THE IMPACT OF DEMOGRAPHIC CHARACTERISTICS AND ROAD NETWORK ON THE SPREAD OF CORONAVIRUS PANDEMIC IN RAKHINE STATE: USING GEOSPATIAL TECHNIQUES

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ABSTRACT: Demographic characteristics give communities information for the past, present and future plan and services. Demographic data and connectivity of road network impact how far people travel and what they do. The spread of COVID-19 cases in the state deals with these data.

In the 31st August 2020 COVID-19 confirmed cases across the state had risen to 350 cases. This is more than that of Yangon Region. The researchers are interested in the reasons for that. The aim of the paper is to analyze the interactions between demographic statistics, road network connectivity and the spatial distribution of Pandemic areas. The objectives of the paper are to study the correlations of the townships based on the demographic characteristics and to examine the road network within the State. Secondary data are demographic data, road network database and COVID-19 confirmed cases in Rakhine State. Factor analysis and road network connectivity have been carried out in IBM SPSS and in ArcMap. The results of theoretical measure and distribution pattern of the cases show that townships included in the factor 1 and 2 have fewer confirmed cases than the other townships in factor 3, 4 and 5. Townships that have the same communities and accessibility chance have the same situation of lower or greater risk.

1. INTRODUCTION

Rakhine State has 5 districts in which 17 townships and 3sub-townships are included. Percentage of urban population is 17%. It has more rural nature. Total number of population in Rakhine State is 3,188,807 (2014 Census). It has an area of 36,778.1 Km^2. Population density is 86.7 per km^2. It faces the Bay of Bengal on the west, Bangladesh in the northwest and the India in the north. In the east it is bordered by state and regions of the country (Figure 1). Waterway is important to the transportation of people and goods in the middle and northern part of the states to travel to other neighbouring countries and townships within the state. Airway is also important to connect to other regions and states of the country. However, land transportation plays a vital role in linking communities to each other in the state and to the other parts of the country.

In the section of results and discussion, relationships between townships are analyzed on the basis of demographic background and road network. Then the distribution pattern of COVID-19 cases in the State is examined. Finally, a comparison of the estimated results and the spread of coronavirus diseases is presented to know their interactions.

The aim of the paper is to analyze the relationships between demographic statistics and connectivity of road network, and their effects on the spread of coronavirus in the State.

The objectives of the paper are to study the clustering of townships based on the demographic characteristics and to calculate the connectivity of road network.

2. RESEARCH BACKGROUND AND LIMITATION

The paper is studied for the researcher is interested in the related causes of the spread of COVID-19 cases in Rakhine State, the western gate of Myanmar.

Rakhine Yoma separated Rakhine State from central Myanmar. Airway and waterway on the long western coast of the State are important transportation modes to connect to other regions and states. Road transportation is more important within the State.

There are many causes to occur a large outbreak of the disease in Rakhine State. They are demographic characteristics, road network, waterway, airway, limited health infrastructure and ethnic crisis. One of the major causes of the pandemic is that nearly 82,000 people were displaced between March 16 and July 6. In this study population data and road network are used because some data are difficult to get and others are indirectly related variables.

Demographic statistics and road network are very important indicators to study the spread of the disease. Demographics explain a generalization of a particular geography's population. However, everyone does not fit a given demographic profile. That is why; transportation is needed to be considered. Therefore, in this paper, the spread of the coronavirus is studied based on the interactions of demographics and road network.

3. DATA AND METHODOLOGY

Demographic data are important for it comprises an array of socioeconomic information, including the total number of population, population by selected age group, male-head population, female-headed population, population in households and in institutions, child and old dependency ratio, urban and rural population, number of households consisting of 9 persons and more, and population density. These data are taken from 2014 Census in Rakhine State. Road network is constructed from Google Earth and generated in ArcGIS. COVID-19 confirmed cases are recorded from the daily issue of Ministry of Health.

At first, demographic database are constructed in SPSS. Then, this is analyzed by factor analysis and tested by reliability analysis. ArcGIS helps to construct a new network database and to calculate the connectivity of road network. GIS database queries to investigate the visualization of the degree of the spread of the cases. Factor analysis is used to answer the correlations of population data, connectivity and the cases.

4. RESULT AND DISCUSSION

4.1. Demographic Characteristics

The objective of the paper is to analyze the clustering of townships based on the demographic characteristics. Demographic characteristics are statistical data collected about the dimensionality of the population. Demographic data plays an important role in assessing the clustering degree of the areas.

