Transportation - Route Sinuosity of Motor Road within Bago Region (East)

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Abstract

There were many changes in Myanmar economy since the market oriented economy was introduced to the state economy after 1988. As a part of changes, transportation routes were expanded throughout the country. This paper analysed the route sinuosity of motor road within Bago Region (East) by comparing the points of 1948, 1988 and 2010. To analyse the motor road network of study area, the administrative towns of respective townships and some villages which are the starting points, end points or junction points to reach other places indicate as vertices (nodes). The motor roads connecting those vertices are defined as edges (links) although these are differences in their quality. The detour index for sinuosity is used in this analysis. Then explanations focus on spatial interaction between the pattern of networks and the physical factors especially relief and drainage. The results reveal that sinuosity does not depend on the additional roads.

Keywords: Route sinuosity, motor road, administrative towns, detour index, spatial interaction, Bago Region (East)

Introduction

Transportation mainly depends on its physical features especially location and relief. People usually want to do their journey between two places with least amount of length. In practice, straight roads are very rare. Majority of them have curve to a certain extent. In addition, slope of the road also varies among the routes based on the topography they are passing.

BalkrishnaC.Vaidya (2003) studied route sinuosity for Rajasthan, India considering the railway and road transport. He calculates topological indices and considers additional factor as detour index. He concludes that there is a low interaction between different parts of the district when connectivity matrix, topological and detour indices is poor.

The detour index is used here to make empirical calculations among 14 townships of Bago Region (East) and compare in the points of 1948, 1988 and 2010. **In the following section this paper** finds out spatial temporal variations based on 14 townships' detour index. The relationship between sinuosity and density **provides** the development of road transportation **in section 3** followed by conclusion in the final section.

Objectives

The overall goal of this study is to provide the nature of sinuosity and is related to transport development. Therefore objectives of the study are:

(1) To find out the sinuosity changes of each township in the study area
(2) To analyse the sinuosity varies with time and space
(3) To assess the relationship between sinuosity and density in the study area

Data and Methods

The road length and topographic map were derived from Work Section, Ministry of Construction and Ministry of Development Affairs, Bago Region. The straight-line distance

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is measured from the quarter inch topographic map. Primary data and information were obtained from the field survey.

According to above data and information, changes of sinuosity indices were examined by detour index. Spatial temporal variations of detour index were described into groups. The latter section discusses the results of network analysis and tries to relate route density and sinuosity.

Geographical Background of Study Area

Bago Region was divided into two parts: Bago Region (East) and Bago Region (West). The Bago Region (East) is located between 16° 47′ to 19° 32′ N and 95° 51′ to 97° 15′ E (Fig. 1). It is covering an area of 24494 square kilometer (9457 square miles).

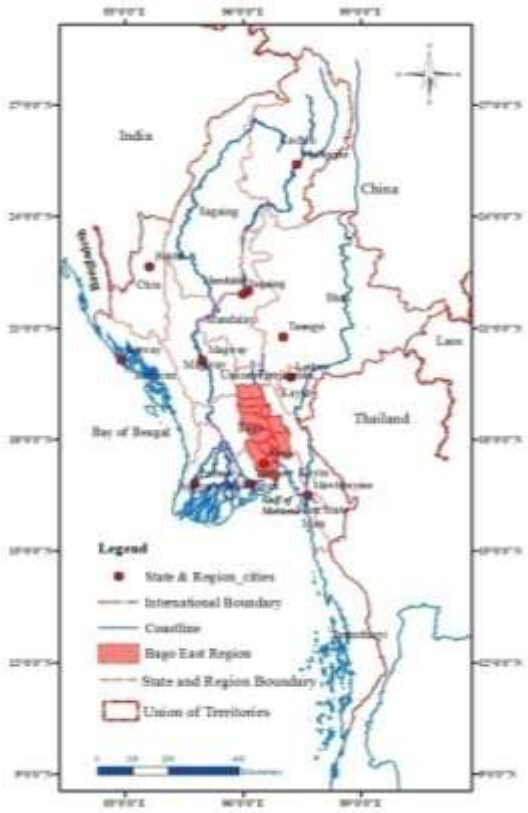

Fig. 1 Location of Bago Region (East) in Myanmar
Source: Based on Topographic Maps (85M, 85N, 94A, 94B, 94C, 94D, 94F and 94G)

