

**ROAD NETWORK AND TRAFFIC DENSITY  
IN SHILLONG**

**ABSTRACT**

**ANUP SAIKIA**

***A DISSERTATION***

**SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT  
FOR THE DEGREE OF  
MASTER OF PHILOSOPHY**

To



**DEPARTMENT OF GEOGRAPHY  
SCHOOL OF ENVIRONMENTAL SCIENCES  
NORTH-EASTERN HILL UNIVERSITY**

**SHILLONG, ( MEGHALAYA )**

**1990**

A B S T R A C T

## I. STATEMENT OF THE PROBLEM :

'Transportation constitutes one of the most vital organs of the modern economic system, and modern economic system involving large scale production and regional and product specialization, simply cannot function without an efficient transportation system.

Contemporary society is also characterised by urbanisation, the complexity and magnitude of which, makes it distinguishable from urban centres in ancient civilizations. Urbanisation has brought, in its train, a number of benefits and problems. One of the 'problems' are the sheer size of urban centres, which in view of rapid growth, gradually impinges on the smooth functioning of the intra-urban transportation network. This is particularly true in the case of Third World urban-centres, where, among other things, investment in infrastructure is a major constraint. Such urban centres have to continue to make-do with limited transportational facilities increasingly hampered by the population increase and increased traffic flow within the city. The city of Shillong conforms to this scenario. The city has experienced rapid population increase over the past few years and its road network (no other transport facility like trains, or trams exist in the city) has been put under much pressure, as a direct outcome of

population increase and increased traffic flow, so much so, that intra-city movements of goods and people is becoming a problem. It is in this background that the present study of the road network and traffic density in Shillong was undertaken.

## II. OBJECTIVES :

The main objectives of the study are :

- (i) to understand the structure of the road network of Shillong,
- (ii) to study some aspects of the traffic flow as an index of spatial interaction within the confines of the city,
- (iii) to identify the existing level of problems of the city's road network, and
- (iv) to gauge the level of problems the city is likely to face in the coming years in view of the rapidly increasing population and the changing economic activities of the city vis-a-vis the road network.

Besides these the following research questions were answered in the study :

- (i) What are the nature of the Connectivities of the network, and what similarities or differences exist in terms of (a) direct connectivities  
(b) Indirect connectivities
- (ii) Is there any relationship between the accessibility of the different nodes of the network and the economic activity-type areas of the city

- (iii) What is the degree of tortuosity of the city's roads and is it related to the accessibility and connectivity of the network ?

### III. METHODOLOGY :

The study is based on secondary as well as primary data, secondary data information relating to the road network of Shillong have been derived from maps collected from the TCPO. Statistics pertaining to the total road length of Shillong was obtained from the Executive Engineer (PWD) office, while statistics regarding the number of registered vehicles in Shillong was obtained from the District Transport Officer, East Khasi Hills, Shillong. Census such as the General Population Tables and the Town and Village Directory, East Khasi Hills were also used to derive information relating to population of the constituent units of the Shillong Urban Agglomeration and their areas etc.

Primary information data relating to traffic flow, peak traffic hours etc. was collected from fieldwork. 61 major nodes were selected from the road network of the Shillong Urban Agglomeration, representative of all the townships and wards of the city. The (direct) linkages between these nodes were plotted on a map, to obtain a topological road network map of Shillong. Various indices were used to analyse the network.

From the network map, connectivities based on

- a) direct connectivity
- b) indirect connectivities of the first level, were derived and analysed.

Traffic counts were taken at seventeen intersections, each representing the seventeen units of the city. From the traffic data, a representative figure (i.e., 50% of passenger movement) of pedestrian movement was calculated which together have been taken as estimated spatial interaction of the given unit with the remaining units. This is taken as the estimated interaction.

On the other hand, the gravity model was used to derive the theoretical interaction during the same period, and statistically tested for correlation with the estimated interaction.

#### IV. FINDINGS AND CONCLUSIONS :

The alpha, beta and gamma indices and the cyclomatic number used to analyse the network structure show that the network structure is a complex one with medium to high levels of connectivity and a high number of fundamental circuits.

However, the network is only moderately developed as the alpha index and cyclomatic number represent only about 30%

of maximum potential development, while the gamma and beta indices show about 50% of potential development.

