



ROAD TRANSPORT SYSTEM OF GREATER RAJSHAHI DISTRICT : A GEOGRAPHICAL ANALYSIS.

A thesis Submitted to the University of Rajshahi in Partial Fulfillment of
the Requirements for the Degree of Master of Philosophy.

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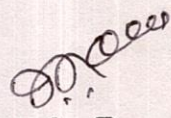
Date: 25-05-95

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ABSTRACT

Greater Rajshahi district consists of four separate district viz-Naogaon, Natore, Nawabgonj and Rajshahi, with an area of 9456 km², having population of 6384068 (1991). In this study the spatial pattern of road transport system of the said district has been analyzed. Two main aspects of road transport system have been outlined in the present study i. e. the development of road, its density and distribution and the measurement of traffic volumes (vehicles, goods and passengers) of different nodes and routes of the study area.

Though different types of vehicles are playing on road yet the author in this study considered only bus, Minibus, and truck as the internode (intercity) connecting vehicles. Out of 32 administrative units of the study area Boalia and Paba are considered as one node named Rajshahi and other six important nodes (Ahmedpur, Amnura, Baneswar, Banpara, Sampur and Walia) which are play an important role on the road transport system considered here as the nodes of the transport network of the study area.

There are 1400 km. of metalled and 11,387 km. of non-metalled road in the study area. Out of 1400 km metalled road 772 km are internode connecting RHD road, which are divided into 43 routes by 37 nodes of the study area. Daily traffic volumes of 37 nodes of the study area are 4906 vehicles. 13,570 tons of goods and 190,5000 passengers. On the basis of collected information the author in this study analyzed the data in three basic concepts: Such as

a) Spatial Interaction:

b) Network Analysis ($m=7$, $\delta=10$, $\alpha=0.10$, $\beta=1.16$, $\gamma=0.41$, $\theta=20.86$, $\eta=107.95$)

c) Urban Hierarchy.

ACKNOWLEDGMENT

Firstly, I express my deep feelings of gratitude to my thesis supervisor professor Jafar Reza Khan for his proper guidance, valuable suggestions, and intellectual advice. It would have been quite impossible to carry on the research work timely without his valuable suggestion and continued encouragement.

Besides, I am also grateful and acknowledge my deep gratitude and thanks to all the teachers of the department of geography for their valuable advice. I express my gratitude to the university authority for helping in various ways to complete my work.

I would also like to thank Mr. Abdul Matin Choudhury, chief subdivisional engineer, Mr. Amzad Hossain, executive engineer Mr. Shahabuddin Ahmed, assistant engineer of RHD Rajshahi and Mr. Said Ahmed chief executive engineer of Traffic Engineering Division, Mr. Tahir Ahmed assistant engineer of Traffic Engineering Division, Mr. Soliman surveyor, Mr. Samir Ahmed office assistant and Yusuf Ali draftsman of RHD division Rajshahi for their sincere help and co-operation.

I am also thankful to M. Mozammel Haque office executive, Abu Hena office accountant of Sarak Paribahan Samitte Rajshahi, M. Hasim Uddin secretary, Monowarul Islam, President, and M. Tazul Islam secretary of Sarak Paribahan Samitte Nawabgonj and Advocate Motahar Hossain Shajada, daptar sampadak, Natore Bus Malik Samitte for supplying me various types of information.

I also express my thank to M. Golam Morshed, assistant engineer of Nawabgonj municipality, Mr. Ansar Ali, chief executive engineer and Mr. Sarat Datta Gupta assistant engineer Rajshahi city Corporation, Profullo Ranjan Ray accountant of Natore Municipality, Abdur Razzak, statistical officer of Paba thana, Mr. Abdullah, economist of RHD Dhaka for help and supplying me necessary data.

I am also grateful to the member of my family who always inspired me for my higher education. Finally I express my deep gratitude to almighty Allah for his kindness and help.

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CHAPTER ONE

THE BASIC CONCEPT

1.1 Introduction

Now a-days it is quite impossible to indicate which came first-transportation or civilization ? But it may be said that there is a close relationship between transportation and civilization and in the history of civilization transportation played the most vital role. In reality, the modern world reached at its highest peak of civilization because of the development of transportation and for this reason the transportation may be regarded as the key to civilization.

Transportation is a precondition for all kinds of social political and economic development and an effective transport system is an indispensable part for the progress of any country. Transport system increases the importance of a place. In a country where transport system is very much developed, naturally the economic condition at that country seems to be strong. So it may be said that economic development and transport system are complement to each other.

1.2 Definition

Transportation is one of the most important parts of geographical study which determines the spatial relationship among places and its role as a bridge among the people of different places (Eliot - Hurst, 1974). According to Robinson and Bamford (1978) transportation provides a means of moving persons or goods from one place to another and it concerned with a movement of persons or goods for some particular purposes. In the same language, Fair and Williams Jr (1959) defined that transportation is the movement of persons or property from one place to another. According to the famous economist Marshal (1921) "Transport industries which undertake nothing more than the movement of persons and things from one place to another have constituted one of the most important activities of man in every stage of advanced civilization". Ogburn (1946) said that transportation carries ideas and inventions to the peoples of different countries and has considerably contributed to the evolution of civilization. On the other hand according to Prasad (1960) and Srivastava (1981) transportation is an indispensable part of culture as the hallmark of civilization. Again transportation may be a service of facility which creates time and place utility through the physical transfer of persons and goods from one location to another as defined by Mossman and Morton (1957). They compared it to a "machine" which fulfill the demand of man and increases the utility of place.

Now-a-days the entire life of the people of the world depends upon transportation service from the production of raw materials to the distribution of finished product (Srivastava, 1981). All

kinds of national and international import and export are facilitated by efficient and adequate transport system. It precedes industrial and agricultural production by bringing raw material from the hinter lands and supplies its fellow production through the distribution of the finished and semifinished articles.

Transportation is a great public utility service which is equally important to producer and consumer. It is useful in satisfying a particular need and to provide link between the supplier and market (Robinson and Banford. 1978). In fact, transport is necessary and equally acceptable to all the people, everywhere and all the time. But the geographer, economist, engineer, sociologist, and all other social scientist have focused on the concept of transportation from their own aspect. Such as the economist may study the cost characteristics of the different modes of transportation, engineers may study the design and implementation characteristics of the modes, where as the political scientists may study the regulation and policies in each mode. But the geographers have focused their attention on the spatial structures formed by the modes and attempts to understand the processes that have created them (Taaffe and Gauthier Jr, 1973) That is why the geographers Eliot - Hurst (1974) recognised transportation as a fundamental aspect of geographic study.

From the above discussion the meaning of transportation may be examined with the following language.

- a) Transportation fulfills the need of human Society.
- b) It increases the utility of goods and importance of places.
- c) It is a bridge or link between the producers and consumers to distribute the goods from the source or origin of production to the center of consumption.

In fact all kinds of social and cultural information, scientific invention and economic development comes out through the development of transportation. So finally it may be said that transportation is the key to economic development or the builder of modern civilization.

1.3 Development

The modern improved transport system which we find at present time is the outcome of man's hard labour for a long time. The means of transportation have also been changed according to the changing conditions and particular requirements. The development of transportation system may be divided into the following three periods:-

- a) Ancient period
- b) The Medieval period;
- c) The Modern Period.

a) The Ancient Period

Since the time of immemorial, the means of transportation was only one human beings who themselves transported their commodities from one place to another on their head or shoulder. At the time of pre civilization there was a custom that the male used to carry their weapons and the female used to carry the load i.e a number of commodities on their head.

The primitive people firstly used animal powers like dogs oxen, horses, camels etc. as the means of transportation. Even today in some parts of the world, specially in rural areas the importance of animals have not diminished. In those days road did not exists and the people used to walk along the tracks. Subsequent^{ly} by these tracks were automatically became wider due to the constant movement of hundreds of animal together.

b) The Medieval Period

With the advancement of civilization and technology, the water transport remained the main mean of movement of goods and people during the medieval period. As a result of the development of technology the use of water transportation as a means of transportation become popular through out the world (Sampson and Farris 1979). In this regard it may be pointed out that by means of improved ocean transport system the new world (America) was discovered by Columbus (1498) and India by Vascodagama (1492).

c) The Modern Period

The industrial revolution of eighteenth century added a new chapter on the improvement of transport system. The establishment of new industry and the speedy movement of goods and passenger increased the demand for land transportation. That is why the roads were established in many places of the world.

The earliert road was established in 1669 between Baston and Plymouth and this earlier road was known as "trodden" path (Fair and Williams Jr. 1959). Later on the improved road was first built in 1794 between Philadelphia to Lancaster at the cost of 465,000 US dollar, by a private enterprise which is known as toll road" (Fair and Williams, Jr 1959) and it was only 66 miles in length.

The invention of steam engine by James Watt (1803) and its application on transportation early in the nineteenth century introduced a new 'golden age' on modern mechanised transportation. This steam power was first used in steamship in 1807 and railways in 1811. The first successful steamship was "clermount" after Robert Fulton's appeared on the river Mississippi and Hudson in 1807 and Ohio in 1811.

In fact the greatest dramatical change took place on transportation at the begining of the present ceutury with the invention of aeroplane by Write brothers—William Write and Orvil Write in 1903. On account of fast and speedy air transportation, man has conquered the physical barrier of distance and the high improved transpart system made this world a city today (Pant 1950).

Today the world rednced its physical distance by means of improved transport system only. Even the modern transport services developed with the automatic energy besides mechanised and steam power. Such as the 'Lenin' of ex-Soviet Union (Valtacharga 1982). Now a days the ivention of high speedy 'Jet Engine' 'Super Tanker' etc have made it possible to reach any part of the world within a few hours. That is why it is very common and popular term to all that the world gradually becoming reduced' which actually indieates the success of modern technology in transportation. Thus Pant (1950) has recognised the human success and ambitions of transportation with the followinglong Language:-

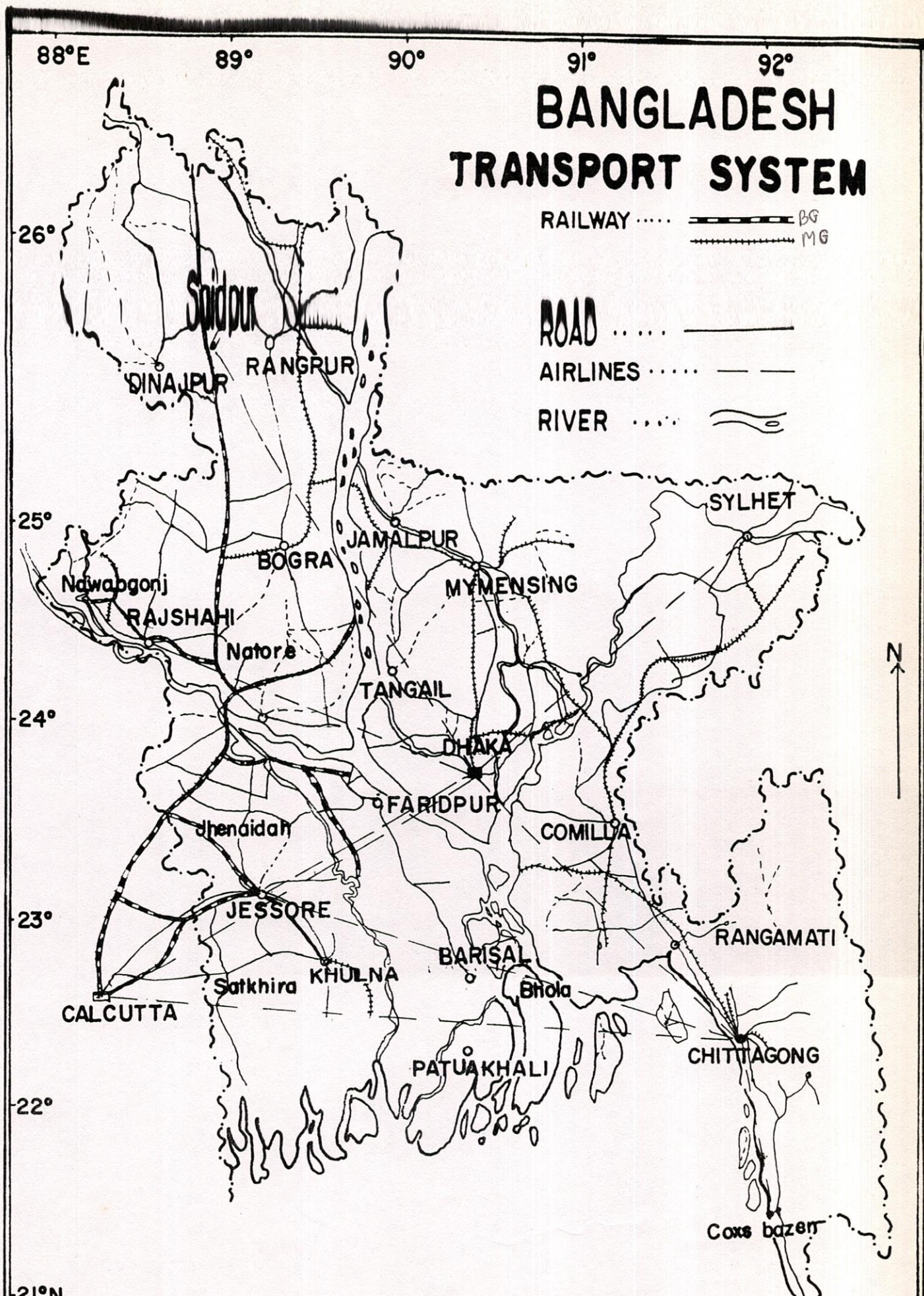
"Transportation has made this world a city today. Different countries are merely streets of this city and tomorrow the other worlds will also be transported into different cities. Thus the inter planetary transport system world be another name for 'Inter city transport.

1.4 Classification of Transport

Transport System may be divided into the following three categories:

- a) Land Transportation
 - b) Water Transportation
 - c) Air Transportation.
- a) Land Transportation

Land transportation is the earliest means of transportation and today its importance has been increased to all over the world. There are two types of land transportation road and railway.



i) Road Transportation

Road is the earliest means of transportation. In ancient time when the primitive people used to move nomadically in search of food paths or tracks were the only means of transportation.

But the pattern of road transportation has been changed throughly and different types of improved road (metalled, semi-metalled and non-metalled) have been constructed. Similarly in Bangladesh about 4827 km of paved and 2892 km of feeder road have been constructed so far (Map 1.1)

Though BRTC is only the public sector agency which provides road transport services to the people of Bangladesh. Road services of Bangladesh are dominated by private sector. It may be mentioned here that the private sector handles about 18% of freight and 95% of passenger traffic by road (FFYP. P -VIII -5).

ii) Railway Transportation

Railway as a means of transportation system which introduced a new era in modern transportation network. People used to carry bulky and heavy goods very easily by means of railways to long distances. The introduction of railway in fact dramatically changed the pattern of transportation through out the world. In Bangladesh, there are 2746 km of railway (924 km) broad gauge and 1822 km of metergauge). These two types of railway of Bangladesh are divided into two zone by the river Jamuna. Major part of the MG railway (1279 km) is located in the eastern zone and remaining 543 km of MG and 924 km of BG railway are located in western zone of the country, (MAP-1.1) The railway of Bangladesh carrying only 10.15% of freight and 25.30% of passenger.

b) Water Transportation

In the early day's water transportation was an another important means of transportation. But with the invention of modern technology the network of water transportation developed far and wide. In fact this type of transportation is very useful for the development of internal and international trade and commerce of a country. It is divided into two categories:-

i) Internal / Inland water Transportation

ii) International water Transportation.

In Bangladesh there are about 5200 km of perennial water ways which increases into 8372 km during the monsoon (FFYP). Inland water transport service is dominated by private sector and about 90% of vessels belongs to the private sector agency. There are only two international

seaports Chalna and Chittagong in Bangladesh and Bangladesh Shipping Corporation (BSC) is only

the public sector agency.

c) Air Transportation

Air transportation is the fastest (more than 320 km some cases more than 800km per hour) means of transportation. Man can move most easily and comfortably by this type of transportation. The greatest advantage of air transport is that it can avoid all the physical barrier, can fly over land and water, and does not require an artificial track.

In Bangladesh air transportation has been flourished within and outside the country after 1972. There are 8 domestic (Map-1.1) and more than 25 international routes across three continents of Asia, Europe and Africa. The maintenance and development of aviation and infra structure of air port are the responsibility of Civil Aviation Authority of Bangladesh (CAAB) Bangladesh Biman is the name of the national Air lines.

1.5 Road Transportation and its Significance

Road Transport is such type of transport system which is equally important to all the people of the world. It is particularly suitable for short and medium distance travel on account of its convenience. It is the most suitable mode of transportation which keeps the link between the urban centers and the country side (FFYP) It is true that no other forms of transportation which is able to provide such a comprehensive door to door service or origin to destination service (Robinson and Bamford,1978). That is why an old economist Jeremy Berthum remarked" Roads are the veins and arteries of a country through which channels every important circulates (Srivastava,1982).

Besides the above facilities road has an extra-ordinary characteristics that all other modes (rail, air and water) are depended on it. So an important function of road is to provide a feeder or connection with other modes (Robinson and Bamford , 1978). Road has some special characteristics as:-

- i) Small investment
- ii) Diversity of interest
- iii) Complement of other modes
- iv) Full freedom of movement
- v) Economy of cost and time etc.

But it has also some weak points as it is less dependable and less safe. The significance of road may be explained by the following statement (Srivastava, 1982).

"The road is one of the general fundamental institutions of mankind . Its history dates back to the dawn of the recorded history and beyond. It develops with man's advance, it retrogrades with the break down intercourse with the outside world, with out the distributives of civilization. Man the road builder thus can not be separated from the builder of civilization.

From the above statement it may be said that an effective road transport is indispensable for all kind of economic, social political. cultural, scientific progress of the world. The significance of road may be analysed in the following aspects: —

- a) Economic Development
- b) Social Development
- c) Political Development

a) Economic Development

Road transport is an integral part of the process of economic development. Economic development of a country and the advancement of civilization depend inter alia ' upon a good road system. An economically and commercially developed and industrially advanced country possesses excellent road service. On the other hand in an economically backward country, the road service is not satisfactory. It possesses the economic development by bringing raw materials to the center of production, supplying of labour, distribution of agricultural and industrial products to the country side, stabilizing of market price etc. Economic significance of road transport is related to the following sector of development :

- i) Agricultural Production
- ii) Industrial Development
- iii) Division of labour,
- iv) Supplies of Employment
- v) Distribution of wealth
- vi) Price stabilization
- vii) Exchange
- viii) Utility of place
- ix) Utility of goods
- x) Urbanization.

b) Social Development

Road has a great social significance. It provides a good means of communication, break the isolation of cities and village and reduced the distance between urban and rural areas. It rises the standard of living of the people of different parts of the world by connecting the points of education, culture, and distributing all other goods and information. It helps to develop the mutual understanding national unity and co-operation. Finally, it may be said that the road transport service is an indispensable part of culture as the hallmark of civilization (Srivastava, 1982).

c) Political Significance

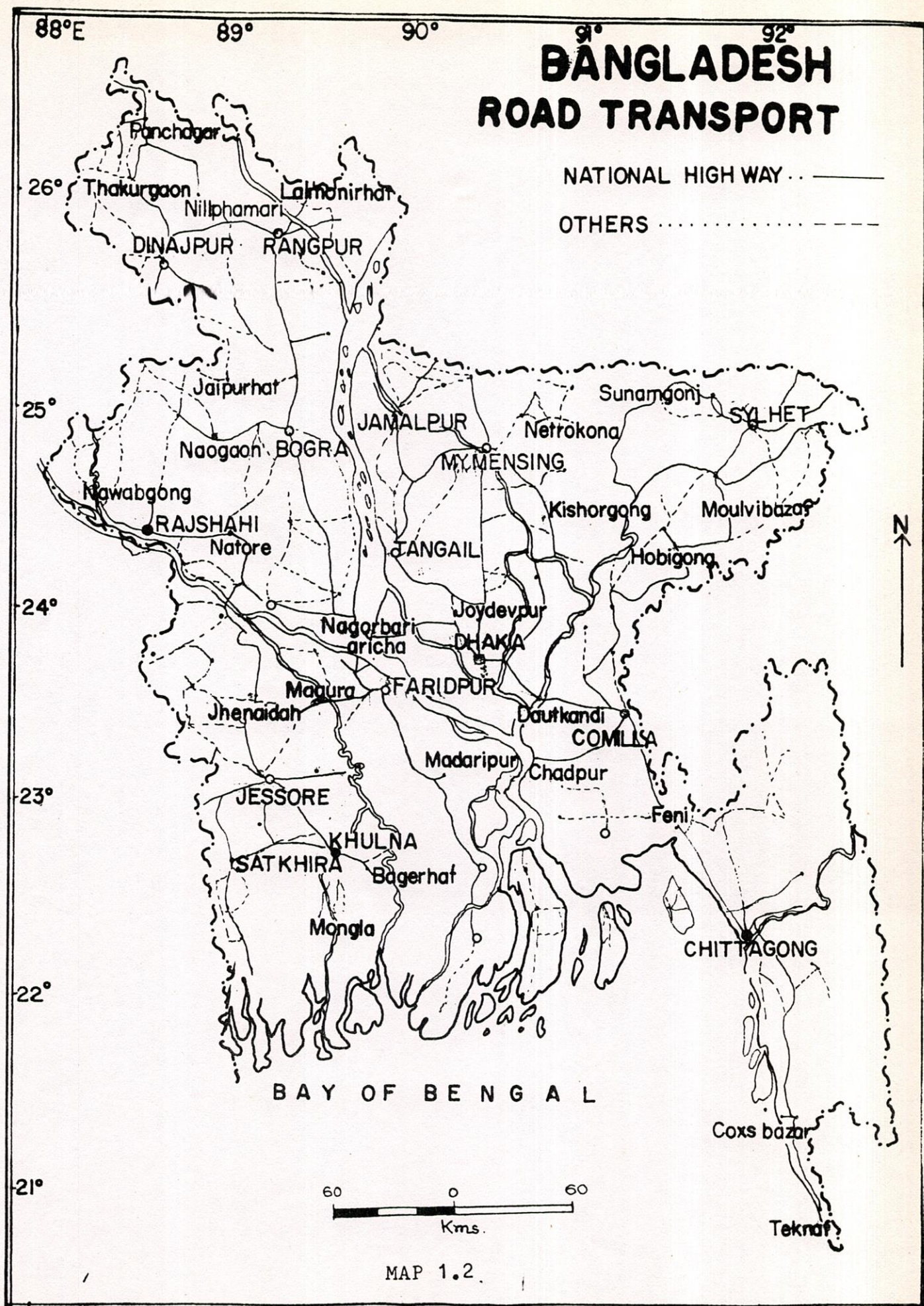
Road transport plays a dominant role not only in the economic and social sphere, but possesses a great political significance. It has given two cardinal political advantages: -

- i) National Unity and
- ii) National Defence

With the help of good road service the troops can be transported quickly to the border areas of the country to check foreign invasion.

1.6 Selection of the Topic

The transport system of Bangladesh consists of railway, road waterway and airway. But the government of Bangladesh has given more emphasis on the development of road transport. In Bangladesh there are only 12.58 km of paved road and 1.92 km of railway per 100 km² of area against 16.76 km in other developing countries of South East Asian region (FFYP). The following table and previous map 1.1 shows comparative length of different routes of Bangladesh.



MAP 1.2.

SOURCE: WEEKLY BICHITRA, JANUARY 5, 1985.

Table 1.1
Transport system of Bangladesh

Category	Subcategory	length (in km)
1. Railway	a) Broad gauge	924
	b) Meter-gauge	1822
2. Road	a) Paved	4827
	b) Feeder	2892
3. Water-way	a) Perinial ⁿ	5200
	b) Monsoon	8372
4. Air-way	a) Internal	8 routes
	b) International	25 routes

Source: GOB: Fourtn Five Years Plan. p-279

Table 1.1 and map 1.2 show the pre-dominant ~~role~~ of the road transport system of Bangladesh. If we consider the physical, social, economic and political coudition of Bangladesh, the priority must be given on the development of road transport. Because, the terrain of Bangladesh is criss-crossed by a large number of river and innudated by flash floods making coustruction as well as maintenance of railway costly and difficult.

Bangladesh is known as a land of rivers and a dense network of rivers and cannals serve major part of the country. Geographically Bangladesh is situted at the meeting point of three main rivers the Padma, the Meghna and the Jamuna which carry millions of tons of silt every year and overladen the river bed and making the rivers un-navigable. That is why the water way of Bangladesh seems to be insufficient because of the physical limitation.

Again due to the economic backwardness of Bangladesh the air way is not avialable in most part of the country. As a result the importance of road to the national economy is increasing day by day and road remain as the chief mode of transportation. Similarly the importance of road transport in Rajshahi district has been increased and it can not be under estimated. For this ^areason an endeavour has been initiated to the study of the Road Transport System of Greater Rajshahi District: A geographical Analysis" of this thesis.

The greater Rajshahi district is not well served by air and railway, though well connected by road with all the areas of Bangladesh. Thus the road transport system of this area naturally plays the

most vital and important role for any kind of development. Therefore realising the significance of road transport in the economy of Rajshahi region an effort has been under taken to examine the pattern of "Road Transport System of Greater Rajshahi District

1.7 Selection of the study Area

Greater Rajshahi district (now consist of four separate district of Naogaon, Natore, Nawabgonj and Rajshahi) has been selected as the study area of my study on the basis of the following reaons:

Firstly, physiographically and economically, Rajshahi is such type of region where road transport system is the chief mode of transportation. That is why it is essential to know the expansion and development of road and the interrelationship of economic aspect to the geographical or spatial variation.

Secondly, the data collection facility is an another important reason for the selection of the study area. It was convenient for the researcher to collect data from the field and different offices.

1.8 Aims and objectives of the study.

The primary purpose of this study is to explain the spatial characteristics of road transport of greater Rajshahi district. The main objectives are:

- a) to evaluate the growth and development of road transport system of the study area;
- b) to examine the road density and spatial distributional pattern;
- c) to explain the pattern of traffic movement of different routes and nodes;
- d) To analyse the road network and to measure the network indices;
- e) to classify the nodes of the urban hierarchy on the basis of traffic movement, network connectivity and to measnre the potentialities of urban centers;
- f) to find out the spatial interaction and to measure the degree of spatial interaction of different nodes within and outside of the study area;
- g) to identify the problems of the development of road transport and to formulate some policy guidelines for integrated regional development;

1.9 Review of Literature

Very few studies so far have been made by the economist, geographer, sociologist and all other social scientist^s on this aspect. However in the writings of Harun-or-Rashid⁽¹⁹⁷⁷⁾ Nafis Ahmed (1976),

M. H. Choudhury (1987), economist L. Haque and M. Rahman (1986), M. A. Hamid (1988), and the other writers as M. H. Ali (1987), M. N. Anzum (1982), the general discussion of the development, distribution and the classification of road transportation of Bangladesh has been observed.

Most of the writers have discussed the road transportation of Bangladesh on the aspect of economy and have not sufficiently focused on geographical or spatial aspects of transportation. M. N. Anzum has also written a book named 'Paribahan' in which a general description of transportation of Bangladesh is found.

Besides the above published books or documents a brief picture of transportation system of Bangladesh has been identified in two un-published Ph. D. thesis and in some published articles (the list of the published and unpublished documents are given at the end of the chapter). A. F. M. Kamaluddin (1967) emphasised on the development of transportation of Bangladesh and Raihan Sarif also focused on the regionalization of Bangladesh on the basis of transport network as a whole, M. A. Taha has discussed the changing pattern of accessibility and its influence on commercial land use of Rajshahi city. These works were undertaken on the basis of secondary data. But the author in her study mostly used area based primary data. The researcher tried to measure the efficiency level of small area transportation whose geographical importance also is much greater.

1.10 Sources of Data and Method of Collection

Necessary data have been collected from both the sources primary and secondary. Most of the primary informations of this study are obtained from:

- a) The Owners Association of bus minibus and truck.
- b) Motor Labour Union.
- c) Bangladesh Road Transport Corporation (BRTC).
- d) Rajshahi City Corporation,
- e) Naogaon, Natore and Nawabgonj Municipality
- f) Rajshahi Development Authority (RDA):
- g) Barendra Integrated Development Project (BIDP).
- h) Naogaon, Natore, Nawabgonj and Rajshahi Roads and High Way Directorate (RHD).
- i) Naogaon, Natore, Nawabgonj and Rajshahi Zila Parishad:
- j) Traffic Engineering Division of Rajshahi and Naogaon.

The data from the primary sources has been collected during the period of July 1990 to June 1991. Data of different centers of the study area has been collected by questionnaire and personal interview. To get up-to-date data, the author made frequent visits in the study area and also formal and informal discussions were made with the related people to observe the ideas and attitude.

i) Three sets of questionnaire have been prepared for passenger survey, daily movement of goods and vehicles of different routes and nodes.

ii) Formal and informal interviews are conducted with the officials of the government, public, semipublic and other private organizations, political leaders, business man, executives, chairman of the municipality and upazilla (now it is known as thana), mayor of city corporation, educationist and other important personalities.

To achieve the objectives and to fulfil the actual purpose of the present study, necessary information from various published census, un-published documents and other publications which are related to the field of the study has been collected. The secondary data are collected from the following documents of:

- a) Population Census of greater Rajshahi District of 1951, 1961, 1974 and 1981.
- b) Preliminary Report of the Population Census of 1991.
- c) District Gazetteers: Rajshahi 1976.
- d) District Statistics: Rajshahi 1983, 1987.
- e) First (1973-78) Second (1980-85) Third (1985-1990) and fourth (1990-95) Five Years Plan and two years (1978-80) Plan.
- f) Traffic Survey Report of 1984-85, 1987-88, 1989-90 and 1990-91 of Rajshahi Zone.
- g) Yearly Report of RHD Division of 1989-90 and 1990-91.
- h) Various types of Dailies, Weeklies, Monthlies, quarterlies and other paper, Periodicals, Journals and historical documents are used.

1.11 Research Method

In this study the following research methods have been adapted.

1) It was necessary to gather knowledge of research and techniques from the relevant books, papers, periodicals, journals and many other published and un-published documents and official records.

2) For this study a large scale map (1" to 4 miles) has been collected from the Roads and Highway Directorate (RHD).

3) After collecting the large scale map necessary data and informations have been collected from the relevant primary and secondary sources. Later on all the data have been analysed and then quantitative techniques have been applied for the explanation of the data.

4) To make this study meaningful relevant chart, table, diagram, graph, figure etc have been prepared with the help of tabulated data.

5) Then the large scale map has been reduced into "1 to 12 miles or 1 cm to 9.69 km. for showing the spatial distributional pattern in the map and making the study more meaningful and attractive.

6) Lastly, author in this study has conducted the pilot survey to measure the reliability of data.

1.12 Organization of the Study

The thesis has been organised into seven chapters:—

Chapter one deals with the basic concept of research. It consists of the introduction, definition, significance and classification of transportation, aims and objectives of the study, selection of the topic and the study area, review of literature sources and methods of data collection, organization and the limitation of the study.

Chapter two highlights the geographical setting of the study area. In this chapter the physiography, hydrography, climate and some socio-economic aspects- population, education occupation, urbanization etc have been discussed.

Chapter three dwells upon the transport system of the study area. This chapter is sub divided into two parts. The first part of this chapter deals with the roads, its development density, distribution etc. and the second part deals with the daily traffic movement of different nodes and routes.

In **chapter four** the spatial interaction between different places has been discussed. To measure the spatial interaction of Rajshahi city to another 24 center within and outside of the study area Ullman's gravity model of interaction have been applied in this chapter.

Quantitative analysis of network indices and the efficiency level of those indices have emphasized in **chapter five**

Chapter six deals with the urban hierarchy of the study area. This chapter measures the centrality and accessibility of the different nodes of the study area. This chapter also deals with the

spacing of 37 nodes of the study area and comparison of urban hierarchy to the Charistallers model.

In concluding chapter seven discusses the summary and conclusion of this study.

1.13 Limitation of the study

It is very much difficult to say that the analysis which has been made in this study is fully accurate. So this study has some limitations also. Because the collection of data from primary sources is very difficult and really a tedious job. That is why this study is not far from its limitations.

Firstly it was difficult to find out any published and un-published materials available towards the study of regional transportation. In census report and all other publications, information were not consistent which eventually has given rise to confusion. In this situation the present study has been based on actual field survey.

Secondly, bus, minibus and truck are considered as the internode connecting vehicles in this study, but there are also some local truck, private car, jeep, motorcar and autocycle etc whose importance on road transport can not be ignored. Because of their irregularity, shortage of research time and the limitation of the thesis scope the author did not count them in this study.

Thirdly some problems also arose during the time of data collection. Some times the author encountered with great challenges. Because the respondents of bus, minibus and truck owner associations particularly the truck Malik Samittee did not want to comply with the request of the researcher to give information. They possibly thought that if the actual information is supplied government may impose further tax on their excess income or may impose punishment for illegal carrying of passengers and goods and disobedience of traffic rules. In this case personal knowledge and pre-vius experience has been applied by the author for the collection of information.

Fourthly, some problems had arisen in identifying the nodes of network and urban centers to urban hierarchy because of the definitional change of urban'. Besides the 32 urban centers of the study area, the six important places (Ahmedpur, Amnura, Baneswar, Banpara Sampur and Walia) considered as the nodes of the study area because of their locational importance only, although urban facilities are quite absent in these places. In network analysis all these centers are considered as nodes and routes or edges but they are not equal in size, quality and category.

Fifthly to delimit the origin and destination of traffic movement and the service area of nodes is an important problem. Becauseⁱⁿ most of the cases the traffic does not follow the administrative boundary.

Sixthly the selection of sample area is another important limitation of this study. Because out of 32 urban centers the author had chosen only the four centers of Naogaon, Natore, Nawabgonj and Rajshahi for investigation. It was not possible for researcher to go to all the centers specially the small and distant centers because of security and time.

Seventhly, the collection of upto-date population data was also a great problem. In the preliminary report of population Census 1991, the total population of the study area and urban population of four district head-quarter^s are given only. For this reason there was no other choice to the author but to calculate the thana population as 1991 over the population figure of 1981 by multiplying the growth rate over 1981.

Naturally, the ranking of cities on the basis of projected population can not be accurate and may be excepted as a hypothetical figure over the figure of 1981.

Though there are some limitations in the present study it may be said that the description which has been made here is more or less accurate, meaningful and significant. The author is hopeful that this study would help the authority to identify the problems of the development of road transport in this region.

Besides its academic value this study would also be helpful for planning the network of roads and overall economic development of greater Rajshahi district.

List of the Book Review

1. Published Book

- i) Ahmed, N (1976) A New Economic Geography of Bangladesh. New Delhi, vicas publishing house pvt LTD pp. 249 - 282
- ii) Ali, M. H. (1987): Economic and Commercial Geography (in Bangali), Dhaka
- iii) Anzum, M. N. (1982) : Transportation (in bengali): Rajshahi. United Printers. pp-1-293.
- iv) Choudhury, M. H (1987): Economic, Regional and commercial Geography (in Bengali): Dhaka. pp-170-190
- v) Hamid, M. A (1988): Rural Development in Bangladesh (in bengali) Mohammad Brothers. pp. 219-233.
- vi) Haque, L. and Rahman, M (1986): Economics of Bangladdesh (in bengali): Bangladesh Books corporation. pp., 340-360.
- vii) Rashid, Harun-or (1977) : Geography of Bangladesh. University Press. LTD. pp 421- 446.

2. a) Un-Published Documents:

- i) Kamaluddin, A. F. M (1967) The Development of Transportation in East Pakistan. Un-published Ph. D thesis Jahangir Nagar University, Savar Dhaka.
- ii) Sharif, A.H.M.R (1986): Transport and Regional Development in Bangladesh. A geographical study. Un-published Ph.D thisis. University of Sheffield. Engand.

2(b) Published Articles:

- i) Kamal uddin. H. F. M (1967) "The geography of Rail Net Reorientation in Bangladesh in the post partition Period" Oriental geographers Vol no -1 pp.39-45.
- ii) Rashid. K. B. S. (1977) "A land Transport Intensity map of Bangladesh" Oriental Geographers vol pp-62 -67.
- iii) Sharif, A.H.M.R (1985): Regionalization of Transport Networks of Bangladesh" Jurnals of the Bangladesh National geographical Assication. Vol -B, 14, December January 1985, 1986 pp. 45- 59.
- iv) Taha, M. A (1987) "The effects of the transformation of Accessibility on commercial land use: A symbolic discussion" The Rajshahi University studies. Pat B./ Vol No - XV. pp-207 - 238.

CHAPTER TWO

GEOGRAPHICAL SETTING OF THE STUDY AREA.

2.1 Origin of the Name of Rajshahi

The name of Rajshahi is commonly believed to mean the royal territory, because it was the home of many Rajas. However the origin of the name of Rajshahi is doubtful but one plausible hypothesis is that at the beginning of 15th century when this part of the country was ruled over by Raja Khan or Ganesh; the Hindu chief of Bhaduria, the Sultan or Mohammendan Governor of Gour became the king of Bengal. According to Professor Blochmann, a Hindu Raja who ascended a Muslim throne and his territory acquired the name of Rajshahi (Siddiqui (1976).

It may be mentioned here that the name of Rajshahi is an extra-ordinary hybrid of the Hind 'Raja' and the Persian 'Shahi'. In the old district records of eighteenth century there are several spelling of the name of Rajshahi as Rajshay, Rajishaye Rajishayye and Rajeshy. Rodshy, Rodshi, Rodshaby, Roudshehi, Raujshahy Raajshiey etc (Siddique, 1976).

Though the name of the district of Rajshahi is a controversial issue today, yet it is recognized to all that the name of Rajshahi is an extraordinary hybrid of Hindia 'Raja' and Persiah 'Shahi'.

2.2. Location Area and Boundary.

The district of Greater Rajshahi is situated in the north west portion of Bangladesh. Geographically it lies between $24^{\circ}6''$ and $25^{\circ}13''$ north latitude and between $88^{\circ}02''$ and $89^{\circ}21''$ east longitude map -2.1).

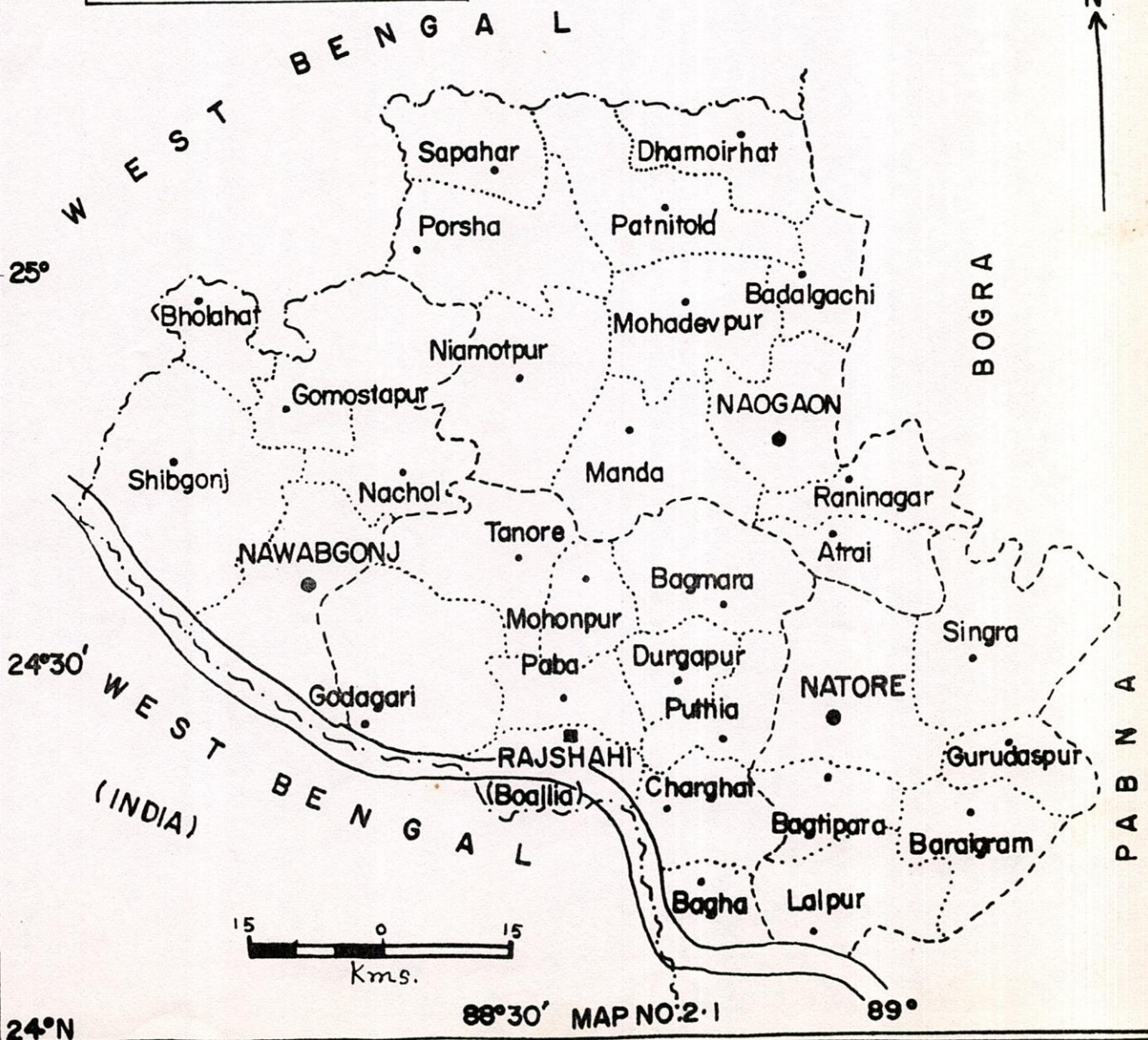
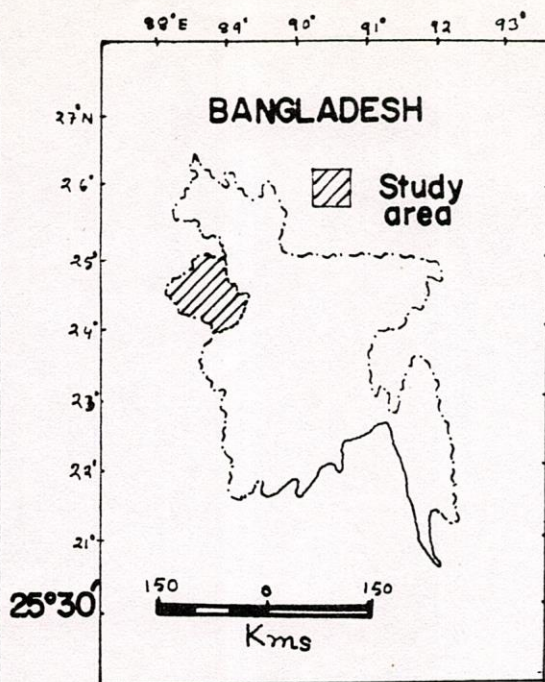
Greater Rajshahi district now consist of four separate districts namely Naogaon, Natore, Nawabgonj and Rajshahi. It is the 6th largest district of Bangladesh in respect of area. The total area of this district is 9456 km^2 which is about 6.6 percent of the total area of Bangladesh (the area beyond river is 9283 km^2 and the river area is 173 km^2). Naogaon is the largest district with an area of 3458 km^2 and Nawabgonj is the smallest district with an area of 1671 km^2 .