The study area comprises of two districts: Bago District in the south and Taungoo District in the north. Bago District involves Bago, Thanatpin, Kawa, Waw, Daik-U, Nyaunglebin, Shwegyin and Kyauktaga townships. Taungoo District includes Phyu, Kyaukkyi, Htantabin, Oktwin, Taungoo and Yedashe townships. Most of the towns are located in the central lowland of the study area. The main routes within the area run in a north-south direction. Thus, the road network also has elongated shape. The segment of Yangon-Mandalay road is located in the study area. The study area is located in the junction of Upper and Lower-Myanmar.

Changes of Sinuosity Indices

Sinuosity can be measured by detour index (D.I). It measures the amount of detour of the shortest route connecting two nodes (Hammond and Cullagh, 1978).

$$D.I = \frac{\text{shortest route distance between A and B}}{\text{Shortest distance between A and B}} \times 100$$

Shortest distance approximates closely to a straight line on the quarter inch topographic map (No.85M, 85N, 94A, 94B, 94C, 94D, 94F and 94G). The actual distance data derive from Work Section, Ministry of Construction (Bago Region). Thus, this distance represents both the curviness (horizontal) and influence of topography (topography).

Generally the detour index varies by additional roads in a network. Table 1 expresses that the shortest road distance is found in 1948 compared with the latter two periods. The nodal mean detour index shows the lowest value in 1948. The second longest road distance can be found in second period (1988) but the nodal mean detour index is the highest among three periods. On the other hand, the longest road distance is in the period of 2010 while nodal mean detour index is second position among three periods.

Table 1 Detour Indexes for Bago Region (East)

Period	Road Distance (Km)	Straight-Line Distance (Km)=100 units	Nodal Mean Detour Index (D.I.)
In 1948	574.4	501	116
In 1988	909.9	785.2	126
In 2010	1404.0	1193.4	119

Source: Calculation based on data obtain from Work Section, Ministry of Construction and Ministry of Development Affairs, Bago Region (East)

Therefore the roads constructed in the period of 1988 have the extent of more curviness and vertical variations (slope factor) than the latest period. It is due to encouragement of the government to construct the road that could connect town to town regardless of its topography. In the third period (2010), the road distance is increased but the nodal mean detour index is decrease to nearly 1948. The roads in this period were constructed to connect the important places with the economic centre of Yangon, the administrative centre of Nay Pyi Taw and the cultural place of Mandalay.

Table 2 Detour index of townships in Bago Region (East)

No.	Township	In 1948			In 1988			2010		
		Actual Distance	Straight Distance	Detour Index (D.I.)	Actual Distance	Straight Distance	Detour Index (D.I.)	Actual Distance	Straight Distance	Detour Index (D.I.)
1	Bago	84.5	76.4	118.2	84.5	76.4	118.2	197.3	170.8	116.3
2	Thanatpin	3.2	3	104.8	16.9	16.7	102.5	16.9	16.7	102.5
3	Kawa	17.2	16.4	106.8	42.1	35.9	124.6	42.1	35.9	124.6
4	Waw	52.6	37.4	142.1	52.6	37.4	142.1	62.8	45	140.4
5	Daik-U	55.3	46.2	114.7	55.3	46.2	114.7	86.5	75.3	112.8
6	Shwekyin	31.5	30.8	102.4	44.4	40.2	203.4	86.2	74.5	187
7	Nyaunglaypin	39	34.3	119.7	60.8	51.2	121.1	60.8	51.2	121.1
8	Kyauktada	69.7	58.4	127.7	69.7	58.4	127.7	124.6	109.3	122.3
9	Kyaukkyi	23.6	19.6	120.2	84.9	68.9	130.4	84.9	68.9	130.4
10	Phyu	44.3	41	108.9	44.3	41	108.9	107.9	84	116.8
11	Oktwin	43.4	41.2	106.7	106.7	97.7	109.9	131.5	121.5	108.8
12	Htantapin	6	4.9	125.2	62.9	58.4	114.4	62.9	58.4	114.4
13	Taungoo	39	34.3	110.7	91.2	82	111.5	146.9	133	111.6
14	Yedashe	65.1	57.4	114.4	93.5	74.8	130	192.7	149.3	127.7

Source: Calculation based on the data obtain from Ministry of Construction and Department of Development Affairs, the Bago Region (East)

Therefore road construction projects are intended to high-speed express highway that connects only important towns and cities.