The connectivity characteristics show higher connectivities along the NH.40 and NH.44 routes and in the CBD areas.

Tortuosity scores indicate greater tortuosity in the peripheral areas of the city, than centrally located nodes.

Centrality and relative accessibility of nodes of the network, measured in terms of (a) actual distances and (b) by interpreting this distance as an accessibility variable using principal component analysis, show that accessibility and centrality of nodes are higher in the geographically central areas of the network and in the CBD areas of the city, and gradually decline towards the peripheral areas.

There is a significant relationship between the estimated interaction in 1990 and the theoretical (expected) interaction in 1991. The residential areas could record more rapidly increasing levels of interaction compared to the non-residential areas in the near future.

Moreover, the fact is that, interaction levels (in terms of traffic flow), already high in the CBD areas of Barabazar-Police Bazar and in the emerging CBD area of Laitumkhrah-

European Ward will increase further. These areas then, will be the traffic-problem areas. However, more areas could join the list of problem areas, with the present residential areas having the potential of experiencing much rapidly increasing levels of interaction between 1991 and 2001. This is explained by, the sort of saturation level reached by the present non-residential areas in terms of potential interaction increase compared to the presently residential areas.

Thus, the rapid increase in interaction levels and traffic flow within the city will have to be tackled on a priority basis if the city's network is to function as a viable transportation medium.

EHU Library 102415  
cc. No. *As*  
rec. by *24.11.192*  
.....  
.....  
.....  
.....  
.....

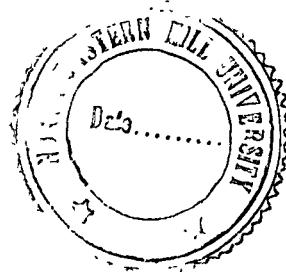
# ROAD NETWORK AND TRAFFIC DENSITY IN SHILLONG

ANUP SAIKIA

*A DISSERTATION*

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT  
FOR THE DEGREE OF

MASTER OF PHILOSOPHY



To



DEPARTMENT OF GEOGRAPHY  
SCHOOL OF ENVIRONMENTAL SCIENCES  
NORTH-EASTERN HILL UNIVERSITY  
SHILLONG, ( MEGHALAYA )

1990

COMPUTERISED



Phone :

Grams : **NEHU**

# North - Eastern Hill University

Dr. A.C. Mahapatra

Mayurbhanj Complex

Head  
Department of **Geography**

Nongthymmai, Shillong - 793014 (Meghalaya)

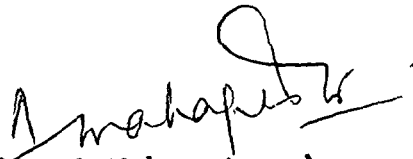
Department of \_\_\_\_\_

## C E R T I F I C A T E

is to certify that the dissertation submitted by Sri. Anup Saikia for the degree of Master of philosophy (M.Phil) to the Department of Geography, North Eastern Hill University, Shillong, Meghalaya, entitled "Road Network and Traffic Density in Shillong" is a bonafide study of the author to the best of my knowledge and belief.

It may be placed before the examiners for due evaluation.

Dated the 31st December 1990  
Shillong.

  
A.C. Mahapatra )  
Supervisor.

Dr. A.C. Mahapatra  
HEAD

Department of Geography  
North Eastern Hill University  
Shillong - 793014

CONFIDENTIAL

238

EHU Library  
Acc. No. 102415  
Acc. By DA  
Date 24/11/92  
By N  
Revised No. 2.18.92

DS  
388.10954164  
SAI

## ACKNOWLEDGEMENT

I wish to thank Dr. A.C. Mohapatra, Head, Department of Geography, NEHU, for supervising the writing of this dissertation. His innovative and analytical suggestions helped immensely. I apologise for giving him more than his share of headaches.

My gratitude to Dr. S.K. Misra, Department of Economics, NEHU <sup>who</sup> painstakingly undertook the computer processing work for this dissertation during its early stages, and also Dr. N.P. Goel, of Geography Department, who worked out various computer programmes during the later part of the dissertation.