Greater Rajshahi district is bounded by the districts of West Dinajpur, Maldaha and Murshidabad of West Bengal of India on the north and western side. The districts of Bogra and Pabna lies on the eastern side and the southern side of the study area is bounded by the Padma river. This river separates the study area from the districts of Maldaha and Murshidabad of West Bangal of India (Map-2.1).

LOCATION MAP GREATER RAJSHAHI DISTRICT

LEGEND

INTERNATIONAL BOUNDARY		~~~~~
DISTRICT BOUNDARY		-----
THANA BOUNDARY		
DIVISIONAL H.Q.		■
DISTRICT H.Q.		●
THANA H.Q.		•



88°30' MAP NO:2.1

2.3. Physiography.

Geologically greater Rajshahi district is a part of the Indo-gangatic trough (Siddiqui 1976) Though most of the part of this district is known as Barind tract, there are also some topographic diversity, that is why the study area is broadly divided into three main types as (Siddiqui,1976):

- a) Barind tract of Pleistocene age
- b) The newly laid alluvial deposits along the bank of the Padma and
- c) The beel or the marshy land.

The Barind tract is the part of the old alluvium of middle pleistocene age. The main characteristics of this tract is that it is slightly high and undulating land with reddish clayey loam soil with abundance of impure calcareous matter. The thanas of Godagari, Gomastapur, Dharmoirhat, part of Mahanpur, Mohadebpur, Manda, Nachole. Niamatpur, Patnitala. Porsha and Tanone are the parts of Barind Tract. (Map-2.2)

The thanas of Charghat, Lalpur, Bagha, Boalia, Nawabgonj, Shibgonj, and the part of Bholahat, Gomastapur, lies under the second physiographic division gangetic flood plain. The main Characteristics of the soil of this region is sandy or sandy loamy. The greater part of Nawabgonj and Shibgonj thana is locally known as char or diar

The third physiographic division is the vast low lying area of the east and south eastern part of this district is known as Beel area. There are a large number of beels in this region but the Chalan beel of Singra thana of Natore district is the largest (approximately. 358 sq. kms in raing season) marshy land of the study area.

According to Nafis Ahmed (1968) the greater Rajshahi district may also be divided into the following three main categories:

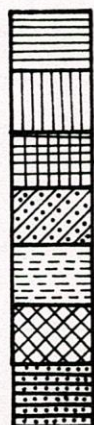
- a) Pleistocene Terraces.
- b) Flood Plain
- c) Deltaic Plain

According to Harun-or-Rashid (1977) the study area may be divided into the following seven categories.: (Map 2.2)

- a) Barind Tract
- b) Lower Mahananda flood Plain
- c) Ganges Flood plain
- d) Middle Atrai flood Plain
- e) Bhar Basin
- f) Little Jamuna flood Plain
- g) Lower Purnavaba valley.

GREATER RAJSHAHI DISTRICT PHYSIOGRAPHY

LEGEND



LOWER MAHANANDA FLOOD PLAIN

BARIND TRACT

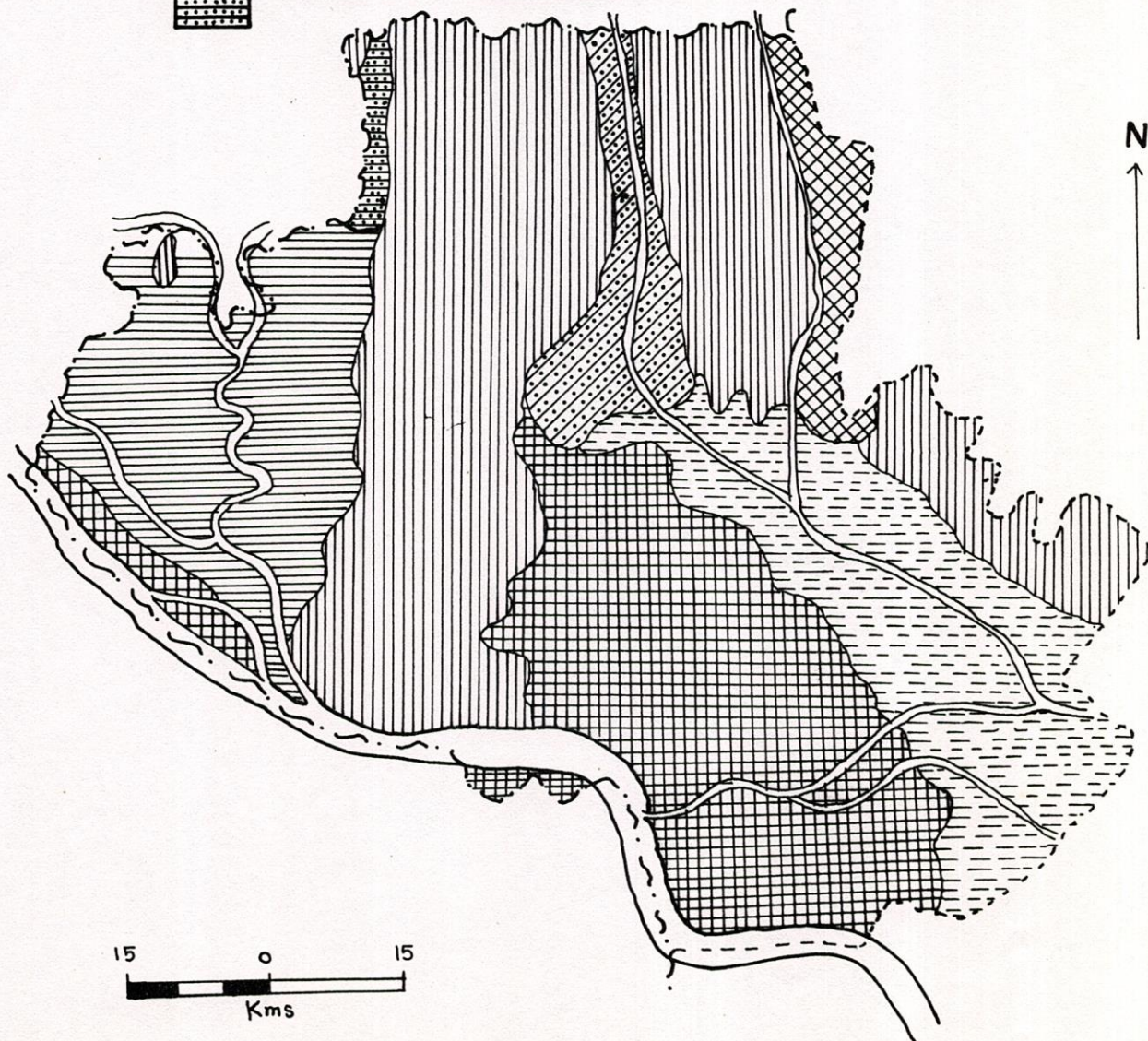
GANGES FLOODPLAIN

MIDDLE ATRAI FLOODPLAIN

BHAR BASIN

LITTLE JAMUNA FLOODPLAIN

LOWER PURNABHABA VALLEY



MAP.2-2

2.4. River system or Hydrography

The most important river of this district is Padma, a greater part of the "ganges" which touches greater Rajshahi district at a place near Shibgonj and forms the international boundary for about one hundred and fifty kms. Near Sardah it takes a course due south and near Bagha it enters into Bangladesh.

The Mohananda is a tributary of Padma and an important river of the study area. It enters into Bangladesh near Bholahat thana and joins the river Purnavaba near Rahanpur. Then the river Mahananda flows south-ward through Nawabgonj district head-quarter and with a meandering system and near Godari thana it joins the river Padma.

The Baral is an important tributary of Padma. It takes off near Charghat and joins the Atrai Gumani river system. The Little Jumuna rises in Jalpaiguri district of India and falls into Atrai in Naogaon district near Dhamoirhat. In the study area Atrai flows almost due to south to Manda thana through east central Barind and receives many small rivulets and streams (Rashid, 1977). Then near Atrai railway station it bifurcates into two parts Gur and "Atrai." The Barlai is another small river which is passing through the north to Rajshahi city.

Besides the above main rivers of the study area there are also some small rivers as Tulsiganga, Musakhan, Godai, Nandakuja, Gumani, Narad, Pagla etc. There are also some narrow drainage basins which are known as kharies in Barind region.

The main characteristics of the most of the rivers of this region is filled with water and overflooded the nearby area during the rainy season and dries up during the summer season and become unnavigable. The main rivers of the study area are shown in map 2.2

2.5 Climate

Climate of greater Rajshahi district is more or less continental type as compared to the other regions of Bangladesh. Generally the study area has a typical tropical monsoon climate with high temperature, good amount of humidity moderate rainfall and fairly marked seasonal variations. The annual rainfall is about 1640 mm and the maximum and minimum temperature varies between 43° and 16° celsius respectively. South westerly winds prevail during March and April, Southerly winds (Kalbaishakhi) in May and South easterly winds during the rainy season (June to October). The three main dominant seasonal characteristics of this region are cold winter, hot summer, and wet rainy season. In short it may be said that the study area is the hottest, coldest and driest region of Bangladesh.

2.6 Population: Growth, Distribution and Density

Greater Rajshahi district is one of the Populous district of Bangladesh. In 1872 the total population of Rajshahi district was 1,421,865 and in 1921 it was 2,028,000. Thus the total growth was 28000 and increasing rate was 1.40 percent against the figure of 1911. But the census of 1941 disclosed a Population of 21,98,000 or an increase rate of 10.25 percent against the figure of 1931. In 1974 the total Population of the study area was 42,68,000 and in 1981 it was 52,70,000. According to the preliminary report of Population census 1991, the total Population of the study area is 63,84,068 which is about 6 percent (5.91%) of the total population of Bangladesh. The increasing rate is 21.14 percent against the figure of 1981.

Population (in million)

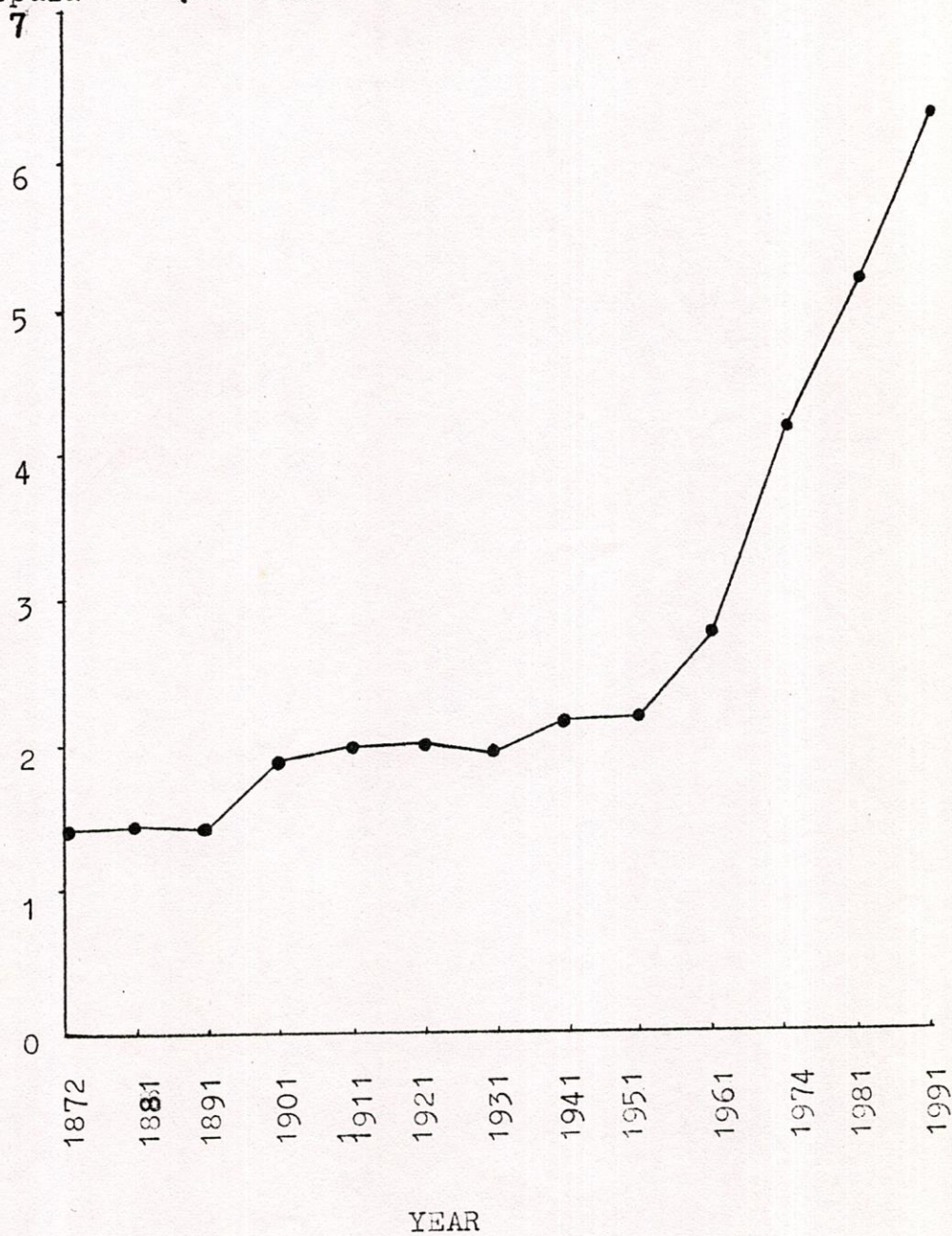


FIG. 2.1. Population growth of greater Rajshahi district
(1872-1991)

Table 2.1 shows the total population, and increasing rate per decade, exponential growth and density of the study area during the census period of 1872 to 1991.

Table - 2.1
Population Growth of the Study Area (1872 - 1991)

Year	Total Population (fig in 000)	Total increase per decade (fig. in 000)	Increasing rate per decade (in %)	Exponenti - al growth rate	Density (per sq kms)
1872	1422	--	--	--	220
1881	1449	27	1.89	0.19	220
1891	1438	- 11	- 0.76	- 0.08	202
1901	1902	464	32.27	2.80	212
1911	2000	98	5.15	0.50	215
1921	2028	28	1.40	0.14	212
1931	1993	- 35	- 1.73	0.18	233
1941	2198	205	10.29	1.02	235
1951	2205	7	0.32	0.03	304
1961	2811	606	27.48	2.43	451
1974	4268	1457	51.83	5.43	556
1981	5270	1002	23.48	1.48	557
1991	6384	1114	21.14	1.92	675

Sources: 1 A, Siddiqui (1976) : Bangladesh District Gazetteers: Rajshahi. Dhaka, GOB Press.

2. GOB (1983): Rajshahi District Statistics 1983. BBS.

3. GOB (1991) : Preliminary Report of Population census 1991.

* Authors Own calculation based on above data.

District -wise distribution of Population of greater Rajshahi district is shown in table 2.2 The table shows that the population of the study area is not uniformly distributed.

Table 2.2
District -wise Population Distribution of the Study Area -1991.

District	House hold	Size of house hold	Population			
			Male	Female	Total	%
Naogaon	404,265	5.08	1048,489	1009,869	2,058,358	32.24
Natore	244,760	5.28	664,610	631,626	1,296,236	20.30
Nawabgonj	196,072	5.84	581,304	565,236	1,146,540	19.96
Rajshahi	360,760	5.21	963,836	919,098	1,882,934	29.50
Total	1,205,857	5.30	3,258,239	3,125,829	6,384,068	100

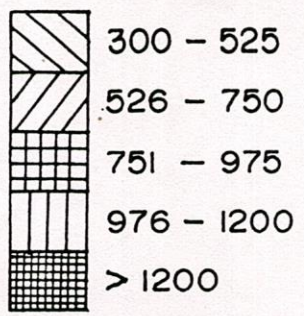
Source: GOB (1991): Preliminary Report of Population Census 1991, BBS, P-8

On the basis of Population census 1991, Naogaon possesses the highest position having a population of 2,058, 358 and Nawabgonj possesses the smallest population of 1,146,540 considering the size of population (projected population shown in appendix -1) Shibgonj thana of

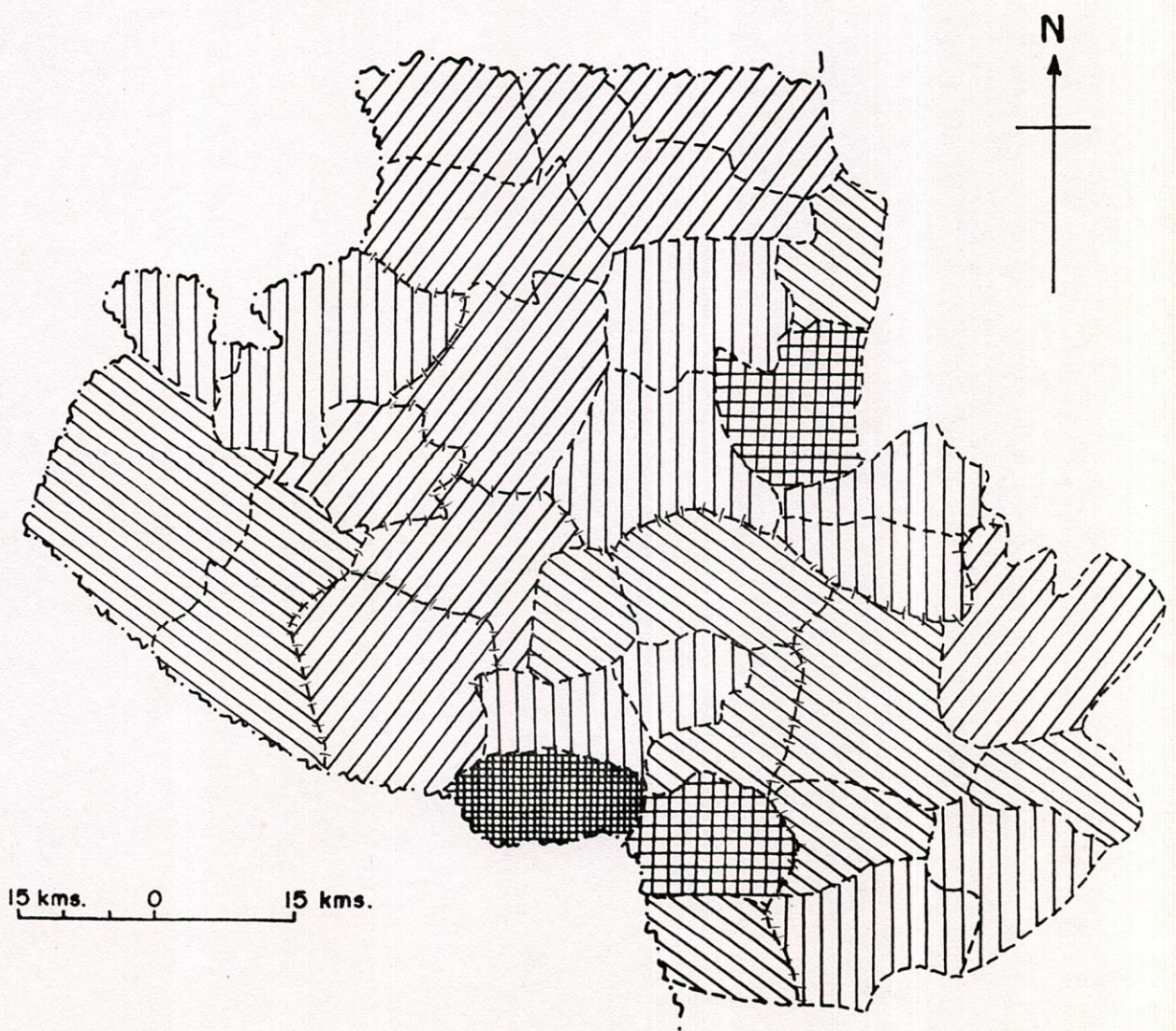
GREATER RAJSHAHI DISTRICT DENSITY OF POPULATION — 1991 (Projected)

LEGEND

Persons per Sq. km.



~ ~ ~ ~ ~ International boundary
- - - - - District boundary
- - - - - Thana boundary



Nawabgonj district possesses the largest population of 410,763 while Bholahat thana in the district possesses the smallest population of 67,021.

Thana-wise density (appendix-1) Map (Map 2.3) shows that Boalia thana (Boalia thana now consist of four separate thana of Boalia, Motihar, Shah Makhdum and Rajpara) or Rajshahi Sadar is the most densely populated (3322 persons/km²) area. Naogaon (1134) and Nawabgonj (932) are also densely populated area. On the other hand the density of population is moderate in the thanas of Badalgachi (919), Bagatipara (765) Bagha (844), Charghat (985) Gurudaspur (825), Mohanpur (753), Manda (722), Natore (826), and Puthia (795). On the other hand the thanas of Nachole (324), Niamatpur (403), Porsha (380), Patnitala (482), Sapahar (513), Singra (516) and Tanore (466) are sparsely populated area because of the rugged topography. Map 2.3 shows the density of population of the study area.

2.7 Education

Though, Rajshahi is famous for the agglomeration of different types of educational institutions yet the literacy rate of this region is not satisfactory in comparison to other region of Bangladesh. According to the population census of 1991, the literacy rate of the study area is 27.45 per cent. Table 2.3 shows the district-wise literacy rate of the study area.

Table 2.3
Literacy Rate of the Study Area -1991

District	Literacy rate (+7 years)
Naogaon	28.40
Natore	27.00
Nawabgonj	23.80
Rajshahi	30.60
Greater Rajshahi district (average)	27.45

Source: GOB (1994): Bangladesh Population Census 1991. National Series.

The above table shows that Rajshahi district possesses the highest position with literacy rate of 30.60% and Nawabgonj lies in lowest position with literacy rate of 23.80%.

The divisional head quarter Rajshahi is known as educational city. where Rajshahi University four government colleges and four private colleges, one medical college, one BIT, one Politechnique Institute and a large number of primary and secondary schools etc, are situated. Besides these institutions there are also different types of educational centers in different parts of the study area. These are shown in table 2.4

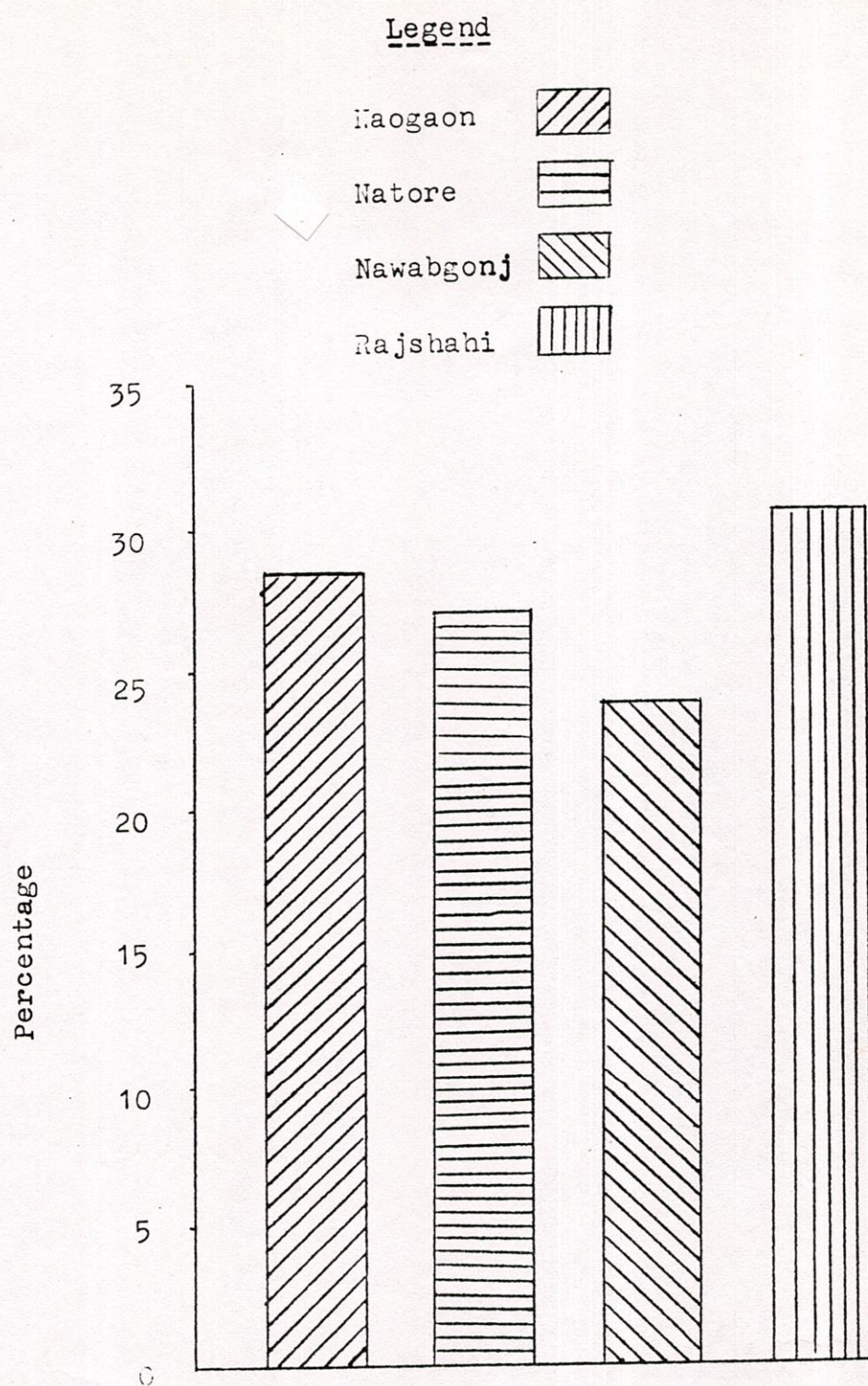


Fig. 2.2. Literacy rate of the study area

Table 2.4
Educational Institutions of the Study Area (1990-91)

Category of Institutions	Number of Institutions	Number of Teacher	Number of Students.
1. Pre-Primary school	73	523	13,803
2. Primary school	2,635	11,213	--
3. Secondary School	626	6442	202,00
4. College	83	2258	50,555
5. Madrasha	305	--	--
6. Profesionalor Technical College	12	216	3639
7. University	1	320	19948

Source: GOB (1992): Bangladesh Education in Statistics 1991, BBS, January 1992. pp. 4-71

According to the educational statistics 1991, there are 73 Pre-Primary schools, 2635 Primary schools, 626 secondary schools, 83 colleges, 305 Madrashes, 12 technical colleges and one University in the study area (Table 2.4)

2.8 Occupation

Greater Rajshahi district is mainly an agricultural region where about three-fourth of her people are engaged in primary activities. Table 2.5 show the occupational pattern of the study area by sex and residence.

Table 2.5
Occupational Structure by Sex and Residence -1981

Category of Activity	Main occupation	Sex		Residence		
		Male	Female	Urban	Rural	Total
Agriculture or Primary	Cultivation	7	32.4	18.6	73.8	69.0
	Forest, tisheries and livestock	1.7	4.1	1.1	1.	1.9
Non-agriculture or Secondary, Tertiary and quartary	Manutacturing	1.4	1.9	4.4	1.1	1.4
	Business	8.9	4.3	26.3	6.9	8.6
	Others	16.5	57.3	49.6	16.3	19.1

Source: GOB (1984) : Bangladesh Population Census (1981). Rajshahi District P. XLIX

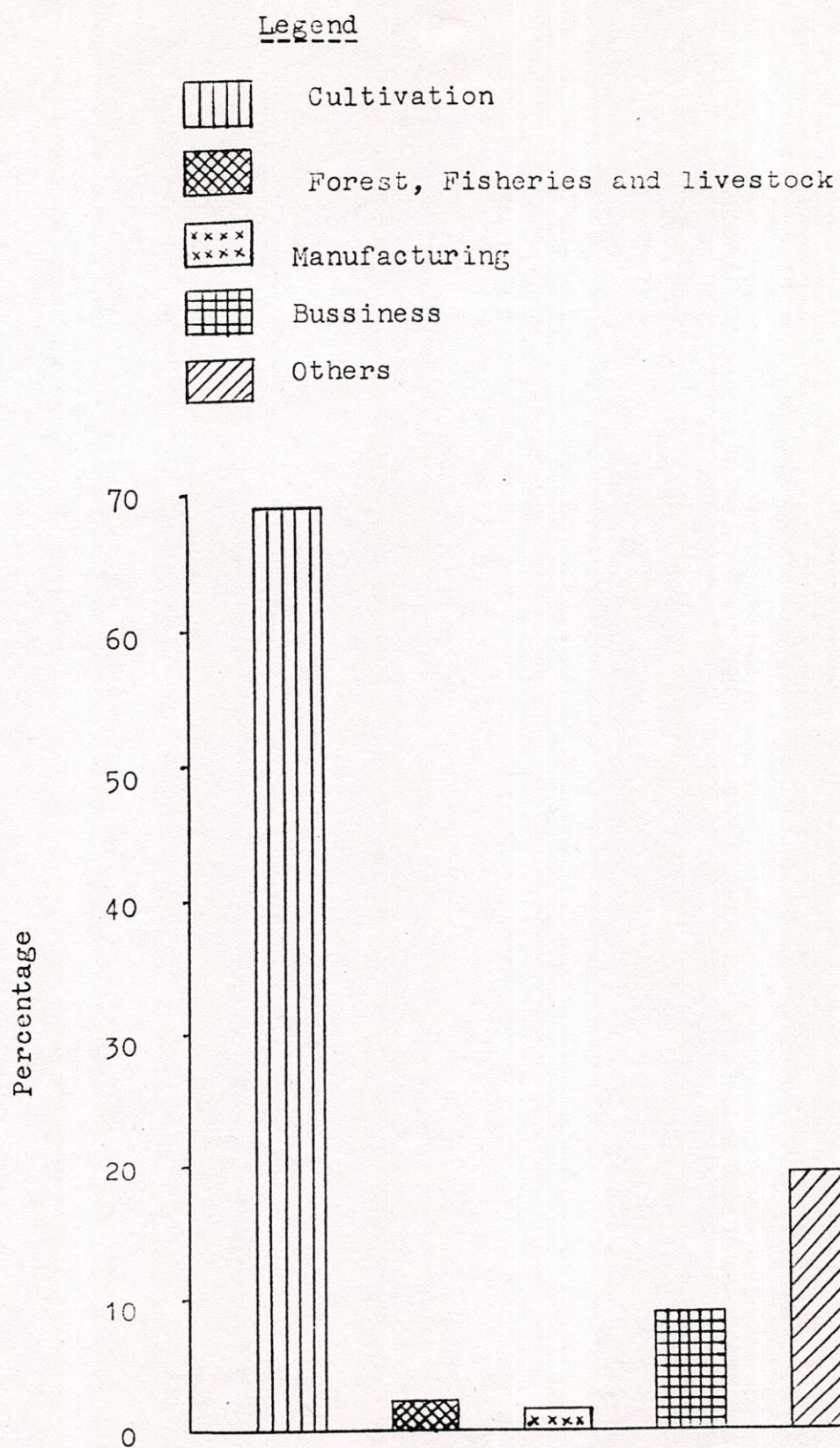


Fig. 2.3. Occupational distribution of the study area.

The above table shows that 69 percent of her total employed persons are engaged in cultivation, whereas only 1.9% in forest fisheries and livestock. From the table 2.5 it is clear that the economy of the study area are basically agriculture and about three fourth (73.8%). Population of the rural areas are engaged in agriculture. where as only 18.6% of urban Population are in agriculture. On the other hand the greater part of urban population are engaged in non-agricultural activities.

The occupational distribution of the study are represents an interesting figure that a smaller part of her employed persons are engaged in non-agricultural activities as only 1.4 percent in manufacturing and 8.6% in business.

2.9. Industry

As mentioned greater Rajshahi district is mainly an agricultural region and industrial units here are few. Except two or three large scale industries, some small scale and cottage industries are functioning in the study area Since eighteenth century, the silk industry of the study area remains famous all over the country. Table 3.6 shows the industrial structure of the study area.

Table - 2.6
Industrial Structure of the Study Area 1983

Name of Units	No. of Units	Persons engaged	Production
1. Hamdlooms	3406	8481	12881190 yards
2. Cottage	12756	37469	4515.23 taka
3. Jute Mill	1	1511	5662 tons
4. Cotton Textile	1	25056	1670 lacs
5. Silk	4	879	73727 yards
6. Sugar Mill	3	1562	21860.78 tons
7. Cold Storage	5	--	7500 tons
8. Registered factory	3125	--	--

Source: GOB (1983) : Rajshahi District Statistics BBS. pp. 69- 77

The above table shows that there are 3406 hamdlooms, 12756 cottage industries, 1 Jute mill, 1 cotton mill, 4 silk factories, and 3 sugar mill in the study area. According to the report of BSIC there are also 3125 registered industries, in the said district. The main factories as food manufacturing (643), textiles (540) chemical and commercial Products (534) metal Products excepts mechnary (305) Printing, Publishing and allied Industry (149) leather and leather products (141), mechnary except electrical mechnary (108), non metrial mineral product (77) etc. are located in different places of the study area (Rajshahi University statistics 1983, pp-69-77).

2.10 Transport system

Transport system of greater Rajshahi district consists of rail, road and air. Water transport is almost absent in district. There are 203 kms of railway 1400 kms of metalled and 11378 kms of non-metalled road and the area is served by one airport. Table 2.7 and map 2.4 shows the transport system of the study area.

GREATER RAJSHAHI DISTRICT TRANSPORT SYSTEMS

LEGEND

- ROADS
- + + + + RAILWAYS
- ~ WATERWAYS
- ☼ AIRPORT
- FERRY
- || BRIDGE

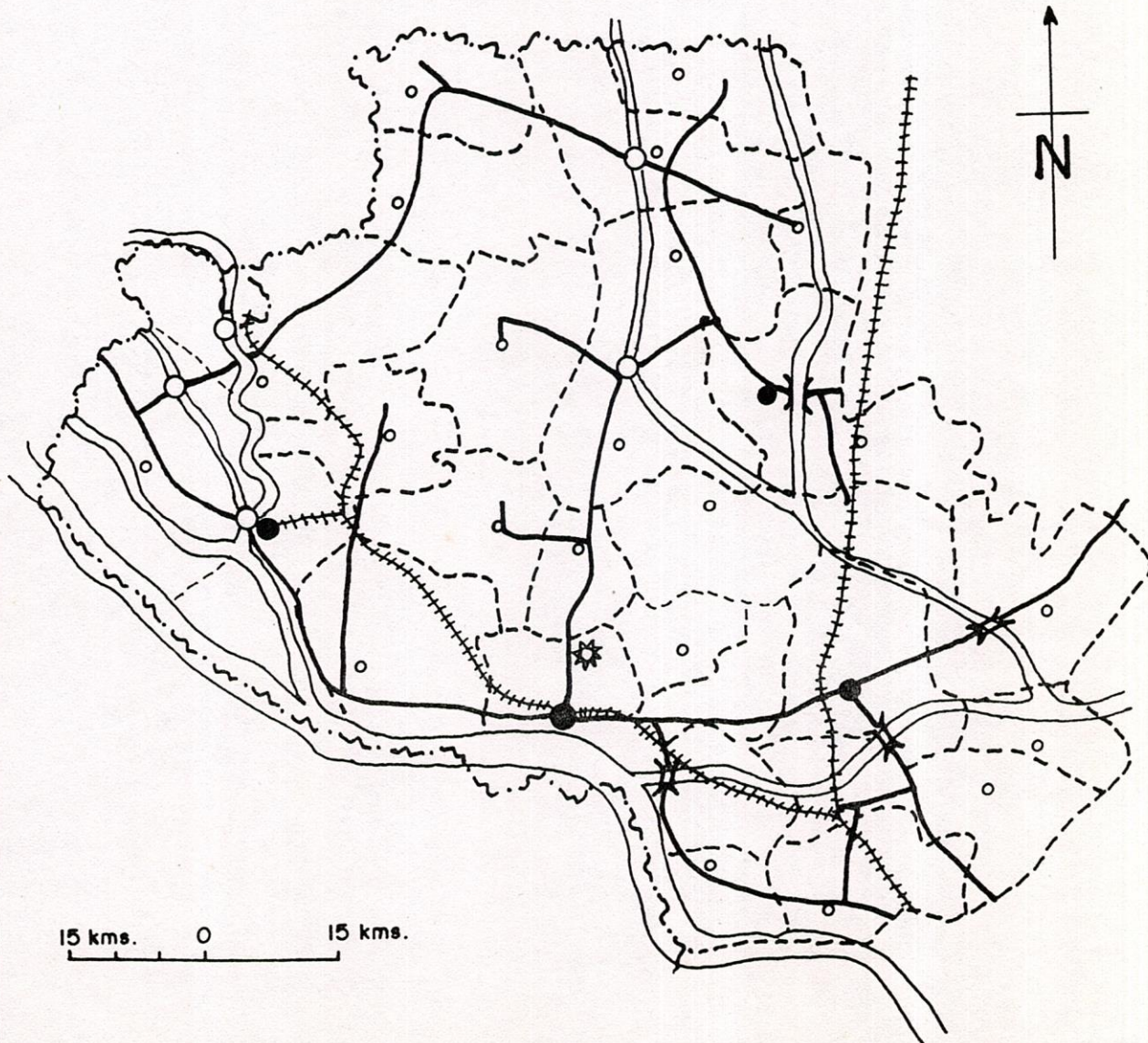


Table 2.7
Transport system of greater Rajshahi district

Transport system		Length (Kms)
1. Railway (broad gauge)		203
2. Road	Metalled	1400
	non-metalled	11378
3. Airport		1 (number)

Source: 1. Population census - 1981
2. Thana statistical office
3. Personal observation

The transport system of the study area is mainly based on road transport. The study area served by a good road services and all of its adjoining thanas and important centers are directly and indirectly connected to the district head-quarter. There are also two intercity railways Khulna to Chihati and Nawabgonj to Sirajgonj passes through this district. Bangladesh Biman has a regular service between Dhaka and Rajshahi.

2.11 Urban Centers and Administrative Units.

In the study area it has been noticed that there is a close relationship between urbanization and administrative decentralization. unlike other region of Bangladesh. That is why all the administrative units are known as urban centers. According to the population census of 1981 all the thana headquarters of the study area irrespective of its area, population and the level of urbanization may be treated as urban area. Different types of urban centers have been shown in table 2.8.