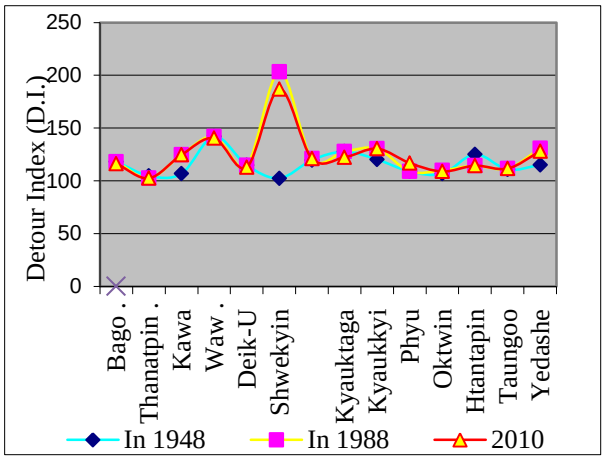

Fig. 2 Detour Index of Bago Region (East) by townships in three periods

Source: Table 2

Fig. 3 Location of the link between Nyaunglepin and Madauk

Source: Department of Development Affairs, Bago Region (East)

In examining detour indices by township, the highest value was observed in Shwekyin Township in 1988 (Table 2; Fig. 2). It is the link connecting between Nyaunglepin and Madauk. One of the important natural obstacles is Sittaung River that runs from north to south in the area (Fig. 3).

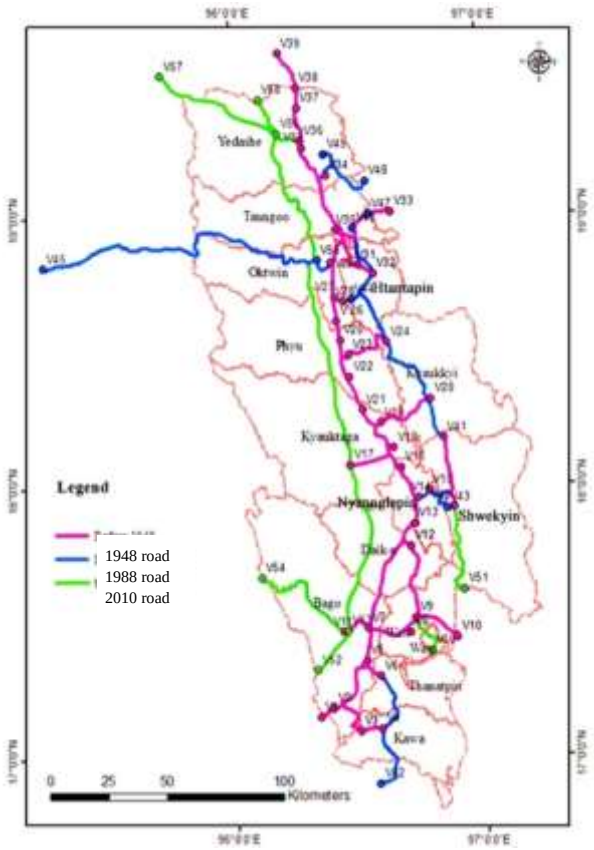

Fig. 4 Motor Road Distribution of Bago Region (East)

Source: Based on Topographic Maps (No. 85M, 85N, 94A, 94B, 94C, 94D,94F and 94G)

For Bago, Waw, Daik-U and Kyauktaga Townships have lower of detour indices in 2010 than in 1988. With the exception of Waw Township, the additional roads of others are on Yangon-Nay Pyi Taw-Mandalay Express Road (Fig. 1). This road is connecting three important places (Yangon, Nay Pyi Taw and Mandalay) which have a shortest distance and therefore it is relatively a straight route.