Population density is one of the important indicators for social networking. Sittway Township is the highest population density because it is a state capital city; it has multi transportation networks to connect other regions and has the highest road network connectivity. The rest of the population high density areas are Mrauk U, Ponnakyun, Rathedaung and Kyaukphyu. Most the high population density areas are located in the north of the state (Figure 1).

To know the correlation of the townships on the basis of population data, demographic statistics are analyzed by factor analysis.

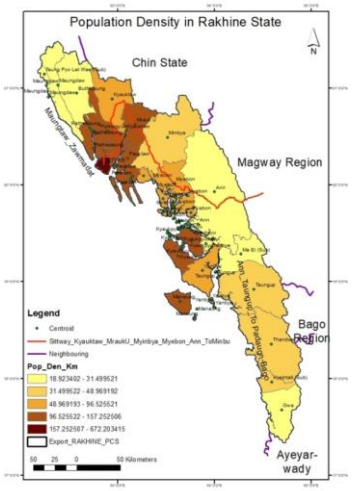

Figure 1. Population Density in Rakhine State
Source: Database Table

Total variance explained indicates that analysis result can clarify 97.45% of the cases (Table 1). Rotated component matrix shows that Manaung, Gwa, Yanbye and Taungup townships are included in component 1. Component 2 comprises Buthidaung, Maungdaw and Taungpyoletwae (Sub-tsp) townships. Rathedaung, Ponnakyun, Pauktaw and Kyauktaw are in Component 3 (Table 2).

Table 1. Total Variance Explained

Rotation Sums of Squared Loadings		
Total	% of Variance	Cumulative %
5.943	29.717	29.717
4.095	20.476	50.193
3.660	18.300	68.493
3.087	15.436	83.929
2.705	13.526	97.455

Extraction Method: Principal Component Analysis.

4.2. Connectivity of Road Network

The objective of the paper is to calculate the connectivity of road network. To travel to Rakhine State, it has three transportation modes; flight, ship and express. Only two townships, Sittway and Thandwe townships have the airports. The eastern part of the state is separated by Rakhine Yoma to connect to other regions. However, Magway Region is connected by Sittway-Kyauktaw-Minbya-Ann Road. Bago and Ayeyarwady regions are connected through Sittway-Kyauktaw-Minbya-Ann-Taungup Road. Another way is Kyaukphyu-Taungup-Gwa road. The western part of the states is a long coastline. Therefore, waterway is important to reach townships of the state by formal and informal ways.

Table 2. Rotated Component Matrix[a]

Cases	Component				
	1	2	3	4	5
Manaung	.988		.120		
Kyeintali (Sub-tsp)	.955	.179		.155	-.130
Gwa	.937	.159	-.256	.168	
Yanbye	.878	-.149	.393		.161
Maei (Sub-tsp)	.764	.429		.397	.260
Minbya	-.636	-.573	.288	.166	.385
Buthidaung		.979		-.163	
Maungtaw		.925	-.209		-.309
Taungpyoletwe (Sub-tsp)	.406	.779		.394	.168
Myauk U	-.620	-.688		.347	
Taungup	-.182	-.158	-.895		-.336
Yathedaung	.103	-.157	.894	.151	
Ponnagyun	-.429	-.132	.672	.409	
Pauktaw	-.452	-.318	.611	.277	.476
Kyauktaw	-.473	-.549	.587	.321	.122
Thandwe			-.179	-.974	
Kyaukpyu	-.209		-.160	-.955	
Myepon		-.344	.242		.899
An			.110	-.527	.835
Sittway	-.398		-.620	.133	-.657

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations

In considering the spread of disease within the state, road network is used to analyze with demographic data.

Connectivity also provides information about the linkages of the people. Connectivity of the townships is calculated by using road network dataset in the state. Sittway, Kyaukphyu, Maungdaw, Minbya, Ann and Taungup have the high connectivity. Kyauktwa and Gwa have the moderate, and Manaung, Rathedaung and Yanbye have the low connectivity (Table 3 and Figure 2).