Table 2.8
Administrative Unit and Uraban Center

Unit	Number
1. Metropolitan city (ISMA)	1
2. Municipality	3
3. District City	4
4. Thana	35
5. Union	271
6. Mouza	5665
7. Village	7435

Source : GOB (1984): Bangladesh Population Census - 1981 P. XXI

The study area now consists of four separate administrative district as Naogaon. Natore Nawabgonj and Rajshahi. Again these four districts^{are} divided into 35 thanas (thana is the lowest urban center) and these thanas are compries with 271 union, 5665 mouzas and 7435 villages. Divisional head-quarter Rajshahi recently declared as a metropolitan city which comprises with four thanas Boalia, Motihar. Rajpara and Shah-Makhdum. Rajshahi SMA is the largest urban center which covers with 46.5% of the total urban population of the study area. Where as Bholahat is the smallest urban center which covers only 0.10% of her total urban population.

2.12 Sculpture and Architecture

Rajshahi is an old district and many sculpture, attractive mosques, and buildings with high architecture of ancient and medieval period are located throughout the region. Among the ancient monuments Sompura Vihara of Naogaon, Kusumba Mosque (1558A.D) of Manda, Mosque of Bagha (1523 A.D), Chhota Sona Massid of Shibgonj (1493 - 1519), Rajbari of Natore (now it is known as Uttara Ganavaban) and Puthia are remarkable.

Besides the above monumets there are also some modern architecture which attacts the people very much. These are Bara Kuthi of Rajshahi, Varendra Research Museum, Rajshahi college and University, Balihar Rajbari of Naogaon, Rajshahi Medical College and Hospital, Rajshahi Teacher Training College and Bangladesh Institute of Technolagy of Rajshahi also attract the people of different region very much.

CHAPTER THREE

ROAD TANSPORT SYSTEM OF THE STUDY AREA

The transportation system of greater Rajshahi district has not been fully developed as compared to the other region of Bangladesh. The partition of 1947, marginal location of this region, absence of large scale industry and the seasonal navigability of rivers are the main causes of this belated development of transport system of the area. Because, before the partition of 1947, this district was mainly connected with the West Bengal of India and there was a good communication system to Calcutta, the capital of west Bengal by railway and water way. That is why after the partition of 1947 this area remains neglected in respect of the development of roads and railways (Weekly Bichitra, June 30 1989). The expansion of railways and development of waterways did not take place at all due to the shortage of fund and physiographic limitation. For this reason people of this district is mainly depended on road transport system.

3.1 Development of Road

There was a good road transport system in the study area at the beginning of the eighteenth century (Siddiqui 1976). Most of those roads are not existed now a days. The road development of this district has been divided into three periods:

1. Ancient Period
2. Pakistan Period
3. Bangladesh Period

3.1.1. The Ancient Period.

It is reported from the writings of ancient travellers Fa-Hi-en, Hu-en-Sang that the people of this region attached greater importance on road transport system than water (Micher, 1965) and there was a good road communication between Pundra Bardhan and 'Gour'. During the Hindu rule (4th to 12th century) there were four important roads which were known as 'Rajpath'. These important roads ~~are~~ were:

- i) Kansat - Choudala - Rahanpur road
- ii) Rukkinipur - Porsha -- Niamatpur -- Rambati -- Jagaddal road.
- iii) Rahanpur -- Ugirpur -- Amnura road.
- iv) Rampur -- Boalia (Rajshahi) - Godagari road.

Later on during the muslim period some roads were constructed for military, cultural and commercial purposes. These roads were known as 'Shahi' or 'Badshahi path'. One of the important 'shahi' path was extended from Maldah to Pabna through Nawabgonj, Godagari, Rampur Boalia, Bagha and Ialpur. Broucke and Rennel (1960) considered that it is the oldest and greatest military path, where as hunter (1876) called it as Patna path in lieu of Pabna path (Micher, 1965). Another 'shahi path' which is shown in Rennel's map was extended from Gour to Jamalgonj of Bogra through Rajshahi and Naogaon.

According to the survey report of 1850 there were two important roads Puthia to Taherpur and Alipur to Puthia which were constructed during the Mughal and Pathan period under the supervision of the Nawabs of Murshidabad road was constructed from Murshidabad to Darjeeling via Godagari, Amnura and Parbatipur, which was known as Dinajpur road at Rajshahi and Murshidabad road at Darjeeling (Micher, 1965). From Rajshahi collectorate office it is reported that three roads were constructed in 1801 in this district (Siddiqui 1976).

- i) Natore to Nawabgonj
- ii) Rampur Boalia to Rangpur
- iii) Natore to Malanchi

These three roads were constructed under magistracy of Mr. Grants (1795) and during the British period in 1830 Some metalled roads were constructed and previous old road was repaired under the supervision of a district executive engineer (Micher 1965). Those roads were as follows :

- i) Rajshahi to Maldah
- ii) Rajshahi to Naohatta
- iii) Rajshahi to Natore
- iv) Murshidabad to Dinajpur
- v) Naogaon to Mohadebpur
- vi) Patnitala to Nagirpur
- vii) Rajshahi to Pabna
- viii) Natore to Bogra
- ix) Akkelpur to Badalgachi

After the transformation of district head-quarter from Natore to Rajshahi in 1825 Mr. Niculus William Machangi an executive engineer coustructed about 19.2 kms. of metalled road at the entrance gate of Rampur Boalia. The Zamindar of Dighapatia of Natore Kali Prasana Raj (1854) repaired the ex-Rampur -Boalia Natore road at the cost of 35,000 taka and since then it was known as Natore road (Micher. 1965).

W. W. Hunter (1876) in his statistical Account of Bengal "Volume -viii reported the existence of nine important roads aggregating 179 miles or 286'4 kms. in this district Table 3.1 shows these nine roads in 1871.

Table 3.1
Roads in this District in 1871

Name of Road			Length in Kilometer
1.	Roads with in the town and civilstation Rampur Boalia		14.40
2.	Rampur	Boali - Natore	49.60
3.	Natore	Atrai	9.60
4.	Natore	Lalpur	32.00
5.	Rampur Boalia	Arankala	67.20
6.	Rampur Boalia	Naohatta	16.00
7.	Rampur Boalia	Bargachi	22.40
8.	Natore	Dadapur	46.00
9.	Baragachi	Dinajpur	28.80
Total			286.40

Source: Ashraf Siddiqui (1976) : Bangladesh District Gazetteers, Rajshahi GOB. P. 139.

In 1916 there were two metalled roads Rampur Boalia to Naohatta and Rampur Boalia to Natore in this district. But there were also some metalled roads as lalpur Gopalpur, Sardah to Natore, Naogaon to Santahar, in the study area. On the other hand there were also some improved unmetalled roads in this area. According to the District Gazetteers of O'Malley (1916) there were only 45 miles (72 kms) of metalled and 928 miles (1485kms) of village unmetalled roads in this district (O'Malley 1916).

3.1.2 Pakistan Period

During the period 1916 -1947 the development programme of road were not under taken. So the road length of this district remained almost static during this period (1916-1947). After the partition of 1947 the government of Pakistan realised the necessity of road transport in this region and greater importance was imposed on the construction of new roads and the maintenance of previous road through out the country. Under the supervision of Roads and Highways Directorate (RHD), many new roads were constructed, old unmetalled roads were transferred into metalled ones, and some new bridges and culverts were constructed at some important places (Siddique, 1976). The total mileage of roads under the supervision of RHD till June 1968 was 182 miles (286 kms) which is shown in table 3.2

Table 3.2
Important roads under RHD in 1968

Name of the road			length (km)
1.	Rajshahi	—— Natore	48
2.	Rajshahi	—— Nawabgonj	48
3.	Rajshahi	—— Naohatta	8
4.	Sartahar	—— Naogaon - Mohadebpur - Dhamoirhat	59
5.	Natore	—— Muladuli	35
6.	Natore	—— Bogra	32
7.	Sardah	—— Baneswar	11
8.	Nawabgonj	—— Shibgonj - Rahanpur	45
Total			286

Source: Ashraf Siddiqui (1976): Bangladesh District Gazetteers, Rajshahi p. 139.

Besides the above RHD roads there were also 55kms of metalled road under the supervision of municipalities. From 1968 to 1973 the road mileage did not increase due to the liberation war of 1971 and political unrest of the country.

3.1.3 Bangladesh Period

After the creation of Bangladesh the transport system of our country faced with a serious problem. Many important roads, culverts, and bridges were either destroyed or damaged due to the liberation war of 1971. After the liberation war, the government of Bangladesh took immediate step to repair the destroyed roads, and to construct the new important roads. To achieve this programme the first, second third and fourth five years plan of Bangladesh allocated a large amount of money for the maintenance and construction of roads. In this way at present all the important centers of Bangladesh have been connected by roads. But a dramatic change has been taken place with the decentralization of administration in 1984. Under the Upazila concept many new roads were constructed which one known as upazila connecting roads, by which all thanas are directly or indirectly connected to the district head-quarter. Besides the upazila or thana connecting roads, an important new road was also constructed from Godagari to Nachole via Amnura by Barendra Integrated Area Development Project, (BIADP)

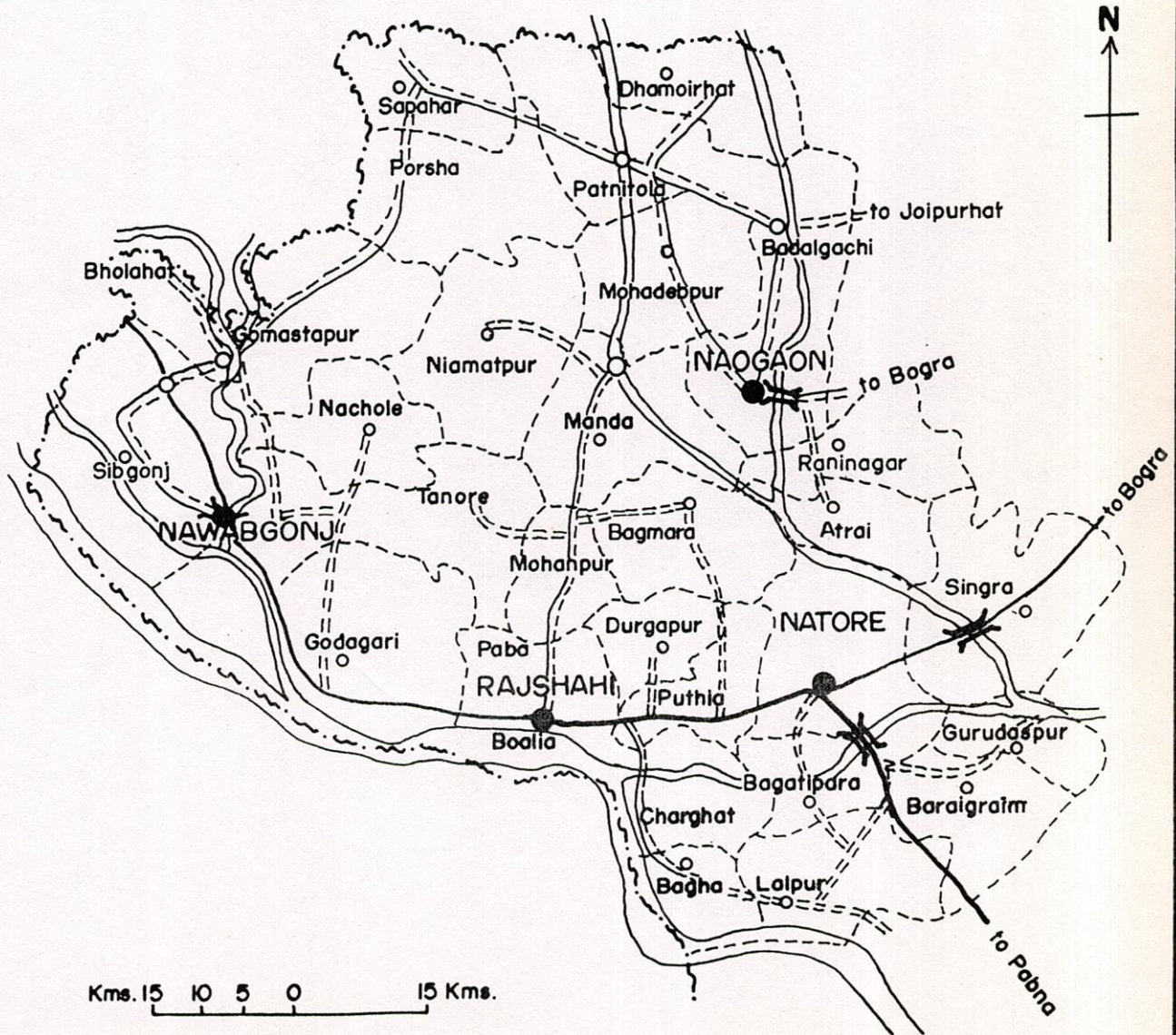
3.1.4. Present Condition of Road.

In June 1991, there are 844 km of RHD roads in this district. Out of 844 km. RHD 84kms are National Highway, 109 km are Regional Highway. and 339 km, are upazila or thana connecting road (Map - 3.1) The main categories of this RHD road can be seen from table 3.3 (Detail in appendix 2),.

GREATER RAJSHAHI DISTRICT ROAD MAP (June 1990)