Spatial Temporal Variations of Detour Index

The sinuosity differs from one place to another based on additional road distance over time. Based on the nature of detour index, townships of the study area can be classified into four groups:

1. High value of detour index in 1988
2. High value of detour index in 2010
3. Low value of detour index in 1988
4. Low value of detour index in 2010

Group No. 1 composed by Kawa, Shwekyin, Nyaunglepin, Kyaukkyi, Oktwin, Taungoo and Yedashe Townships. Phyu is grouped as No. 2. Thanatpin and Htantapin Townships fall in group No.3. The rest townships of Bago, Waw, Daik-U and Kyauktaga are included in group No. 4 (Table 3; Fig. 4).

Table 3 Detour Index among 4 Groups in Bago Region (East)

Group	Township	1948 (Detour Index)	1988 (Detour Index)	2010 (Detour Index)
Group -1	Kawa	106.8	124.6	124.6
	Shwekyin	102.4	203.4	187.0
	Nyaunglaypin	119.7	123.1	121.1
	Kyaukkyi	120.2	130.4	130.4
	Oktwin	106.7	109.9	108.8
	Taungoo	110.7	110.3	111.6
	Yedashe	114.4	130.7	127.7
Group -2	Phyu	108.9	108.9	116.8
Group -3	Thanatpin	104.8	102.5	102.5
	Htantapin	125.2	114.4	114.4
Group -4	Bago	118.2	118.2	116.3
	Waw	142.1	142.1	140.4
	Daik-U	114.7	114.7	112.8
	Kyauktaga	127.7	127.7	122.3

Source: Calculation based on the data obtain from Ministry of Construction and Department of Development Affairs, the Bago Region (East)

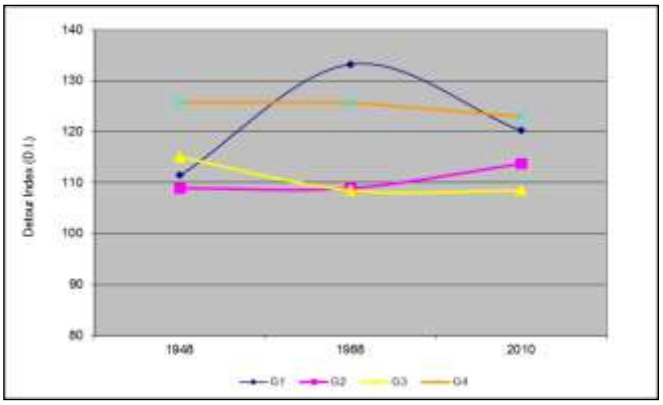

Fig. 4 Variation of Detour Index among 4 Groups
Source: Table 3

Group No. (1) has relatively low detour index in 1948 but it increases in 1988 due to construction of new roads around 1988. Group No. (2) is lowest detour index in 1948 and keeping low in 1988 and slightly increased in 2010. Group No. (3) has relatively high detour index in 1948 but decreased in latter two periods. Group No. (4) had the highest detour index in 1948. Nearly same index is recorded in 1988 and slightly decreased in 2010. It is for the construction of Yangon-Nay Pyi Taw-Mandalay Express Way (Fig. 5).