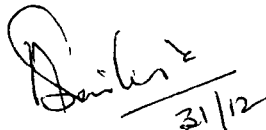
I would like to thank Prof. A.B. Mukerji, Punjab University, for sending me a copy of Kansky's Ph.D. Thesis.

Many persons are responsible for various other help rendered : Mr. Sajid Alam, Assistant Town Planner, Directorate of Urban Affairs, Shillong and Bah Knain, of the DPO's Office in particular.

A couple of friends put in time as well : Konwar, Thanga, Danny, Noel, Riju and Miki.

Mr. S.H. Fde, for typing the dissertation and pointing out a couple of mistakes.

Date : 31<sup>st</sup> December, 1990.  
Shillong.

  
31/12  
( A. SARKIA )

## C O N T E N T S

Acknowledgement	i
List of Maps	iv
List of Tables	v
CHAPTER-I : INTRODUCTION	1-28
1.1 General Background	1
1.2 Statement of the Problem	5
1.3.1. Objectives of the Study	9
1.3.2. Research Questions	10
1.4 Study Area	11
1.5 Survey of Literature	16
CHAPTER-II : DATA AND METHODOLOGY	29-42
2.1 Data	29
2.1.1. Secondary Sources	29
2.1.2. Primary Sources	30
2.2 Methodology	31
2.2.1. Analysis of Aggregate Network Characteristics	32
2.2.2. Analysis of Nodal Characteristics	35
CHAPTER-III : NETWORK STRUCTURE	43-72
3.1 Introduction	43
3.2 The Aggregate Characteristics of the Network	44
3.3 The Connectivity Characteristics of the Network	49
3.4 Tortuosity Index	58

3.5.1. Accessibility Mapping	62
3.5.2. Accessibility by Factor Analysis	65
3.6 Summary of Findings	71
CHAPTER-IV : TRAFFIC FLOW	73-104
4.1 Introduction	73
4.2.1. Population and Vehicular Increase	77
4.2.2. Activity Classification	81
4.3 Interaction Levels and Gravity Estimates	85
4.4 Summary of Findings	103
CHAPTER-V : SUMMARY AND CONCLUSIONS	105 - 111
BIBLIOGRAPHY	112 - 116

LIST OF MAPS

Fig. No.	Title	Page No.
1.1	Shillong Urban Agglomeration	13
1.2	Constituent Wards of Shillong	15
3.1	Road Network of Shillong	44
3.2	Topological Road Network of Shillong	46
3.3	Traffic Accessibility by Actual Distances	64
3.4	Traffic Accessibility by Factor Loading	69
4.1	Activity Classification of Towns other than Shillong	83
4.2	Ward-Wise Activity Classification of Shillong	84

LIST OF TABLES

Table No.	Title	Page No.
3.1	Direct and Indirect Inter-Nodal Connections	51
3.2	Direct Connectivity Quartile Classes	52
3.3	Indirect Connectivity Quartile Classes	55
3.4	Actual Shortest Distances and Direct Distances	59
3.5	Eigen Values and Percentage Explained Variations	66
3.6	Eigen Vector Values	67
4.1	Shillong - Population Growth	76
4.2	Annual Increase in Registered Vehicles in Shillong	78
4.3	Projected Population of Shillong	79
4.4	Ward-wise Population Projections of Shillong Municipality	80
4.5	Activity Classification	82
4.6	Estimated and Theoretical Interactions	90
4.7	Estimated Interaction - 1991	92
4.8	Ratios of 2001 Estimates to 1991 Estimates	97
4.9	Estimated Interaction - 2001	101

CHAPTER -IINTRODUCTION

## 1.1 General Background

Transportation constitutes of the most vital organs of the modern economic system. It allows to overcome the friction of space to move goods and people,, albeit at a cost, whether in terms of energy, time or the surrogate in terms of monetary value. Is it necessary to move goods and people over space ? Is there an economic rationale of this ? Yes. Without such a rationale no movement over space is necessary. The economic advantages of the movement must far exceed (or at least equate with) the cost of friction. The advantages may be purely utilitarian, say the tourist's travel for aesthetic satisfaction or recreation, somewhat difficult to estimate in terms of benefit, but nevertheless discernable. The movement over space to people is far more complex due to the complexity of human affairs.