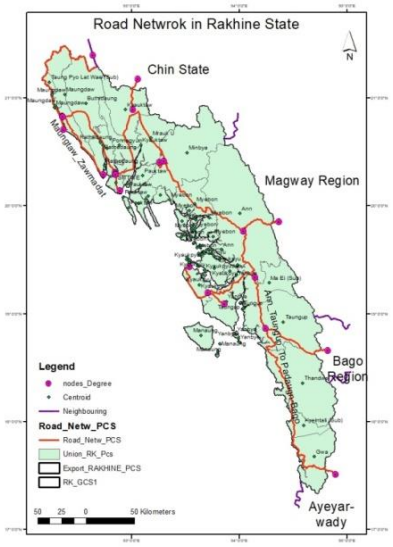

Figure 2. Road Network Structure
Source: Table 3

Table 3. Calculating the Degree of a Node Based on Road Network

Name of Townships where Nodes are located	Connectivity
Maungdaw	1
Maungdaw	3
Zawmadat	1
Taung Pyo Let Wae (Sub)_Maungdaw_Buthidaung_To Chin State	2
Rathedaung	1
Rathedaung	1
Sittway	1
Sittway	3
Sittway	1
Kyauktaw	1
Kyauktaw to Chin State	2
Minbya	1
Minbya	3
Kyaukphyu	1
Kyaukphyu	3
Yanbye	1
Ann	3
Ma Ei (Sub)	3
Taungup	3
Ann to Magway Region	2
Taungup to Bago Region	2
Gwa to Ayeyarwady Region	2

Source: Based on Road Network Structure

4.3. The Correlations between Demographic Data, Road Network and Pandemic Area

4.3.1. Relationships between Demographic Characteristics and Connectivity

Demographic data and road network dataset used to define the grouping of the areas can contribute new dimensions to analyze the interactions of the causes. Total variance explained of statistical results explains 95.28% for data analysis (Table 4). This is important for the interpretation and further works.

Table 4. Total Variance Explained

Compo-nent	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	7.313	36.564	36.564
2	3.862	19.310	55.874
3	2.946	14.732	70.606
4	2.594	12.971	83.577
5	2.342	11.709	95.286

Extraction Method: Principal Component Analysis.

Analytical results of demographic statistics and road network dataset show the relationships between townships. Factor 1 comprises Maugdaw, Gwa, Taungup and Ann townships. They are strongly related. Factor 2 consists of Manuang, Gwa and Yanbye. Pauktaw, Ponnakyun and Myepon, Rathedaung and Kyauktaw are in factor 3 (Table 5). Sittway and Mrauk U townships which are not very related to others are included in the last factor. Kyaukphyu is in factor 1, but its correlation value is 0.3. Threfore, its situation is different from the other areas in factor 1.

The rotated component matrix determines what the components represent. Eigenvalue, a measure of explained variance, for the first component 1 is 7. The first component is most highly correlated with population statistics and road network within the townships.

Table 5. Rotated Component Matrix[a]

Cases	Component				
	1	2	3	4	5
Myauk U	-.947	-.105	-.075	-.169	.127
Maei (Sub-tsp)	.947	.018	.148	-.094	.263
Maungtaw	.920	-.295	-.159	.108	.071
Gwa	.892	.393	-.010	-.104	.158
Pauktaw	-.868	-.109	.445	.032	.126
Ponnagyun	-.811	-.116	.311	.110	.308
Taungup	.754	-.264	-.467	-.360	.007
An	.736	-.336	.398	-.255	-.299
Myepon	-.733	.125	.500	.027	-.093
Manaung	-.046	.972	.201	.092	.048
Kyeintali (Sub-tsp)	.141	.937	.012	.274	.143
Yanbye	-.029	.838	.524	-.047	-.030
Minbya	.185	-.653	.270	-.645	.186
Sittway	.002	-.261	-.952	-.025	.100
Yathedaung	-.354	.094	.683	-.037	.326
Buthidaung	-.311	.019	-.025	.921	-.206
Taungpyoletwe (Sub-tsp)	.248	.264	.218	.807	.347
Kyauktaw	-.428	-.422	.402	-.521	.416
Thandwe	-.407	.147	-.002	.201	-.875
Kyaukpyu	.360	-.297	-.031	-.106	-.860

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

Note: Factor Analysis-Statistics Solutions explain, "The rotated component matrix, sometimes referred to as the 'loadings', is the key output of principal components analysis. It contains 'estimates of the correlations' between each of the variables and the estimated components."

The estimates of the correlations between Sittway, Mrauk U, Kyaukphyu and other townships are very low in the rotated component matrix. The first two townships are in factor 5 and the last one is in factor 1. It means that their variables are different from the others. They are highly or poorly connected with the others.

Reliability statistics for factors are calculated for testing the correlation results. If the component is very strong and highly reliable, Cronbach's Alpha value is greater than 0.7. The results are shown in table 6. The first 3 factors are strongly related to each other.

