A Geographic Study on Road Transportation Network of Meikitla District

Wai Wai Lwin[1], Tun Aung Kyaw[2]
[1]Lecturer, Department of Geography, Meiktila University, Myanmar
[2]Dr,Associate Professor, Department of Geography, Kyaukse University, Myanmar

Abstract

The development of transportation in a region is closely related to the geographic factors of that region. The study area, Meiktila District has an area of 2,235.246 square miles. The main aim of this paper is to examine the road transportation network of Meiktila District by comparing two periods: 1988 and 2017. In order to analyse the motor road network of study area, four towns (Meiktila, Mahlaing, Wundwin and Thazi) of respective townships and some villages and junction points connecting each others are defined as vertices (nodes). The roads connecting those vertices are edges (links). The planar graph is mainly used to reveal the structural pattern of road network. The topological indices for connectivity are examined with graph theory and, accessibility matrix and density of network are calculated in this research. As a result, Meiktila Township was highest in road density while Wundwin Township was the lowest road density in two periods. The size, shape, junction point and centrality determine the network density of the study area.

Key words: Structural analysis, Road Transport Network, Meiktila District

Introduction

After 1988, transportation routes were expended throughout the country. The transportation routes of Meiktila District have developed like other areas. Reciprocally, the development of transportation network of study area has resulted in the regional development. From the physical geographic point of view, Meikitla District is located in the Central Dry Zone of Myanmar or central portion of Myanmar. The Highways of Myanmar connecting from upper Myanmar to lower Myanmar and from central lowland to the eastern and western areas of Myanmar cross through Meiktila District. Therefore, the development of transportation network may be one of the major controlling factors for the socio-economic development of the study area.

The evolution of transportation network in terms of link and node is markedly observed in Meiktila District. Within thirty-year period, this network has already been progressed with regional development.

Aim and objectives

The main aim of this paper is to identify and examine the road transportation network of Meiktila District. Therefore, the objectives of the study area as follows:

- to examine the connectivity of road transportation network
- to anslyse the accessibility chance of each node in study area
- to investigate the network density of each township of district.
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Data and Methods

The general sketch maps of road network and length were collected from building department and road management department of Ministry of Construction, and the District Administration Office, Meiktila District. The straight line distance is measured from UTM Topographic Maps (Map series 2095- No.5,9,13 and 14, Map series 2096-No.1,2,5,6,9 and 10 and Map series 2195 – No 3, 4, 8, 11, 12 and 15). The development of network was examined by simulated planar graph. Some indices for connectivity were explored by the value of connectivity. To evaluate the accessibility of vertices, connectivity matrix was used in this research. And then researcher discussed the results of network analysis and find out about the route density of study area.

Geographical Background of Meiktila District

Meiktila District is composed of four townships, namely Meiktila, Mahlaing, Wundwin and Thazi. Meiktila District is situated between latitudes 20° 20' 30" N and 21° 45' 48" N and between longitudes 95° 28' E and 96° 35' E.

Meiktila District has an area of 2,235.246 square miles (or) 5,790.99 square kilometers (or) 1,430,557 acres. It is the fourth largest district in size within Mandalay Region. The geographic location of Meiktila District is presented in Fig (1). Meiktila District is bounded on the west and north-west by Myingyan and Nyaung U districts, on the north by Kyaukse District, on the east by Taunggyi District, on the south by Yamethin District, and on the south-west by Magwe District. According to relief features,

Meiktila District can be divided into three areas. (1) western undulating area, (2) central plain area and (3) eastern highland area . In the census year 2014, the total population of the district was 881,530. Because the total number of population of district was 924,810 in 2017, the total number of increased population was 43, 280 within three years from 2014 to 2017.