L E G E N D

————	NATIONAL HIGHWAY	●	DISTRICT H.Q.
————	REGIONAL HIGHWAY	○	THANA H.Q.
-----	FEEDER ROAD	○	FERRY
-----	THANA CONNECTING ROAD	≡	BRIDGE
		~~~~~	RIVER



MAP 3-1

SOURCE: ROADS AND HIGHWAYS DIRECTORATE RAJSHAHI.



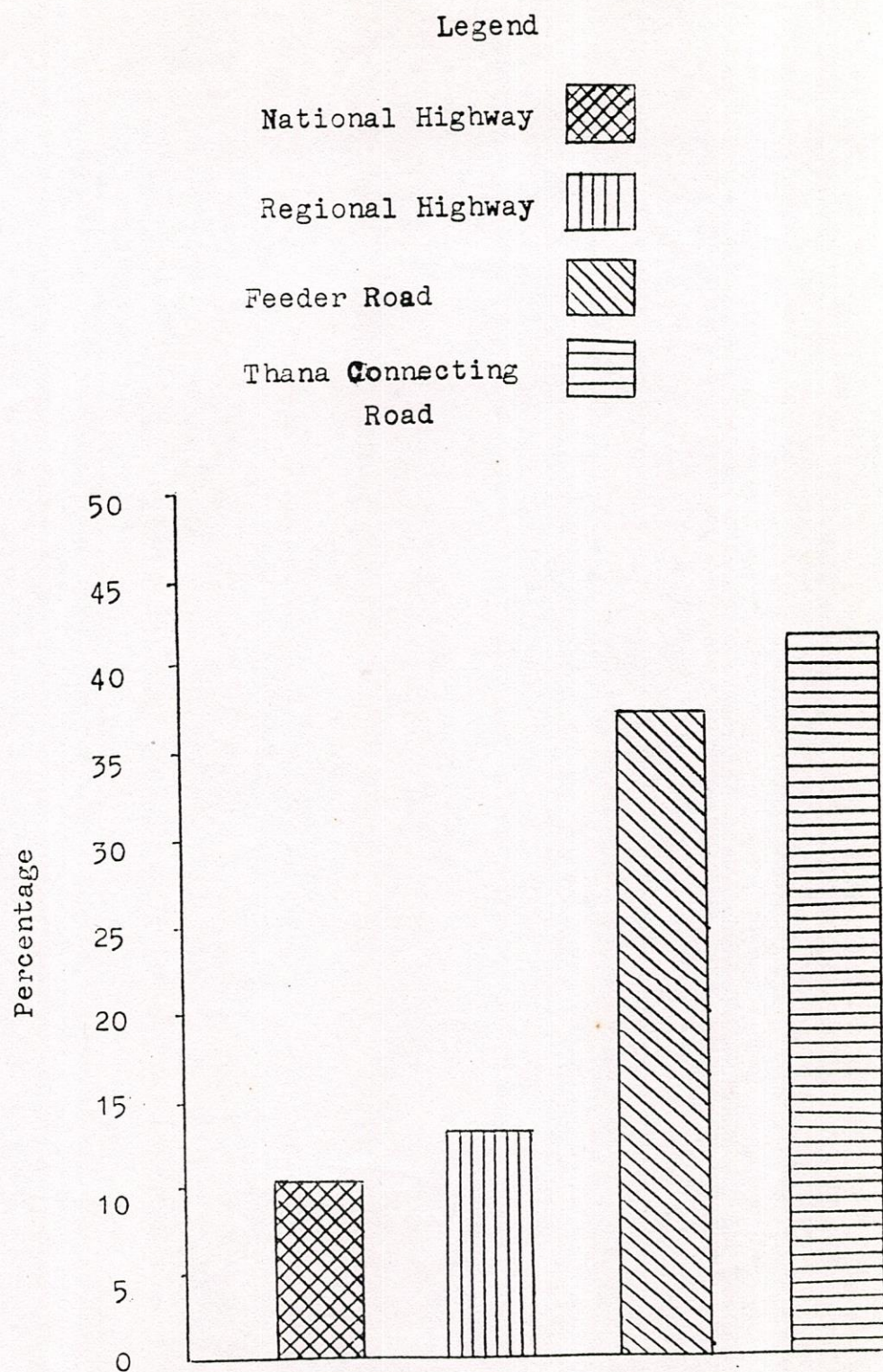


Fig. 3.1. Category-wise road of the study area.



**Table 3.3**  
**Category-wise Road under RHD Division 1991.**

Category	length (km)	Percentage
1. National Highway	84	9.95
2. Regional Highway	109	12.91
3. Feeder Road	312	36.97
4. Thana connecting Road	339	41.17
Total	844	100%

Source : GOB ( 1992) : Yearly Report of RHD Road Division in 1990-91. Ministry of planning P. 41.

### 3.2. Regional Distribution of Road.

Besides 844 kms of RHD road there are also some metalled and unmetalled road under the supervision of different organizations. Such as Zila Parisad, Thana Parisad, municipality, city Corporation, Rajshahi Development Authority (RDA), Barendra Integrated Area Development Project ( BIADP), Union Parisad etc. The total mileage of road under all these organisations are 1400 kms of metalled and 11,387 kms of non-metalled or kutchha road. Table 3.4 shows the district wise distribution ( appendix 3. shows the thana wise distribution) of metalled and non-metalled road of the study area.

**Table 3.4**  
**District-wise road distribution**

District	Metalled (1990) ¹		Non-metalled (1983) ²			Total
	length	%	length	%	length	%
Naogaon	338	24.15	4082	35.85	4420	34.57
Natore	302	21.57	1668	14.65	1963	15.35
Nawabgonj	233	16.64	1685	14.80	1918	15.00
Rajshahi	527	37.64	3952	34.71	4479	35.08
Total	1400	100%	11.38/	100%	12787	100%

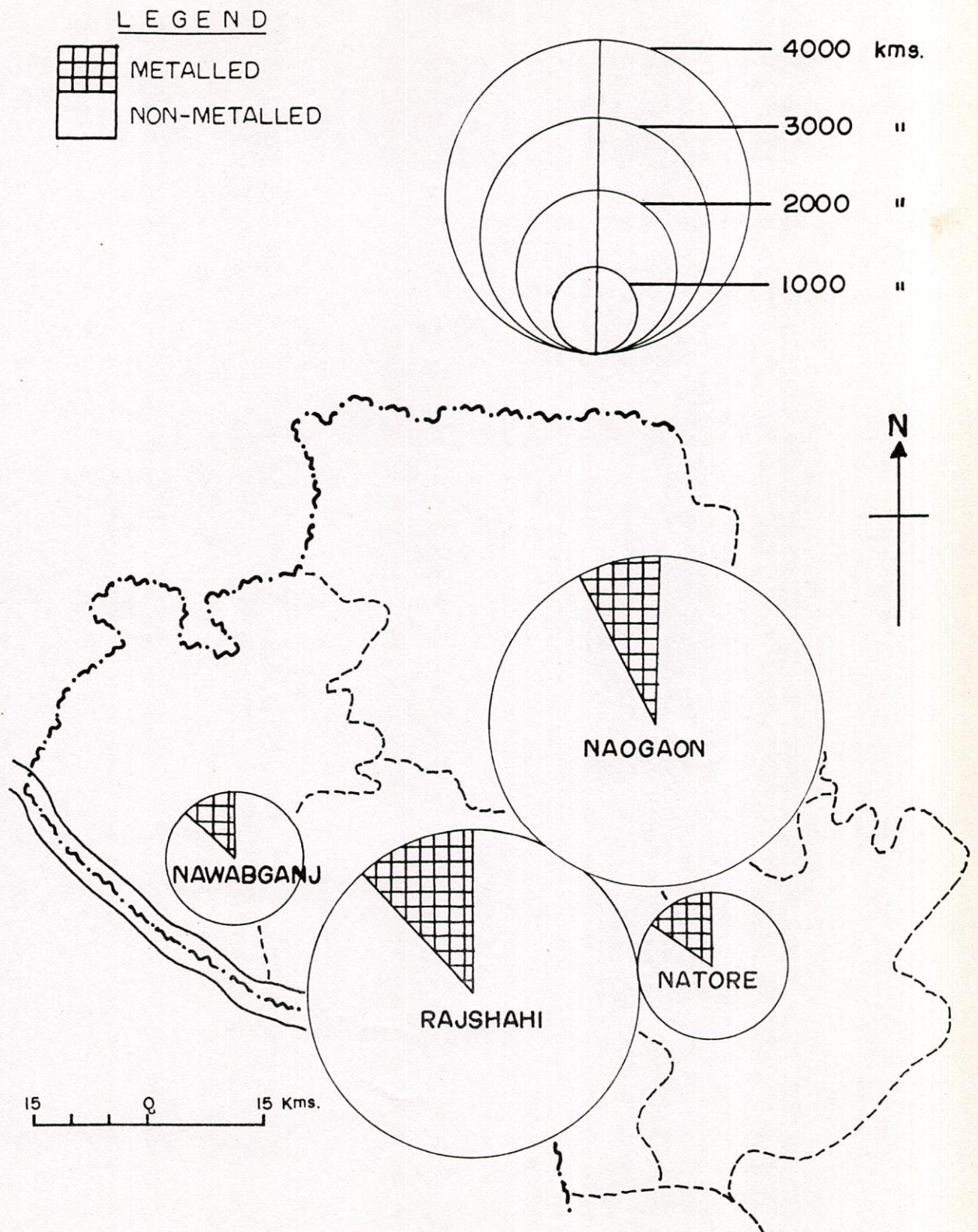
Source: 1. Statistical office of different Thana Parisad ( ex-Upazila Parisad).

2. ( GOB (1987): District Statistics. Rajshahi p. 131.



# GREATER RAJSHAHI DISTRICT

## DISTRIBUTION OF METALLED AND NON-METALLED ROAD



MAP 3-2



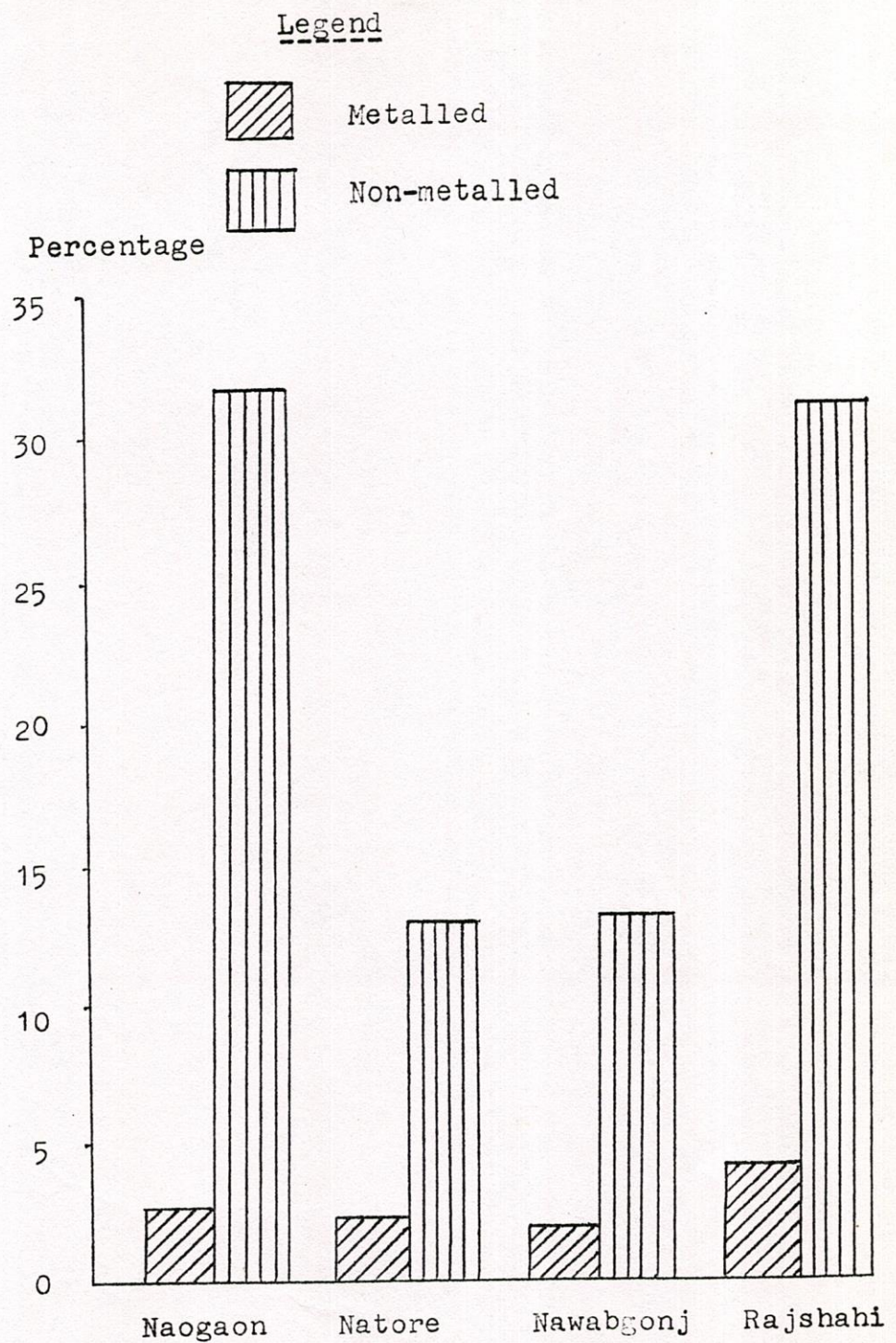


Fig. 3.2. District-wise distribution of road.



Tabel 3.4 shows that out of 1400 km of metalled road 338 kms in Naogaon district, 302 kms in Natore district, 233 kms in Nawabgonj district and 527 kms in the district of Rajshahi are located (detailed in appendix-3), District wise distribution of roads are shown in map 3.2

### 3.3 Road Density

It can be seen from the thana-wise distribution of metalled road ( appendix-4) that about 40 percent of the total metalled roads are concentrated in four main centers of Naogaon (70 kms), Natore (102kms), Nawabgonj (108kms) and Rajshahi (266 kms). The mileage of road in the thanas of Atrai, Badalgachi Bagha, Bagatipara, Bholahat, Bagmara, Dharmoirhat, Durgapur, Gurudaspur, Nachole, Niamatpur, Porsha, Sapahar and Singra are very insufficient and the condition of roads are also very bad due to some phisiographic limitations and backward location.

The average density of road of the study area is 0.15 km per km² or about 15kms per 100 km² of area ( total area is 9456 km² and total road mileage is 1400 kms). The maximum density of road (2.06 km²) lies in Pajshahi sadar and the minimum density lies in Namatpur thana (0.03 km/km²) of Naogaon district . Map 3.3 shows the density of different thanas (appendix-4 shows the ^{thana} wise density) of the study area.

The demisty of road in the study area is not satisfactory in comparision with the developing countries of the world. For example, the road mileage per 100 km² of areas in Japan is 720 kms, in United Kingdom is 140 kms, in United states is 72 to 80 kms, in China is 21 kms and the countries of South East Asia is 16.76 kms ( Srivastava 1981). However, the road density of the study area is only about 15 kms per 100 kms² of area. It is some what better in respect to the national figure (12.58) 100 km² of Bangladesh (FFYP, 1985-90). The retastionship between road mil age and individual thana area is shown in appendix-5 . The degree of relationship ( 0.26) is very low).

### 3.4 Road Transport Service of the Study Area.

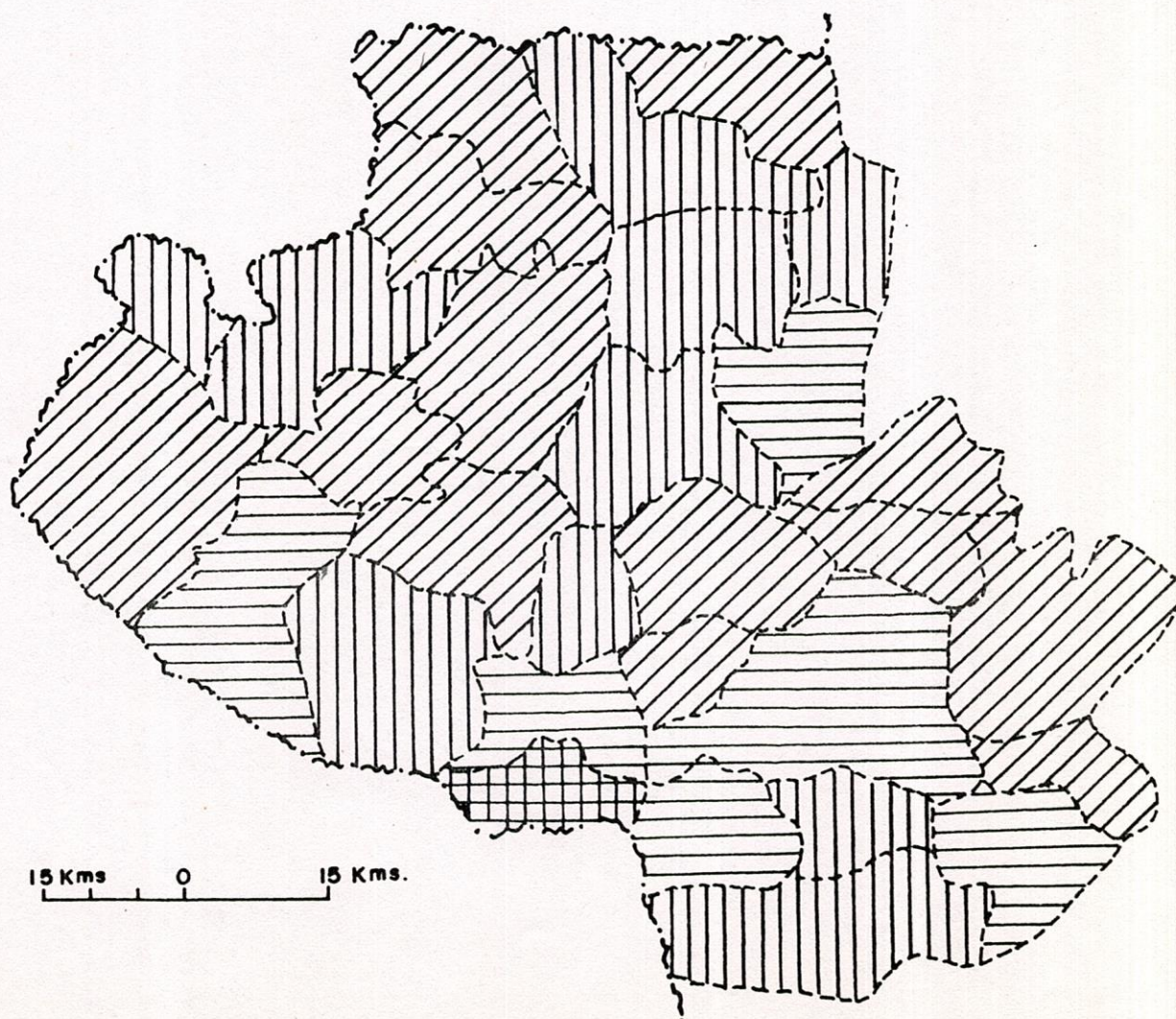
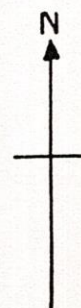
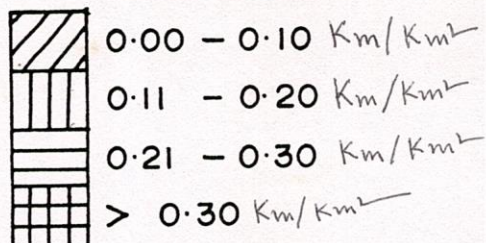
Greater Rajshahi district is such a region, where road transport is the chief mode of transportation. Each thana and all other important centers of this district are directly or indirectly connected by road to the divisional city Rajshahi and the district city of Naogan, Natore and Nawabgonj.

Out of 37 nodes (31 urban centers or administrative units and other 6 important centers- Ahmedpur, Amnura, Baneswas. Banpara, Sampur and Walia are considered as nodes in this study) of the study area, the daily traffic movements are 4906 vchicles 13,570 tons of goods, and 190,500 passengers. The maximum (17.58%) traffic flows were observed in Rajshahi city (682 vehicles 2,660 tons of goods and 32,920 passengers) and the minimum were found at Walia (12 vchicles, 60 tons of goods and 700 passengers) The movement of more than two fifth portion (4.59%) of total traffic flows ( passenger) from the four main nodes of Naogaon, Natore, Nawabgonj and Rajshahi were observed . The traffic flows of Naogaon, Natore, Nawabgonj are respectively 8.48%, 6.22%, 6.42% of vehicles 11.68%, 10.65%, 11.05%, of goods and 9.34%, 7.06%, 7.61%, of passengers. Table 3.5 shows the daily traffic flows of the study area.



# GREATER RAJSHAHI DISTRICT ROAD DENSITY (METALLED - 1990)

## LEGEND



15 Kms      0      15 Kms.



**Table 3.5**  
**Daily Traffic Volume of Greater Rajshahi District (Outflow)**

Code	Name of the center	Traffic Volume					
		Vehicles		goods		Passenger	
		(in no)	%	(ton)	%	(in no)	%
01.	Ahmedpur	55	1.12	140	1.03	2510	1.34
02.	Amnura	65	1.32	175	1.29	2600	1.39
03.	Atrai	70	1.43	160	1.18	3050	1.63
04.	Badalgachi	75	1.53	190	1.40	3500	1.87
05.	Bagatipura	85	1.73	175	1.29	3150	1.68
06.	Bagha	65	1.32	165	1.22	3060	1.63
07.	Bagmara	130	2.65	290	2.14	5050	2.70
08.	Baneswar	126	2.57	255	1.88	5200	2.78
09.	Banpura	65	1.32	160	1.18	2550	1.36
10.	Baraigram	70	1.43	150	1.11	3040	1.62
11.	Bholahat	80	1.63	165	1.22	3005	1.60
12.	Charghat	155	3.16	275	2.03	5105	2.73
13.	Dhamoirhat	80	1.63	130	0.96	2650	1.41
14.	Durgapur	65	1.32	135	0.99	2550	1.35
15.	Godagari	170	1.47	300	2.21	5250	2.80
16.	Gomastapur	75	1.53	175	1.29	2700	1.44
17.	Gurudaspur	75	1.53	165	1.22	3150	1.68
18.	Lalpur	80	1.63	185	1.36	2650	1.41
19.	Manda	190	3.87	265	1.95	5040	2.69
20.	Mohaddpur	155	3.16	270	1.99	5200	2.78
21.	Moharpur	180	3.67	255	1.88	5090	2.72
22.	Machole	55	1.12	170	1.25	2670	1.43
23.	Naogaon	416	8.48	1585	11.68	17,450	9.34
24.	Matore	305	6.22	1445	10.65	13,215	7.06
25.	Nawabgonj	315	6.42	1500	11.05	14,255	7.61
26.	Niamatpur	90	1.83	185	1.36	2600	1.39
27.	Patnitala	160	3.26	260	1.92	5050	2.70
28.	Porsna	70	1.43	160	1.18	2600	1.39
29.	Puthia	150	3.06	265	1.95	5040	2.69
30.	Rajshahi	682	13.90	2660	19.60	32,920	17.58
31.	Raninagar	65	1.32	155	1.14	27,00	1.44
32.	Sampur	10	0.20	50	0.37	800	0.53
33.	Sapahar	65	1.32	160	1.18	2650	1.41
34.	Shibgonj	170	3.47	295	2.17	5010	2.67
35.	Singra	150	3.06	255	1.95	3190	1.50
36.	Tanore	80	1.63	175	1.29	1200	0.64
37.	Walia	12	0.24	60	0.44	700	0.37
Total		4906	100%	13,570	100%	190,500	100%

Source: 1. Direct observation ( July 1990 to June 1991)

2. Survey Report of Traffic Engineering Division, Rajshahi.



It has been mentioned earlier that greater Rajshahi district now consists of four separate districts of Naogaon, Natore, Nawabgonj and Rajshahi. For the investigations of daily traffic movement those four important nodes of this district have been carried out and are shown separately in table 3.6.1, 3.6.2, 3.6.3 and 3.6.4

### 3.4.1 From the study area^a to Chittagong Division

There is no direct bus service from the study area to Chittagong division. But the daily movement of 5 trucks 35 tons of goods and 50 passenger from Naogaon, 10 trucks, 80 tons of goods and 150 passengers from Natore: 5 trucks, 40 tons of goods and 200 passengers from Nawabgonj and 15 trucks, 120 tons of goods and 250 passengers from Rajshahi to Chittagong division have been observed.



**Table 3.6.1**  
**Daily Traffic Movement of Naogaon city** (Out flow)

Traffic Volume		Vehicles (in no)				goods (ton)		Passenger	
Code\ Centers		Bus	Minibus	truck	total	(ton)	%	(in on)	%
01. Atrai		2	8	5	15	35	2.21	550	3.15
02. Badalgachi		4	6	7	17	55	3.37	600	3.44
03. Bogra		10	15	15	40	100	6.94	1700	9.74
04. Chittagong		*	-	5	5	35	2.21	1500	8.60
05. Dhaka		12	-	25	37	190	11.99	1200	6.88
06. Dhamoirhat		5	10	10	25	75	4.73	800	4.58
07. Dinajpur		-	-	5	5	35	2.21	100	0.57
08. Jessore		-	-	5	5	35	2.21	80	0.46
09. Khulna		-	-	8	8	60	3.79	100	0.57
10. Kustia		2	-	5	7	35	2.21	1500	0.86
11. Manda		10	20	10	40	75	4.73	1300	7.44
12. Mohadebpur		10	15	15	40	120	7.57	1050	6.02
13. Mohanpur		-	-	5	5	35	2.21	600	3.44
14. Nagarbari		2	-	5	7	35	2.21	250	1.43
15. Natore		-	-	4	4	30	1.89	225	1.29
16. Nawabgonj		-	-	5	5	40	2.52	550	3.15
17. Niamatpur		2	2	8	12	65	4.10	520	2.99
18. Pabna		-	-	5	5	35	2.21	220	1.26
19. Patnitala		10	20	10	40	75	4.73	1200	6.88
20. Porsha		5	5	5	15	35	2.21	580	3.32
21. Rajshahi		-	-	15	15	125	7.89	3250	18.62
22. Rangpur		1	-	5	6	40	2.52	125	0.72
23. Raninagar		2	5	8	15	65	4.10	550	3.15
24. Saptahar		-	8	10	18	70	4.42	900	5.16
25. Sapahar		5	10	10	25	75	4.73	700	4.01
Total		82	124	210	416	1585	1005	17450	100

Source: Direct Observation ( July 1990 to June 1991)



**Table 3.6.2**  
**Road Transport Service of Natore City (outflow)**

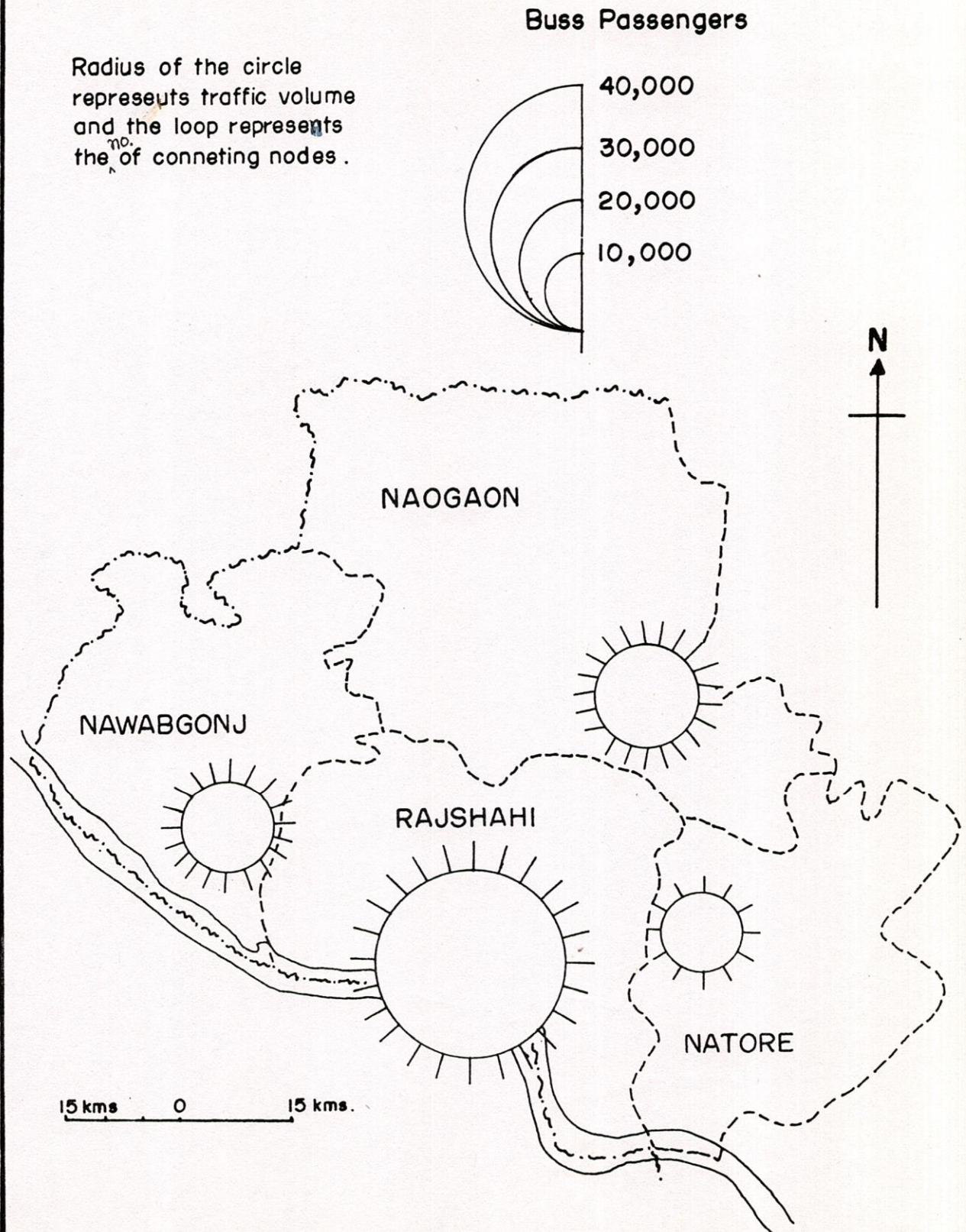
Traffic Volume		Vehicles				goods		passenger	
Code		bus	Minibus	truck	total	(tons)	%	(in no)	%
01.	Anmedpur	-	-	2	2	20	1.38	300	2.46
02.	Bagatipara / Dayarampur	4	8	7	19	55	3.81	650	5.32
03.	Banpara	-	-	5	5	40	2.77	350	2.07
04.	Baraigram	1	-	8	8	50	3.46	575	4.71
05.	Bogra	2	10	20	32	150	10.38	800	6.14
06.	Chittagong	-	-	10	10	80	5.54	150	1.23
07.	Dhaka	5	-	15	20	120	8.30	1000	5.73
08.	Gurudaspur	-	10	5	15	35	2.42	565	4.63
09.	Jessore	1	-	4	05	30	2.08	100	0.82
10.	Khulna	1	2	10	13	75	5.19	175	1.43
11.	Kustia	-	7	5	12	40	2.77	400	3.27
12.	Lalpur/Gopalpur	-	6	15	21	110	7.61	575	3.89
13.	Nagarbari	1	4	5	10	35	2.42	350	2.07
14.	Naogaon	-	-	4	04	30	2.08	225	1.84
15.	Nawabgonj	-	-	10	10	75	5.19	700	4.09
16.	Pabna	-	6	18	24	150	10.38	625	4.30
17.	Putnia	-	-	5	05	30	2.08	425	3.07
18.	Rajshahi	5	30	25	60	190	13.15	4250	34.79
19.	Rangpur	1	1	8	10	60	4.16	1500	1.23
20.	Singra	-	11	9	20	70	4.84	850	6.96
Total		20	95	190	305	1445	100%	13,215	100%

Source: Direct Observation. (July 1990 to June 1991).



# GREATER RAJSHAHI DISTRICT

## TRAFFIC VOLUME OF FOUR MAIN NODES



MAP 3.4



**Table 3.6.3**  
**Road Transport Service of Nawabgonj city (Outflow)**

Traffic Volume Code Center	Vehicles				goods		passenger	
	bus	Minibus	truck	total	(tons)	%	(in no)	%
01. Amnur	5	3	7	15	50	3.33	500	3.27
02. Bholaha	10	16	5	31	40	2.67	650	4.50
03. Bogra	2	2	8	12	65	4.33	350	2.04
04. Chittagong	-	-	5	05	40	2.67	200	0.82
05. Dhaka	10	-	35	45	300	20.00	1400	9.79
06. Dinajpur	-	-	04	04	30	2.00	150	0.41
07. Godagari	4	6	10	20	85	5.67	1200	8.16
08. Gomastapur / Rahanpur	6	10	10	26	80	5.33	1250	10.20
09. Jessore	-	-	5	05	35	2.33	200	0.82
10. Khulna	-	-	8	08	60	4.00	300	1.64
11. Kustia	-	-	5	05	35	2.33	220	0.98
12. Nachole	-	-	8	08	65	4.33	400	2.45
13. Naogaon	-	-	5	05	40	2.67	550	3.67
14. Natore	2	-	10	12	75	5.00	700	4.08
15. Pabna	2	-	10	12	80	5.33	500	3.26
16. Rajshahi	10	25	30	65	250	16.67	3850	28.97
17. Rangpur	-	-	5	05	35	2.33	85	0.69
18. Shibgonj	10	15	15	40	135	9.00	1750	14.28
Total	55	75	185	315	1500	100%	14,255	100%

Source: 1. Direct observation ( July 90 to June 91)

Besides the above information daily traffic movement increases in summer season specially. in mango period.

D-2744



**Table 3.6.4**  
**Daily Traffic Movement of Rajshahi city (Outflow)**

Traffic Volume		Vehicles				goods		passenger	
Code	Center	bus	Minibus	truck	total	(tons)	%	(in no)	%
01.	Bagha	15	25	10	50	85	3.22	1250	3.80
02.	Bagmara	12	12	12	36	95	3.60	1550	4.71
03.	Baneswar	-	-	5	5	38	1.44	300	0.91
04.	Bogra	12	12	30	44	240	9.09	2000	6.08
05.	Charghat	-	-	10	10	80	3.03	1650	5.01
06.	Chittagonj	-	-	15	15	120	4.55	250	0.76
07.	Choubaria	-	7	3	10	22	0.83	350	1.06
08.	Dhaka	30	-	40	70	300	11.36	2275	6.91
09.	Dinajpur	2	-	5	7	40	1.52	150	0.46
10.	Durgapur	-	12	10	22	75	2.84	800	2.43
11.	Gaibandha	1	-	2	3	15	0.57	80	0.24
12.	Godagari	4	6	15	25	120	4.55	1500	4.56
13.	Jessore	1	-	8	9	60	2.27	80	0.24
14.	Kamargaon	-	3	3	6	25	0.95	200	0.61
15.	Khulna	2	-	15	16	120	4.55	180	0.56
16.	Kustia	-	5	10	15	75	2.84	300	0.91
17.	Manda	25	26	10	62	78	2.95	1200	3.65
18.	Mohanpur	-	-	15	15	120	4.55	1480	4.80
19.	Nagarbari	10	5	10	25	70	2.65	750	2.28
20.	Naogaon	-	-	15	15	125	4.73	3250	9.87
21.	Natore	5	10	25	60	190	7.20	4250	12.91
22.	Nawabgonj	10	25	30	65	125	9.47	3850	10.78
23.	Niamatpur	-	2	5	7	35	1.33	250	0.76
24.	Pabna	3	15	10	28	85	3.22	1775	5.70
25.	Putnia	-	-	12	12	85	3.22	1025	3.72
26.	Rangpur	7	5	8	20	60	2.27	750	2.28
27.	Sirajgonj	2	-	5	9	35	1.32	185	0.56
28.	Tanore	4	8	8	20	65	2.36	790	2.40
29.	Thakurgaon	3	-	3	6	22	0.82	200	0.61
30.	Vangura	1	2	2	5	15	0.56	250	0.76
Total		149	180	353	682	2660	100%	32920	100%

Source: Direct Observation ( July 1990 to June 1991)



### 3.4.2 From the study Area to Dhaka Division

Dhaka the capital city is well connected to the study area by road services. Daily 12 buses, 25 trucks, 190 tons of goods and 1200 passengers from Naogaon, 5 buses, 15 trucks, 120 tons of goods and 1000 passengers from Natore, 10 buses, 35 trucks, 300 tons of goods and 1400 passengers from Nawabgonj and 30 buses, 40 trucks, 300 tons of goods and 2275 passengers are playing from Rajshahi to Dhaka.

### 3.4.3 From the study Area to Khulna Division

Jessore, ~~Jheraidaha~~, Khulna and Kushtia of Khulna division are directly connected to the study area by road. Daily movement of 2 buses, 22 trucks, 100 tons of goods and 460 passengers to Jessore 5 buses, 185 trucks 315 tons of goods and 755 passengers to Khulna and 14 buses, 25 trucks, 185 tons of goods and 1070 passengers to Kushtia has been noticed from the study area.

### 3.4.4 With in the Division Rajshahi

Within the division ^{of} Rajshahi, the study area has good road services to the district of Bogra, Dinajpur, Pabna and Rangpur. Everyday about 65 buses, 73 trucks, 555 tons of goods and 4850 passengers to Bogra, 2 buses, 14 trucks 105 tons of goods and 400 passengers to Dinajpur 26 buses, 43 trucks, 340 tons of goods and 3120 passengers to Pabna and 12 buses, 26 trucks, 195 tons of goods and 1110 passengers are moving to Rangpur from the four important centers of Naogaon Natore Nawabgonj and Rajshahi.

### 3.4.5 Within Study Area.

There is a good road transport services to the different nodes of the study area. Rajshahi has a direct connectivity to the district of Naogaon, Natore and Nawabgonj. From Rajshahi to Naogaon, Natore and Nawabgonj about 15 buses, 15 trucks, 125 tons of goods and 3250 passengers, 15 buses, 25 trucks, 190 tons of goods and 4250 passengers and 35 buses 30 trucks, 250 tons of goods and 3800 passengers are respectively moving every day. There is no direct regular bus services between the routes of Naogaon to Natore and Naogaon to Nawabgonj. But there are some irregular truck-services in these routes also. Naogaon to Natore has no direct road linkage but Natore to Nawabgonj has a direct linkage via Rajshahi.



### 3.4.6. Intra-District Road services.

#### a) Naogaon District

Intra-district road services of Naogaon district is quite satisfactory. Ten thanas of this district are directly or indirectly connected to the district head-quarter of Naogaon. Daily 10 to 15 buses or minibuses, 5 to 10 trucks, are running from Naogaon to the each thana of this district. Maximum traffic flow was notice between Naogaon-Mohadebpur route (Daily 10 buses, 15 minibuses, 15 trucks, 120 tons of goods and 1050 passengers), Specially there are good transport services from Naogaon to Manda, Mohadeppur, and Patnitala thana. But the road srvcies from Naogaon to Atrai, Porsha, and Sapahar are not stisfactory because of their backward location, and bad road condition.

#### b) Natore District.

Intra district road services of Natore district is also very normal and each thana is directly connected by road services to the district head-quarter. Maximum and minimum traffic flows have been observed between Natore to Singra (65%) and Natore to Lalpur (3.89%) routes ( table 3.6.2)

#### c) Nawabgonj District

Inter district road service of Nawabgonj district was not safistactory even in 1984. After the deformation of administration of 1984, Bholahat and Gomastapur thana have been connected to the district head-quarter Nawabgonj by upazila (now thana) connecting road. Even today the road services between Nawabgonj to Nachole thana is very bad and the road services of this route is irregular. Travel from Nawabgonj to Nachole is costly and time consuming. This route is motorable only in the dry season. Where as there is a good road service between Nawabgonj and Shibgonj thana since Pakistan period. Daily movement of 25 buses 15 trucks, 135 tons of goods and 1750 passengers are recorded in this route. Newly constructed bridge of Mahananda river has significantly in creased the traffic movement and has made the journey easy.

#### d) Rajshahi District

The intra -district road services of Rajshahi district is quite satisfactory and all thans are directly linked with road services. The thanas of Charghat, Godagari, Mahanpur and Pathia have a well connectivity to Rajshahi Where as the thanas of Bagha Bagmara, Durgapur and Tanore have no directlinkage to Rajshahi and the road condition is unsatiffactory Maximum and minimum traffic flow have been observed between Rajshahi Charghat (5.01%) and Rajshahi Tanore (2.40%) routes ( table 3.6.4).



Besides these intra district road services, there are also some important places - Banerwar, choubaria, Kamargaon, Manda, Niamatpur etc where available road services. But the traffic volume in these routes are also thin.

### 3.5. Accessibility of Route

Forty nine routes of the study area (out of 49 routes, 43 are considered as the edges of network which has been analysed in the next chapter) are considered here as motorable but they are not equally accessible. They differ from one another by traffic volume and road condition. These 49 routes are classified into six accessible group on the basis of daily traffic movement. Table 3.7 and map 3.5 shows these accessibility of different routes of the study area ( appendix -6 shows the accessibility of each route).

**Table 3.7**  
**Accessibility of Routes on the Basis of Daily Traffic Movement**

Category	Accessible Group	Accessibility V= Vehicles g= goods p= Passenger	Number of Routes.
First order Route	Most Accessible	V = > 800 g = > 2500 p = 30,000	3
Second order Route	Very High Accessible	v = 401 - 800 g = 1001 - 2500 p = 15001 - 30,000	7
Third order Route	High Accessible	V = 201 - 400 g = 501 - 1000 p = 6001 - 15,000	6
Fourth order Route	Medium Accessible	v = 101 - 200 g = 251 - 500 p = 3001 - 6000	7
Fifth order Route	Low Accessible	v = 51 - 100 g = 101 - 250 p = 1501 - 3000	21
Sixth order Route	Very Low Accessible	v = 0 - 50 g = 0-100 p = 0 - 15000	5

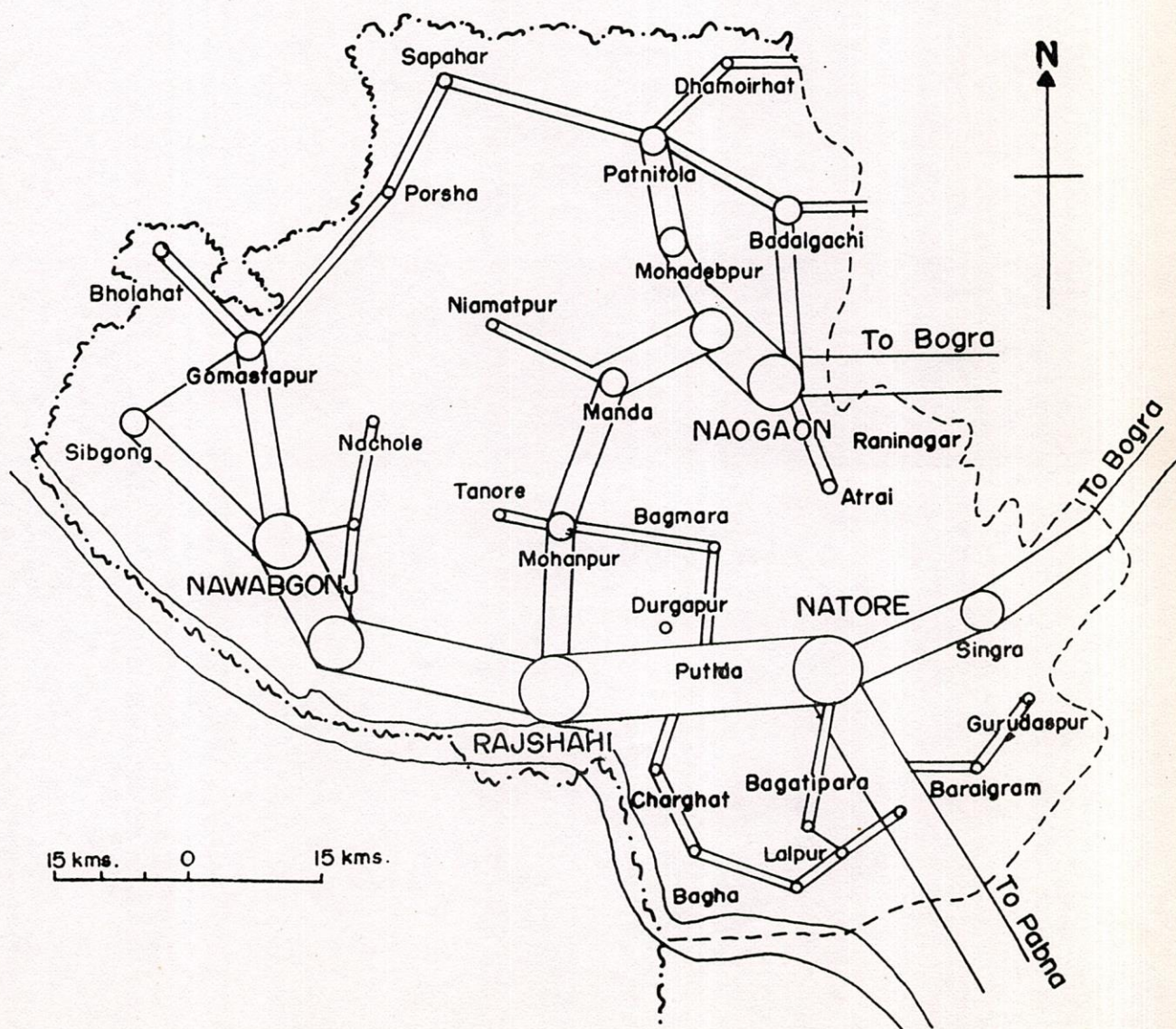
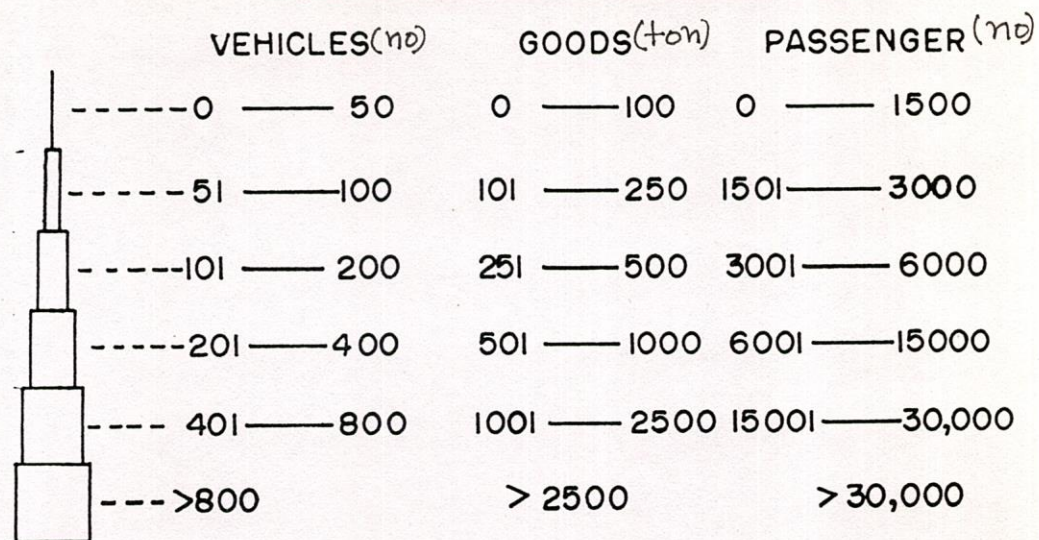
Source: Author's own classification on the basis of daily traffic movement.



# GREATER RAJSHAHI DISTRICT

## DAILY TRAFFIC FLOW AND ROUTE ACCESSIBILITY

### LEGEND (DAILY MOVEMENT)



MAP 3.5



Table 3.7 Shows that there are 3 first order, 7 second order 6 third order, 7 fourth order, 21 fifth order. and 5 Sixth order routes. Three first order routes are considered as the most accessible route.

Rajshahi to Natore via Baneswar and Puthia is the most accesible route in the study area. Seven routes of second order also considered as very high accessible route in the study area. Rajshahi to Nawabgonj via Godagari, Natore to Pabna via Ahmedpur and Bnpara, Natore to Bogra via Singra and Naogaon to Bogra via Santahar are the important routes in this category.

There are 6 high accessible or third order routes in the study area. Rajshahi to Mohadebpur via Mohanpur and Manda and Natore to Bogra via singra are the most important routes of this category. Fourth order or medium accesible routes of the study area are Baneswar Charchat Bagha, Naogaon Badalgachi, Patnital, Nawabgonj Gomastapur and Nawagonj Shibgonj. Fith order or low accessible routes of the study area are Bagha to lalpur, Godagari to Nacholer via Amnura, Mohanpur to Tanore, Mahanpur to Bagmara, Manda to Niamatpur Patnitala to Dhamoirhat, Patnitala to Porsha via Sapahar, Gomstapur to Bholahat etc. The main characteristics of these routes are that they are extend from one thana to another and have no direct linkage to district city. Very low accesible routes of this study area are Gomastapur ( Rahanpur) to Porsha, Shibgonj to Gomastapur, Nawabgonj to Amnura etc. The main characteristics of these low accesible routes are that they have no regular services and are not motorable during all the seasons. Obviously the roads become muddy during rainy season and absence of buses etc. are conspicuous.

### 3.6 Variation of Traffic Movement

The data of daily traffic movement which have been analysed in this Chapter are not constant every where and round the year. That is why, yearly, seasonal, mouthly, weekly and daily fluctuation of traffic movement are very common. However, various types of flucfuation of traffic movement have been analysed in the following manner:

#### 3.6.1 Yearly Variation

Collection of data on yearly variation of traffic movement was an arduous task and because of time it could not be measured accurately. However necessary information were collected during July 1990 to June 1991 with much difficulty and the result has been analysed.

It is a fact that the traffic movement never remains constant. If the road is free and no disturbances occur, then the flucfuation of traffic movement would normally be expected from year to year. Table 3.7.1 Shows the yearly fluctuation.



# GROWTH OF TRAFFIC FLOW (1976-86)

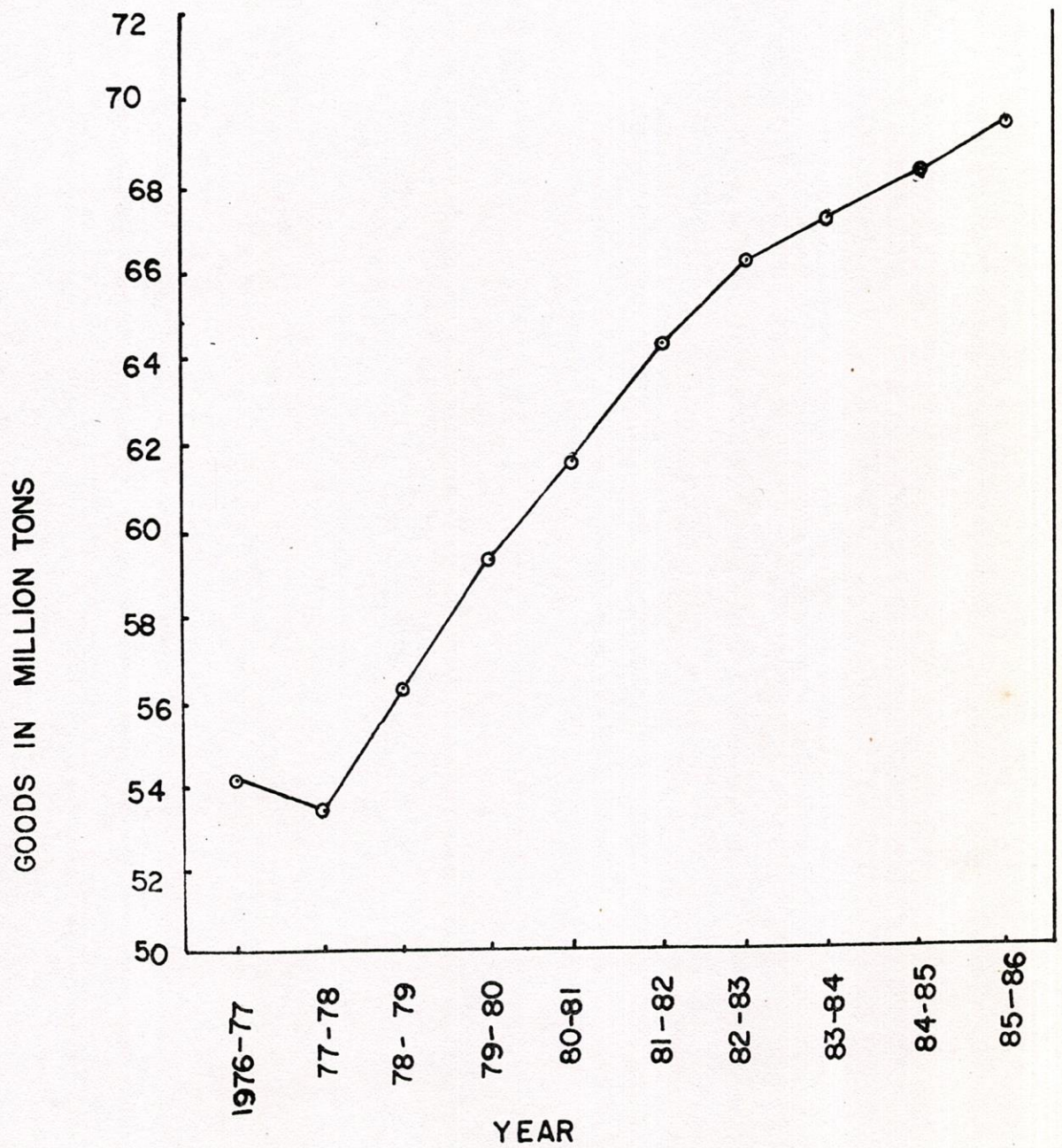


FIG. 3.3



**Table 3.7.1**  
**Yearly Fluctuation of Traffic ( goods) Movement**

Year	Traffic Volume ('000 tons)
1976-77	54,232
1977-78	53,512
1978 - 79	56,890
1979 - 80	59,482
1980-81	61,661
1981-82	64,375
1982 -83	66,351
1983-84	67,371
1984-85	68,664
1985-86	69,663

Source : GOB (1986). Statistical Year Book BBS P. 508.

It can be seen from the table 3.7.1 and figure 3.3 that the traffic movement of Bangladesh from year to year are increasing.

### 3.6.2 Seasonal Variation

Seasonal variation of traffic flow is more prominent than yearly variation. The traffic movements are fluctuated with the changes of season. Because, agricultural crops, industrial products and all other perishable goods are not available all the year round at the same time. That is why the traffic flow also increases or decreases on the basis of the availability of various products. Seasonal variation of traffic flow is shown in table 3.7.2.

**Table 3.7.2**  
**Seasonal fluctuation of Traffic Flow (goods).**

Season	Month	% of yearly traffic
1. Winter	December - January	21
2. Spring	February - March	19
3. Summer	April - May	13
4. Rainy	June - July	20
5. Autumn	August - September	12
6. Late Autumn	October - November	15

Source : Author's own calculation on the basis of direct observation and the given data of Traffic Engineering Division.



## SEASONAL VARIATION OF TRAFFIC FLOW (GOODS)

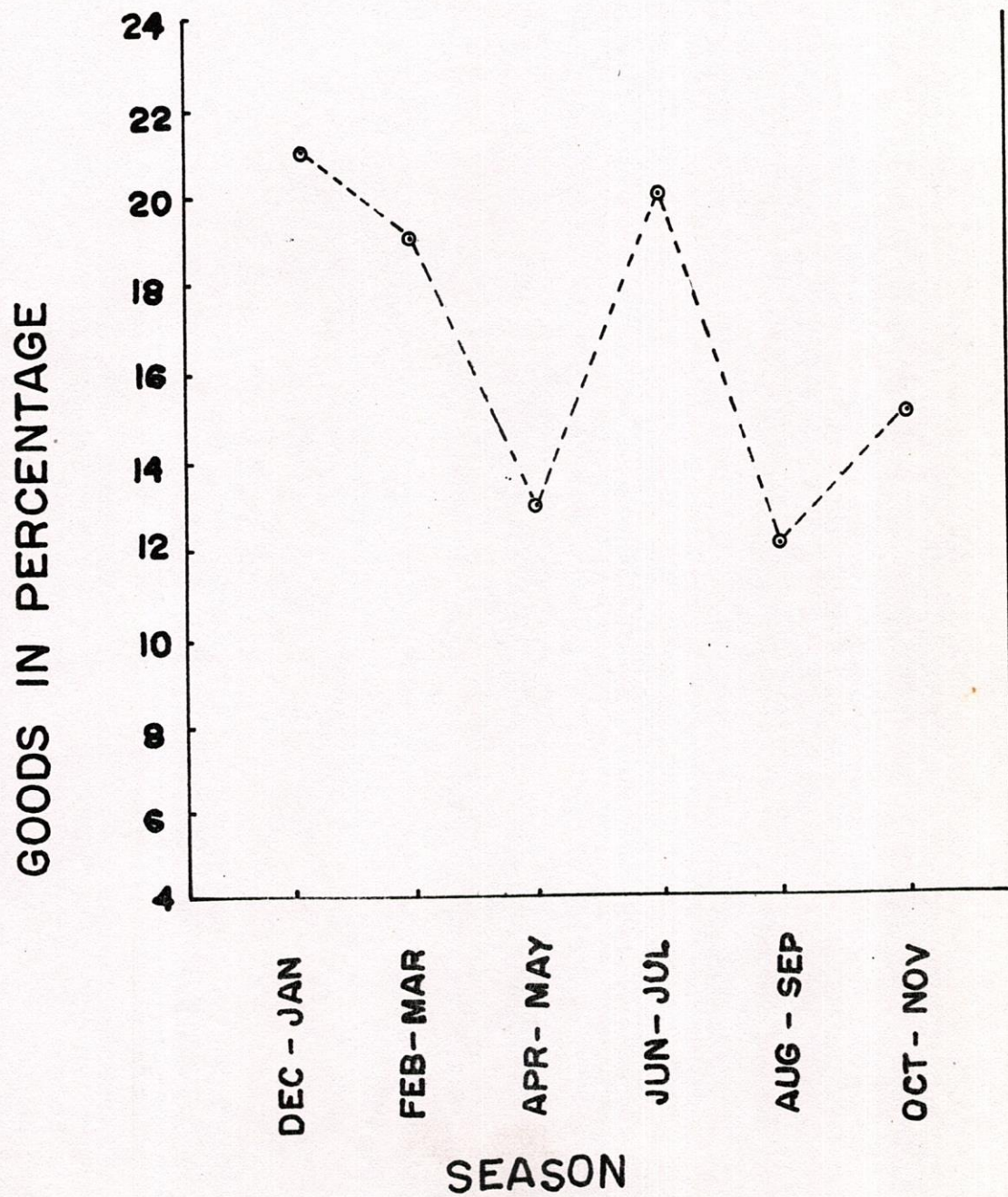


FIG 3.4



Table 3.7.2 and figure 3.4 shows the two peak period of traffic movement during winter and summer seasons. The main two agricultural products Aman rice and Sugarcane of this area are grown in winter season ( Haimata). That is why the traffic movement increases during this season because of the supplying of raw material to the sugarmills ( three sugar mills of Gopalpur, Harian of Rajshahi and Natore) and the procurement of Aman paddy by the government of Bangladesh and the traders.

Another Peak movement of traffic movement has been observed in summer season because of the availability of mango in Nawabgonj. Mango of Nawabgonj is famous all over the country and has a high demand through out Bangladesh. For this reason in addition to regular bus service in the area of Nawabgonj at least 50 trucks carry mango everyday to the districts of Chittagong Dhaka and khulna divisions. But the traffic volume declines from April to May and August to September .

### 3.6.3 Monthly and Weekly Variation

The monthly variation of traffic movement is not remarkable but the weekly variation is noticeable. It has been observed that traffic flow either increases or decreases at some specific day of the week. Table 3.7.3 shows the weekly variation of traffic flow of Rajshahi city.

**Table 3.7.3**  
Weekly Variation of Traffic Flow

Day	Passenger(но)	Percentage (%)
Saturday	33,644	14.60
Sunday	32,884	14.27
Monday	32,769	14.22
Tuesday	32,976	14.31
Wednesday	32,746	14.21
Thursday	34,289	14.88
Friday	31,132	13.51
Total	230,440	100%

Source: Field Observation.



Fluctuation of Traffic Flow (Passenger)

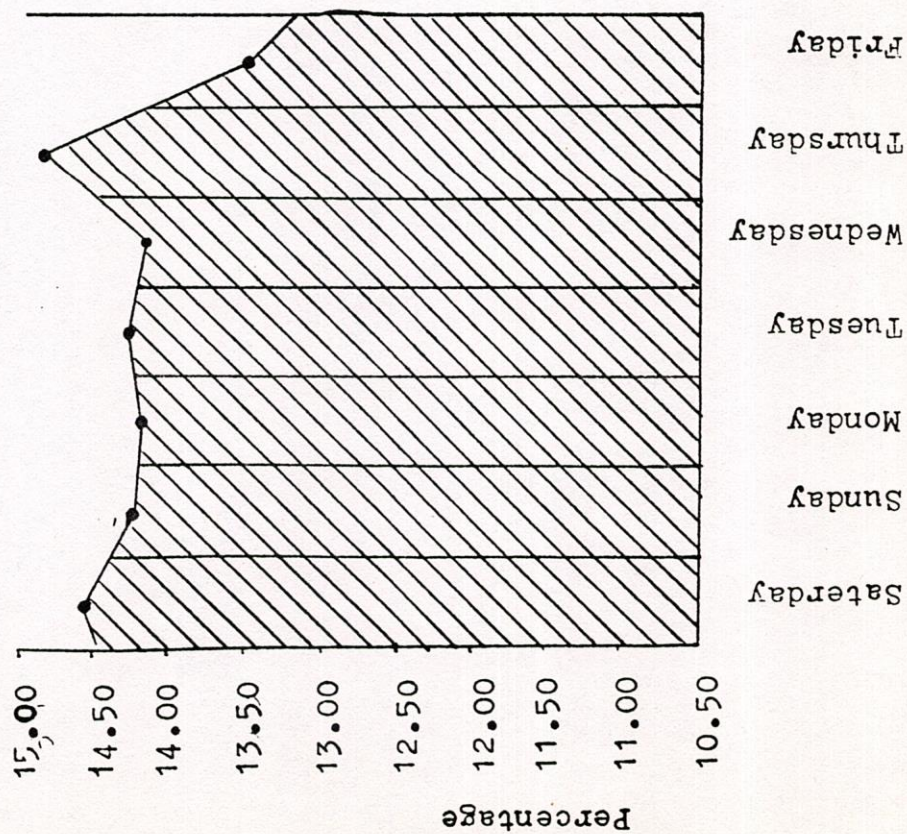


Fig. 3.5. Weekly Fluctuation

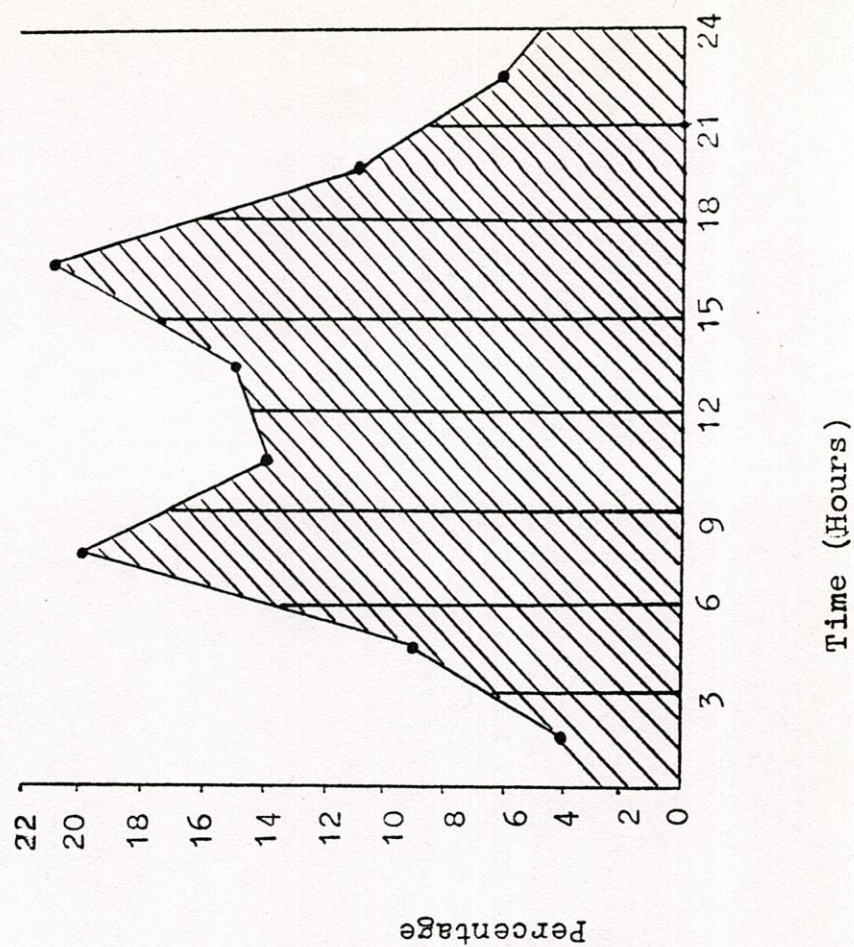


Fig. 3.6. Daily Fluctuation



It can be seen from table 3.7.3 and figure 3.5 that the traffic flow increases on Saturday and Thursday. Because the people who work in the urban center, come home on Thursday to meet their family members and again return back to their working place on Saturday. Since most of the people stay at home with the members of their family on Friday. That is why, the increasing of traffic flow on Saturday and Thursday and decreasing on Friday is very common picture.

### 3.6.4 Daily Variation

Daily variation of traffic flow is the most significant variation. Because, different types of economic activities are agglomerated in the urban centers and every day a large number of people come from various areas to the urban centers in first half of the day for their purpose and need and after finishing their desired and specific objectives, they leave these centers in the afternoon or in the evening. Naturally the traffic flow increases in the morning and afternoon or evening and declines of noon and mid-night. Table 3.7.4 shows the daily fluctuation of traffic flow of Rajshahi city.

**Table 3.7.4**  
**Daily Fluctuation of Traffic Volume**

Hour	Passenger (no.)	Percentage (%)
0 - 3	2634	4
4 - 6	5926	9
7 - 9	13,168	20
10- 12	9,218	14
13 - 15	9,876	15
16 - 18	13,826	21
19 - 21	7,242	11
22 - 24	3,950	6
Total	65,840	100

Source: Field work in 1990 - 1991

It can be seen from table 3.7.4 and figure 3.6 that there are two peak period ( 6 to 9 A. M and 3 to 6 p.m) of traffic flow in a day. It has been observed that the traffic flow in the local routes is more or less the same or remains constant through the day. But most of the vehicles of distant routes (Chitagong, Dhaka, Dinajpur, Jessore, Khulna, Kustia and Rangpur) leave from Rajshahi in the morning and almost the same number of vehicles reach Rajshahi in the afternoon or evening.



Besides those quoted informations, a large number of coaches leave Rajshahi for Dhaka in the evening and vice-verse reach Rajshahi from Dhaka before dawn.

### 3.6.5 Casual Variation

The casual variation of traffic flow is also very significant. The pattern of the flow is not constant and frequently changes through out the year. The traffic flow increases in some specific occasions as Eid, Puja, Summer and Winter vacation of educational institutions etc. It has been observed that the traffic flow increases four times during Eid, two and half times for Puja two times during summer and winter vacation when the educational institutions declared closed and one and half times during the government holiday, such as Shahid day, Victory day, Revolutionary day etc Weekly Bichitra, may 26, 1984).

During all the period it may be pointed out here since every body wants to go home, acute shortages of spaces either in the bus steamer or in the train is a common phenomena. Due to overcrowding, the home bound people compelled to travel at the roof of the buses or train and made their journey risky and hazardous. Thus to avoid all these problems, road transport system in this part of the country should be developed.

In conclusion it may be said that the transport system of greater Rajshahi district is moderately developed. In the study area, only 1400 km of metalled road is recorded and out of this total 844 km are internode connecting RHD road. It has been found that average density of road of the study area is 0.148 km per km² or about 15 km per 100 km². It is interesting to note that Rajshahi Sadar has the highest density.

As mentioned out of 37 nodes of the study area, the daily traffic volumes are 4906 vehicles, 13,570 tons of goods and 190,500 passengers. The maximum traffic flows (17.58%) are Rajshahi city and minimum in Walia (0.37%) Direct Road services from Naogaon to 25 centers, from Natore to 20 centers, from Nawabgonj to 18 centers and from Rajshahi to 30 centers have been observed.

In this study 844 km RHD inter node connecting road are divided into 43 routes by 37 nodes of the study area and these 43 routes are classified into six accessible groups. Rajshahi-Natore via Baheswar and Puthia is considered as the most accessible route and Shibgonj Gomastapur is recorded as the least accessible route in this area.

It has been noticed that the pattern and nature of traffic flow is not always similar and static. It varies from year to year, season to season, day today even hour to hour. But the daily variation traffic flow is more prominent than all other variation.