All movements over space require a medium, whether a railway track or a cart track or the waterway or the air, which provides inertial-resistance in the opposite direction of the 'applied force'. This application of force involves energy, which involves financial considerations. Therefore, with the process of development and emergence of complex societies the expenditure of energy was enormously increased.

Often, a direct correspondence is sought between the level of development of a society and the per capita consumption of energy.

However, the use of energy is not only related to distance over which people and goods are to be transported, but also with the medium of transportation (the friction surface), the efficiency of combustion technology (conversion of heat to mechanical energy), the efficiency of fuel, the efficiency of the transportation network etc.

In modern complex human society, urbanisation can be considered as a special spatial feature; not that there were no urban centres in the ancient civilizations, but that the nature and magnitude of contemporary urbanisation is cardinally different compared to its ancient counterpart.

Often it is argued that the urbanisation process itself is the result of energy economy in the society, where large scale consumption and production centres are located in close proximity to reduce the cost of transportation ( and therefore energy ). But with the increase in the magnitude and complexity of the urban centre (or system), further efficiency for smooth and low cost of movement becomes an important goal. Cost of time becomes

a significant variable and is sought to be minimised. In the developing countries like India where investment in infrastructure is a major constraint, particularly in view of rapid urbanisation and growing size of urban centres, intra-city movements of goods and people is gradually becoming an important problem.

While in developing countries transport facilities are considered as an essential component of infrastructure, in the developed realm it is seen as a necessary social amenity. Whichever view is ascribed to, the conclusion remains the same. That transport services are intrinsic to contemporary civilisation. The importance of transport can be understood in terms of its three capacities in fostering development<sup>1</sup>:

First, transport serves as a basic physical and economic infrastructure. Transport enables raw materials, intermediate products and final products to be distributed to various locations, local, regional or international and also expands the geographical extent of markets fostering large-scale production.

Secondly, transportation serves as a basic social and political infrastructure, facilitating the flow of

---

1. F.Moavenzadeh and David Geltner, "Transportation, Energy and Economic Development : A Dilemma in The Developing World ", Elsevier Science Publishing Company Inc. New York, 1984, p 89.

1

people, ideas, information and goods, at the same time enhancing the political and social integration of territories.

Third, transportation can serve as a force for industrialization through its requirements of infrastructure and equipment, which if produced locally can boost industrial development.

Present day society which involves large-scale production, regional and product specialization and international trade relies heavily on the transport sector. So much so that a modern economy simply cannot exist without an efficient transport system. Transport and economic development are symbiotically linked, and transport development is a necessary condition, although in itself not a sufficient condition, for the economic development of an economy. In fact, transportation has ever been cited as a precondition for economic growth.<sup>2</sup>

In brief, then, transport services are essential components of society : necessary for daily movements of goods, ideas and people; integrating regions and making

---

2. W.W.Rostow, "The Stages of Economic Growth", Cambridge, The Cambridge University Press, 1964, p.24, Rostow considers the railways as the critical investment sector, in identifying the stimulus for the take-off stage of economic growth in the U.S.

accessible peripheral areas, serving as channels between areas of consumption and those of production, thus allowing for regional production specialization and finally, one of the important factors in the matrix of overall economic development.

## 1.2 Statement of the Problem

A transport network can be understood as a transport system with " a set of geographic locations interconnected in a system by a number of routes."<sup>3</sup> Thus, two basic elements of a transport network can be identified : first, a set of locations (or nodes or centres) and second, the linkages (or routes) that connect the centres of the network. Kolars and Malin (1970)<sup>4</sup> suggest two reasons for the existence of transportation networks :

- (a) routes exist as links between urban centres,
- (b) routes serve as links connecting administrative or manufacturing centres and ports to their respective hinterlands.