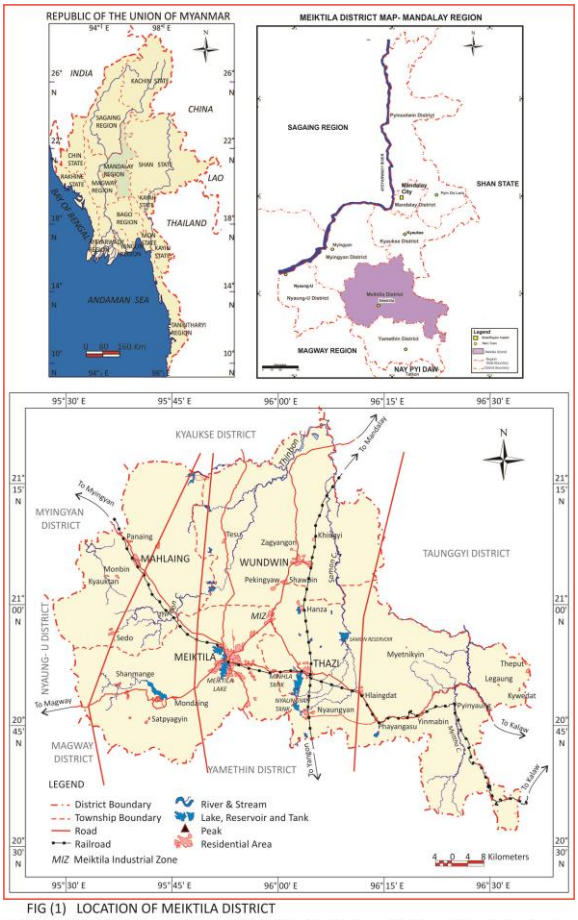

FIG (1) LOCATION OF MEIKTILA DISTRICT

Source: Topographic Map No. 2095_5, 2095_09,2095_10, 2095_13, 2095_14, 2096_01, 2096_02, 2096_05, 2096_06, 2096_09, 2096_10, 2195_08, 2195_11, 2195_12, 2195_15, 2195_16, 2196_03, 2195_04.

In examining townshipwise population of Meiktila District, Mahlaing Township had the smallest population of 176,008 and Meiktila Township had the largest population of 310,020.

Among the four towns in Meiktila district, Meiktila and Wundwin are situated on the Yangon Mandalay Highway. On the other hand, Thazi and Mahlaing are also situated on the Taungyi-Thazi-Meiktila- Myingyan- Pakokku Highway.

Connectivity of Road Transportation Network

The connectivity of network can be measured with the use of graph theory. (Garrison, 1960 and Kansky, 1963). The road network of Meiktila District is separated into two periods shown in the figures: one is in the year of 1988 and the next is 2017. The topological indices of the study area are calculated in Table (1).

The road network in 1988 connected the 20 edges with 18 vertices. There were no vertices that not connected to the main roads of Meiktila District. Most of road were connected at least one trunk line. The main trunk roads of the study area in 1988 were Yangon-Meiktila-Mandalay Road, Tarchileik-Taungyi-Thazi-Meiktila Road, Meiktila-Mahlaing-Taungtha-Myingyan Road, and Meiktila-Kyaukpadaung Road. Planar graph of road network in 1988 are shown in Figure (2).

Table (1) Topological Indices of Road Network of Meiktila District

Indices	1988	2017
Number of Edges (e)	20	64
Number of Vertices (v)	18	49
Number of Sub graph (g)	1	1
Cyclomatic Number (u = e-v+g)	3	16
$\beta = e/v$	1.11	1.30
$\infty = [u / 2v-5] 100$	9.66%	17.20%
$\gamma = [e / 3(v-2)] 100$	0.4166 or 41.66%	0.4539 or 45.39%

Source: calculated by the researcher

In 2017, the main roads of the study area were Yangon-Meiktila-Mandalay Road, Tarchileik-Taungyi-Thazi-Meiktila Road, Meiktila-Mahlaing-Taungtha-Myingyan Road, Meiktila- Kyaukpadaung Road District to District connecting Road No (1), District to District connecting Road No (2) and Yangon Mandalay Express Way (ASEAN HIGHWAY 1).According to figure (3), there were 64 edges and 49 vertices in 2017. To access the measurements of connectivity, the values of beta index, gamma index and alpha index were calculated. Figure (3) and Table (1).