It is obvious that Dhaka city is well connected to all the centers of the study area. In this connection, it may be said that all the towns of northern region ( Bogra, Dinajpur, Pabna, Rangpur) have a well connectivity with this region by road than the areas of southern region ( Jessore, Khulna and Kustia) The reason of this low connectivity with the southern regions may be the physical barrier of the Padma river and the absence of bridge over this river. However this region is well connected with the study area by the railways and it has been observed that the people of southern region like to move by train instead of buses. In the next chapter of spatial interaction will be discussed detailed.



**CHAPTER FOUR**  
**SPATIAL INTERACTION**



The movement of population goods services and all other information from one place to another is known as spatial interaction. Spatial interaction is one of the basic concept of modern geography. According to Fred Lukerman " geography is a spatial science which deals with different places and these places are interrelated to each other by spatial interaction. The spatial interaction is increasing everyday between places and transport system is playing an important role on spatial interaction. The author has tried to discuss the relationship between transportation and spatial interaction in this chapter.

#### 4.1. Bases of Interaction.

Spatial interaction between places mainly depends on the population and distance of those places. The geographer Edward Ullman (1950) postulated three conditions affecting transportation development and useful model of spatial interaction. These three as affecting factors - regional complementarity, intervening opportunity and transferability are known as the bases of spatial interaction (Haggett, 1974) Ullman (1950) suggested that these three factors are the fundamental bases underlying all spatial interaction. In this chapter Ullman's model in the context of spatial interaction has been examined.

The first factor on which this model is based regional complementarity, is a function of the resources available in any particular region. The concept of regional complementarity developed on the basis of 'areal differentiation'; i.e. all the places differs from one another. That is why in order to regions to interact, there must be a supply or surplus of resources in one region and a demand or deficit in another and where such situation exists, the two areas are said to be complementary. Again it may be said that there must be a relationship of demand and supply or one area must have want and another area must be prepared to supply (Lloyd and Dicken, 1972). For example, the study area has a surplus of agricultural product and a deficiency of industrial finished product Dhaka, Chittagong, Khulna and other industrial cities are able to satisfy the 2want of industrial finished products of the study area and surplus agricultural products are supplied from greater Rajshahi district to other divisional areas of Bangladesh. Since the mango of Nawabgonj has a high demand through out Bangladesh, the study area is complementary to the other regions of Bangladesh.

Ullman's second interaction principle relates to the existence of intervening opportunity which can be defined for our purpose as an alternative sources of supply For example. Though the university of Dhaka is big and better than Rajshahi university, the students of Khulna division are more interested to study at the university of Rajshahi than Dhaka University because of distance and communication facilities For this reason a good spatial interaction has been developed between Rajshahi and Khulna. But other the establishment of Khulna university and the Islamic university at Kustia the interaction between Rajshahi and Khulna division has been interrupted. Obviously these two universities are playing some role as intervening opportunities between the interaction of Rajshahi and Khulna division. On the other hand the absence of those facilities (University) in the northern portion (Bogra, Dinajpur and Rangpur) of Rajshahi division, the greater portion of the people of this region come to Rajshahi to avail of the educational and administrative facilities.



The third and the most important factor, which Ulman called transferability, refers to the possibility of moving a product. Transferability is a function of distance measured in real costs or time, as well as of the specific characteristics of the product. If there is perfect complementarity and an absence of intervening opportunities, interaction will be reduced or even absent altogether if the costs of such movement of transferability is excessive (Lloyd and Dicken, 1972). For example, the education center of Rajshahi and the port city of Chittagong are complement to each other in many cases. But their spatial interaction is not up to expectation (as discussed in the preceding chapter three in table 3.4.1; 3.4.2, 3.4.3 and 3.4.4) because of excessive distance and high travel cost and time. Transferability differs between places, between classes of movements and between mode^s of movements (Abler. et.al, 1972).

## 4.2. The Gravity Model of Interaction

The gravity model is one of the earliest model in pure science. The greatest English mathematician and physicist of seventeenth century sir Isaac Newton (1687) has given a revolutionary idea physics the law as gravitation. Newton's law of gravitation stated that two bodies attract each other in direct proportion to the product of their masses and inversely proportion as the square of their distance apart (Haggett, 1979).

The social scientist systematically applied the Newtonian law of gravitation in social sciences to measure the social and economic interaction between places. More than a century ago the British demographer E.G. Ravenstein (1885) first observed the human behavior of migration between England and Wales and successfully incorporated the idea of the law of gravitation to measure the rate of migration. But the gravitational concept were specifically introduced in geography by W.T. Reilly in 1929 in discussing the ways in which trade areas are formed and his concept is known as Law of Retail Gravitation, (Haggett et al, 1977).

The gravitational concept in geography suggests that the amount of movement or rate as interaction between two places directly proportion to the population as two cities and inversely proportion to the square of the distance from these two cities. This concept usually expressed in the following generalised formula:-

$$I_{12} = \frac{P_1 P_2}{d_{12}^2}$$

$I_{12}$  = Interaction between 1st and 2nd place.

$P_1 P_2$  = Population of 1st and 2nd place.

$d_{12}$  = Distance between those places.

From the above formula it can be seen that two basic factors affecting the amount of flow or interaction, between any two points: Population and distance. (In social sciences the mass has been equated with population size). Therefore it is proved that the greater the population of two centers, the greater the interaction and the greater the distance the less the interaction.



On the basis of above discussion and hypothesis simply be examined that Natore, Nawabgonj and Bagha are situated at similar distance (48km) apart from Rajshahi. But the expected interaction between Rajshahi and those places differs from each other because of the difference of population only such as:-

It can be seen from the figure:-

1. Interaction between Rajshahi and Nawabgonj

$$I_{rn} = \frac{PrPn}{(D_{rn})^2} = \frac{299.671 \times 121.205}{(48)^2} = 15,764,594$$

2. Interaction between Rajshahi and Natore area:-

$$I_{rn} = \frac{PrPn}{(D_{rn})^2} = \frac{299.671 \times 36,186}{(48)^2} = 4,706,552$$

3. Interaction between Rajshahi and Bagha:-

$$I_{rb} = \frac{299,671 \times 5000}{(48)^2} = 651,000$$

4. Interaction between Rajshahi and Mahanpur:-

$$I_{rm} = \frac{PrPm}{(D_{rm})^2} = \frac{299.671 \times 3440}{(23)^2} = 1950.000$$

The above equations show that the interaction between Rajshahi and Nawabgonj is about four times greater than the interaction between Rajshahi and Natore because of population only. Again the population as Mohanpur thana is lesser than Bagha but Mohanpur is nearer to Rajshahi than Bagha. That is why the interaction between Rajshahi and Mahanpur is about three times greater than the interaction of Rajshahi and Bagha because of the distance only (Fig.4.1).

### 4.3. Relationship between Mass and Distance

From the earlier discussion it may pointed out that two limiting factors: Population and distance determines the strength of interaction ( volume of movement) and form the basic gravity model. the interaction has a positive relationship to the distance. So it may be interpreted that the



# GRAVITY MODEL OF INTERACTION

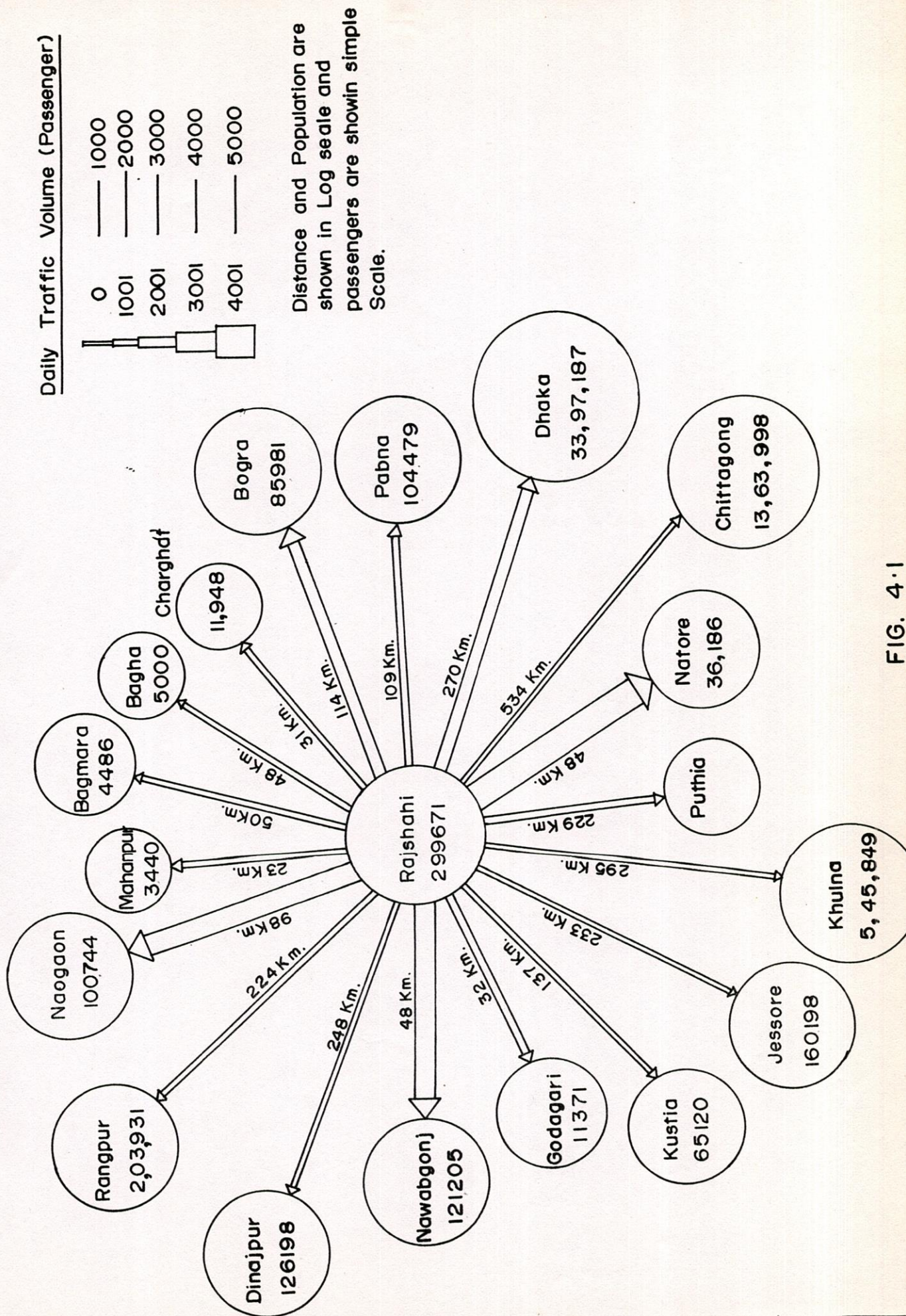


FIG. 4.1



greater the population the greater the interactions and greater the distance, the less the interaction. If this statement is computed to measure the spatial discussion Rajshahi considered as origin and its adjoining 24 direct linkage centers as destination it can be seen that bigger cities are more interacted than smaller one and near places are more related than distant places.

### Table 4.1

#### Application of gravity model

(Interaction between Rajshahi and another 24 centers. (Population of Rajshahi are 299,671 or about 300,000 and distance 'O'km)

Code no. Center	Population ¹ (1991)	Distance (kms)	Actual ² passenger	Expected passenger ³ $I_{r-24} = K \frac{P_r P_{1-24}}{d(r-24)^2}$
01. Bagha	5000	48	1250	651
02. Bagmara	4486	50	1550	538
03. Bogra	85,981	114	2000	1985
04. Charghat	11,948	31	1650	3730
05. Chittagong	13,63,998	534	250	1435
06. Dhaka	33,97,187	270	2275	13,979
07. Dinajpur	1,26,198	284	150	1565
08. Durgapur	4637	30	800	1546
09. Gaibandha	40,491	180	80	3752
10. Godagari	11,371	32	1500	3331
11. Jessore	1,60,198	233	80	884
12. Khulna	5,45,849	295	180	1885
13. Kustia	65,120	137	300	1039
14. Manda	8,000	50	1200	960
15. Mohanpur	3,440	23	1480	1950
16. Naogaon	1,00,794	86	3250	4096
17. Natore	36,186	48	4250	4712
18. Nawabgonj	1,21,205	48	3850	15,781
19. Niamatpur	3,126	59	250	269
20. Pabna	1,04,479	109	1775	2638
21. Puthia	9,408	30	1025	3136
22. Rongpur	2,03,931	224	750	1219
23. Tanore	9,229	36	790	2136
24. Thakurgaon	34,778	333	200	946

1. Projected population on the basis of 1981 GOB, Preliminary Report of the Population Census of 1991.

2. Personal observation.

3. Author's own calculation.



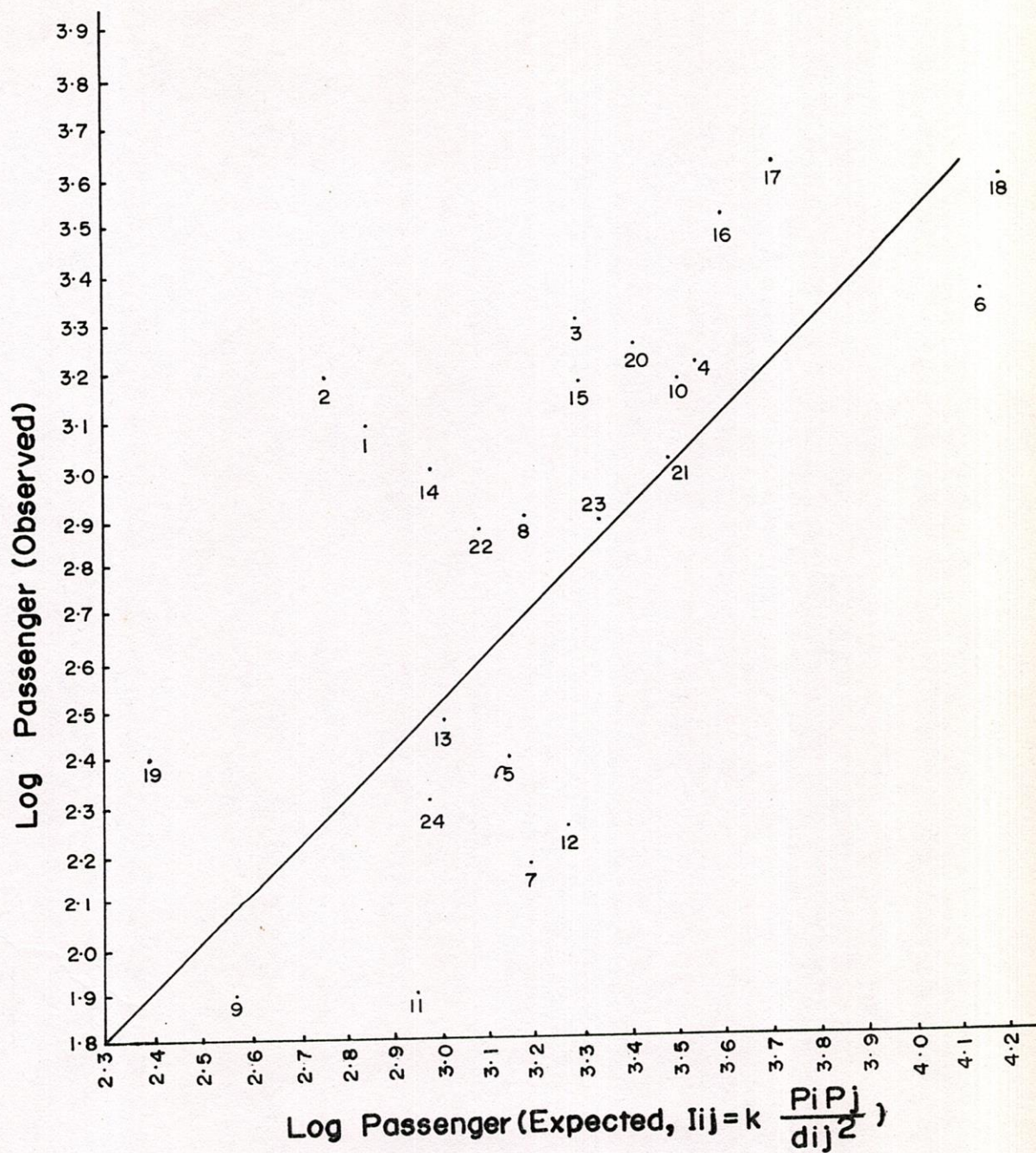


Fig. 4.3 Relationship Between observed and expected Interaction.

Location of centers

1.....24 Code no of the centers



Table 4.1. shows the interaction between Rajshahi and its adjoining 24 direct linkage centers. this table clearly shows the reality at above statement. Such as, the interaction at Rajshahi and its surrounding thanas is much greater than the interaction between Rajshahi and another big cities as Chittagong, Khulna, Jessore, Dinajpur etc. because of greater distance only. On the basis of reality Tobler (1970) has given a formula which is known as the "first law of geography". According to this first law, "Everything is related to everything else and near thing is more related than distant things. For example Chittagong is the second largest urban center (13,63,998) of Bangladesh in respect of population. But the interaction between Rajshahi and Chittagong (daily actual 250 and expected 1435) is lesser than the interaction between Rajshahi and its adjoining thanas as Charchat (observed 1650, expected 3730), Bagha (observed 1250, and expected 651), Mahanpur (observed 1480 and expected 1950) etc.

It can be seen from the statistical analysis of the relationship between distance and interaction is  $-0.43$  (appendix-8) Though this relationship has a little significance but it may be said that this negative value of coefficient of correlation ( $-0.43$ ) represents the reality of the above statement of Tobler's first law of geography.

Again, when the relationship of distance and interaction represented graphically in figure 4.2. (X-axis of graph paper is distance and Y-axis is interaction or observed passenger), the scattered diagram shows the negative slope. That is why it is noted from this figure that if the distance is less interaction is in greater and where greater distance there is lesser interaction. It is termed by Olson (1965) as the "distance decay function" or the "inverse distance law".

Again the relationship between interaction and population can also be represented on the graph paper. The interaction has a positive relation which has been discussed earlier. That is why in this case the graph paper would be represent a positive slope. Similarly the expected and observed interaction are also positively related. This relationships shown in figure 4.3 (x-axis is expected and Y-axis is observed interaction). The figure represent that the center whose expected interaction is greater, the observed interaction also greater and the center whose expected interaction is lesser the observed interaction is also lesser.

#### 4.4. Relationship Between Interaction and Relative Distance (Travel Cost and Time).

The negative relationship between interaction and distance has already been discussed in the above discussion. In this section the author tried to discuss the relationship between interaction to relative distance (here the travel time and costs are considered as relative distances). It is a fact that now-a-days the distance can not be measured only by length as mile or kilometer, but travel time and cost are more important. Such as convenience faces for people, terminals costs and delivery changes for goods may be taken into account (Haggett 1977). If the rate of interaction is compound to the relative distances (travel time and costs) it may be said that the rate of interaction increases with the decreases of travel time and cost. Table 4.2 shows the actual distance relative distance (travel cost and time), and interaction of Rajshahi city to 24 centers.



# Relationship Between Distance and Bus Passenger

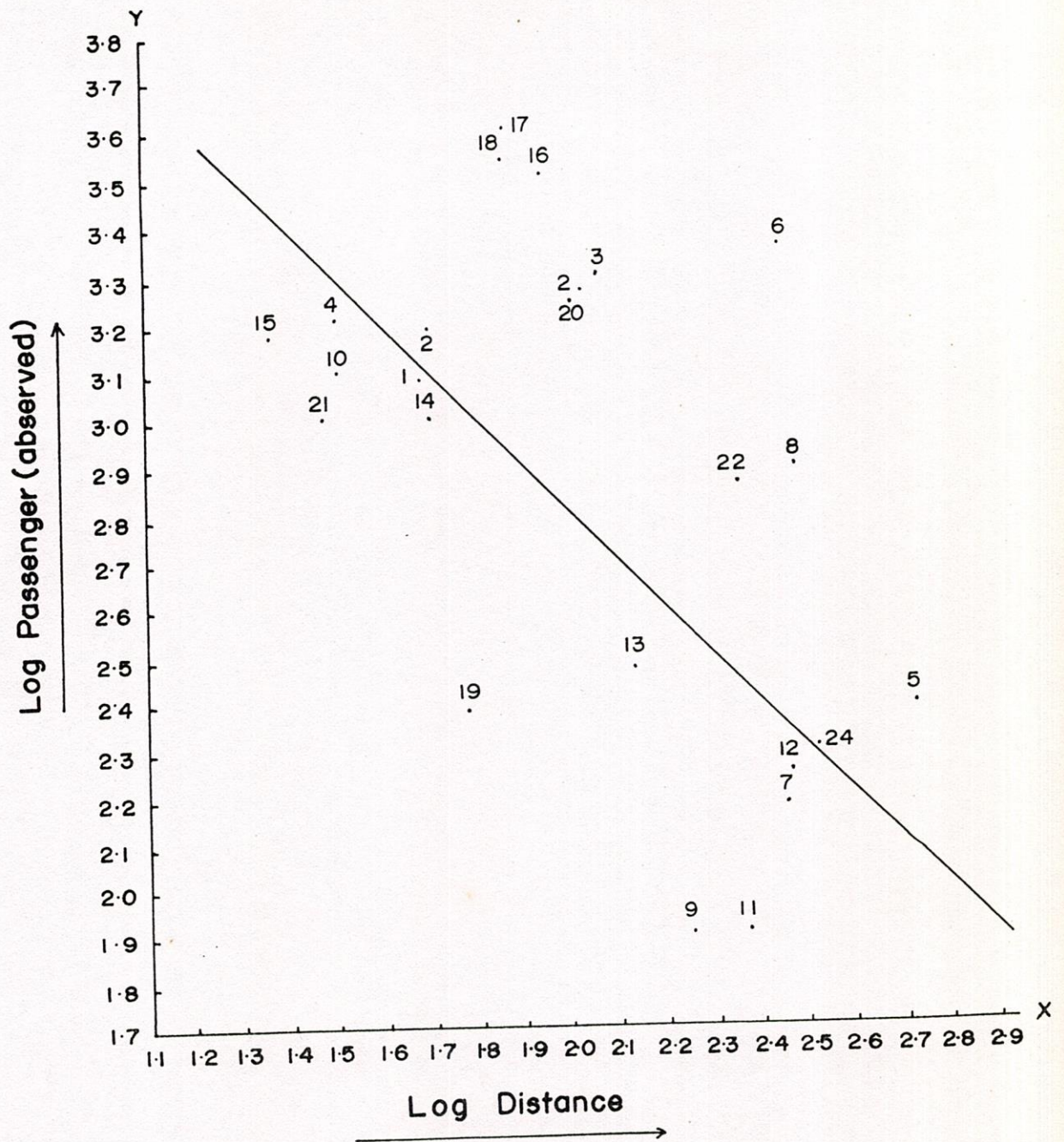


Fig. 4-2 Relationship Between Distance and Bus Passenger.

..... Location of centers.

1----24 Code number of the centers.



**Table - 4.2**  
**Relationship between Absolute and Relative Distances and Interaction**  
**of passenger**

Code no.	Center	Absolute ¹ distance(km)	Relative distance ²		Passenger ³
			time (hour)	cost (taka)	
01.	Bagha	48	2	16	1250
02.	Bagmara	50	4	23	1550
03.	Bogra	114	3 ½	41	2000
04.	Charghat	31	1 ½	10	1650
05.	Chittagong	534	18	210	250
06.	Dhaka	270	9	106	2275
07.	Dinajpur	284	6 ½	95	150
08.	Durgapur	30	1 ½	12	800
09.	Gibandha	180	4	65	80
10.	Gobagari	32	1 ½	12	1500
11.	Jessore	233	6	85	80
12.	Khulna	295	7	105	180
13.	Kustia	137	4	50	300
14.	Manda	50	2	17	1200
15.	Mohanpur	23	1	7	1480
16.	Naogaon	86	4	35	3250
17.	Notore	48	1 ¾	14	4250
18.	Nawabgonj	48	2	18	3850
19.	Niamatpur	59	2 ¾	26	250
20.	Pabna	109	3 ½	37	1775
21.	Puthia	30	1 ½	9	1025
22.	Rangpur	224	5	75	750
23.	Tanore	36	2	17	790
24.	Thakurgaon	333	9	117	200

Source: 1. Roads and Highways Directorate(RHI) Rajshahi Zone, Rajshahi.  
 2. Bus Terminal, Rajshahi  
 3. Direct observation.

The coefficient of correlation between travel cost and interaction is -0.43(appendix-9) and travel time and interaction is -0.36(appendix-10). From this negative value of coefficient of correlation it can be said that the regions of less travel time and cost are more intensively interacted than the regions of greater travel time and cost.

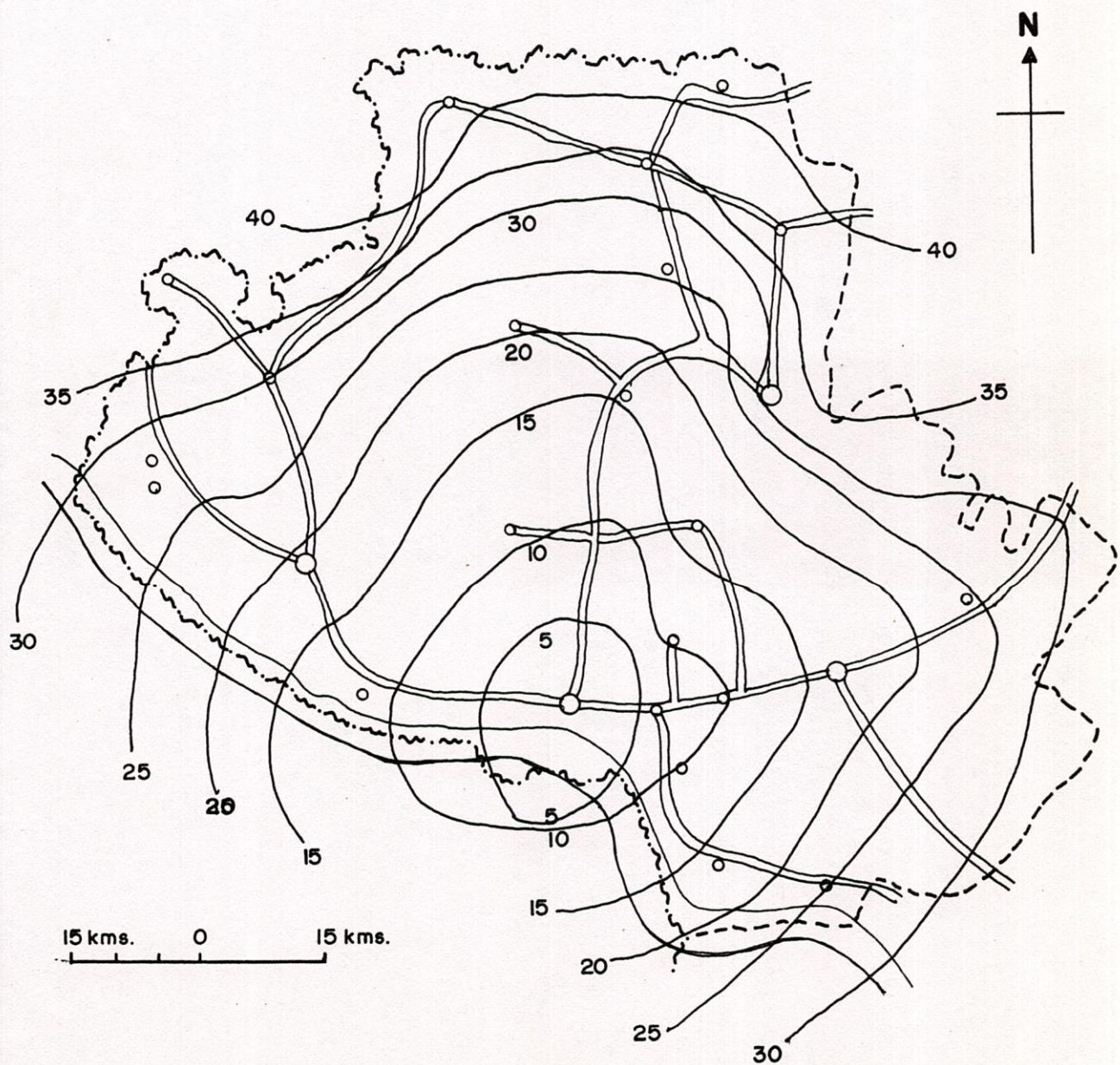
There is no doubt that travel time and cost increases with the increases in physical distance. However in this case a logical view point is reflected in the table 4.3. It can be said from this table



# GREATER RAJSHAHI DISTRICT

## LINES OF EQUAL TRAVEL COST

——— ISO - COST LINE (IN TAKA)



MAP 4.1



**Table ---4.3**  
**Travel time and cost in different Routes**

Route	Travel time		Travel cost	
	Km/Hour	Hour/Km	Km/ taka	taka/Km
1.Rajshahi to Naogaon	22.31	0.044	2.41	0.39
2.Rajshahi to Natore	36.30	0.027	2.85	0.35
3.Rajshahi to Naogaon	27.00	0.037	2.60	0.37

Source: Author's own calculation on the basis of the field work (table-4.2).

The above table shows that travel time and cost are comparatively less in Rajshahi Natore road than another two roads of Rajshahi Naogaon and Rajshahi Nawabgonj (Map 4.1 and 4.2). In Rajshahi Natore route the velocity of vehicles is maximum (36.38 km/hour) but the bus fare is minimum (2.41 km/taka) or 0.39 taka/km in Rajshahi Naogaon road. Rajshahi Nawabgonj road is in the middle position in comparison with these two routes. Comparatively it is less accessible than Rajshahi Natore road but more accessible than Rajshahi Naogaon road.

The pattern of equal travel time and distance is shown in map 4.1. It can be analysed from this map that because of the quality of road, it is possible to move more quickly in Rajshahi Natore road. More distance has been crossed in this road in lieu of same travel time and cost than another two roads. Rajshahi Naogaon and Rajshahi-Nawabgonj. Therefore it can be said from the above discussion that the journey in Rajshahi-Natore road is comparatively easy, comfortable and less expensive and in Rajshahi-Naogaon road it is expensive and time consuming where as the journey in Rajshahi-Nawabgonj is less expensive and comfortable than Rajshahi-Naogaon road and more expensive and less comfortable than Rajshahi-Natore road.

The variation of travel time and cost in different routes as mentioned above, the condition as road, accessibility and the length at connectivity are considered the main reasons at those variations of travel time and cost. Such as the condition of Rajshahi-Natore road is very good and wide where two buses can move freely and it also connects the capital city Dhaka and many other important centers. On the other hand the condition of Rajshahi-Naogaon road is not so good.

It is single way and it connects only the district town of Naogaon and some thanas as Mohanpur, Manda etc. Rajshahi-Nawabgonj road also connects the district town Nawabgonj but it is wide and better than Rajshahi Naogaon road.

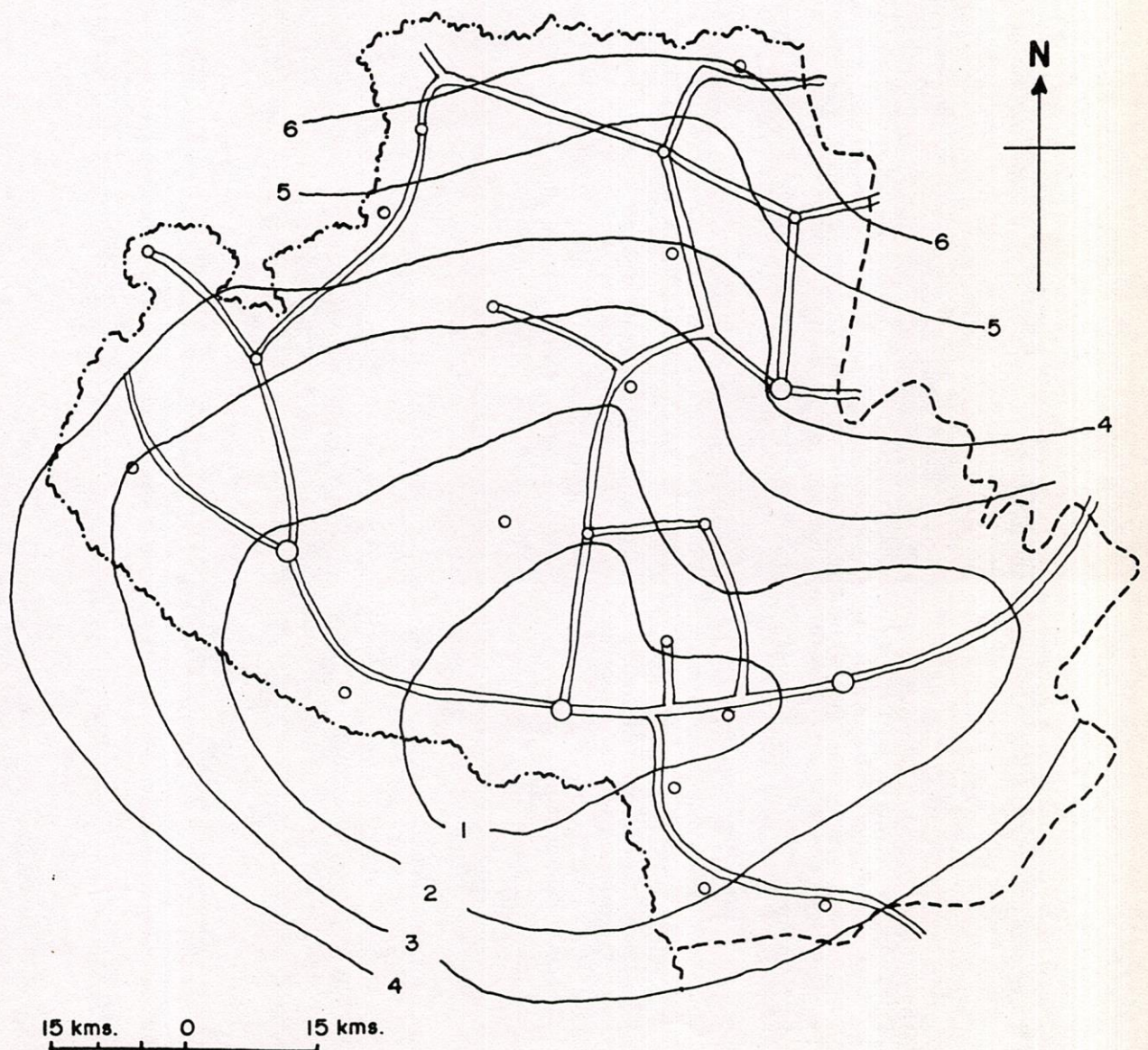
Besides these three main routes, there are also many thana connecting routes, where it is difficult to analyse the actual rate of travel time and cost. Because the conditions of those roads are very bad and hardly these roads are repaired. (Semi-pucca or HBB). The journey in these routes is very expensive and difficult too and takes more time to reach the destination because of



# GREATER RAJSHAHI DISTRICT

## LINES OF EQUAL TRAVEL TIME

— ISO LINES HAVE BEEN DRAWN BY ONE HOUR INTERVALS.



MAP 4.2



the bad quality of buses. There are also some thana connecting roads as -Nawabgonj Shibgonj, Rajshahi- Changhat-Baga which are good in quality.

#### 4.5. Variation of Interaction^(Temporal)

In this study the author tried to fit the model of spatial interaction according^{to} three bases of Ullman's model. But in reality it has been faced with some physical, political and economic barrier which varies the rate of interaction. So the rate of interactions are not fixed and constant during whole day, week, month, season or year. It is not also equal in all routes all centers all directions and all distances. The functions of distance has already been discussed, Connectivity is an another important factor of this variation of interaction. In this regard the functions of direction and connectivity should be considered.

Map 3.5 shows that the rate of interaction is greater in east west direction than north south direction of the study area. The tendency of movement in east west direction depends on the length of connection. Because, Nawabgonj Rajshahi Natore road connected all the important centers of Bangladesh including Dhaka the capital city. That is why all the interaction of Nawabgonj and Rajshahi to different centers of Bangladesh depends on Rajshahi Natore road. So it is regarded as the most accessible route (appendix 6 and 3 of chapter three) in this region. Rajshahi Nawabgonj road is also high accessible. The absence of any physical barrier on those two road is the main reason for high accessibility. On the other hand the presence of Rajshahi Naogaon road of Atrai river near Manda thana (there is a ferry ghat named Manda Ferry ghat) interrupted the interaction between Rajshahi and Naogaon. Again its length of connection extend from Rajshahi to Naogaon only. It is an important factor of low interaction in Rajshahi Naogaon route.

It is a matter of fact that though Rajshahi is a divisional city and one of the important center of Bangladesh the traffic movements are limited only in three dimensions east, west and north. The south ward movement is hindered by the presence of the padma river and the political boundary of Bangladesh and India. For this reason the traffic movement is highly restricted in east, west and north directions.

In conclusion spatial interaction is one of the modern concepts^s in geography. Because of spatial interaction, distant places are gradually coming to close contact to each other. But according to the gravity model of interaction near places are more interact than distant places. Interactions between two places are determined by the population and distance. Today travel cost and time are also regarded as relative distances.



# **CHAPTER FIVE**

## **NETWORK ANALYSIS**



Network study is one of the fundamental aspects of geography. Transport network is a man-made phenomenon over physical landscape. Transport system of any country facilitates the human needs. That is why, with the changing condition of human civilization man has constructed different path or route for their journey or for transporting goods from one place to another. Therefore, the path or route connects the different place or centers and these connecting paths created a transport network over the earth surface. Increasing human needs created a complex transport network everywhere. In this chapter the road network of the study area has been analysed based on spatial network structure relating to its location, density change over time.

## 5.1 Definition

According to Haggett and Chorley (1974), "A network is a measured fabric of intersecting lines and interstices." But in geographical term transportation network is defined as a set of geographic locations interconnected in a system by a number of routes (Kansky, 1963). In other words, the movement of man, goods and information on the earth surface through channels, roads, railways, airlines, telephone lines, pipe lines may be regarded as transport network (Warntz, 1961).

In thick populated and highly industrialised urban areas, there is usually a dense pattern of transportation lines. A set of transportation lines or routes which may and frequently do join and cross junctions forms a transportation network. Basically, a transportation network may be regarded as a set of interconnections route along which movement take place (Robinson and Bamford, 1978). At the highest level of abstraction, transportation networks can be represented by a series of vertices (vertices also known as points, nodes, junctions, intersections, terminals, zero-cells,) and a set of edges (edges also known as arcs, sides, segments, branches, routes etc.) together with a relationship of incidence that associates each edge with two vertices (Taaffe and Gauthier, 1973). In reality networks are highly complex spatial system which is connected by a set of points by a set of line segments and form an essential and permanent feature at the economic landscape (Haggett, 1979).

## 5.2 Network Structure

Network structure means a configurations consisting of points and lines and the network configuration means a geometrical arrangement transport network (Garrison and Marble, 1961). The contribution of Konig (1936), a Polish mathematician, played an important remarkable role on the development of network structure. For the easy analysis of transportation network Konig (1936) transferred it into graph which is known as topological map in geographical dictionary. "Graphs" arrays of points, which are connected or not connected to one another by lines (Haggett and Chorley, 1974). A topological map or "graph" reduced a transport network into simplest form and such simplicity may help us more easily to understand the characteristics of transport networks (Robinson and Bamford, 1978). A topological map does not concern with actual lengths or distances and orientations or directions but rather upon contiguity relative



# GREATER RAJSHAHI DISTRICT TRANSPORT NETWORK OR TOPOLOGICAL MAP

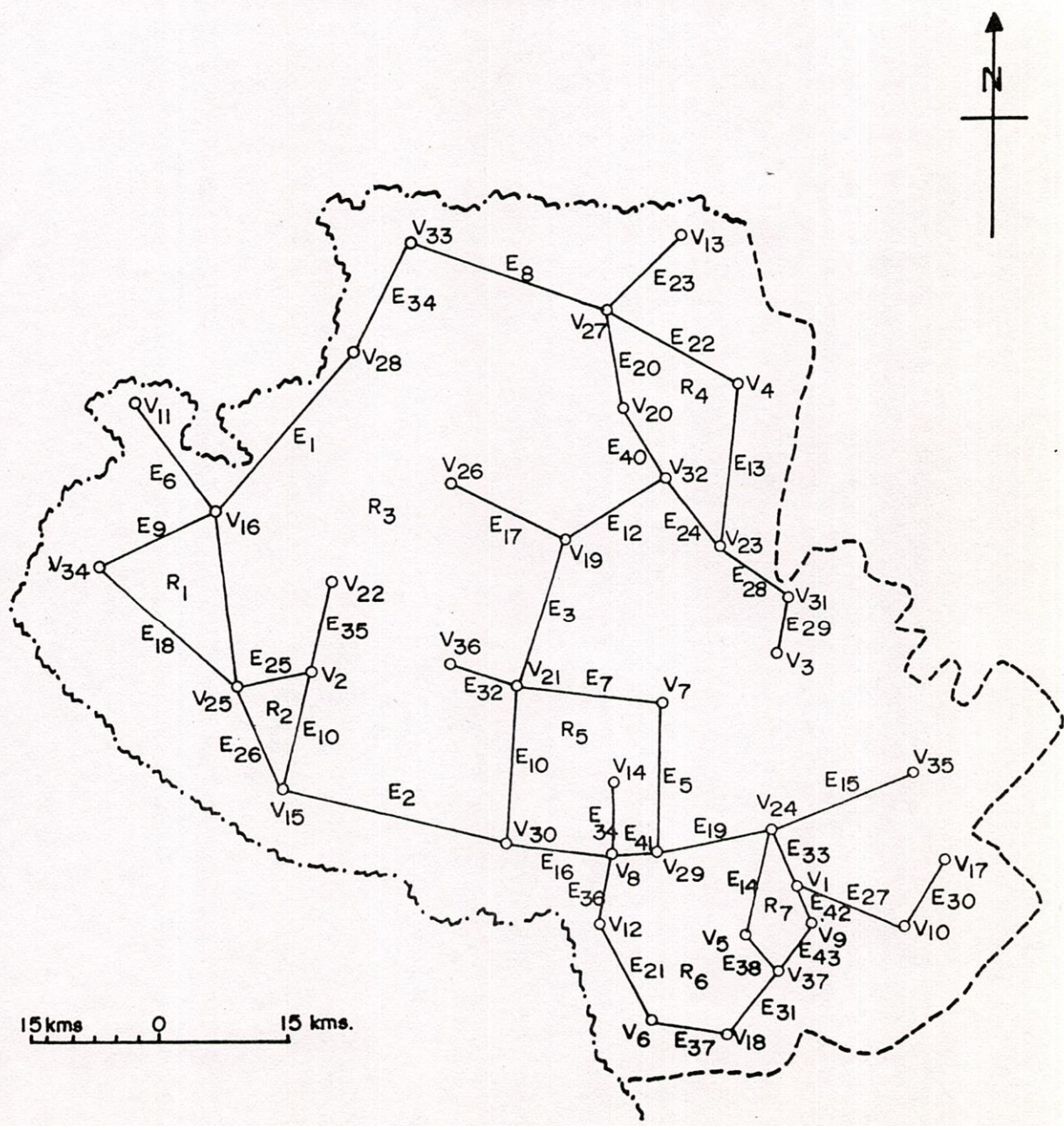
## LEGEND

oooo VERTICES OR NODES

— EDGES OR PATH OR ROUTES

V₁—V₃₇ CODENO. OF VERTICES (According to Alphabetical serial)

E₁—E₄₃ SERIAL NO OF EDGES (According to Numerical Value)





locations and the systemisation of lines and junctions. Above all, the topological map is a form of geometry which is connected with the positions and relationship between points, lines, and arcs, but not with the distances between points, the straightness of lines or the size of the arcs (Briggs, 1971). In topology the diagrams are said to be equivalent. Because, contiguity or positional relationships are preserved even through distances and directions may not be true (Robinson and Bamford, 1978). Map 5.1 is an example of topological equivalence of the road map (map 3.1 of chapter three) of the study area.

The study of network in topological sense begun with Euler's (1736) and continued with the colouring problems of Cayley's map (1879). But comprehensive treatment of network topology was not published until 1936 in König's *Theorie der eulichen and Unendlichen Graphen* (Haggett and Chorley, 1974). The branch of topology dealing with elementary structure which may be called graph theory. The graphs are of different geometrical figure as planer (two dimensional), tree-like, free, null, connected etc.

In transportation network the centers or points are known as nodes, vertices, junctions, intersections, terminals, zero cells and the linking lines are commonly referred to us as arcs, edges, sides, segments, branches, routes, etc. (Haggett and Chorley, 1974) and area enclosed by arcs are usually termed as 'regions' or 'faces' (Robinson and Bamford, 1978). The term node or vertices represent as from the small farmstead to standard Metropolitan Area or SMA or megapolish, the biggest urban center the edges represent as human carts to national or international high ways. There are 37 nodes ( $V_1, \dots, V_{37}$ ), 43 edges ( $E_1, \dots, E_{43}$ ) and 7 regions ( $R_1, \dots, R_7$ ) in the topological map or transportation network of study area (map-5.1).

### 5.3 Quantitative Analysis

Adequate transport system is an essential part of economic development of a country. Thus it is necessary to know the modes, structures, arrangement and characteristics of transport network for the economic development. Therefore, the analysis of transportation network has become an important aspect of geographical studies only in recent years. But during the post war period the changes and development in transport focused upon the analytical study of networks. After the application of 'graph theory' by König (1936), the analytical measurement of transportation network has begun. The geographical simplifications of the real network may be analysed using those graph theoretic concepts and theorems that suggest potential structural measures of transportation networks.

More recent studies have also considered the spatial pattern of transportation system from graph theoretical points of view. Garrison and Marble (1964) have first designed a set of measures based on the concept of graph theory (Kansky 1961). They applied certain graph-theoretic measures to regional high way networks. But most remarkable contribution to measure the transportation network by Kansky (1963) who applied indices to quantitative analysis of network. Because networks also varies in their size (Planar or non-planar) connectivity (connected



or not connected, tree-like), and complexity (null, complete, universal etc.). By measuring such relations Kansky (1963) divided the measurement indices into the following two categories:

- i) Non-ratio measure
- ii) Ratio measure

Similarly the author in this study has tried to analyse the data quantitatively and measured the structure of transportation network on the basis of above model. Certain mathematical terms are also used for describing the structure of transportation network in this study.

## 5.4 Indices of Network

The structure of transportation network and development of several descriptive indices for measuring the connectivity of networks including the alpha ( $\alpha$ ), beta ( $\beta$ ), gamma ( $\gamma$ ), mew ( $\mu$ ), delta ( $\delta$ ), eta ( $\eta$ ), theta ( $\theta$ ), pi ( $\pi$ ), etc. have been studied by Kanasky (1963). In this section the above indices based on the field data of the study area have been measured. In this connection it may be pointed out that in the study area there are 37 nodes, 43 routes aggregating 772 kms. The thana Boalia (now four separate thana which mention above) Paba considered here as one node named Rajshahi. Besides Rajshahi, the 30 thana sadar (ex-upazila head -quarter) other 6 important centers (Ahmedpur, Amnura, Baneswar, Bampur, Sampur and Walia) which plays an important role in road transport in this region are considered here as the nodes of the network. It is interesting to note here that within the 37 nodes and 43 routes, the daily traffic volume of 4906 vehicles, 13570 tons of goods and 190500 passengers have been observed.

### 5.4.1 Non-Ratio Measure

There are only two indices- cyclomatic number ( $\mu$ ) and diameter ( $\delta$ ) in non-ratio measurement.