Although transport development does not follow a

- 
- 3. K.J.Kansky, " Structure of Transportation Networks", Research paper No. 84., Deptt. of Geography, The University of Chicago, Chicago, 1963, p1.
  - 4. J.Kolars & H.J.Malin, " Population and Accessibility : An analysis of Turkish Railroads ", Geographical Review, 60, (1970) pp 229-246.

definite pattern, Taaffe, Morrill and Gould (1963)<sup>5</sup> have put forward an idealized process of transport development based on their study of transport development in Nigeria and Ghana. A quick look at their idealized scheme is not out of place in order to understand how network development occurs within a city. The authors outline four stages of transport development. In the first phase transport development is characterised by a number of scattered ports and trading centres along the seacoast, each having small hinterlands and poor connections between themselves, as also with the interior points. In the second stage, major penetration lines develop from certain ports to their hinterlands. In this stage, there is slight expansion of market and also the beginnings of regional specialization. The third stage is one of expansion of the penetration lines to interconnections between them leading to increased regional specialization and market expansion. With the dominance of the urban centres increasing, agglomeration economies set in, creating additional demand for transportation. In the last stage, there is the emergence of high priority trunk lines and linkages between the largest centres, which have the best roads and heaviest traffic

---

5. E.J.Taaffe , R. Morrill and P.R. Gould, " Transport expansion in Underdeveloped Countries : A Comparative Analysis, " Geographical Review, 53 (1963) pp 503-529.

signifying close spatial interaction between the metropolitan centres. Such development of transport network is a gradual process and the four stages are not distinct and could even exist together in a given system.

Similarly, transport network development takes place within a city, connecting the various points and localities of the city. This, essentially results out of increasing spatial interaction within the city itself. An urban centre with its various functional zones, such as wholesaling and retailing areas, residential areas, the C.B.D., production centres or agricultural areas and educational centres give rise to spatial interaction within the city, which in turn leads to a demand for transport facilities and finally leads to the gradual development of a transport network. Thus population, spatial interaction and transportation facilities are interwoven with each other, and " as population increases in an area, the demand for transportation is intensified; as new transport lines are built into the areas a greater population increase is encouraged, which, in turn, call for still more transportation."<sup>6</sup>

Interaction between the city and its hinterland and between its various zones leads to increased transport

---

6. Taaffe , Morrill and Gould, op.cit., 1963.

links. However, with the increase in population and consequent increase in the built-up area of the city and also, increase in the volume of traffic within the city, the efficiency of the road transport network could be put to stress. The efficiency of the network lies in allowing safe and speedy movement of goods and people within its confines and to and from other centres. However, since it might not be possible to physically expand the network, particularly in the C.B.D. areas and densely populated areas, alternative methods to maximize efficiency of the network, or simply to maintain a particular level of efficiency of the network, are required. In order to be in a position to put forward remedial measures a study of the network and its elements, viz. its connectivity, traffic flow etc. must first be undertaken. The city of Shillong, the capital of Meghalaya, is a fast-growing city of the North-Eastern region of India. The city is experiencing rapid population growth and a motor vehicle boom, which taken together will pose a severe constraint to the city's road network, which in view of its irregular width and heavy traffic pressure, is already facing constricted traffic flow. The city's transport network system then, conforms to the pattern outlined above and merits serious consideration.

A geographer approaches such an issue from the point of view of spatial organisation and since there is a spatial expression of transportation also, the geographer studies organisation as an aspect of the organisation of space.<sup>7</sup>

### 1.3.1 Objectives of the Study

The following are the objectives of the study :

- (i) to understand the structure of the road network of Shillong,
- (ii) to study some aspects of the traffic flow as index of spatial interaction within the confines of the city,
- (iii) to identify the existing level of problems of the city's road network, and
- (iv) to gauge the level of problems the city is likely to face in the coming years in view of the rapidly increasing population and the changing economic activities of the city vis-a-vis the road network.

---

7. E.J.Taaffe and H.L.Gauthier, "Geography of Transportation", Prentice -Hall Inc., Englewood Cliffs, New Jersey, 1973.

Besides these objectives, the following research questions have been raised.

### 1.3.2 Research Questions

(a) What is the nature of connectivity of the network, and what similarities or differences exist in terms of

- (i) direct connectivities
- (ii) indirect connectivities.

(b) Is there any relationship between the accessibility of the different nodes of the network on the one hand and the economic activity -type areas of the city, for instance accessibility and location in the C.B.D. area.

(c) What is the degree of tortuosity of the city's roads and is it related to the accessibility or connectivity of the network ?

(d) In view of the rapid increase of population, what is likely to be the magnitude of spatial interaction/ traffic flow in the future ? Does the gravity model provide us a clue to understanding the nature of flow pattern within the city ? If so, how significant is its predictive value ?