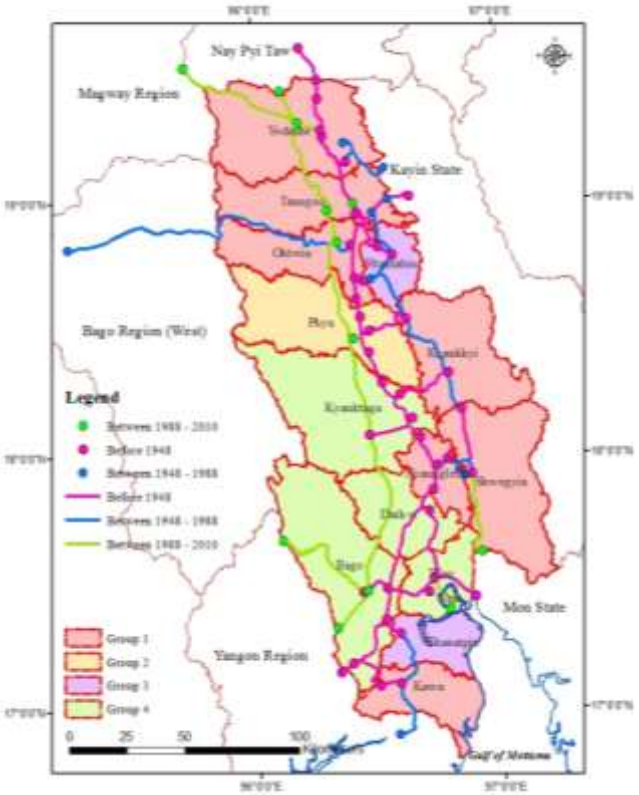

Fig. 5 Motor Road Distribution among 4 Groups of the Bago Region (East)
Source: Based on Topographic Maps (85M, 85N, 94A, 94B, 94C, 94D, 94F and 94G)

Relationship between Sinuosity and Density

Sinuosity reveals the effect of physical and human impacts on road development. Higher sinuosity represents longer distance, taking more time. The road density is one of the

effective factors of regional development. The relationship between sinuosity and density can be considered in above four groups. Relationships between sinuosity and density are shown in Table 4; Figures 6, 7, 8 and 9.

In group No. (1), density continuously increases in three periods. The detour index increases in 1988 but it decreases in 2010. In group No. (2), density and detour index are not changed in the former two periods. The density and detour index together increase in the third period. In group No. (3), density is the lowest but the detour index is the highest in 1948. The density is increased in 1988 period but detour index decreases in that period. The detour index and density of the latest period have same condition with 1988. In group No. (4) there are low density and high detour index in 1948. The same condition can be found in 1988. The density is high and detour index is low in 2010.

Therefore the increased density is not always increased detour index (Fig. 6). It is good character for a network (i.e. the additional road has least curviness).

The increased density does not always coincide with increased detour index (Fig. 10). The links will connect the important places when the nodes are completely connected to each other in a network.

Table 4 Network Density and Detour Index (D.I) among Group 4

Group	Township	1948		1988		2010	
		Network Density	D.I	Network Density	D.I	Network Density	D.I
Group -1	Kawa	1.0	106.8	2.5	124.6	2.5	124.6
	Shwekyin	1.3	102.4	1.8	203.4	3.5	187
	Nyaunglaypin	5.3	119.7	8.3	123.1	8.3	121.1
	Kyaukkyi	1.2	120.2	4.2	130.4	4.2	130.4
	Oktwin	3.0	106.7	7.5	109.9	9.2	108.8
	Taungoo	2.3	110.7	5.3	110.3	8.6	111.6
	Yedashe	2.5	114.4	3.6	130.7	7.4	127.7
Group -2	Phyu	1.9	108.9	1.9	108.9	4.6	116.8
Group -3	Thanatpin	0.3	104.8	1.7	102.5	1.7	102.5
	Htantapin	1.1	125.2	11.7	114.4	11.7	114.4
Group -4	Bago	2.9	118.2	2.9	118.2	6.8	116.3
	Waw	5.4	142.1	5.4	142.1	6.4	140.4
	Deik-U	4.3	114.7	4.3	114.7	6.7	112.8
	Kyauktada	2.5	127.7	2.5	127.7	4.4	122.3

Source: Calculation based on data obtain from *Settlements and Land Records Department of BagoRegion and ** Ministry of Construction, Bago Region