#### i) Cyclomatic Number ( $\mu$ ):

The cyclomatic number is one of the fundamental index of network study. It is an arithmetic comparison between individual elements of the network system. This index represents how many fundamental or complete circuits are present in the transportation network. It may be written as:

$$\begin{aligned} \mu &= e - v + p & e &= \text{number of edges} \\ & & v &= \text{number of vertices} \\ \text{or } \mu &= 43 - 37 + 1 = & p &= \text{number of subgraph} \\ \mu &= 6 + 1 = 7 \end{aligned}$$



But 7 complete circuit has been observed in the study area. If the graph in its complete form, then the number of circuit would be 59. In this network, the circuits are indicated by the symbols of  $R_1$  .....  $R_7$ .

## ii) Diameter ( $\delta$ ):-

The index diameter represent the maximum associated number of a graph. In other words, index is the maximum number of edges by shortest path between two most distant points of graph. It may be expressed as :-

$$\delta = \max_{x,y} d(n,x,y)$$

In this graph the delta value is 10. Because these are two pairs of maximum distant paths-one is Bholahat to Gurudaspur the next one is Dhamoirhat to Lalpur & these pairs needed 10 routes to make path shortest.

## 5.4.2 Ratio Measure

Three general groups of ratio measure used for analysing the structural transport network. These three groups are as follows:-

- i) Alpha ( $\alpha$ ), Beta ( $\beta$ ) and gamma ( $\gamma$ ) expressing the relation between the distinguishable elements of network.
- ii) Indices eta ( $\eta$ ) and pi ( $\pi$ ) Iota ( $\iota$ ) and theta ( $\theta$ ) expressing relations between the network as a whole and the remaining elements.

All the indices of ratio measures are given below:-

### i) Alpha ( $\alpha$ ) Index

One of the most useful and perhaps the best measure of the connectivity of a network is alpha index ( $\alpha$ ). It is known as connectivity index. The term connectivity of a network means the degree of connection between all vertices (Taaffe and Gauthier 1973). Alpha index is an adjusted form of the cyclomatic number. This index expressed as:-

$$\text{Alpha } (\alpha) = \frac{\text{actual circuit}}{\text{maximum circuit}}$$

$$\text{or } \alpha = \frac{e-v+p}{2v-5} = \frac{\mu}{2 \times 37 - 5}$$

$$\text{or } \alpha = \frac{7}{69} = 0.1014$$



The alpha ( $\alpha$ ) index gives the ranges values possible from 0 to 1 and multiplied by 100 this will convert into percentage. The higher the value of index, the greater the degree of connectivity in the network. Here the value of alpha index is 0.10 which represents the degree of connectivity of the study area only 10 percent.

### ii) Beta ( $\beta$ ) index

The beta index is the simplest form of the three measures which records the relation between two individual elements of network. It can be calculated by dividing the total number of routes in a network by the total number of nodes and it is expressed as-

$$\beta = \frac{\text{arcs}}{\text{nodes}} = \frac{e}{v} = \frac{43}{37} = 1.16 \text{ or } 38.67\%$$

The value of beta index ranges between the lower limit of 0 to the upper limit of 3. In this study the value of beta index is 1.16 i.e. the number of routes per node is only 38.67% or about 39% in terms of its necessity.

### iii) Gamma ( $\gamma$ ) index

The gamma index ( $\gamma$ ) describes in numerical terms the connectivity of a network. It is a ratio between the edges and the vertices of a given network.

It is derived from the formula :-

$$\gamma = \frac{\text{arcs}}{3(\text{nodes}-2)} = \frac{e}{3(v-2)} = \frac{43}{3 \times 37-2} = \frac{43}{105} = 0.41 = 41\%$$

The value of gamma ( $\gamma$ ) index lies between 0 to 1. In the given network the value of gamma index is only 0.41 or 41% of the graph in respect to expectation.

### iv) Pi( $\pi$ ) Index

The pi( $\pi$ ) index is a measure of relation between a transportation network as a whole and specific edges of that network (Kansky, 1963). Generally the pi index is a number expressing the relations between the circumference of a circle and its diameter. It is written as :-

$$\text{Pi Index}(\pi) = \frac{\text{Circumference}}{\text{Diameter}}$$

$$\text{or } \pi = \frac{c}{d}$$



In this network, there are two pairs of most distant routes-Bholahat to Gurudaspur Lalpur to Sapahar, both the pairs are connected by shortest path with 10 routes. In this case, the measurement of pi index indicated as  $\delta_1$  and  $\delta_2$  Thus:-

$\delta_1$  = Bholahat to gurudaspur 191kms.

$\delta_2$  = Lalpur to Sapahar 192 kms.

$$\text{Therefore } d = \frac{\delta_1 + \delta_2}{2} = \frac{191+192}{2} = \frac{383}{2} = 191.5$$

$$\text{or } \delta = \frac{c}{d} = \frac{772}{191.5} = 4.03$$

It has been observed that the pi index increases with the increase in connectivity index. Because the pattern of well connected network reduce the distance between most distant pairs of different path. For this reason the value of pi index is greater in most of the developed countries.

#### v) Eta ( $\eta$ ) Index

The eta index ( $\eta$ ) is expressing relations between the transportation network as a whole its routes as individual elements the network (Kansky, 1963). In graph theory the eta index is a ratio of the sum of all edges and all vertices to the observed number of edges of the network. It is written as:-

$$\eta = \left( \frac{e + v}{v} \right) \dots \dots \dots (i)$$

Again the eta index represents as a ratio between the total mileage of the network and the observed number of edges. In this case the formula may be written as:-

$$\eta = \frac{\text{Total network mileage}}{\text{Number of arcs}}$$

$$\eta = \frac{M}{E} = \frac{772}{43} = 17.95 \text{ km.}$$

Therefore the eta index represent the average length of edges. In the network of the study area the average length is 17.95 or about 18kms.



## VI) Theata ( $\theta$ ) Index

The theta index express the to totality of transportation networks in terms of the total mileage (kansky 1963). It is a ratio of the network as a whole and its vertices. It is written as:

$$\text{Theta}(\theta) = \frac{\text{total network mileage}}{\text{number of vertices}}$$

$$\text{or } \theta = \frac{M}{V} = \frac{772}{37} = 20.86 \text{ Km}$$

in the case of the study area the average road mileage per nodes or vertex has been calculated as only 20.86 kms or about 21 kms.

Again the theta index express the ratio between the traffic flow and vertices. then the index may be rewritten as follows:

$$\theta = \frac{T}{V} = \frac{\text{total traffic flow}}{\text{number of vertices.}}$$

a) In the case of vehicles the index is:

$$\theta = \frac{T}{V} = \frac{4906}{37} = 132.59 \text{ vehicles/nodes}$$

b) In the case of good the theta index is

$$\theta = \frac{T}{V} = \frac{13570}{37} = 366.76 \text{ tons/ node.}$$

c) In the case of passenger the index is

$$\theta = \frac{T}{V} = \frac{190.500}{37} = 5013.16 \text{ persons/ nodes.}$$

So he average traffic flow of each node of the study area are 366.76 tons of goods. 132.59 vehicles. and 5013.16 passengers daily.



## VII) Iota (i) Index

The iota measures the ratio between the transportation networks as a Whole and its weighted vertices. It may be expressed as:

$$i = \frac{\text{total network mileage}}{\text{weighted functions of vertices}} = \frac{m}{w}$$

This index also may be expressed as the ration between network mileage and traffic flow. Then this index may be written in the following formula :-

$$i = \frac{\text{total mileage } M}{\text{total traffic flow } T}$$

a) In the case of vehicles index is :-

$$i = \frac{M}{T} = \frac{772}{4906} = 0.16 \text{ km/vehicles}$$

b) In the case of goods the index is

$$i = \frac{M}{T} = \frac{772}{13.570} = 0.06 \text{ km/tons of goods.}$$

c) In the case of passenger index is

$$i = \frac{M}{T} = \frac{772}{790.500} = 0.0004 \text{ km/passenger}$$

Again the iota (i) index is written as:-

$$i = \frac{\text{total traffic flow } T}{\text{total mileage } M}$$



Then :-

a) In the case of vehicles the index is

$$i = \frac{T}{M} = \frac{4906}{772} = 6.36 \text{ vehicles/km.}$$

b) In the case of goods the index is

$$i = \frac{T}{M} = \frac{13.570}{772} = 17.58 \text{ tons/km.}$$

c) In the case of passenger the index is

$$i = \frac{T}{M} = \frac{190.500}{772} = 246.76 \text{ persons/km.}$$

Therefore the daily average traffic flows of the study area per kilometer are 6.36 vehicles, 17.58 tons of goods and 246.76 passengers. Again the road mileage per vehicle is 0.16 km per ton of goods is 0.06 km and per passenger it only 0.0004 km.

### VIII) Degree of Connectivity

The degree of connection between all vertices is defined as the connectivity of network (Taaffe and Gaufhier, 1973)

Again it may be defined as the degree of completeness of the links between nodes. The measurement of this type compares the relative position of an observed networks connectivity on a scale limited by maximum and minimum connectivity ratio. The maximum connectivity ratio is always equal to one.

1. The maximum connectivity written as:

$$MxC = \frac{v(v-1)/2}{37(37-1)/2} = 1$$



2. Whereas the minimum connectivity written as

$$M_i C = \frac{v(v-1)/2}{v-1} = \frac{37(37-1)/2}{37-1} = \frac{(37 \times 37)/2}{4 \times 36} = 18.5$$

3. The degree of connectivity may be expressed by the following formula

$$d.c = \frac{v(v-1)/2}{c} = \frac{37(37-1)/2}{43} = \frac{37 \times 18}{43} = 15.49$$

If the degree of connectivity is compared with the value of maximum and minimum connectivity it has been observed that the degree of connectivity of greater Rajshahi district (15.49), seems to be very close to the minimum (18.5) value of connectivity. Thus may be pointed out that the degree of connectivity of the study area is not significantly sufficient.

Thus in this chapter some basic structural properties network of the study area by applying the graph theory has been analysed. It has been observed that the indices of network represent the very insufficiency of road transport system in the study area. For example, there are 37 nodes, 43 routes which have calculated only 7 regions or complete circuits.

The indices of alpha ( $\alpha$ ), beta ( $\beta$ ), and gamma ( $\gamma$ ) also indicate the insufficiency of road network in greater Rajshahi district. On the other hand the statistical analysis of the indices of eta ( $\eta$ ), theta ( $\theta$ ), and iota ( $\iota$ ) have also been indicated the imbalance character of road network pattern of the study area. For example the average length of routes are 17.95 kms. But most of the routes (28 or 65.12%) lies between 13 edges (30.23%) are in and only one route lie between (Appendix -11). According to the index, the average traffic flow of nodes in this study is 366.76 tons (here only considered the goods as traffic) (appendix -12) But the traffic flow of main four nodes Naogaon, Natore Nawabgonj and Rajshahi lie above the average figure and 33 node lie under the average value. When the theata index indicated as the ratio between road mileage and nodes, it can be seen that the road mileage of above main four nodes is much greater than the other nodes.

Again the calculated iota index has shown imbalance ratio of traffic flow and road of the study area. This index also indicates the over loaded traffic flow in respect of road. But the ratio is not constant in all the routes during all the season of the year. For example the traffic flow of Rajshahi Natore and Rajshahi Nawabgonj routes are much greater than all other routes. The traffic flow also increases during the winter and summer season than other season of the year which has already been discussed in chapter three. Finally, it may be said that the pattern of road network system of the study area is subjected to many limitations and general factor of the limitations may be observed in any region of Bangladesh.



## **CHAPTER SIX**

^{AR}  
**URBAN HIERCHY**_A



One of the most important question about nodal distribution in urban geography is the hierarchical organization of settlements. The term urban hierarchy might be used to refer a ranking of cities into successive groups on the basis of size or on various other bases (Murphy, 1966). But in urban geography it has a special meaning and the idea of an urban hierarchy is that there exist discrete classes of central places (A central place is a settlement that provides one or more services for people using out side it) and associated groups of functions organized together in nesting pattern (Murphy, 1966). The earlier urban geographers and location theorists have been adapted many methods to determine the urban hierarchy. The earliest attempt of ranking of town were made by Christaller (1933) and Lösch (1954), the German locational theorists based on size and spacing of the settlements (Haggett et. al, 1977). Berry and Garrison (1958) prefaced an examination of the functional bases of hierarchical class system of centers (Carter, 1982).

In this regard it may be said that different methods have been used by different expert for ranking of cities. The "Rank size Rule" of Zipt (1949) and the "Law of Primate City" of Jefferson (1939) in ranking of cities are based on population only. Smailies (1944), Green (1955), Carruthers (1957) classified the urban centers on the basis of bus service only (Murphy, 1966). J. Taaffe and Gauthier (1973), Robinson and Bamford (1978), Morrill (1979), Hurst (1974), and some other transport geographers emphasized upon network structure and nodal accessibility on ranking of cities.. The ranking and urban hierarchy of 37 nodes of the study area on the basis at some variables or indicators as centrality (administrative function, population, traffic volume) and accessibility (direct linkage or connectivity associated or König number and shortest path matrix etc.) have been examined in this chapter. In later part of this chapter these indicators have been discussed.

## **6.1. Centrality and Accessibility.**

The term centrality and accessibility are complement to each other. Centrality means the functional opportunities at a place (Christaller, 1933) and accessibility means the relative facilities to reach one place to another (Morill, 1979). It is very difficult to separate from one another but there is a close positive correlation between them. Because, the centers whose centrality is greater has the higher accessibility and the centers with high accessibility serve a large number at central facilities. Such as different types at economic activities are agglomerated in a center based on accessibility, which increases the centrality at that place. For example Rajshahi is the most accessible center at the study area and its centrality also greater than all other centers of the study area. So it is difficult to identify the cause and effect rather they are complement to each other. In this chapter two important factors--centrality and accessibility for the determination of urban hierarchy of the study area have been analysed.

## **6.2. Centrality and Urban Hierarchy.**

The founder of hierarchy concept Christaller (1933) defined the term centrality of an urban center as the ratio between all the services provided there (for both its own residents and for visitors from its complementary region) and services needed just for its own residents



(Haggett, 1977). It measured only in terms of goods and services offered (Carter, 1985). Towns with high centrality is supplied by many services per resident and those with low centrality is supplied by few services per resident. Centrality of a center in terms of administration, whole sale, retail, medical, public health, education may be measured in two ways qualitatively and quantitatively. But for measuring the centrality on the basis of ranking of cities of the study area three indicators have been considered. Such as:-

- 1) Administrative Unit
- 2) Population
- 3) Traffic Volume.

### 6.2.1. Administrative Unit

Though the earlier geographer did not consider the administrative unit for ranking or the hierarchical order of the cities in Bangladesh the administrative unit is the prime factor towards urbanization as in all the developing countries of the world. In Bangladesh it can be seen that the urban center which is greater in size, urban facilities also available there. For example the capital city Dhaka is the biggest urban center of Bangladesh where most of the urban facilities are provided. Besides Dhaka, the three divisional head quarters are the next largest urban centers in Bangladesh. In the study area, the divisional city Rajshahi is the largest urban center whose goods and services overlap the complementary region of all other centers of lower order. According to the administrative function the urban centers of the study area may be divided into the following three classes:-

- a) Divisional City
- b) District City
- c) Thana town.

Besides the above three administrative unit there are also some nodes are playing an important role on road transport system. These centers are considered as urban centers though urban facilities and administrative functions are quite absent in these places. Therefore the urban centers are classified in to four hierarchic groups. Table 6.1 shows the hierarchic order of urban centers of the study area on the basis of administrative function.

The table 6.1 shows that there are only one first hierarchic order center i.e. Rajshahi (now if is declared as metropolitan city which is consist of four new thanas -Boalia, Moliha, Rajpara and Shah- makhda within area of 125 sq.km and population of 6,88,000- appendix-13) which serves all the center within the study area. Beside Rajshahi three district city -Naogaon, Natore and Nawabgonj are considered as the center of second hierarchic order. Twenty seven thana town regarded as third order and another 6 centers like Ahmedpur, Amnura, Baneswar, Banpana, Sampur and Walia are considered as the center of fourth order. these 6 fourth order centers have no administrative function but they are also playing a vital role on road transport network and the economy of the study area.



**Table-6.1**  
**Ranking of Urban center According to Administrative function.**

Heirarchic order	Administrative function	No of center	Percentage %
1.	Divisional city	1	2.70
2.	District City	3	8.11
3.	Thana	27	72.97
4.	Other	6	16.22
Total		37	100.00

Source:- Population census Report.1981.

### 6.2.2. Population.

Population is the earliest indicator of ranking town. On the basis of population there are two types of distribution of urban center. These two distribution are:-

- a) Rank size Rule or log Normal Distribution and
- b) Primate Type of Distribution.

#### a) Rank-Size Rule

The founder of Rank size Rule zipf (1949) described that a set of cities ranked according to the size from the largest to down ward. According to this rule status that the population of a given city tends to be equal to the population of the largest city divided by the rank of the given city is  $1/n$  the size of the largest city's population (Haggett 1979) which is written by the following formula:-

$$P_n = \frac{P}{n}$$

$P_n$  = population of nth city  
 $P$  = population of the largest city  
 $n$  = Rank of the given city

If it try to compare the distribution of population of the study area to the Rank size Rule of Zipf(1949) it can be seen that there are less similarity which has been shown in table 6.2.



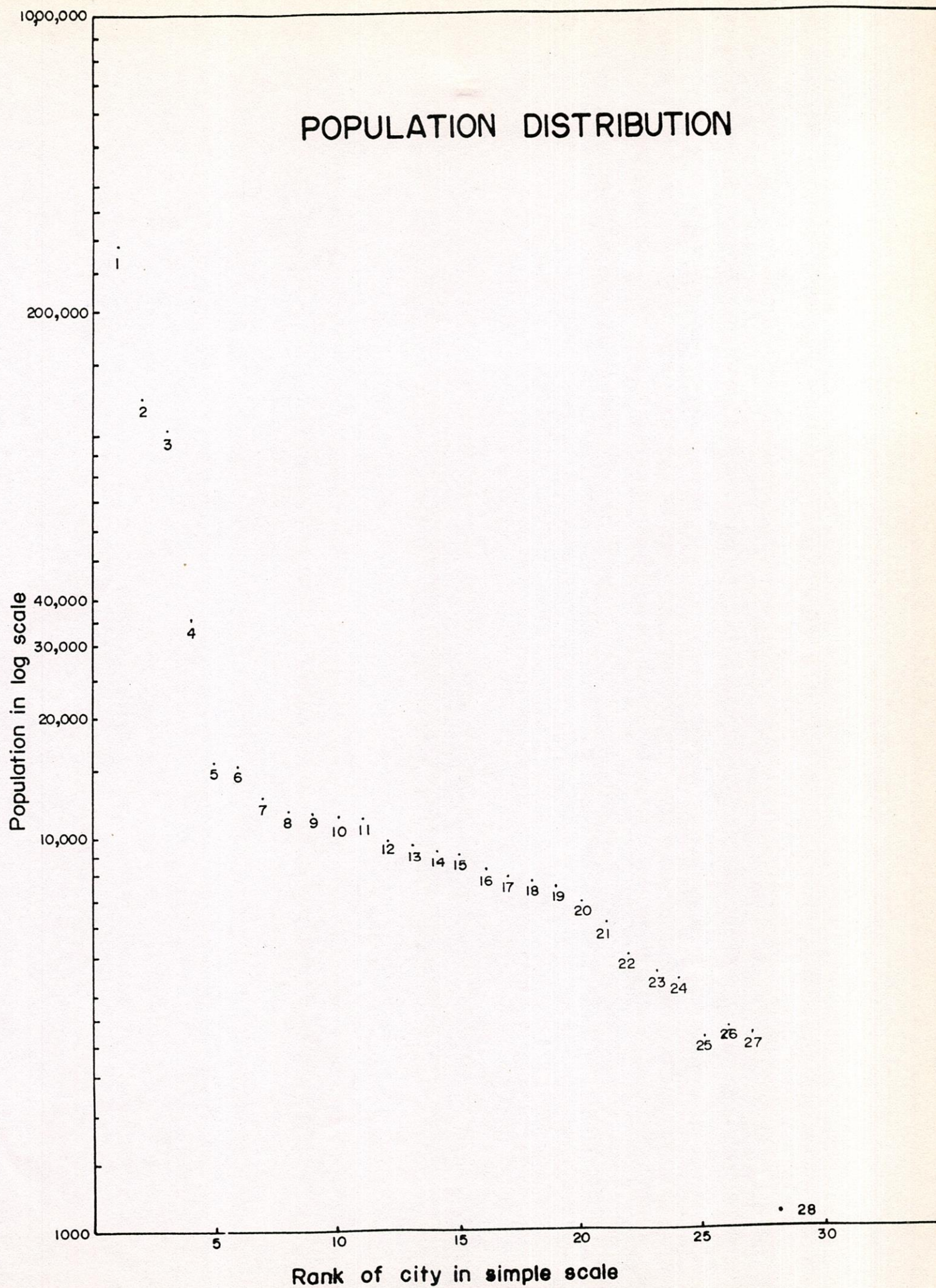


FIG. 6·1



**Table --6.2**  
**Comparison of population distribution to rank size Rule**

Name of city	Rank of city	Population as fraction of largest city	population According to rank-size rule	Actual population	Variation
Rajshahi	1	1	299,761	299,761	-
Nawabgonj	2	$1/2=0.50$	149,863	121,205	28,631
Naogaon	3	$1/3=0.33$	99,890	100,795	-905
Natore	4	$1/4=0.25$	74,918	36,186	38,732

Source: GOB: Preliminary report on population

Table 6.2 shows that according to the rank size rule the population of Nawabgonj, Naogaon and Natore are half, one third and one fourth portion of the population of Rajshahi. From the table it can be seen that the population of Natore and Nawabgonj are lesser than expected population and the population of Naogaon is larger (905) than the expected population. Therefore it may be said that the rank size rule does not properly fit in the study area.

### b) Primate Type of Distribution

According to the primate type of distribution Jefferson (1939) and other geographers suggest that there may be a largest city and many small cities in a country or in a region. The largest city known as primate city where agglomerated all kind of activities. About 40% of urban population of a country live in this primate city and it would be about 8 times greater than the next largest city.

According to the law of primate city the largest city regarded as super eminent, whose primacy is considered not only in size but also in national and international level of influence. This type of dominance in respect of whole economic, cultural and political sense by one city is associated with what is sometimes called "The Great Tradition".



In the case of the study area (if it considered as a discrete region) it may be observed that about 46% of her urban population live in the largest city Rajshahi. But it is not 8 or 10 times greater than the next order center i.e. Nawabgonj. The graphical representation of population is shown in figure no. 6.1. The x-axis of graph represents the rank and y- axis as population of the city. The J-shaped curve represents the more or less primate type of distribution. It can be seen from the figure 6.1 that the slope of first five cities is very steep and the next order cities slope is quite gentle or the first four cities are more or less following the pattern of rank size rule. But the lower order center follows the primate type of distribution. Thus it can be said that the distribution of population of the study area is not completely normal or purely primate type but a mixture of those two type of distribution. (Column of table 6.9 shows the rank and population of 37 centers of the study area.)

### 6.2.3. Traffic Volume

Traffic Volume is the most important indicator to measure the centrality in this section. Because, different economic activity have been agglomerated on different centers because of the difference on the basis of their connectivity. Such as Rajshahi has connection to 29 centers where as Naogaon, Natore and Nawabgonj have connection to 26, 20 and 18 centers respectively ( table 3.6.1, 3.6.2, 3.6.3 and 3.6.4 of chapter three).

Daily total traffic Volume of 37 roads of the study area have been observed as 4,906 vehicles, 13,570 tons of goods and 190,500 passengers (detailed in table 3.5 of chapter three) On the basis of daily traffic volumes the roads are divided into the following five hierarchic order. Table 6.3 and map 6.1 shows the hierarchic order of the study area.

Table 6.3 and map 6.1 shows that there are only one first order center i.e. Rajshahi whose daily traffic volumes are 682 vehicles, 2660 tons of goods and 32,920 passengers. Rajshahi considered as the most accessible center of the study area. This table also shows that there are 31 centers of second order or high accessible, 11 centers of third order or moderate accessible, 20 centers of fourth order or low accessible and only 2 centers of very low accessible. It can be seen from the table 6.3 that the accessibility of the most of the centers (20) are very low. Most of the backward thanas and other centers lie in these two low accessible groups. (column 3 of table 6.9 shows the daily traffic volumes and rank of 37 roads of the study area)

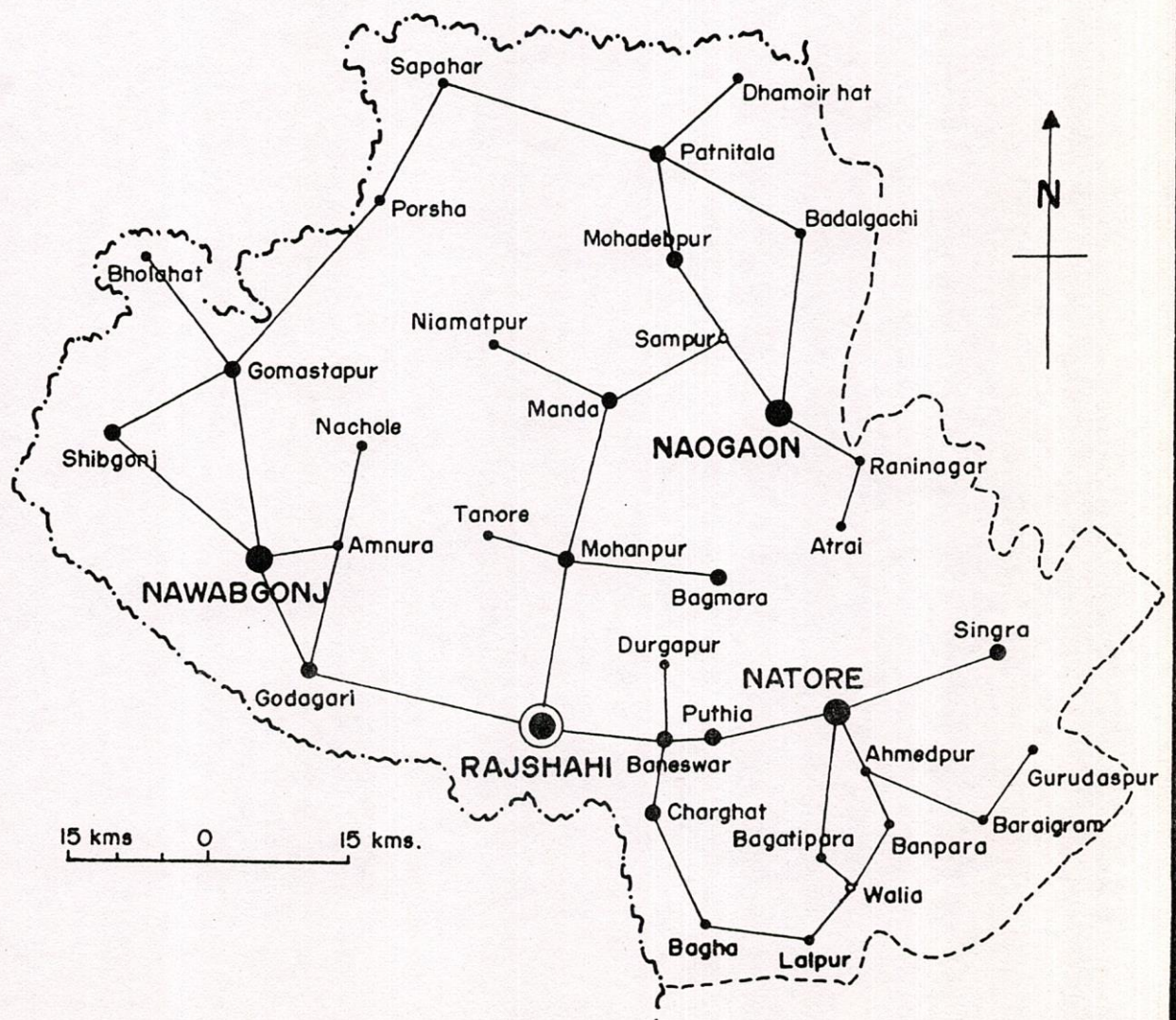


# GREATER RAJSHAHI DISTRICT

HIERARCHY OF CENTERS ON THE BASIS OF DAILY TRAF-  
FIC FLOW

## LEGEND

- FIRST ORDER CENTRE (MOST ACCESSIBLE)
- SECOND ORDER CENTRE (HIGH ACCESSIBLE)
- THIRD ORDER CENTRE (MEDIUM ACCESSIBLE)
- FOURTH ORDER CENTRE (LOW ACCESSIBLE)
- FIFTH ORDER CENTRE (VERY LOW ACCESSIBLE)



MAP. 6-1



**Table 6.3**  
**Hierarchic order of the urban center on the Basis of Daily Traffic flow:-**

Hierarchic order	Accessibility	Traffic Flow	No of center	Name of the center.
First order center	Most Accessible	$P = >20,000$ $g = >2,000$ $v = >500$	1	Rajshahi
Second order Center	High accessible	$p = 10,000-20,000$ $g = 1,000-2000$ $v = 250-500$	3	Natore and Nawabgonj
Third order center	Moderate Accessible	$p = 5,000-10,000$ $g = 250-500$ $v = 125-250$	11	Bagmara, Baneswar, Charghat, Godagari, Mohda, Mohadebpur, Mohanpur, Patnitala, Puthia, Shibgonj, Singra.
Fourth order center	Low Accessible	$p = 2500-5,000$ $g = 250-500$ $v = 50-125$	20	Ahmedpur, Amnura, Atrai, Badalgachi, Bagatipara, Bagha, Banpara, Baraigram, Bholahat, Dhamoirhat, Durgapur, Gomastapur, Gurudaspur, Lalpur, Nachole, Niamatpur, Porsha, Raninagar, Sapahar, Tahore.
Fifth order center	Very low Accessible	$p = < 2500$ $g = < 125$ $v = < 50$	2	Sampur and Walia

Source: Author's own calculation on the basis of primary data.



### 6.3. Nodal Accessibility

Another important attributes to determine the urban hierarchy is nodal accessibility. Nodal accessibility depends on route network and relative distances (travel cost and time). Specially the mode of transportation, physical characteristics of route network play more vital role than actual distances (Taha, 1987). Such as the node which is easy access from all place is more accessible.

The place which has a high level of connectivity is more accessible than that of low level of connectivity place. For example Natore and Nawabgonj are more accessible to Rajshahi than Naogaon because of the distance and physical barrier of the river Atari. On the other hand Nawabgonj is closer to Rajshahi (in respect of travel cost and time) than its own surrounding thanas- Bhaolahat and Nachole because of the bad condition of road only. thus it may be said that the accessibility depends upon various factors. Accessibility in this study can be measured topologically in the following three ways:-

- a) Direct linkage or connectivity.
- b) Associated Number or Konig Number.
- c) Shortest path matrix.

#### 6.3.1. Direct Linkage or Connectivity.

The most primitive measurement of accessibility is obtained directly from the connectivity matrix. A summation of individual rows of the matrix produces a column or vector of values. Each row sum equals the total number of direct linkage from a given center to the set of all other center in the network and as defined as the degree of node. The higher the value of individual node the greater is its accessibility to all other center (Taaffe and Gauthier Jr, 1973). Table 6.4 shows the connectivity matrix which has been directly prepared on the basis of direct road linkage between 37 nodes of the study area and they may be classified into four hierarchic order in table 6.5.

Table 6.5 shows that there are 6 nodes with four route which are considered as the first hierarchic order or most accessible center in the study area. Nine centers are in second order, 13 are in third order or two route node and 9 are in fourth order or low accessible center which are low accessible in the study area. It has been observed from the connectivity matrix (table 6.4) and table 6.5 that more important and less important centers are considered as same group because of direct linkage or connectivity only. For example the most important center Rajshahi and the least important centers Sampur, Walia etc. regarded as same accessible group two. Because they are all three route node or they have direct linkage with three centers. On the other hand Banerwar, Gomastapur, Mohanpur, and Patnitala, these four less important centers regarded as the first hierarchic order or most accessible node of the study area in terms of direct linkage with four centers. But in real world the picture will not be the same as discussed above. For this reason it may be said that this method is not completely appropriate for measuring the accessibility of the study area.







**Table-6.5**  
**Classification of Urban center on the Basis of Direct linkage:-**

Hierarchic order	Accessibility	Number of direct linkage	Number of nodes	Percentage %
1	Most Accessible	4	6	16.22
2	High Accessible	3	9	24.32
3	Moderate Accessible	2	13	35.14
4	low Accessible	1	9	24.32
Total			37	100%

Source:-Calculated on the basis of connectivity matrix.

### 6.3.2. Associated or Konig Number

Associated or Konig number is an another important indicator to measure the accessibility of nodes. Associated number means the number of areas needed to connect a node to the most distant node from it (Robinson and Bamford,1978). Polish mathematician Konig(1936) first time measured the accessibility by this method and is known as koning number (Taha,1987). The higher the associated number represents lower the accessibility and the lower the associated number represents the higher accessibility. On the basis of associated number the nodes of the study area are classified into seven hierarchic order which are shown in table 6.6.

Table 6.6 shows that Baneswar , and Mahanpur are considered as the mast accessible node in the study area with associated number of 5, where as Bagmara, Durgapur, Puthia and Rajshahi are regarded as second hierarchic orderode with associated number of 6.Godagari, Naogaon,Natore and Sanpur are as third hierarchic order node with associated number of 7. On the other hand Sapahar and Walia are regarded as the least accessible node with associated number of 11 i.e. these two centers needed 11 routes to reached the most distant points (Last column of connectivity matrix of table 6.4 and map 6.2).



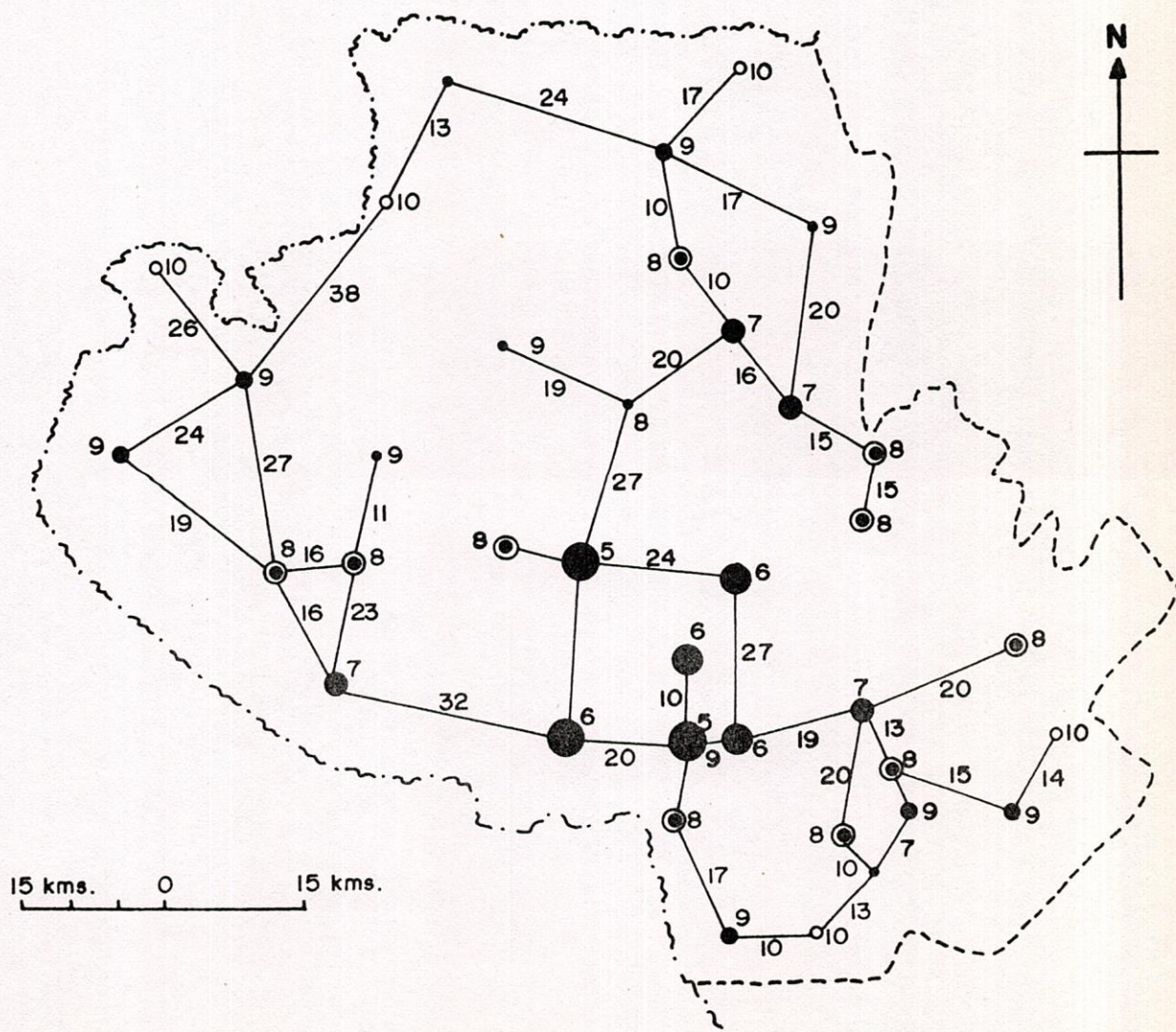