#### 1.4 Study Area

The area chosen for study is the city of Shillong, the capital of Meghalaya and headquarters of the East Khasi Hills District of Meghalaya.

##### (a) Location

Occupying an area of 21.27 square Kms., Shillong (U.A.) is situated at 25°34'N latitude and 91°53'E longitude in the central part of the East Khasi Hills district, which is sandwiched between West Khasi Hills district and Jaintia Hills districts of Meghalaya, Kamrup district of Assam and Bangladesh in the West, East, North and South respectively. It is well connected by roads with the remaining four district headquarters of Meghalaya and is connected with Guwahati by NH 40 and with Cherrapunjee and Dawki also by NH 40 and with Silchar and Jowai by NH 44. The road connections to Agartala and Aizawl, the state capitals of Tripura and Mizoram respectively, pass through Shillong adding to the traffic problems of the city.

The Shillong Urban Agglomeration comprises of the six townships of Shillong Municipality, Shillong Cantonment, Madanryting, Mawlai, Nongthymmai and Pynthorumkhrah with

Shillong Municipality lying in the centre and the remaining towns occupying the peripheral areas ( Fig.I ).

(b) Physiography and Relief

The Shillong Urban Agglomeration occupies the Shillong Valley of the Meghalaya Plateau which slopes down gently to the Brahmaputra valley to the north, and rises more steeply from the plains of Bangladesh in the south. The plateau itself can be considered as the eastward extension of the peninsular Indian block<sup>8</sup>.

The valley is flanked by the Shillong Peak (1961 metres) of the Shillong range in the south and Mawpat Peak (1957 metres) of the Mawpat Hills to the north-east and is drained by the tributaries of the Umshyrpi and the Umkhrah rivers.

The relative relief of Shillong<sup>9</sup> varies considerably over different areas, ranging from over 300 feet per square furlong in the southern and north-western borders of the

---


8. D.N.Wadia, Geology of India, London, 1961, p.434.

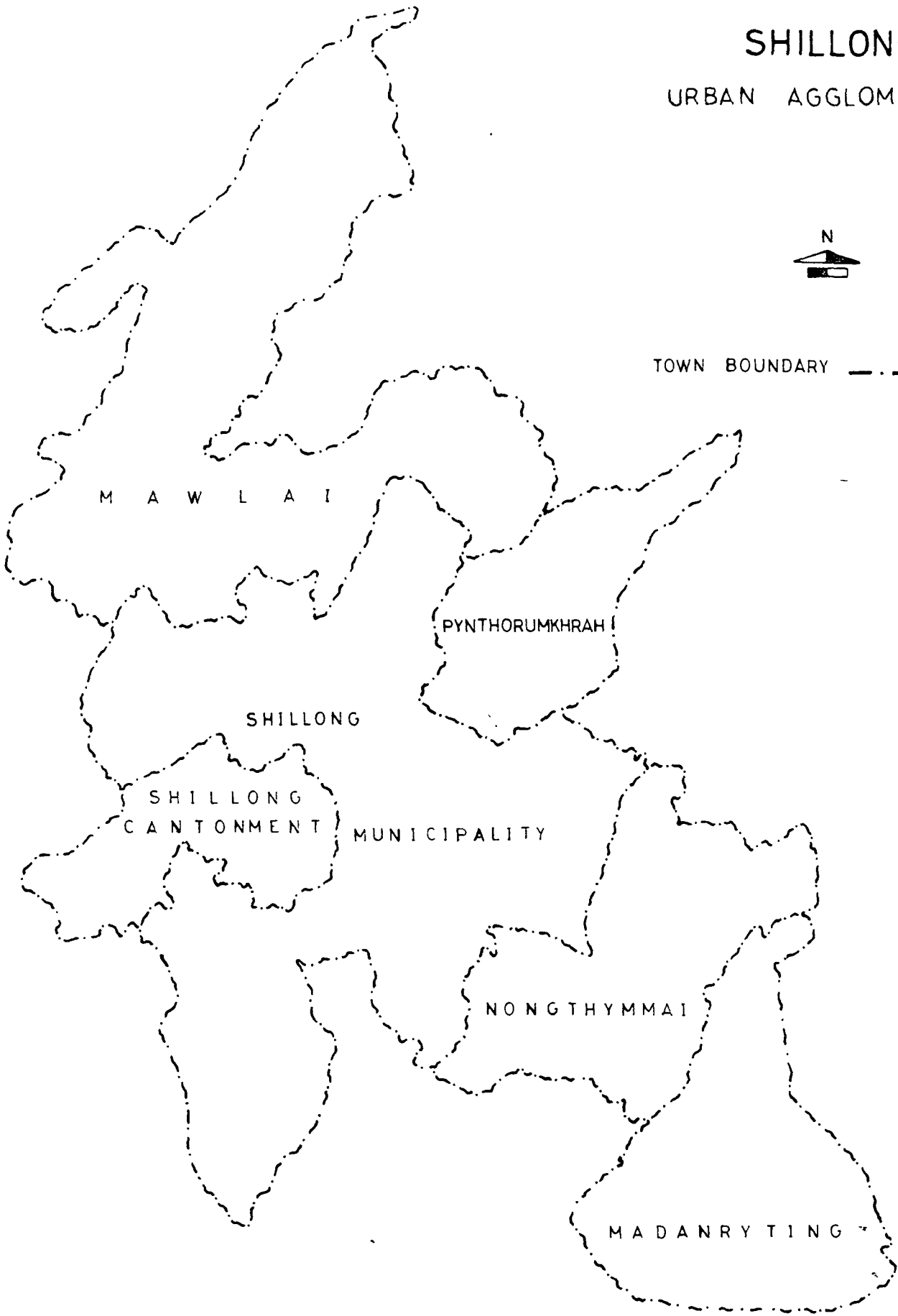
9. J.P.Singh, Urban Landuse Planning in Hill Areas : A case study of Shillong, Inter India Publications, New Delhi, 1980, p.40.

