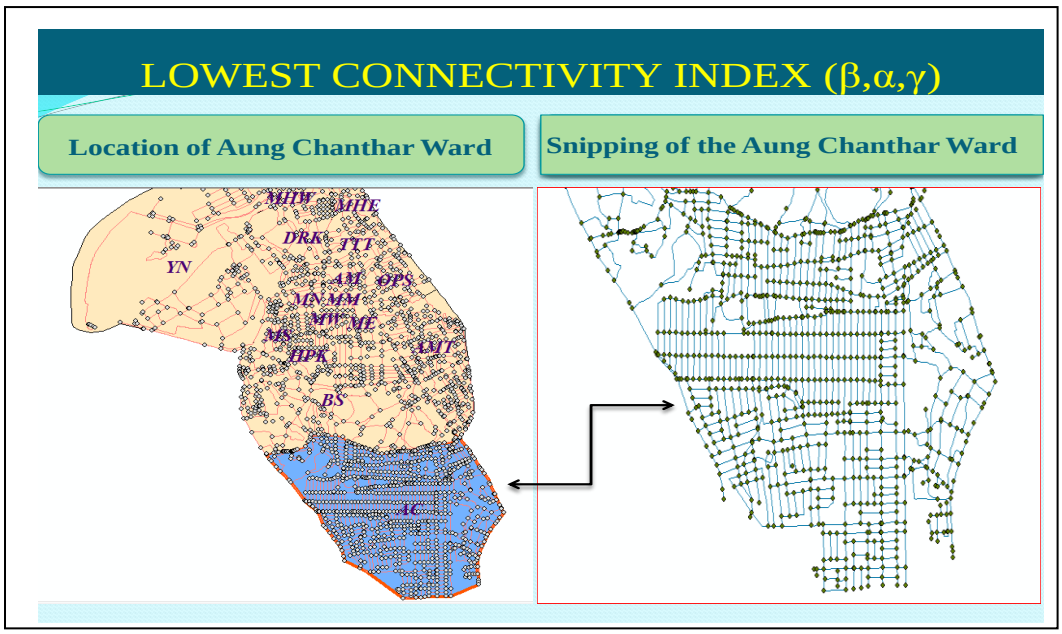
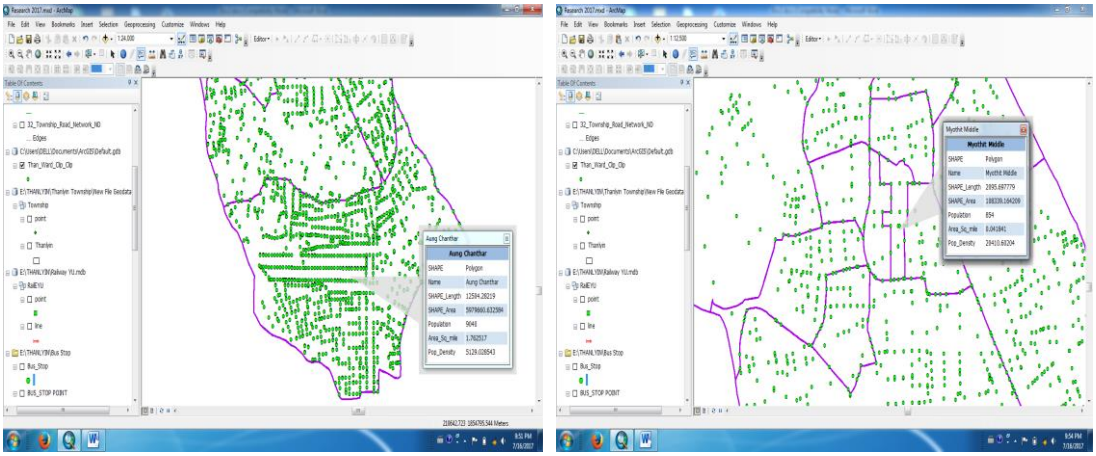


Figure: (5.2) Lowest Connectivity Index of Aung Chanthar Ward Snipping Tools
Source: Google Earth Image in 2014



FINDINGS AND SUGGESSIONS

The main findings of this research, according to the Buffer analysis will be provide to main location of coverage for Thanlyin Town. Total lengths of the road are 6.07 miles (9.712 km) in 2014. This connectivity is provided to a characteristic of transportation network structures and infrastructure facilities.Thanlyin Town's connectivity indixes **β =*o.66*** are well connected to topology structures, circuits ***α* = *0.26*** are not bad conditions and nodes **γ = *0.51*** are medium value number of connection with direct link to all nodes for the Thanlyin Town.

These relationships seem between Town and Ward connectivity for the Thanlyin Town. The findings of highest values are found in Myothit Middle Ward and the lowest value are found in Aung Chanthar Ward from the above facts.The greater accessibility of nodes, the more value of connectivity indicies,goods and passengers will be flow as a indicator for the transportation network in the near future.

The road infrastructures are one of the indicators to measure the transportation network development. Due to the existence of upgraded main road and secondary road, local inter & extra road and earth road for higher connectivity structures and roads, economic standards of commodities flow and the increase number & quality of bus types for Thanlyin Town.

On the Other hand, *' Yae Nan'* Ward has a *largest area* and *lowest population densi*ty and *lowest road density*. Myoma (N/S) Ward has the *highest population density* & *largest road density area*. Although bus stop stations are not enough because of bus stop station is only one in Myoma (N/S) ward. Therefore, new bus stop station should be created in ***Aung Thukha, Myoma Market and Aung Chanthar Ward*** for as Multi Bus Line Services Area and predominantly uses of customers as a finding.

Generally, dispersed settlements are settled by nearest neighbor area through tThanlyin Town.Travel costs are also the factors affecting development in public transportation for passengers. Therefore, road infrastructure development affects provide to traveling pattern of local people as well as people who are living in neighboring areas. If the roads will be improved & upgrade in Thanlyin Town as new service area, transportation network would be better in current situration than before.

On the other hand, cost per mile decreased for travel distance but need to trace for long term study.After, Thanlyin Town will be improvement in the near future.

If the new bridge and new roads, connectivities provide for better accessibility, these will be increased the flow of passengers and freight tons .Nowadays, the products are being carried by public and pravite car passing through the Thanlyin and Yangon Road. Therefore, the role of road transportation facilities need to increased for in the near future.

From the above facts, consequences of road infrastructures and good transportation networks necessary to increase of Gross Domestic Product (GDP) for Thanlyin Town from transportation services.These effects of transportation and communication facilities, commodities flow,the conditions of wholesales and retails in trade, introduce to industrial zone and agricultural activities will be created for improvements of the Thanlyin Town from this public transportation network research. The findings of the research survey based on Thanlyin Town are reported in December, 2014.

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