Complex networks have a high value of Beta. A connected network with one cycle has a value of 1. More complex networks have a value greater than 1. According to the table (1) , the beta index indicated that road network was slightly more than unity (unity = 1) in 1988. Due to beta index value is more than unity; the connectivity of road transport had been a higher degree level since 1988. In 2017, the beta index value was 1.30 and it was more than unity and rather more than the condition of 1988 level.

The alpha index shows the degree of network circuitry. The higher the alpha index, the more a network is connected. The indices are 9.66% in 1988 and 17.20% in 2017. The network circuitry of 2017 has doubled than that of 1988. .

Gamma is an efficient value to measure the progression of a network in time. The gamma indices

of the study area were 41.66%and in 1988 and 45.39%in 2017.

The cyclomatic number is 3 in 1988 and 16 in 2017. Thus, there were 3 circuits in 1988 and 16 circuits in 2017. So, it can be said that later periods had more complex network. More alternative routes are developed in the study area in 2017. Obviously the indices of cyclomatic number, beta index, alpha index and gamma index had increased from 1988 to 2017

As a result, the number of 31 vertices has increased in the network of 2017. This condition is due to the construction of new road such as construction of Yangon-Mandalay Express Highway, No (1) and (2) roads connecting districts and Meiktila detour road for truck, and due to upgrading the some earthen road connecting the villages to tarred road.

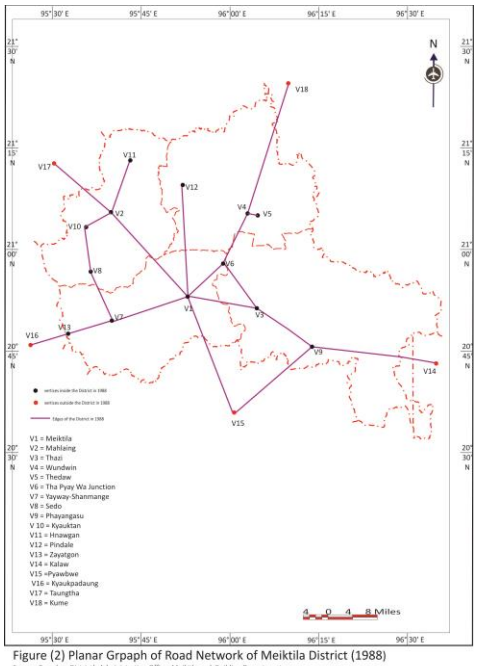

Figure (2) Planar Grpaph of Road Network of Meiktila District (1988)

Source: Based on District's Administration Office, Meiktila and Building Department and Road Management Department, Ministry of Construction

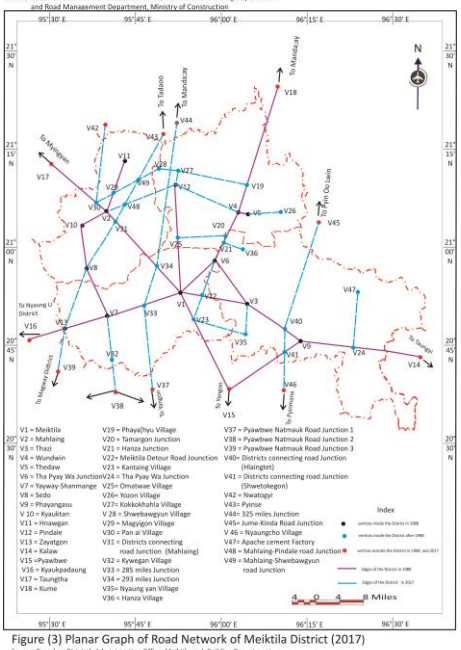

Figure (3) Planar Graph of Road Network of Meiktila District (2017)

Source: Based on District's Administration Office, Meiktila and Building Department and Road Management Department, Ministry of Construction

Accessibility

Accessibility is the measure of the capacity of a location to be reached by, or to reach different locations. Therefore, the capacity and the arrangement of transport infrastructure are key elements in the determination of accessibility. (Dr. Jean-Paul Rodrigue, 2017).The accessibility is one of the spatial structures of component node-linkage associations of transport network. The higher the value of an individual node, the greater is its accessibility to all other center.