# SHILLONG

URBAN AGGLOMERATION



TOWN BOUNDARY 



not to scale

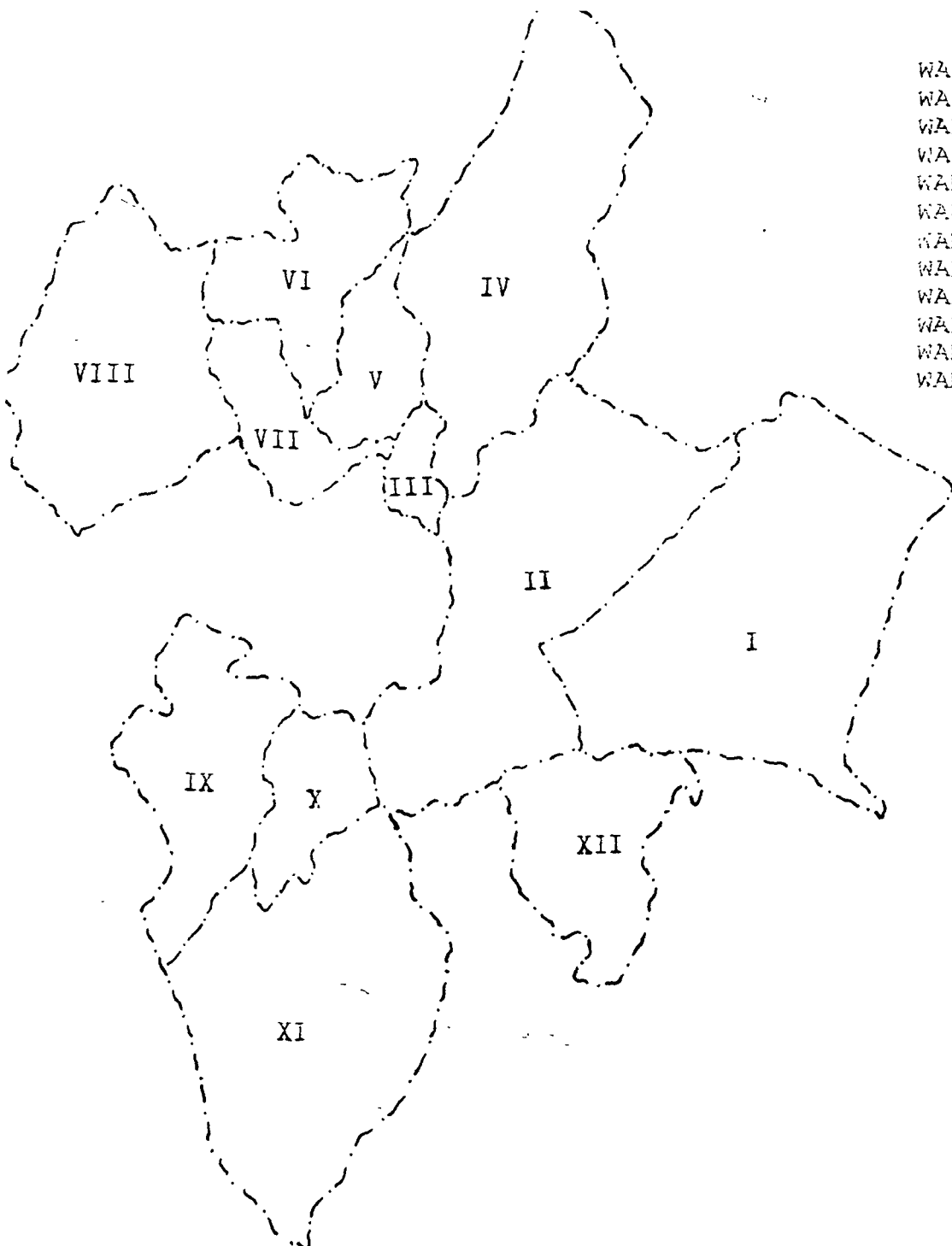
city to over 200 feet in the north-eastern, north-western and southern parts of the Shillong Municipality, 50 to 100 feet in most of the same, and between 0 to 50 feet and 100 to 200 feet in Nongthymmai to 100 to 200 feet or 300 to 400 feet in the northern parts of Mawlai and less than 100 feet for most of the Cantonment area. Singh (1980) further notes that generally areas with a relative relief of less than 100 feet per square furlong have been more suitable for urban development. For the present study, the topography of the city has not been considered as the city lies largely in a valley area and road development within the city has taken place almost independent of topography and local relief.