# GREATER RAJSHAHI DISTRICT

## URBAN HIERARCHY ON THE BASIS OF ASSOCIATED OR KONIG NUMBER.

### LEGEND

● ● ● ● ● Hierarchy of centers from higher to lowest.

1---37 The numerical number beside the nodes represent the Associated on konig number of that node and the numerical number beside the route represent the length of that edge in kms.





**Table 6.6**  
**Hierarchy of Urban center on the basis of associated or Konig number**

Hierarchic order	Associated number	Number of node	Name of rode
1	5	2	Baneswar, Mohanpur
2	6	4	Bagmara, Durgapur, Puthia and Rajshahi
3	7	4	Godagari, Naogaon, Natore and Sampur
4	8	11	Ahmedpur, Amnura, Atrai, Bagatipara, Charghat, Manda, Mohadebpur, Nawabgonj, Raninagar, Singra, Tanore
5	9	9	Badalgachi, Bagha, Bampana, Barigram, Gamastapur, Nachole, Niamatpur, Patnitala, Shibgonj
6	10	5	Bholahat, Dhamoirhat, Gurudaspur, Lalpur, Porsha
7	11	2	Sapahar and Walia

Source: Authors own calculation on the basis of connectivity matrix (table 6.4).

This system to measure the accessibility is more accurate than the system of direct connectivity. But it has some limitations also. Such as the nodes within the same hierarchic order are not similar in status. For example Baneswar and Mohanpur are less important than Naogaon, Natore, Nawabgonj and Rajshahi in considering different aspects. But these two centers are regarded as the first hierarchic order or most accessible node because of their central location only. They have needed only 5 route to reached the most distant pair. Again the most important center Rajshahi is considered as the second hierarchic order with less important centers of Bagmara, Durgapur, and Puthia which needed 6 routes to reached their most distant pairs. Thus it can be said that the measurement of accessibility by this method is not completely accurate.

### 6.3.3. Shortest Path Matrix

Shortest path means the number of arcs used in the shortest path between all possible pairs of nodes. It is more accurate way to measure the accessibility of node than previous two methods. It indicates the number of arcs needed to conned any node with all other nodes in the network by



# TABLE-6.7 SHORTEST PATH MATRIX (Number of Routes)

Node	Code	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Total Rank		
Ahmedpur	01	●	6	10	9	2	4	3	3	1	1	8	4	10	4	5	7	2	3	6	8	5	7	8	1	6	7	9	8	2	4	9	7	9	7	2	6	2	195	24	
Amnura	02	6	●	9	7	6	5	4	3	7	7	3	4	6	4	1	2	8	6	4	6	3	1	6	6	1	5	5	3	4	2	7	5	4	2	6	4	7	168	14	
Atrai	03	10	9	●	3	10	9	6	7	11	11	8	8	5	8	7	7	12	10	4	3	5	9	2	9	8	5	4	6	8	6	1	3	5	8	10	6	11	255	36	
Badalgachi	04	9	7	3	●	9	8	5	6	10	10	5	7	2	7	6	4	11	9	3	2	4	7	1	8	5	4	1	3	6	5	2	2	2	5	8	5	10	201	27	
Bagatipara	05	2	6	10	9	●	3	3	3	2	8	8	4	9	4	5	7	4	2	5	7	4	7	8	1	6	6	8	2	4	9	6	9	7	2	5	1	189	22		
Bagha	06	4	5	9	8	3	●	4	2	3	5	7	1	9	3	4	6	6	1	5	7	4	6	7	4	5	6	8	7	3	3	8	6	9	6	5	5	2	186	20	
Bagmara	07	3	4	6	5	3	4	●	2	4	4	6	3	6	3	3	5	5	2	4	1	5	4	2	4	3	5	6	1	2	5	3	6	5	3	2	5	159	8		
Baneshwer	08	3	3	7	6	3	2	2	●	4	4	5	1	7	1	2	4	5	3	3	5	2	4	5	2	3	4	6	5	1	1	6	4	6	4	3	3	4	131	2	
Banpara	09	1	7	11	10	2	3	4	9	●	2	9	5	10	5	6	8	3	2	7	9	6	8	9	2	7	8	10	9	3	5	10	8	10	8	3	7	3	217	33	
Baraigram	10	1	7	11	10	3	5	4	4	2	●	9	5	10	5	6	8	1	4	7	9	6	8	9	2	7	8	10	9	3	5	10	8	10	8	3	7	3	217	33	
Bholahat	11	8	3	8	5	8	7	6	5	9	9	●	6	5	6	3	1	10	8	6	5	5	4	6	5	4	7	2	4	2	6	4	7	6	3	2	8	6	9	206	30
Charghat	12	4	4	8	7	4	1	3	1	5	5	6	●	8	2	3	5	6	2	4	6	3	5	6	3	4	5	7	6	2	2	7	5	7	5	4	4	3	169	9	
Dhamoirhat	13	10	6	5	2	9	9	6	7	10	10	5	8	●	8	6	4	11	10	4	2	5	7	3	9	5	5	1	3	8	6	4	3	2	5	10	6	11	225	35	
Durgapur	14	4	4	8	7	4	3	3	1	5	5	6	2	8	●	3	5	6	4	4	6	3	5	6	3	4	5	7	6	2	2	7	5	1	5	4	4	5	168	14	
Godagari	15	5	1	7	6	5	4	3	2	6	6	3	3	6	3	●	2	7	5	3	5	2	2	5	4	1	4	6	3	3	1	6	4	4	2	5	3	6	143	4	
Gomastapur	16	7	2	7	4	7	6	5	4	8	8	1	5	4	5	2	●	9	7	5	4	4	3	5	6	1	6	3	1	5	3	6	5	2	1	7	5	8	166	13	
Guruduspur	17	2	8	12	11	4	6	5	5	3	1	10	6	11	6	7	9	●	5	8	10	7	9	10	3	8	9	11	10	4	6	11	9	11	9	4	8	4	262	37	
Laipur	18	3	6	10	9	2	1	5	3	2	4	8	2	10	4	5	7	5	●	6	8	5	7	8	3	6	7	9	8	4	4	9	7	9	7	4	6	1	206	28	
Manda	19	6	4	4	3	5	5	2	3	7	7	6	4	4	4	3	5	8	6	●	2	1	5	2	5	4	1	3	5	4	2	3	1	4	5	6	2	6	147	6	
Mahadeppur	20	8	6	3	2	7	7	4	5	9	9	5	6	2	6	5	4	10	8	2	●	3	7	2	6	5	3	1	3	5	4	3	1	2	5	7	4	8	176	16	
Mohanpur	21	5	3	5	4	4	1	2	6	6	5	3	5	3	2	4	7	5	1	3	●	4	3	4	3	2	4	5	3	1	4	2	5	4	5	1	5	135	3		
Nachole	22	7	1	9	7	7	6	5	4	8	8	4	5	7	5	2	3	9	7	5	7	4	●	8	6	2	7	6	4	5	3	9	7	5	3	7	5	8	205	29	
Naogaon	23	8	6	2	1	8	7	4	5	9	9	6	6	3	6	5	5	10	8	2	2	3	8	●	6	6	3	2	4	4	5	4	1	1	3	6	7	4	8	183	19
Natore	24	1	5	9	8	1	4	2	2	2	2	7	3	9	3	4	6	3	3	5	6	4	6	6	●	5	5	7	7	1	3	7	6	8	6	1	4	2	163	12	
Nawabganj	25	6	1	8	5	6	5	4	3	7	7	2	4	5	4	1	1	8	6	4	5	3	2	6	5	●	5	4	2	4	2	7	5	3	1	6	4	7	158	7	
Niamatpur	26	7	5	5	4	6	6	3	4	8	8	7	5	5	5	4	6	9	7	1	3	2	7	3	5	5	●	4	6	4	3	4	2	5	6	6	2	7	179	17	
Patnitala	27	9	5	4	1	8	8	5	6	10	10	4	7	1	7	6	3	11	9	3	1	4	6	2	7	4	4	●	2	6	5	3	2	1	4	8	5	9	194	23	
Porsha	28	8	3	6	3	8	7	6	5	9	9	2	6	3	6	3	1	10	8	5	3	5	4	7	2	6	2	●	6	4	5	4	1	2	8	6	9	186	20		
Puthia	29	2	4	8	6	2	3	1	1	3	3	6	2	8	2	3	5	4	4	4	5	3	5	5	1	4	4	6	6	●	2	6	4	7	5	2	3	3	144	5	
Rajshahi	30	4	2	6	5	4	3	2	1	5	5	4	2	6	2	1	3	6	4	2	4	1	3	4	3	2	3	5	4	2	●	5	3	5	3	4	2	5	125	1	
Raninagar	31	9	7	1	2	9	8	5	6	10	10	7	7	4	7	6	6	11	9	3	3	4	9	1	7	7	4	3	5	6	5	●	2	4	7	8	5	9	216	32	
Sampur	32	7	5	3	2	6	6	3	4	8	8	6	5	3	5	4	5	9	7	1	1	2	7	1	6	5	2	2	4	4	3	2	●	3	6	6	3	7	161	10	
Sapahar	33	9	4	5	2	9	9	6	6	10	10	3	7	2	7	4	2	11	9	4	2	5	5	3	8	3	5	1	1	7	5	4	3	●	3	9	6	10	199	26	
Shibgonj	34	7	2	8	5	7	6	5	4	8	8	2	5	5	5	2	1	9	7	5	5	4	3	6	6	1	6	4	2	5	3	7	6	3	●	7	5	8	182	18	
Singra	35	2	6	10	8	2	5	3	3	3	3	8	4	10	4	5	7	4	4	6	7	5	7	7	1	6	6	8	2	4	8	6	9	7	●	5	3	196	25		
Tanore	36	6	4	6	5	5	5	2	3	7	7	6	4	6	4	3	5	8	6	2	4	1	5	4	4	4	2	5	6	3	2	5	3	6	5	5	●	6	162	11	
Walia	37	2	7	11	10	1	2	5	4	1	3	9	3	11	5	6	8	4	1	6	8	5	8	8	2	7	7	9	9	3	5	9	7	10	8	3	6	●	212	31	



**TABLE-6.8 INTER NODE ROAD DISTANCES (in distance)**



shortest path. It is known as shimbil index which indicates the smaller the numerical value of a node to the network. By using shimbil index Rajshahi considered as the most accessible center with a value of 125 and Banes was as the second accessible center with the value of 131. Where as Gurudaspur is regarded as the least accessible center with the value of 262. Which represent that Gurudaspur needed 262 routes to connect another 36 center of the study area by shortest path. The shortest path matrix is shown in table 6.7 (fifth column of table 6.9 and appendix show the ranking of 37 nodes of the study area on the basis of shortest path matrix).

The method of shortest path matrix of measure the accessibility is more or less accurate in respect to another methods. But it has Some limitations also. Because the above method is only considered the number of edges. Since all the edges are not equal in length. So the number of edges does not refer the actual accessibility of nodes. That is why to measure the actual accessibility the shortest path matrix transferred into the valued graph ( Taaffe and Gauthier ,1973). It also follows the rule of shortest path matrix but here the topological distance is considered. By using the topological distance Rajshahi is considered as the most accessible node with the shortest path value of 2419 and Atrai regarded as the least accessible center with the value of 4622. Table 6.8 deals with the shortest path value of 37 nodes of the study are (In column 7 of table 6.9 and appendix 15 shortest path value and their ranking can be seen).

It can be analysed from the table 6.8 that three important centers like Naogaon, Nawabgonj and Natore needed 3003 km, 3284 km and 3640 km to reach another 36 centers or they may be placed in 9th, 14th and 24th rank in terms of shortest path accessibility. On the other hand some less important centers--baneswas, Mohanpur, Puthia, Charghat, Dargapur, Bagmana, Manda etc. lie above the rank of those important centers because, of their fair location only. Therefore it may be recommended that there is an inverse relationship between the accessibility of nodes to the network and the value (length of the shortest path connectivity to all other nodes).

#### 6.4. Combination of Seven Indicators

In the previous discussion different indicator for variables have been described separately. In this section the previous indicators have been combined. The ranking or hierarchic order of 37 nodes of the study area on the basis of 7 indicators are separately shown in to 6 column of table 6.9 The total and average rank of different center have also been calculated and it has shown at last two column in table 6.9.



Ranking of nodes on the basis of seven variables and their rank.

	Adminis- tration	Population		Traffic volume		Conne- ctivity Matrix		Associa- ted number		Shortest Path Matrix				Total	Aver age
		Admini- strative unit	Hie- rar- chy	Projected population 1991	Rank	Pass- enger	Hiera- rchy	Direct linkage	Hie- rar- chy	Numb- er	Hie- rar- chy	Topolo- gical length	Hiera- rchy		
01. Ahmedpur		Other	4	N.A.	29	2510	33	3	2	8	4	195	24	111	15.86
02. Annura		"	4	N.A.	29	1600	35	3	2	8	4	168	14	111	15.86
03. Alrai		Thana town	3	12647	7	3050	20	1	4	8	4	255	36	111	15.86
04. Badalgachi		"	3	7548	14	3500	16	2	3	9	5	201	27	111	15.86
05. Bagatipara		"	3	9010	15	3160	17	2	3	8	4	189	22	82	11.71
06. Bagha		"	3	N.A.	29	3060	19	2	3	9	5	186	20	92	13.14
07. Bagmara		"	3	4486	24	5050	13	2	3	6	2	159	8	60	8.571
08. Baneswar		Other	4	N.A.	29	5190	7	4	1	5	1	131	2	46	6.571
09. Bampara		"	4	N.A.	29	2540	32	2	3	9	5	222	34	126	18.00
10. Barigram		Thana town	3	3663	26	3040	21	2	3	9	5	217	33	120	17.14
11. Bholahat		"	3	1071	28	3005	22	1	4	10	6	206	30	129	18.43
12. Charchat		"	3	11948	9	5105	10	2	3	8	4	160	9	43	6.143
13. Dharnohat		"	3	5148	22	2640	28	1	4	10	6	225	35	132	18.86
14. Durgapur		"	3	4637	23	2560	31	1	4	6	2	168	14	83	11.86
15. Godagari		"	3	11371	11	5250	5	3	2	7	3	143	4	39	5.571
16. Gomastapur		"	3	11985	8	2700	23	4	1	9	5	166	13	74	10.57
17. Gurudaspur		"	3	N.A.	29	3140	18	1	4	10	6	262	37	132	18.86
18. Lalpur		"	3	11444	10	2660	26	2	3	10	6	204	28	93	13.29
19. Manda		"	3	8000	17	5040	14	3	2	8	4	147	6	54	7.714
20. Mohadebpur		"	3	8030	16	5220	6	2	3	8	4	176	16	64	9.143
21. Mohanpur		"	3	3440	27	5090	11	4	1	5	1	135	3	49	7.00
22. Nachole		"	3	6931	20	2670	25	1	4	9	5	205	29	117	16.71
23. Naogaon		Distri- ct city	2	100794	3	1745	2	3	2	7	3	183	19	55	7.857
24. Natore		"	2	36186	4	1321	4	4	1	7	3	163	12	35	5.00
25. Nawabgonj		"	2	121205	2	1425	3	4	1	8	4	158	7	33	4.714
26. Niamatpur		Thana town	3	3126	25	2620	29	1	4	9	5	179	17	105	15.00
27. Patnitala		"	3	9408	13	5070	12	4	1	9	5	194	23	77	11.00
28. Porsha		"	3	9735	12	2580	30	2	3	10	6	186	20	106	15.14
29. Puthia		"	3	7972	18	5030	15	3	2	6	2	144	5	49	7.00
30. Rajshahi		Divisi- onal city	1	299671	1	3292	1	3	2	6	2	125	1	9	1.286
31. Raninagar		Thana town	3	6078	21	2700	23	2	3	8	4	216	32	119	17.00
32. Sampur		Other	4	N.A.	29	800	36	3	2	7	3	161	10	96	13.71
33. Sapahar		Thana town	3	N.A.	29	2650	27	2	3	11	7	199	26	125	17.86
34. Shibzoni		"	3	15938	5	5150	9	2	2	9	5	182	18	68	9.714



In this section the 37 nodes of the study area have been classified into 7 hierarchic order on the basis of total and average rank. These hierarchic orders are shown in table 6.10. With the consideration of 7 indicators Rajshahi considered as the first order center which is in the highest position in respect of centrality and accessibility. Another three important centers- Godagari Natore and Nawabgonj are regarded as second order which are also very high accessible centers in the study area. It has been observed that 7 centers of third order, 8 of fourth order, 4 centers of fifth and seven order and 10 centers of 6th order are considered as low accessible centers. There hierarchic order are represented in table 6.10 and map 6.3.

**Table -6.10**  
**Classification of urban center on the Basis of the combination as seven Indicator.**

Hierarchic order	Accessibility and centrality	Rang of rank	Number of node	Name of node
1	Most accessible	1-3.00	1	Rajshahi
2	Very High Accessible	3.01-6.00	3	Godagari, Natore, Nawabgonj
3	High Accessible	6.01-9.00	7	Bagmana, Baneswar, Charghat, Manda, Monanpur, Naogaon and Puthia.
4	Medium Accessible	9.01-12.030	8	Bagatipara, Durgapur, Gomastapur, Mohadebpur, Patnitala, Shibgonj, Singnaand Tanore.
5	Moderate Accessible	12.01-15.00	4	Bagha, Lalpur, Niamatpur, Sampur
6	Low Accessible	15.01-18.00	10	Ahmedpur, Amnura, Atrai, Badalgachi, Bampana, Baraigram, Nachole, Porsha, Raninagar, and Sapahar.
7	Very Low Accessible	18.01-21	4	Bnolahat, Dhamoirhat, Guruduspur and Walia.
Total			37	Greater Rajshahi District.

Source: Authors own calculation on the basis of table 6.9.



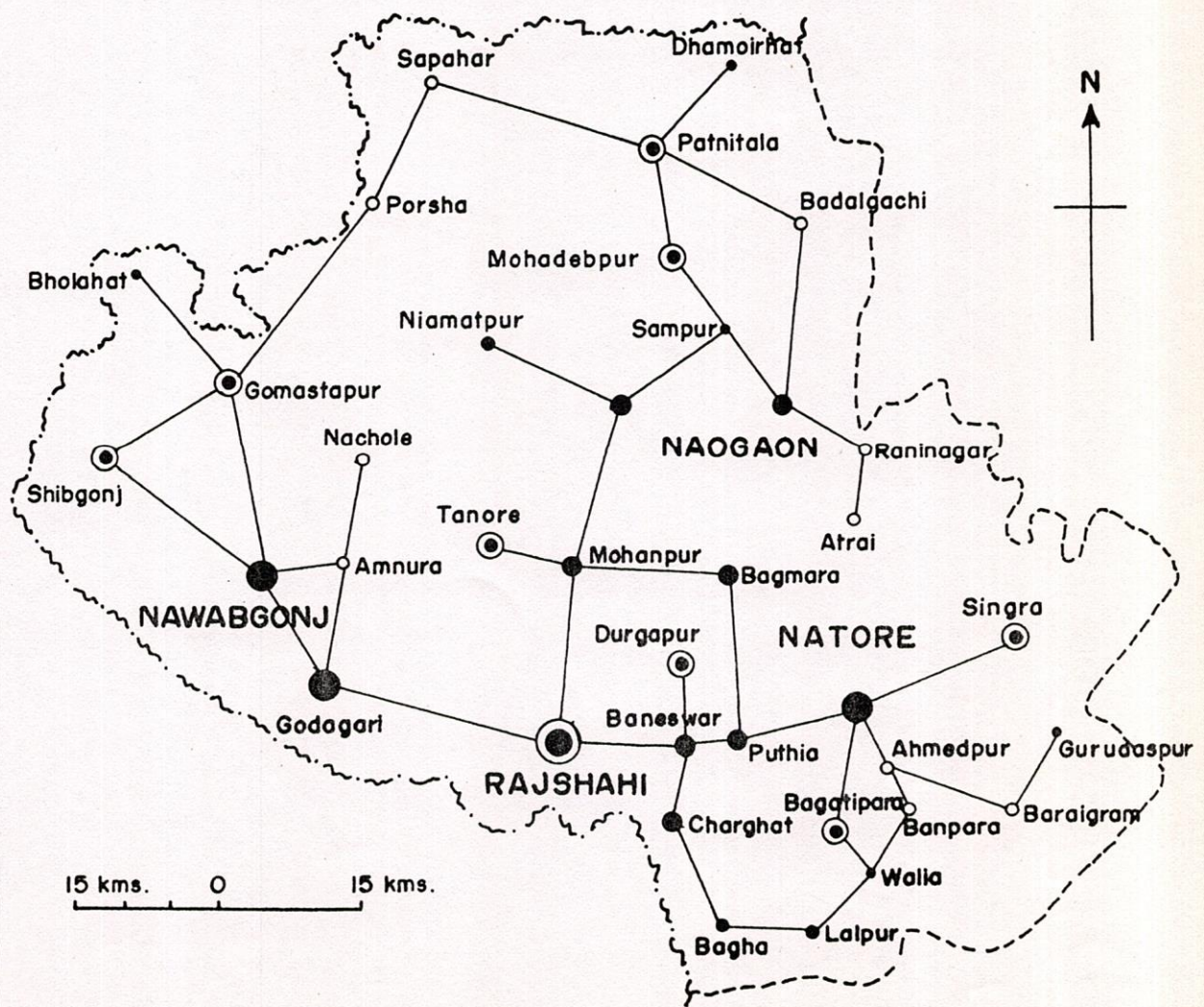
# GREATER RAJSHAHI DISTRICT

## HIERARCHY OF URBAN CENTERS

(On the Basis of Seven Indicator)

### L E G E N D

- FIRST ORDER CENTRE (MOST ACCESSIBLE)
- SECOND ORDER CENTRE (VERY HIGH ACCESSIBLE)
- THIRD ORDER CENTRE (HIGH ACCESSIBLE)
- ⊙ FOURTH ORDER CENTRE (MEDIUM ACCESSIBLE)
- FIFTH ORDER CENTRE (ACCESSIBLE)
- SIXTH ORDER CENTRE (LOW ACCESSIBLE)
- SEVENTH ORDER CENTRE (VERY LOW ACCESSIBLE)





The classification of urban centers with the consideration of seven indicators is more or less accurate. For example in this method Rajshahi regarded as the center of first hierarchy order which is actually the biggest and the most accessible center with the highest centrality. Again the seven order centers Bholahat, Guradaspur, Dharmoirnat and Walia are identified as very low accessible center with low centrality. In reality the seventh order centers Bholahat and Guradaspur are identified as the most distant pair in network ( the diameter index of chapter five) of the study area.

But the system of ranking of city by this method does not seems to be accurate and some limitations was observed. For example Naogaon is more important than Godagri in terms of area, population, administrative, traffic volumes, and all other social and economic activities. But godagari is regarded as second hierarchic order and Naogaon is regarded as third hierarchic order center like other low status centers Bagmara, Banwswar, Charchat, Manda, Pathia, etc.

Though there are some limitations in ranking of cities with help of the combination of seven indicators for the purpose of classification, this technique may be applied in many studies of this type. However the centers of low status are regarded as higher hierarchic order, only for their connectivity or locational facilities. So it may be said that this classification has a similarity to real field. Map 6.3 shows the hierarchic order of cities.

### **6.5. Spacing or Locational Arrangement or Spatial Distribution of Nodes.**

Different Urban centers or settlements are arranged over the earth surface in different way. The settlements are distributed in clustered, Uniform, random, scattered etc. forms. Many geographers have classified the distributional pattern of settlement into the following three categories:-

- 1) Clustered
- 11) Random
- 111) Regular or Uniform.

The plant ecologist and geographer Clark and Evens (1954) first developed a spacing index to measure the spatial distributional pattern by comparing the observed pattern of settlement in an area with a theoretical random distribution (Haggett, 1979). This technique is known as nearest neighbor technique or index which is determined by the comparison of observed spacing to a expected spacing. The nature of distributional pattern has been determined by the value of  $R_n$ , which is written as:-



$$R_n = \frac{d_o}{d_e}$$

Here,  $R_n$  = Value of nearest neighbor index.

$d_o$  = average observed distance between each nearest neighbor points.

$d_e$  = expected average distance

$$\text{Again } d_o = \frac{d}{n} \text{ and } d_e = \frac{1}{2} \frac{N}{A}$$

Here also,

$d$  = Sum of the distance between each node to its neighbor

$N$  = Number of node

$A$  = Area, where all other roads are distributed.

King (1962) suggested that the value of  $R_n$  ranges between zero to 2.17. The  $R_n$  value zero means all the points are clustered in one location,  $R_n$  value of one represents a random distribution and up to 2.15 for a uniform triangular lattice (Haggett et. al, 1977).

Table 6.11 shows pairs of nearest neighbor points and their topological distances. To get the nearest neighbor index firstly determines the nearest neighbor points of each node then if measure

the topological distance between each nearest neighbor pairs. Average observed distance ( $d_o$ ) has been calculated by dividing the sum of observed distance by the number of roads. In topological map of this study the sum of observed distance is 48.55 cm or 470.45 km. Therefore the average observed distance calculated by the following formula of:-

$$d_o = \frac{d}{n} = \frac{48.55}{37} = 1.31 \text{ cm or } \frac{470.45}{37} = 12.71 \text{ km}$$

Here the average observed distance ( $d_o$ ) is 1.31 cm or 12.71 km.

Again the expected average distance calculated as :-

$$d_e = \frac{1}{2} \frac{N}{A}$$

$N$  = number of node = 37

$A$  = area is 9456 km

$$\text{Therefore, } d_e = \frac{1}{2} \frac{37}{9456}$$

$$\text{or } = \frac{1}{2} \times \frac{1}{0.06} = \frac{1}{0.125} = 8 \text{ km}$$



**Table 6.11**  
**The measure the nearest neighbor Index**

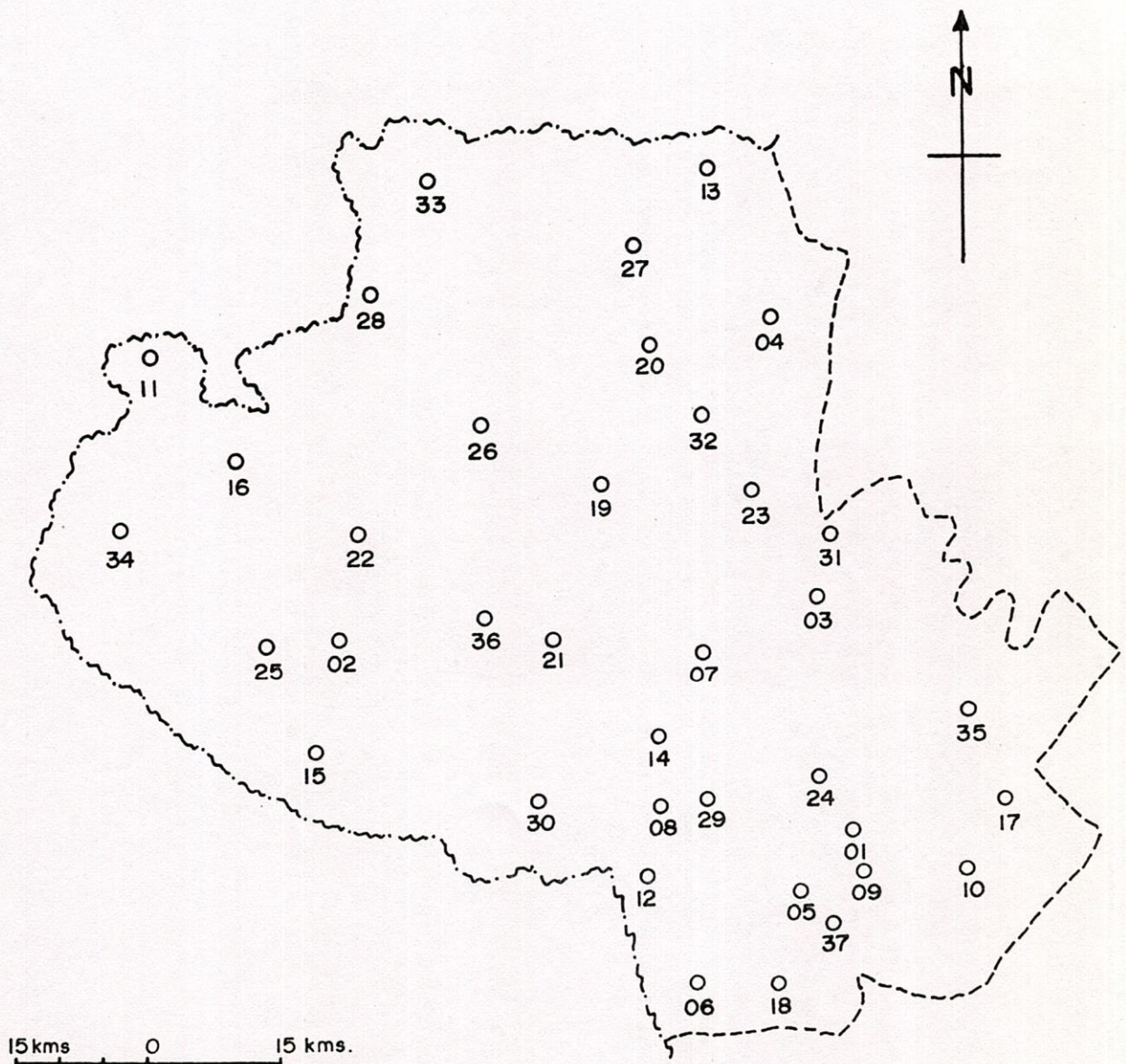
Code number	Nearest neighbor point.	Observed straightline distance between each nearest neighbor point.	
		Distance in cm.	Distance in km.
01	09	0.70	6.78
02	25	1.20	11.63
03	31	1.00	9.69
04	20	1.80	17.44
05	37	0.70	6.78
06	12	1.30	12.60
07	14	1.50	14.54
08	24	0.75	7.27
09	01	0.70	6.78
10	17	1.309	12.60
11	16	2.00	19.38
12	08	1.00	9.69
23	27	1.50	14.54
14	08	1.15	11.14
15	25	1.70	16.47
16	34	1.90	18.41
17	10	1.30	12.60
18	37	1.15	11.14
19	32	1.80	17.44
20	32	1.25	12.11
21	36	1.10	10.66
22	02	1.10	14.54
23	31	1.25	12.11
24	01	0.90	8.72
25	02	1.20	11.63
26	19	1.90	18.41
27	20	1.50	14.54
28	33	1.80	17.44
29	08	0.75	7.27
30	08	1.70	16.47
31	03	1.00	9.69
32	20	1.25	12.11
33	28	1.80	17.44
34	16	1.90	18.41
35	17	1.50	14.54
36	21	1.10	10.66
37	05	1.10	6.78
Total		48.55	470.45

Source: Author's own measurment.



# GREATER RAJSHAHI DISTRICT

## THE MEASUREMENT OF THE MEAREST-NEIGHBOR INDEX



MAP 6.4



$$d_o = \frac{d}{n} = \frac{48.55}{37} = 1.31 \text{ cm} \quad \text{or} \quad \frac{470.45}{37} = 12.71 \text{ km}$$

$$d_e = \frac{1}{2} \frac{N}{A} = \frac{1}{2} \frac{1}{37/4956} = \frac{1}{2 \times 0.06} = \frac{1}{0.125} = 8$$

$$R_n = \frac{d_o}{d_e} = \frac{12.71}{8} = 1.58$$

Lastly the nearest neighbor index or  $R_n$  value calculated with the comparison of observed distance ( $d_o$ ) to expected distance ( $d_e$ ). Therefore the nearest neighbor index estimated as 1.58

In this study the  $R_n$  value (1.58) is not very close to 10 (random distribution) or 2.15 (uniform distribution) but lies between the middle point of these two type of distribution. The value of  $R_n$  does not signify any distributional pattern. So it may be said that the distributional pattern of the nodes of the study area is not absolutely random or regular. But a mixture of these two type of distribution or an irregular pattern of distribution has been observed in the study area. If there is no obstacle, the pattern would be regular or uniform. But the influence of social, political, economic and physical factors greatly contributed to the distributional pattern. That is why the formation of regular pattern is rare.

## 6.6. Comparison of the urban hierarchy to Christaller's model

The founder of hierarchy concept, a German locational theorist Walter Christaller (1933) developed his theoretical system to include various levels or orders of central places. His concept of urban hierarchy is known as central place system. In this concept he computed the population of these centers, their distance apart, size and population of their complementary areas in accordance with his hexagonal theory (Murphy-1966).

Walter Christaller postulated seven levels of urban hierarchy from the lowest to the highest or from the market hamlet to the capital city or megalopolis. According to Christaller's  $k=3$  model the number of central places follow a norm from the largest to the smallest in the following sequence of 1, 3, 9, 27, 81, 243, 729 etc. According to his hexagonal theory a higher order center serves its own service area plus one third portion of each of its nearest neighbor centers and the service area of different order center will remain hexagon in shape. The size and population of tributary areas also increase in accordance with his hexagonal theory by ranking order of  $k=3$ . Christaller suggested that the distance between the similar status centers also equal but it increases by 3 times over the preceding smaller category.



In the present study the author tried to compare her observation (in section 6.5 of this chapter the nodes of the study area classified into seven hierarchic order to Christaller  $k=3$  model. Table 6.3 shows this comparison.

**Table - 6.12**  
**Comparison of the urban hierarchy of the study area to Christaller  $k=3$  model**

Hierarchic order (lowest to highest)	Number of expected ¹	Nodes observed ²	Population expected ¹	Observed	Distance ² apart (3)
7	729	4	1,000	2805	4.00
6	243	10	3,000	4052	6.90
5	81	4	9,000	5642	12.00
4	27	8	27,000	10509	20.70
3	9	7	81,000	19526	36.00
2	3	3	243,000	56254	62.10
1	1	1	729,000	299671	108.00

Source: 1. Expected: P.Haggett (1979): Geography: A Modern synthesis, Harper and Row publishers. Newyork.p.364

2. Observed: Authors own calculation on the basis of relevant secondary data.

The table also shows the observed and expected number of nodes population and distance apart from adjacent center of similar order of seven hierarchic order. In it compare the hierarchic system of the study area to Christallers  $K=3$  model it can be seen that there is no significant relationship. Such as christaller  $K=3$  model suggested that the number of central places increase from higher to lower order in accordance to 1,3,9,27,81,243,729 etc. But in the study area the number of node does not follow the above sequence of norm 3. For example, there are one center of first hierarchy order and three are second hierarchic order. Though these two hierarchic order follow the sequence of norm but all the order of the study area does not follow it. If it completely follows the christaller  $k=3$  system the number of different hierarchic order (highest to lowest) would be 1,3,9,27,81,243, and 729 but in the study area the number of nodes were observed like 1,3,7,8,4,10, and 4 respectively. Similarly the population size and distance apart do not follow the above rule of  $K=3$ .



Again the shape, service area and spacing of roads have also no similarity with that of Christaller's model which is entirely hexagonal. For example, Christaller's central place system suggested that the distance between the similar status centers also equal but in the study area this distance is not fixed at the spacing of the centers. Such as the second hierarchic order centers Godagari, Natore and Nawabgonj are not located at similar distance apart ( Godagari is located 16 Km apart from Nawabgonj and 64 km from Natore).

Christaller's central place system also suggested that the lower order centers may be located closer than the higher order centers and it increases by 3 times over the preceding smaller category. But in the study area this norm does not exist. For example, the, seven order center. Bholahat, Gurudaspur, Dharmoirhat, and Walia are distantly situated than the next higher order centers of Bagmara, Bameswar, Charchat, Manda, Monanpur etc. That is why, from the discussion it may be said that Christaller central place system does not properly fit in the study area.

At the same time the basic idea of central place system can not be completely ignored. In fact, the population, service area etc. increase by order, though they do not follow the norm of 3. For example the largest or first hierarchic order center Rajshahi has also large service area and influence over the entire study area even the entire North bangal in general. On the other hand the lower order centers Bholahat, Gurudaspur, Sampur, Walia etc. have small population and small service area also.

The applicability of Christaller's central place system depends on the homogeneity of the region. But the study area is not a homogenous region. There are physiographic, economic and many kind of inhomogeneity in this region also. That is why the urban hierarchic pattern of the study area can not be analysed according to Christaller's  $K=3$  model. From the comparison of the hierarchic pattern of the study area to Christaller central place system, it can be seen that there are no similarity. But finally it may be said that the number of nodes, population size, distance apart do not follow the sequence of norm 3 but the urban hierarchy follow the basic idea of Christaller central place system.

In this chapter the hierarchy of different centers of the study area have been discussed. The 37 nodes of the transport network of the study area are considered here as urban center, though they are not similar status. They differ from each other in terms of area, population, social, economic and political facilities. That is why these 37 nodes are classified into seven hierarchic order on the basis of seven indicators or variables administration, population, traffic volume, direct road linkage, associated number and shortest path distance.

On the basis of those indicators Rajshahi regarded as the center of first hierarchic order or most accessible center with highest centrality. Godagari, Natore and Nawabgonj are considered as the center second hierarchic order or very high accessible center with very high centrality. Again Bholahat, Dharmoirhat, gurudaspur and walia are identified as the center of seven hierarchic order center or very low accessible center with the lowest centrality. Actually Walia identified as the least accessible center with a rank value of 19.29.



The locational pattern of 37 nodes of the study area is not entirely random or uniform. From there locational pattern it may be said that the distributional pattern of the roads of the study are is an extraordinary pattern or a mixture of those two types. Finally it may be said that the urban centers of the study area have a special characteristics and it is very difficult to analyse in the light of Christaller's central place system.



# **CHAPTER SEVEN**

## **SUMMARY AND CONCLUSION**



## Summary and Conclusion

In this study the patterns and systems as road transport of greater Rajshahi district has been analysed. Road transport system is an indispensable part of the socio-economic development of a country. The importance of road transport in the over all development of Bangladesh can not be underestimated. In this respect it may be said that road transport is a part of culture as the hallmark of civilization.

The road transport system of greater Rajshahi district is not sufficiently developed in respect to its need of the size of population and area. There are only 1400 km. of metalled road within the area of 9456 Km.² and within the population of 63,84,068 in the study area ( table 3.4 shows the total length, appendix 4 shows the density and appendix 1 shows the total population of the study area). In the study area it has been observed that there are 15Km. of road per 100 Km.² of area and only 0.02 Km. of road per 100 people. This ratio is slightly lower than the national figure( 15.58 Km/100 km.²) of Bangladesh but it is much lower than the developed countries and even many developing countries of south east Asia (16.76 Km /100 Km²)

It has been observed that roads in the study area are not of similar category and evenly distributed all over the district. Such as most of the thana connecting roads are semimetalled and single way, where heavy vehicles can move with great difficulty. Even some road remains muddy in wet season. For example Nawabgonj- Amnura, Gomastapur- Porsha are such type of roads. Road condition between Rajshahi -Natore is very good. The quality of road between Rajshahi - Nawabgonj and Natore- Bogra, and Natore- Pabna are also good. The roads of Baneswar- Charchat- Bagha, Nawabgonj-Shibgonj and Rajshahi -Naogaon are more or less good. But the quality of newly thana connecting roads (Bagha- Lalpur, Mahanpur-Bagmara, Mahanpur-Tanore, Nawabgonj -Amnura- Nachole etc.) are very bad.

It may be pointed out that the roads of the study area are not evenly distributed. The total length of metalled road in 32 urban centers is 1400 Km and the average length per center is only 43.75 Km. The length of road of 10 thanas- Boadia, Barigram, Godagari, Nawabgonj Paba and Puthia lies the above of average figure and 22 thanas lies below the average figure of the study area. Specially, the length of roads of the thanas of Atrai, Bagha, Bholahat, Dhamoirhat, Gurudaspur, Nachole, Niamatpur, Porsha, Raninagar, Sapahar, Singra and Tanore are very insufficient and the condition is also worn out

The daily traffic volumes of 37 nodes of the study area are 4,906 vehicles, 13,570 tons of goods and 1,90,500 passengers. However, frequency of traffic flow of all nodes are not equal. About two fifth part of the total traffic volumes( 35.02%of vehicles, 52.98% of goods and 41.59% of passengers) are observed in the four main nodes of Naogaon, Natore, Nawabgonj and Rajshahi of the study area. But the traffic flow of some nodes as Ahmedpur, Amrura, Atrai, Bagatipara, Bholahat, Dhamoirhat, Dungapur, Lalpur, Nachole, Niamatpur, Porsha, Raninagar, Sapahar, Singra,



Tanore, Walia etc. are not so adequate. In fact, Naogaon, Natore, Nawabgonj and Rajshahi have direct road services with 26, 20, 18 and 24 centers respectively. All the thanas of the study area have direct road service with the district head quarter. Where as there are no direct road services between the thanas until the time of survey was established.