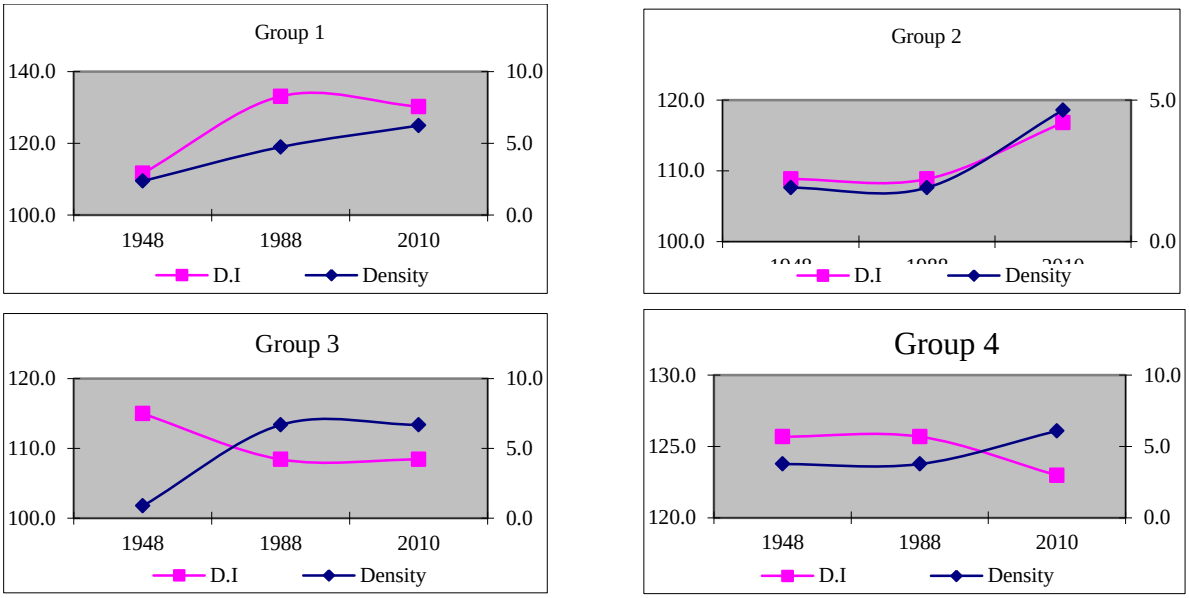

Fig. 6 Relationship between Detour Index and Density in Group 1, Group 2, Group 3 and Group 4. (Source: Table 4)

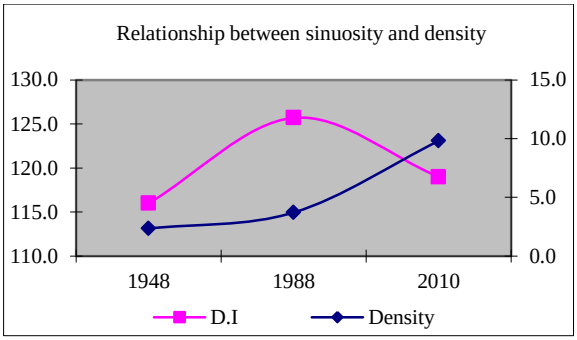

Fig. 10 Relationship between sinuosity and density (the whole network) (Source: Table 4)

Conclusions and Discussions

Current methods for the evaluation of road transportation rely on calculated sinuosity depend on road distance and township area. One interesting question is emphasized on the physical factors and government policy. The increased density does not always increase detour index. Route sinuosity is examined by township and classified into four groups. The current situation of four groups can be seen in Table 6. Only Group 3 has not increased road length between 1988 and 2010 because Thanatpin and Htantabin Townships are far from high-speed express highway. So these townships are not included in expressing road construction project. The longest additional road distance can be found in Group (1). But the nodal mean detour index is lower than 1988 which answered minus. So Group (1) is defined as level.

Table 7 Situation of road length and sinuosity in Group 1, Group 2, Group 3 and Group 4 between 1988 and 2010

Level of good	Group	The value of subtraction 1988 and 2010	
		Road Length	Sinuosity
1	1	221.5	-20.1
2	4	209.0	-10.9
3	2	63.6	69.4
4	3	0	0

Source: Calculation based on data obtain from Settlements and Land Records Department of Bago Region and Ministry of Construction, Bago Region

The road in this period has constructed to connect the important places with the economic centre of Yangon, the administrative centre of Naypyitaw and the cultural place of Mandalay. The roads connecting to nearly all towns of Central Valley of study area was already completed in 1988. Therefore the government policy shifted to construct high-speed express highway that connect only important towns and cities. The new roads constructed with the motive of shrinking of length and saving time. At present many people use this express highway for social, economic and government affairs.

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