The total number of direct linkages from a node to other nodes in the network is defined as the degree of a node. The direct connectivity for the road network of Meikitla District is shown in Table (3). In 1988, Meiktila (V1) had the largest number of the direct linkages in Meikitla District. In 2017, Meiktila (V1) was also the largest number of direct linkages. That is why, during two periods, Meiktila is the most accessible town in the road transportation of Meiktila District.

Total accessibility matrix (T)

Repeat the construction of the Nth order connectivity matrices until the number of Nth-linkages paths is equivalent to the diameter (path between most distant nodes) of the network. In 1988, matrix C8 (8th order connectivity) is added to matrix C1 (single paths; connectivity matrix). This summation represents the total number of paths for each node. For this network, there are thus 92,051 possible paths, with node V1 (Meiktila) having the largest number (14,860).

Since the road network of Meiktila had a diameter of 12 from Kalaw to Taungtha in 2017, it was twelve matrices diameter network (paths between most distant nodes). Thus, C1 (1st order connectivity) and C12 (twelve order connectivity), need to be constructed.

For the road network of Meiktila District in 2017, matrix C12 (twelve order connectivity) was added to matrix C1 (single paths; connectivity matrix). This summation represents the total number of possible paths for each node. For this network, there are thus 48,200,123 possible paths, with node V1 (Meiktila) having the largest number (3,609,532); either originating from it or having it as a destination.

Table (2) A Hierarchy of Nodes according to Number of Direct Links in Meikitla District

Number of Direct Links of a Node	1988	2017
6	V1	V1
5	-	V2
4	V2, V7	V3, V4, V6, V7, V8, V12, V13, V22, V23, V29, V30, V31, V33, V34, V40, V41, V48,V49
3	V3, V4, V6, V9,	V9, V19, V20, V21, V24, V25, V27
2	V8, V10, V13, V15	V5, V10, V15, V28, V32, V35
1	V5,V11, V12,V14, V16, V17, V18	V11, V14, V16, V17, V18, V26, V36, V37, V38, V39, V42, V43, V44, V45, V46, V47,

Sources: Based on figure (2) and (3)

Road Network Density

The development of network is related to the network density. Therefore, the comparisons were made among four townships of the Meiktila district. The network density increased in two periods. The network development of Meiktila District by Township is shown in Table (4). Meiktila Township has highest road density with 11.01 km per 100 square kilometer while lowest road density is observed in Wundwin Township (3.06km/100 sq-km) in 1988. Even though Meiltila Township is the third smallest area, the road density is highest among the townships, due to the center location or junctions of road networks. The slightly rolling flat plain is probably to provide the road constriction.

Table (3) Road Network Density of Meiktila District

Period	Area (sq.km)	Road Length (km)	Road Density (per 100 sq-km)
1988	5789.24	365.8	6.31
2017	5789.24	801.99	13.85

Source: Calculated by the researcher

Wundwin Township is lowest in road density due to the eastern portion is hilly area. Except from being located Yangon-Mandalay Highway No 1 Road, there were no other roads in Windwin area.