Table 6. Reliability Statistics for Factors

Factors	Cronbach's Alpha	No of items
1	0.917	5
2	0.913	3
3	0.889	5

4.3.2. Distribution Pattern of Coronavirus in Rakhine State

In Myanmar Coronarvirus started on 23th March 2020. At that time COVID-19 cases were very rare in Rakhine State. However, starting from 16th August 2020 the confirmed cases are increased daily in the State. This starts with the dissemination disease within the State. Up to 7th September 2020, a total of COVID-19 confirmed cases in Rakhine State are 556. Sittway, the capital of the city, has the highest. And the second is Kyaukphyu. Other townships occurring high COVID-19 cases are Pauktaw, Mrauk U, Myebon and Ponnakyun. The lowest townships are Manaung, Gwa and Ann. Yanbye Island has no confirmed cases (Figure 3). What are the reasons for this distribution pattern?

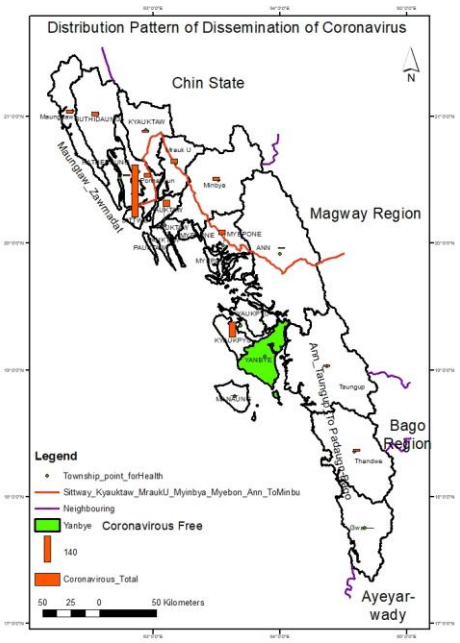

Figure 3. Distribution Pattern of Coronavirus in Rakhine State
Source: Table 7.

4.3.3. Comparisons of Theoretical Result and Practical Situation

The aim of the paper is to find out the interaction between demographic statistics, connectivity of road network, and the spread of coronavirus in the State.

The analytical results of database query and network analysis are nearly the same with the real world situation of the cases (Table 7). Sittway and KyaukPhyu are the exceptional case because their demographics, the density of connection and the transmission of the virus are different from the others. They have a well-connected network than the other townships. According to the theoretical results, Pauktaw, Myebon, Ponnagyun, Kyauktaw and Rathedaungn townships are strongly correlated. In the real world situation, most of them are high risk areas. Taungup and Ann are also strongly correlated in component 2. They are low risk areas. Manaung, Gwa and Yanbye are correlated in component 3. Their COVID-19 confirmed cases are the least. Analysis reveals that demographics and transport network are directly correlated with respect to the spreading of the confirmed cases.

Table 7. Estimated Loadings and Rankings for the Spread of Confirmed Cases

CONNECT _ID	Townships	Coronavirus confirmed cases Total
6	Sittway	277
9	Kyaukphyu	80
14	Pauktaw	35
3	Myauk U	24
13	Myebon	23
5	Ponnagyun	21
8	Maungtaw	20
10	Buthidaung	19
4	Minbya	18
17	Kyauktaw	12
1	Thandwe	9
7	Taungup	8
15	Rathedaung	5
11	Ann	3
12	Manaung	1
2	Gwa	1
16	Yanbye	0

Source: Table 5 and Data from MOH
Note: Red colour is the high risk areas, and Yellow and Blue are low risk areas in the spreading of disease.

5. CONCLUSION

The main theme of the paper is to group the areas in the State which have similar or different backgrounds on the basis of the fundamental and important data such as demographics and road transportation. Then, these theoretical results will be compared with the real situation of the spread of the Coronavirus cases.

Why the researchers use demographic data is that it can be derived from Census which offers the source of reliable data that provides valuable insights about a community's needs and demand for services.

Road network is also an important indicator to explain the degree of the connection. In this study an attempt has been made to analyze the road network connectivity and spatial distribution pattern of disease.

To determine the correlations of demographic statistics and the network connectivity can explain virus spreading areas.

According to the analytical results of multivariate dataset, Pauktaw, Myebon, Ponnakyun and Kyauktaw comprising in component 3 have great potential for occurring. Manuang, Gwa and Yanbye are included in component 2 having the least chance to occur. Analysis can highlight the clustering of the townships which have the similar social and physical backgrounds.

An obvious situation takes place in Sittway and Kyaukphyu townships in which correlation results are different from the other townships and confirmed cases are highest among 17 townships and 3 sub-townships in the State.

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