Again the traffic flow between different edges of the study area are not also equal. The maximum traffic flow in Rajshahi- Natore road (1,248 vehicles 5,500 tons of goods and 46,190 passengers daily) and minimum in Shibgonj Gomastapur road (only 26 vehicles, 45 tons of goods and 560 passengers daily) have been noticed. So Rajshahi-Natore road is considered as the most accessible route and Shibgonj - Gomastapur road is the least accessible route in the study area. It has been observed that the frequency of traffic flows varies from year to year, season to season, month to month, week to week and day to day. Monthly and weekly variation is not so significant but the seasonal and daily variation are more remarkable.

The spatial interaction of Rajshahi city to 24 centers represents that the maximum interaction take place between the pairs of Rajshahi - Natore (60 vehicles ;190 tons of goods and 4250 passengers) Rajshahi-Naogaon (15 vehicles, 125 tons of goods and 3250 passengers) and Rajshahi- Nawabgonj (65 vehicles, 250 tons of goods and 3850 passengers). The minimum interaction has been observed between the pairs of Rajshahi-Gaibandha (daily only 80 passengers) and Rajshahi-Jessore.

If the effect of two delimiting factors of distance and population on interaction of the study area are considered it can be said that the influence of distance is much greater than population. For example the interaction between Rajshahi and the largest urban center Dhaka (33,97,187) is more or less satisfactory (daily 70 vehicles, 300tons of goods and 2,275 passenger).

But the interaction between Rajshahi and second largest city Chittagong (13,63,998) is very insignificant (only 15 vehicles, 120 tons of goods and 250 passengers daily) because of the greater distance only. Again the interactions between Rajshahi and its surrounding thanas are much greater than the interaction between Rajshahi and other big cities as Bogra, Dinajpur, Jessore, Khulna, Kustia, Rangpur etc. Thus it can be summarise that the function of population on interaction is also important. But the distance plays more dominant role on interaction than population.

Moreover it has been observed that the interaction has been fluctuated by the physical barrier also. Such as the interaction between Rajshahi and the cities of northern region (Bogra, Dinajpur, Gaibandha, Pabna, Rangpur etc) is much greater than the interaction of Rajshahi and the cities of southern regions (Jessore, Khulna, Kustia etc.) Because the southern region is separated from Rajshahi by the river of Padma and it is directly connected by intercity train from Rajshahi to Khulna. Infact the people of southern region finds it easier to travel by rail way instead of bus. On the other hand the northern district towns are not directly linked by intercity train and also moves mostly by road.



The quantitative analysis of network indices has been examined in chapter five. The result of this computed indices ( $\mu = 7$ ,  $\delta = 10$ ,  $\alpha = 0.10$ ,  $\beta = 1.16$ ,  $\gamma = 0.41$ ,  $\theta = 20.86$ ,  $\eta = 17.95$  etc.) represent the insufficiency of road transport system in the study area. Such as the alpha ( $\alpha$ )

index represents only 10% of optimum connectivity, beta index ( $\beta$ ) represents as 38.67% gamma index ( $\gamma$ ) represents as only 41% of expected network. Again the theta, eta and iota index indicate the insufficiency of road mileage, unequal distribution of traffic flow and over loading of traffic. It has been observed that the interdistrict (out side of the study area) road transport system more or less used to obey the traffic rule, but the intradistrict (within the study area) transport does not obey the traffic rule. Because, the intra- district vehicles always used to carry the load beyond the capacity by violating the traffic rule.

Urban hierarchy has been examined in chapter six. In analysing the urban hierarchy of 37 nodes of the transport network of the study area considered as urban centers though they are not similar in status. They differ from each other by population, service area, traffic volume, complementary region, centrality, connectivity, accessibility etc. Therefore the 37 nodes of the study area have been classified into seven urban hierarchic order from highest to lowest on the basis of seven indicators as population, administrative functions, traffic flows, direct linkage associated number and shortest path accessibility. with the consideration of above seven indicators, Rajshahi was determined as the first hierarchic order center which is the most accessible center with highest centrality of the study area with a rank value of 1.29. On the other hand Bholahat, (18.43), Dhamorhat (18.86), Gurudaspur (18.86) and Walia (19.29) are identified as the center of seven hierarchic order or very low accessible center with low centrality. Walia was considered as the least accessible center of the study area with a rank value of 19.29.

In order to find out the locational patterns of nodes of the study area the nearest neighbor technique has been applied successfully. The value of nearest neighbor index ( $R_n = 1.58$ ) represents that the locational pattern of nodes of the study area is not purely random or completely regular or uniform. But it may be said from the above value of  $R_n = 1.58$  that the distributional pattern of nodes of the study area is a mixture of these two types. Again if it compared to the Christaller's central place system, it can be seen that it does not completely follow the sequence of norm of  $K=3$  or can not be denied completely. So there is a less similarity to Christaller's model such as the number of nodes do not increase with the increase in order in accordance with  $K=3$ . But the population, service area and other urban facilities decrease with the increasing of rank. That is why finally it may be said that the distributional pattern doesn't completely follow the sequence of norm but they also follow the basic idea of Christaller's central place system.

Finally it may be said that the present study deals with different aspects of road transport system of the study area. From the above discussion of road transport of greater Rajshahi district the following findings have been observed:



1. Road transportation system is the chief mode of transportation of greater Rajshahi district.
2. Road length (1400 Km metalled road) is very insufficient in respect to its needs (area 9,456 Km² and population 63,82,068).
3. All these roads are not similar category and these roads are not motorable in all the season of the year.
4. Most of the thana connecting roads are single way and narrow. Some of them are semi metalled or HBB.
5. With the consideration of traffic flow, the number of vehicles are very insufficient in respect to passengers and goods.
6. The traffic flow of four main centers of Naogaon, Natore, Nawabgonj and Rajshahi is much greater (about two-fifth portion of total traffic) than the other centers of the study area.
7. Spatial interaction of Rajshahi and its adjoining 24 centers represent that maximum interaction has been taken place between Rajshahi and three main centers of Naogaon, Natore and Nawabgonj
8. It has been observed from the spatial interaction that the adjoining thanas are more related than the greater district of Bogra, Chittagong, Dinajpur, Jessore, Khulna, Kustia, Pabna, Rangpur etc. In that case the distance played more predominant role than population.
9. Network indices ( $\mu=7$ ,  $\delta=10$ ,  $\alpha=0.10$ ,  $\beta=1.16$ ,  $\gamma=20.86$ ,  $\eta=17.95$  km.) represent the inadequacy of transport system of the study area.
10. The urban hierarchy of the study area represent that the distributional pattern of nodes don't completely follow the Christallers system but they follow the basic idea of Christaller's central place system.

From the above finding which has been observed in this study it may be said that these problems are not only present in greater Rajshahi district, but in fact these traffic problems are one of the main problem of Bangladesh. However it may be said that there is no definite direction to solve these problems. That is why the author has suggested the following steps for solving the problems of the road transport of the study area.

1. To increase the road length and number of vehicles according to necessity.
2. To construct new roads and repair the old fructured roads.
3. To built new culvert over the canals and bridge over the rivers.



4. To increase the number of vehicles under the supervision of public sector.
5. To apply the proper traffic rule .
6. To increase the number of traffic police and traffic island for proper application of traffic rule.
7. To arrange the training program for the drivers.
8. To convert the single way into double way.
9. To improve the thana connecting semi metalled road into metalled road.
11. To arrange seminar or symposium for increasing the consciousness of people relating to traffic rule etc.
12. To the construction of a road efficient engineers should be employed (H. Zakir 1989)

Finally it may be said that the road transport system of greater Rajshahi district is not adequate. Where as there no denying fact that road transport system is the chief mode of transportation of this part of Bangladesh. Though there are many problems and limitations in the road transport system of this region the priority must be given in planning the network of road transport system than the other mode of transportation. Because these limitations are not a permanent feature and there is a great possibility for the development of road in respect of all other modes (air, rail and water) in this region. Finally it may be concluded that road transport system of this region has changed the economic pattern radically and the construction of bridges on Atrai river and river Mahananda at Singra and Nawabgonj have greatly increased the economic importance of the study area. In this respect it may be further pointed out that the construction of Manda bridge on Atrai river will be add a new chapter for the economic emancipation of the entire greater Rajshahi district.

Lastly, it may be recommended that the road transport system regarded as the chief mode of transportation of the study area and all kinds of development depends on the road transport system. Therefore, road transport system may be regarded as the precondition of the socio-economic development of greater Rajshahi district.



## **APPENDIX**



## Appendix - 1

### Density of population (1991)

Upazila/Thana	Area ¹ Sq Kms	Population ²	Density ³ Persons per Sq. Kms
Atrai	286	1,65,085	616
Badalgachi	211	1,93,984	919
Dhamoirhat	301	1,48,439	493
Manda	410	2,96,118	722
Mohadebpur	395	2,36,251	598
Naogaon	273	3,09,474	1134
Niamatpur	449	1,81,142	403
Patnitala	379	1,82,829	482
Porsha	253	96,120	380
Raninagar	256	1,47,750	577
Sapahar	245	1,01,166	513
Naogaon Zila	3458	20,58,358	595
Bagatipara	138	1,05,552	765
Baraigram	300	2,07,407	691
Gurudaspur	200	1,65,187	825
Lalpur	296	2,13,633	722
Natore	401	3,31,415	826
Singra	529	2,73,142	516
Natore Zila	1864	12,96,236	695
Bholahat	123	67,021	545
Gomastapur	352	1,89,058	537
Nachole	284	92,001	324
Nawabgonj	416	3,87,697	932
Shibgonj	496	4,10,763	828
Nawabgonj	1671	11,46,540	686
Bagna	181	1,52,710	844
Bagmara	365	2,87,432	787
Boalia	93	3,08,901	3322
Chargnat	166	1,63,526	985
Durgapur	195	1,36,087	698
Godagari	476	2,10,823	443
Mahanpur	163	1,22,790	753
Paba	334	2,08,935	623
Puthia	195	1,55,081	795
Tanore	295	1,37,349	466
Rajshahi Zila	2463	18,82,934	764
Greater Rajshahi District	9456	63,84,086	675
Bangladesh	1,44,000	10,79,92,940	750
Region as % of BD	6.6	5.91	-

Source: 1. GOB. Bangladesh Population Census 1981 District Rajshahi.

2. Thana Population is a projected figure of 1991. The author calculate the project population on the basis of district population of preliminary report 1991 by applying growth rate over 1981.

3. Author's own calculation by formula of  $d = \frac{P}{A}$



## Appendix-2

### Category wise road under RHD division-1990

Category	Route	Length(in km)	Total
1. National Highway	a) Rajshahi- Natore- Muladuli-Dasura	84	84
2. Regional Highway	a) Natore-Bogra b) Rajshahi-Nawabgomj c) Santahar-Naogaon-Maahadebpur	32 48 29	109
3. Feeder Roads	a) Rajshahi Greater Road b) Rajshahi Station Road c) Baneswar-Sardah-charghat d) Nawabgonj-Kasat e) Kansat-Gomostapur-Porsha f) Rajshahi-Naohatta-Nahadepur g) Natore-Barpara-Dayarampur h) Nawabgonj-Shibgonj i) Shibgonj-Monakusa j) Mahadepu-Patnitala-Dhamoirhat k) Mohadepur-Naolatfa-Rajshahi l) Patritala-Saparhar-Khanjanur m) Nagaon-Badalgachi-Patnitala n) Gomastapur-Porsha	4.20 2.40 11.00 24.50 45.00 32.00 12.00 19.00 11.00 31.00 35.00 24.00 37.004 24.00	312
4. Thana Connecting Road	a) Mahanpur-Tanore b) Nawabgonj-Arnura-Nachole c) Nawabgonj-Gomastapur d) Rahnpur-Bholahat e) Puthia-Taherpur-Bagmara f) Shibpur-Durgapur g) Chargat-Bagha h) Sardah-Charghat-Lalpur-Iswardi i) Ahmedpur-Baraigram-Gurudaspur j) Gurgaspur-Taras k) Banpara-Gopalpur-Lalpur l) Mahanpur-Bagmara-Bhabanigonj m) Manda-Niamatpur n) Naogaon-Rajshahi-Hitai o) Joypurhat-Akkelpur-Badalgachi p) Joipurhat-Dhamoirhat q) Sapahar-Porsha-Khanjanpur	13.00 27.00 27.00 26.00 27.00 10.00 17.00 23.00 29.00 10.00 20.00 24.00 19.00 30.00 13.00 13.00 11.00	339
Total		844	844

Source: GOB. Yearly Report of RHD Road Division 1989-90, Ministry of Planning. P.41.



## Appendix - 3

**District and thana wise distribution metalled and non-metalled road(in Kms).**

NO.	Thana	Metalled ¹ (km) (June-1990)	Non-Metalled ² (km) (1985)	Total (km)
01.	Atrai	15	80	90
02.	Badalgachi	25	141	166
03.	Dhamoirhat	23	168	191
04.	Manda	48	320	368
05.	Mohadebpur	44	488	532
06.	Naogaon	100	659	729
07.	Niamatpur	13	600	613
08.	Patritala	42	528	570
09.	Porsha	25	384	409
10.	Romiragar	15	362	372
11.	Sapahar	18	352	370
Naogaon District		338	4082	4420
01.	Bagatipura	25	256	280
02.	Baraigram	65	200	265
03.	Gurudaspur	15	155	170
04.	Lalpur	60	271	331
05.	Natore	95	445	547
06.	Singra	35	341	371
Natore District		302	1668	1963
01.	Bholahat	18	64	82
02.	Gomastapur	51	258	336
03.	Nachole	16	272	288
04.	Nawabgonj	108	520	628
05.	Shibgonj	40	544	576
Nawabgonj District		233	1685	1918
01.	Bagha	25	277	302
02.	Bagmara	36	365	395
03.	Boalia	190	195	385
04.	Charghat	40	248	288
05.	Duurgapur	15	274	289
06.	Godagari	57	600	657
07.	Mohanpur	25	459	484
08.	Paba	76	771	847
09.	Putuia	52	184	236
10	Tanore	12	579	587
Rajshahi District		527	3952	4479
Greater Rajshahi District		1400	11387	12787

Source: 1. Statistical Division of Thana Parishad (ex-Upazila parishad).

2. GOB. District Statistics, Rajshahi, BBS, 1987, P.131.



## Appendix--4

### Road Density (Km/Sq.Km)- 1991

Code No.	Thana	Length(Km) ¹	Area(Sq.Km) ²	Density ³ (Km/Sq.Km)
01.	Atrai	15	286	0.055
02.	Badalgachi	25	211	0.120
03.	Dhamoirhat	23	301	0.08
04.	Manda	48	410	0.12
05.	Mahadegpur	44	395	0.11
06.	Naogaon	70	273	0.26
07.	Niamatpur	13	449	0.03
08.	Patnitala	42	379	0.11
09.	Porsha	25	253	0.10
10.	Raninagar	15	256	0.06
11.	Sapahar	18	245	0.07
Naogaon District		338	3458	0.10
01.	Bagatipara	24	138	0.17
02.	Baraigram	65	300	0.22
03.	Gurudaspur	16	200	0.08
04.	Lalpur	60	296	0.20
05.	Natore	102	401	0.25
06.	Singra	35	529	0.07
Natore District		302	1864	0.15
01.	Bholahat	18	123	0.15
02.	Gomastapur	51	352	0.14
03.	Nachole	16	284	0.06
04.	Nawabgonj	108	416	0.26
05.	Shibgonj	40	496	0.08
Nawabgonj District		233	1671	0.13
01.	Bagha	25	181	0.14
02.	Bagmara	33	365	0.09
03.	Boalia	190	92	2.06
04.	Charghat	40	166	0.24
05.	Durgapus	15	195	0.08
06.	Godagari	57	476	0.12
07.	Mahanpur	25	163	0.15
08.	Paba	76	335	0.23
09.	Puthia	52	195	0.27
10.	Tanore	12	295	0.04
Rajshahi District		527	2463	0.21
Greater Rajshahi District		14003	9456	0.14

Source: 1. Different Thana Statistical offices.

2. Government of the people's Republic of Bangladesh: Population Census 1981, District Rajshahi.

3. Author's own calculation on the basis of source 1 and 2.



## Appendix -5

### Relationship between road length and area.

No	Thana	Area (Sq. km)	Hierarchy	Roads (km)	Hierarchy	d	d ²
1	Singra	529	1	35	16	15	225
2	Shibgonj	496	2	40	14	12	144
3	Godagari	476	3	57	8	5	25
4	Niamatpur	449	4	13	31	27	729
5	Nawabgonj	416	5	104	2	3	9
6	Manda	410	6	48	11	5	25
7	Natore	401	7	102	3	4	16
8	Mahadebpur	395	8	44	12	4	16
9	Patnitala	379	9	42	13	4	16
10	Bagmara	365	10	33	17	7	49
11	Gomastapur	352	11	51	10	1	1
12	Paba	335	12	76	4	8	64
13	Dhamoirhat	301	13	23	23	10	100
14	Baraigram	300	14	65	6	8	64
15	Lalpur	296	15	60	7	8	64
16	Tanore	295	16	12	32	16	256
17	Atrai	286	17	15	28	11	121
18	Nachole	284	18	16	26	8	64
19	Naogaon	273	19	70	5	14	196
20	Raninagar	256	20	15	28	8	64
21	Porsha	253	21	25	18	3	9
22	Shajpahr	245	22	18	24	2	4
23	Badalgachi	211	23	25	18	5	25
24	Gurudaspur	200	24	16	26	2	4
25	Durgapur	195	25	15	28	3	9
26	Puthia	195	26	52	9	16	256
27	Bagha	181	27	25	18	9	81
28	Charghat	166	28	40	14	14	196
29	Mahanpur	163	29	25	18	11	121
30	Bagatipura	138	30	24	22	8	64
31	Bholahat	123	31	18	24	7	49
32	Boalia	92	32	190	1	31	961
	n= 32	9456		1400			4027

$$r = 1 - \frac{6 \sum d^2}{n(n^2 - 1)} = 1 - \frac{6 \sum d^2}{n^3 - n}$$

$$r = 1 - \frac{6 \times 4027}{323 - 32} = 1 - \frac{24162}{32768 - 32} = 1 - \frac{24162}{32736}$$

$$\text{or } r = 1 - 0.738 = 0.26$$

That is why the relationship between the area of thana and road length is not so significant.



## Appendix-7

### Application of gravity model (log figure)

Rajshahi to other 24 centers(Rajshahi distane "0"km population 299,671= 5.4766				
Center	Distance	Population	Observed population	Expected population
01.Bagha	1.68124	3.69897	3.09641	2.813581
02.Bagmara	1.69897	3.65180	3.19033	2.730782
03.Bogra	2.05690	4.934	3.30103	3.297760
04.Charghat	1.49136	4.077	3.21748	3.57171
05.Chittagong	2.72754	6.139	2.39794	3.15685
06.Dhaka	2.43136	6.531	3.35698	4.14548
07.Dinajpur	2.45331	5.101	2.17609	3.19451
08.Durgapur	1.47712	3.666	2.90309	3.18921
09.Gaibanda	2.25527	4.6073	1.90309	2.57403
10.Godagari	1.50515	4.0557	3.17609	3.52257
11.Jessore	2.36735	5.2046	1.90309	2.94645
12.Khulna	2.46982	5.737	2.25527	3.27462
13.Kustia	2.13672	4.813	2.47412	3.01662
14.Manda	1.69897	3.903	3.07918	2.98227
15.Mohanpur	1.36172	3.536	3.17026	3.29003
16.Naogaon	1.93449	5.003	3.51188	3.61236
17.Natore	1.68124	4.558	3.62838	3.67321
18.Nawabganj	1.68124	5.083	3.58546	4.19813
19.Niamatpur	1.77085	3.494	2.39794	2.42975
20.Pabna	2.03742	5.019	3.24919	3.42127
21.Puthia	1.47712	3.973	3.01072	3.49 638
22.Rangpur	2.35024	5.309	2.87506	3.08600
23.Tanore	1.55630	3.965	2.89762	3.32960
24.Thakurgaon	2.52244	4.541	2.30103	2.97589

Source: Author's own calculation based on table 4.1 of chapter four.



## Appendix-8

### Relationship between distance and interaction

Centers	Distance (X)	Interaction (passenger-Y)	dx	dx ²	dy	dy ²	dx dy
01. Bagha	48	1250	-89	7921	50	2500	-4450
02. Bagmara	50	1550	-87	7569	350	122500	-30450
03. Bogra	114	2000	-23	529	800	640000	-18400
04. Charghat	31	1650	-106	11236	450	202500	-47700
05 Chittagong	534	250	397	157609	-950	902500	-356250
06. Dhaka	270	2275	133	17689	1075	1155625	142975
07. Dinajpur	284	150	147	21609	-1050	1102500	-154350
08. Durgapur	30	800	-107	11449	-400	160000	42800
09. Gaibandha	180	80	43	18849	-1120	1254400	-48160
10. Godagari	32	1500	-105	11025	300	90000	-31500
11. Jessore	233	80	96	9216	-1120	1254400	-107520
12. Khulna	295	180	158	24964	-1020	1040400	-161160
13. Kustia	137=A	300	0	0	-900	810000	0
14. Manda	50	1200=A	-87	7569	0	0	0
15. Mohanpur	23	1480	-114	12996	280	78400	-31920
16. Naogaon	86	3250	-51	2601	2050	4202500	-104550
17. Natore	48	4250	-89	7921	3050	9302500	-271450
18. Nawabgonj	48	3850	-89	7921	2650	7022500	-2358850
19. Niamatpur	59	250	-78	6084	-950	902500	74100
20. Pabna	109	1775	-28	784	575	330625	-16100
21. Puthia	30	1025	-107	11449	-175	202500	18725
22. Rangpur	224	750	87	7569	-450	168100	-39150
23. Tanore	36	790	-101	10201	-410	1000000	41410
24 Thakurgaon	333	200	196	38416	-1000		196000
Total	3248	30885	-4	396176	2085	31977575	-153495

$$\sum dx \sum dy$$

$$\frac{\sum dx dy}{n}$$

$$\text{Coefficient of correlation (r)} = \frac{\sum dx \sum dy}{\sqrt{(\sum dx^2) (\sum dy^2)}}$$

$$\frac{-4 \times 20885}{24}$$

$$= \frac{-1534950}{24} = \frac{-1534950 - 347.5}{\sqrt{(396176 - \frac{4^2}{24}) (31977575 - \frac{2085^2}{24})}} = \frac{-1535297.5}{\sqrt{125969^{13}}}$$

$$= \frac{-1535297.5}{3549220} = -0.4325 \text{ Ans.}$$



## Appendix---9

Relationship between travel costs and interaction of Rajshahi city to other 24 centers.

Sl. no.	To	Costs-X (taka)	Passenger Y	Rank of X=R _x	Rank of Y=R _y	Rank difference d=R _x -R _y	d ²
01	Bagha	16	1250	18	11	7	49
02	Bagmara	23	1550	14	8	6	36
03	Bogra	41	2000	10	5	5	25
04	Charghat	10	1650	23	7	16	256
05	Chittagong	210	250	1	18	-17	289
06	Dhaka	106	2275	2	4	-2	4
07	Dinajpur	95	150	5	22	-17	289
08	Durgapur	12	800	20	14	6	36
09	Gaibandha	65	80	8	23	-15	225
10	Godagari	12	500	20	9	11	121
11	Jessore	85	80	6	23	-17	289
12	Khulna	105	180	4	21	-17	289
13	Kustia	50	300	9	17	-8	64
14	Manda	17	1200	16	12	4	16
15	Mohanpur	7	1480	24	10	14	196
16	Naogaon	325	3250	12	3	9	81
17	Natore	14	4250	19	1	18	324
18	Nawabgonj	18	3850	15	2	13	169
19	Niamatpur	26	250	13	18	-5	25
20	Pabna	37	1775	11	6	5	25
21	Puthia	9	1025	22	13	9	81
22	Rengpur	75	750	7	16	-9	81
23	Tanore	17	790	16	15	1	1
24	Thakurgaon	117	200	2	20	-18	324
		8	30,885				3295

$$r = 1 - \frac{6d^2}{n^3 - n} = 1 - \frac{6 \times 3295}{24^3 - 24} = 1 - \frac{19770}{13800}$$

$$r = 1 - \frac{19770}{13800} = 1 - 1.43 = -0.43 \text{ Ans}$$



## Appendix --- 10

**Relationship between travel time and interaction of Rajshahi city to other 24 centers.**

Sl. no.	To	Travel time- X (hour)	Interaction Y (Passenger)	Rank on X=R _x	Rank on Y=R _y	Rank difference d=R _x -R _y	d ²
01	Bagha	2.00	1250	15	11	-3	9
02	Bagmara	4.00	1550	8	8	0	0
03	Bogra	3.50	2000	12	5	7	49
04	Charghat	1.50	1650	20	7	13	169
05	Chittagong	18.00	250	1	18	-17	289
06	Dhaka	9.00	2275	2	4	-2	4
07	Dinajpur	5.50	150	6	22	-16	256
08	Durgapur	1.25	800	23	14	9	81
09	Gaibandha	4.00	80	8	23	-15	225
10	Godagari	1.50	1500	20	9	11	121
11	Jessore	6.00	80	5	23	-18	324
12	Khulna	7.00	180	4	21	-17	289
13	Kustia	4.00	300	8	17	-9	81
14	Manda	2.00	1200	15	12	3	9
15	Mohanpur	1.00	1480	24	10	14	196
16	Naogaon	4.00	3250	8	3	5	25
17	Natore	1.75	4250	19	1	18	324
18	Nawabgonj	2.00	3850	15	2	13	169
19	Niamatpur	2.75	1250	14	18	-4	16
20	Pabna	3.50	1775	12	6	6	36
21	Puthia	1.50	1025	20	13	7	49
22	Ramgaur	5.00	750	7	16	-9	81
23	Tanore	2.00	790	15	15	0	0
24	Thakurgaon	9.00	200	2	20	-18	324
							3216

Coefficient of correlation on Spearman Rank system.

$$r = 1 - \frac{\sum 6d^2}{n^3 - n} = 1 - \frac{\sum 6d^2}{n(n^2 - 1)} = 1 - \frac{6 \times 3216}{24(24^2 - 1)} = 1 - \frac{18756}{24 \times 575}$$

$$\text{or } r = 1 - \frac{18756}{13800} = 1 - 1.359 = -0.36 \text{ Ans}$$



## Appendix 11

### Measurement of the standard deviation of eta index

Serial no.	Name of route (According to length)	Length (km)	(x-x)	(x-x) ²
1	Gomastapur-Porsha	38	20.05	402.00
2	Rajshahi-Godayari	32	14.05	197.40
3	Mohanpur-Manda	27	9.05	81.90
4	Nawabgong-Gomastapur	27	9.05	81.90
5	Puthia-Bagmara	27	9.05	81.90
6	Gomastapur-Bholahat	26	8.05	64.80
7	Mahanpur-Bagmara	24	6.05	36.60
8	Patnitala-Shapahar	24	6.05	36.60
9	Shibgonj-Gomastapur	24	6.05	36.60
10	Amnura-Gadagari	23	5.05	25.50
11	Rajshahi-Mahanpur	23	5.05	25.50
12	Manda-Sampur	20	2.05	4.20
13	Naogaon-Badalgachi	20	2.05	4.20
14	Natore-Bagatipara	20	2.05	4.20
15	Natore-Singra	20	2.05	4.20
16	Rajshahi-Baneswar	20	2.05	4.20
17	Manda-Niamatpur	19	1.05	1.10
18	Mawabgonj-Shibgonj	19	1.05	1.10
19	Puthia-Natore	19	1.05	1.10
20	Mohadebpur-Patnitala	17	-0.95	0.90
21	Chargehat-Bagha	17	-0.95	0.90
22	Pathitala-Badalgachi	17	-0.95	0.90
23	Patintala-Dhamoirhat	17	-0.95	0.90
24	Naogaon-Sampur	16	-1.95	3.80
25	Nawabgonj-Amnura	16	-1.95	3.80
26	Nawabgonj-Godagari	16	-1.95	3.80
27	Ahmedpur-Baraigram	15	-2.95	8.70
28	Naogaon-Raninagar	15	-2.95	8.70
29	Raninagar-Atrai	15	-2.95	8.70
30	Barignam-Gurudaspur	14	-3.95	15.60
31	Lalpur-Walia	13	-4.95	24.50
32	Mahanpur-Tanore	13	-4.95	24.50
33	Natore-Ahmedpur	13	-4.95	24.50
34	Porsha-Shapahar	13	-4.95	24.50
35	Amnura-Nachole	11	-6.95	48.30
36	Baneswar-Charghat	11	-6.95	48.30
37	Bagna-Lalpur	10	-7.95	63.20
38	Bagatipara-Walia	10	-7.95	63.20
39	Baneswar-Durgapur	10	-7.95	63.20
40	Sampur-Mahadepur	10	-7.95	63.20
41	Baneswar-Puthia	9	-8.95	80.10
42	Ahmedpur-Walia	8	-9.95	99.00
43	Banpara-Walia	7	-10.95	119.90
Total		772		1800.40



$$\bar{x} = \frac{\sum x}{n} = \eta = \frac{772}{43} = 17.95$$

$$\delta = \sqrt{\frac{\sum (x-\bar{x})^2}{n}} = \sqrt{\frac{1800.4}{43}} = \sqrt{41.869763} = \pm 6.47$$

Stadard deviation	Range	No. of Route	%
$\pm 1\delta$	24.42-----11.48	28	65.12
$\pm 2\delta$	30.89-----5.01	13	30.23
$\pm 3\delta$	37.36----- -1.46	1	2.33
$\pm 4\delta$	43.83----- -7.93	1	2.33
Total			100



## Appendix 12

### Quantitative analysis of theata( $\sigma$ ) index (for goods only)

Code	Node	Traffic volume $x$ =(goods in ton)	$(x-\bar{x})$	$(x-\bar{x})^2$
1	Ahmedpur	140	226.76	51420.10
2	Annura	175	191.76	36771.90
3	Atrai	160	206.76	42749.70
4	Badalgachi	190	176.76	31244.10
5	Bagatipara	175	191.76	36771.90
6	Bogha	165	201.76	40707.10
7	Bagmara	290	76.76	5892.10
8	Baneswar	255	111.76	12490.30
9	Banpara	160	206.76	42749.70
10	Baraigram	150	216.76	46984.90
11	Bholahat	165	201.76	40707.10
12	Charghat	275	91.76	8419.90
13	Dhamoinhat	130	236.76	56055.30
14	Durgapur	135	231.76	53712.70
15	Godagari	300	66.76	4456.90
16	Gomastapur	175	191.76	36771.90
17	Gurudspur	165	201.76	40707.10
18	Lalpur	185	181.76	33036.70
19	Manda	265	101.76	10355.10
20	Mohadbpur	270	96.76	9362.50
21	Mahanpur	255	111.76	12490.30
22	Machole	170	196.76	38714.50
23	Nogaon	1585	1218.24	1484108.70
24	Natore	1445	1078.24	1162601.50
25	Nawabgonj	1500	1133.24	1284232.90
26	Niamatpur	185	181.76	33036.70
27	Patnitala	260	106.76	11397.70
28	Porsha	160	206.76	42749.70
29	Puthia	265	101.76	10355.10
30	Rajshahi	2660	2293.24	5258949.70
31	Raninagar	155	211.76	44842.30
32	Sanpur	50	316.76	100336.90
33	Sapahar	160	206.76	42749.70
34	Snibgonj	295	71.76	5149.50
35	Singna	255	111.76	12490.30
36	Tanore	175	191.76	36771.90
37	Walia	60	306.76	94101.70
	Total	13570		10279674.00

$$\sum x = 13570$$

$$\bar{x} = \frac{\sum x}{n} = \frac{13570}{37} = 366.76 = \bar{x}$$

$$\sigma = \sqrt{\frac{\sum (x-\bar{x})^2}{n}} = \sqrt{\frac{10279674}{37}}$$

$$= \sqrt{277829.03} = \pm 527.09$$

Standard deviation	Range		Nodes	%
	(-)	(+)		
$\pm 1 \sigma$	- 160.33	- 893.85	33	89.19
$\pm 2 \sigma$	- 687.42	- 1420.94	0	0.00
$\pm 3 \sigma$	- 1214.51	- 1948.03	3	8.11
$\pm 4 \sigma$	- 1741.60	- 2475.12	1	2.70
Total				100



## Appendix- 13

### Rajshahi Metropolitan city at a glance

* Municipality-----	1876, April
* Pouro Corporation-----	13th August, 1987
* City Corporation -----	1990
* Metropolitan City-----	1st July, 1992
* Population -----	6,88,000
* Metalled Road-----	171,79 km.
* Un-metalled Road-----	105,48 km.

### Structure of Rajshahi Metropolitan City

Sl.No.	Thana	Area (in km)	Population	Mouza
1	Bolia	14.4	2,06,000	Bhadra, Choto Bangram, Dargapara, Meherchardi, Narikalbari, Ramchardnapur, Sagarpara, Seroil and Uzirpur
2	Motihar	53.2	1,92,000	Belgharia, Dasmari, Dharampur, Kagla, Kharkari, Khogapur, Mirjapur, Minkamari, Harian, Satbaria, Sahapur, Sanpur, Maskatadighi, Valukpur.
3	Rajpara	35.2	1,68,000	Terokhadia, Bahrampur, Lakshipur, Kazihata, Chondipur, Helevebad, Mahisbathan, Haragram, Kesabpur, Charsrirampur, Basu, Mollapara, Aliganj, Harupur, Charnabinagar, Charsonikandi, Nabagonga, Kasiadanga, Pukmia and Deluabari.
4	Shahmakhdum	21.6	1,22,000	Bara Bangnam, Baya, Srirampur, Barabaria, Vokipur, Doulotpur, Matigram, Sindur, Kusundi.
	Total	124.4	6,88,000	

Source :- Rajshahi city corporation



## Appendix - 14

### Hierarchy of 37 nodes on the basis of shortest path matrix.

Code	Monde	Shortest Path (route)	Rank
30	Rajshahi	125	1
08	Baneswar	131	2
21	Mohanpur	135	3
15	Godagari	143	4
29	Puthia	144	5
19	Manda	147	6
25	Nawabgonj	158	7
07	Bagmara	159	8
12	Charghat	160	9
32	Sampur	161	10
36	Tanore	162	11
24	Matore	163	12
16	Gomastapur	8166	13
14	Durgapur	168	14
02	Amnura	168	15
20	Mohadebpur	176	16
26	Niamatpur	179	17
34	Shibgonj	182	18
23	Naogaon	183	19
06	Bagha	186	20
28	Porsha	186	21
05	Bagatipara	189	22
27	Patnitala	194	23
01	Ahmedpur	195	24
35	Singar	196	25
33	Sapahar	199	26
04	Badalgachi	201	27
18	Lalpur	204	28
22	Nachole	205	29
11	Bholahat	206	30
37	Walia	212	31
31	Raninagar	216	32
10	Barigram	217	33
09	Bampara	222	34
13	Dhamoirhat	225	35
03	Atrai	255	36
17	Gurudaspur	262	37

Source: Author's own calculation



## Appendix - 15

Hierarchy of 37 nodes on the study area According to shortest path Accessibility.

Rank	Node	Shortest Path distance (in km)
1	Rajshahi	2491
2	Bameswar	2603
3	Mahanpur	2606
4	Puthia	2726
5	Charghat	2834
6	Durgapur	2839
7	Bagmara	2899
8	Manda	2967
9	Naogaon	3003
10	Tanore	3028
11	Godagari	3031
12	Sampur	3115
13	Bagha	3253
14	Nawabgonj	3284
15	Ahmedpur	3338
16	Mohadevpur	3347
17	Lalpur	3435
18	Bagalipara	3480
19	Banpara	3528
20	Patnitala	3531
21	Gomastapur	3565
22	Niamatpur	3588
23	Amnura	3622
24	Natore	3640
25	Shibgonj	3680
26	Walia	3782
27	Singra	3802
28	Bagatipara	3846
29	Bardigram	3894
30	Sapahar	3900
31	Nachole	4017
32	Porsha	4030
33	Raninagar	4071
34	Dhamoirhat	4282
35	Gurudaspur	4375
36	Bholahat	4451
37	Atrai	4622

Source: Author's own calculation



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### Some Abbreviation

1. ^ABIDP: ^{Area}Barendra Integrated Development Project
2. BSC: Bangladesh Shipping Corporation.
3. CAAB: Civil Aviation Authority of Bangladesh.
4. FFYP: Fourth Five Years Plan.
5. GOB: Government of the Peoples Republic of Bangladesh.
6. RDA: Rajshahi Development Authority
7. RHD: Roads and Highways Directorate.

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