Table (4) Townshipwise Road Network Density of Meiktila District

Sr	Township	Area (sq.km)	1988		2017	
			Road Length	Road Density	Road Length	Road Density
1	Meiktila	,231	135.61	1.01	53.3	0.57
2	Mahlaing	,110.3	8.13	.93	07.23	8.64
3	Thazi	,039.89	8.85	.84	02.16	.9
4	Wundwin	,407.86	3.21	.06	29.1	.1

Source: Calculated by the researcher according to the statistic data of Road Construction and Maintenance Department. Ministry of Construction, Meiktila District

In 2017, Meiktila Township was continued the highest density of road Network. New roads were increasingly constructed after the 1988 period, of which the Yangon-Mandalay Expressway construction is a remarkable evidence of road network extension. The centrality of Meiktila is more obvious in network infrastructure of the district. Other townships increased in road distance and density but they could not reach the level of Meiktila. Wundwin Township also continued to be the least network density, but the road distance and density have been increased to three folds than the network of previous time. According to above mention results, network density is related to location, relief, size and shape of geographic area, those having junction and centrality. If the township possesses two or more factors of these criteria, it will be high network density. Table (5).

Findings and result

In 2017, the beta index value of road network of the district was 1.30 and it was more than unity and it can be said a more complex networks, because have a value greater than 1. In a network with a fixed number of nodes, the higher the number of links, the higher the number of paths possible in the network. The alpha indices of the road network of Meiktila District were 9.66% in 1988 and 17.20% in 2017. The network circuitry of 2017 had doubled than that of 1988. The alpha index shows the degree of network circuitry. The higher the alpha index, the more a network is connected.

A classification used by engineers consists of three basic network configurations: spinal, grid and delta. According to Edward J. Taffe and Floward L Gauthier; the ranges of gamma index value for three classical network patterns are: Spinal : $1/3 \leq \gamma \leq 1/2$, Grid : $1/2 \leq \gamma \leq 2/3$ and Delta: $1/2 \leq \gamma \leq 2/3$. The gamma indices of the study area were 0.4166 or 41.66% and in 1988 and .4539 or 45.39%% in 2017, respectively. That is why; the patterns of network structure are spinal. In examining the direct connectivity, Meiktila (V1) had the largest number of the direct linkages (six linkages) in Meikitla District in 1988 and 2017. Thus, Meiktila is the most accessible town in the network, because it connects with other

nodes to all directions.For the road network of Meiktila District in 2017, matrix C12 (twelve order connectivity) is added to matrix C1 (single paths; connectivity matrix). This summation represents for each node the total number of paths. For this network, there are thus 48,200,123 possible paths, with node V1 (Meiktila) having the largest number (3,609,532); either originating from it or having it as a destination.

As a result, high level of direct connectivity, high accessibility and high road density of the Meikitla Township cause Meikatila Town as a leading town of district for the socio-economic development of study area.

Conclusion

Meiktila District is composed of four townships, namely Meiktila, Mahlaing, Wundwin and Thazi. It has an area of 2,235.246 square miles (or) 5,790.99 square kilometers. It is the fourth largest district in size within Mandalay Region. The total population of the district was 924,810 persons in 2017. Among the four towns in Meiktila district, Meiktila and Wundwin are situated on the Yangon Mandalay Highway. In the same way Thazi and Mahlaing are also situated on the Taungyi-Thazi-Meiktila- Myingyan- Pokkokku Highway. According to calculation of indices of connectivity, accessibility and road density the road network of study area, it is a developing road network are of central Myanmar. Meiktila Township has the highest road density while the lowest road density was observed in Wundwin Township in 1988 and it was also continued the highest density of road Network until 2017. This developing network is going to support the socio-economic welfare of the local people of district.

Acknowledgements

First and foremost, I have to pay my respects toward my parents who give birth and look after with great kindness to me. All respectful teachers throughout my life are given my obeisance with this paper. My Special thanks are due to Dr. Ba Han (Rector, Meiktila University, Mandalay), for his permission to submit this paper. I would like to express my special thanks to Dr. Khin Thein Oo (Professor and Head, Department of Geography, Meiktila University) for her permission, well wishes and supportive suggestions. I have to pay my thanks to Dr. Hlaing Myo Myo Htay (Professor, Department of Geography, Meiktila University) due to her best comments for this paper. I am greatly indebted to Daw San Aung (Professor (rtd:), Department of Geography, University of Mandalay) with special thanks for giving good advices, reading and guiding in my works

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