(c) Growth and Present situation

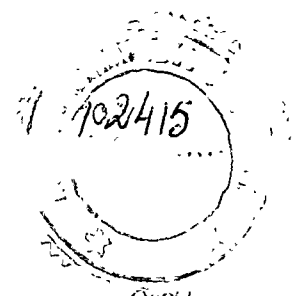
The study area, Shillong, has had a meteoric growth to its present proportions. This is true in its historical perspective, as well as its growth in the past few decades. Historically, the importance of Shillong grew quickly from the weekly market of Iewduh<sup>10</sup> to district headquarters of the Khasi and Jaintia Hills district (between 1864-1866), headquarters of the Chief Commissioner of Assam (1874) till it finally became capital of Assam.

---

10. Initially, Shillong was no more than the locality of Laban and its few settlements, and the weekly market of Iewduh ( Barabazar of today ).



- WARD I LAITUMKHAH
- WARD II EUROPEAN
- WARD III POLICE BAZAR
- WARD IV JAIL ROAD
- WARD V MAWKHAR
- WARD VI JAIAM
- WARD VII S.E. MAWKHAR
- WARD VIII MAWPREM
- WARD IX KENCH'S TRACE
- WARD X LABAN
- WARD XI LUMPARING
- WARD XII MALKI



CONSTITUENT WARDS  
OF SHILLONG

not to scale

In the past few decades since Shillong became the capital of the newly created state of Meghalaya, it has experienced rapid growth in terms of its population size, in the nature and diversification of the functions - commercial, administrative and educational -, and as a corollary to population increase there has been a significant increase in the number of vehicles plying in the city.\* Population increase and the city's functional diversification have given an impetus to building and construction work (for both residential as well as non-residential/commercial/administrative purposes) particularly along the major and arterial roads; as a result, expansion of the existing roads or improvements to the same have severely been affected. With the present trend of population increase, increase in the city functions etc likely to continue alongwith increased pressure on roads, the situation could literally be electric.

### 1.5 Survey of Literature

The study of transportation in geography is a relatively recent development. This emerging sub-field of

---

\* The number of vehicles registered in Shillong increased by over 90% between 1985 and 1989. In addition to this there are vehicles registered elsewhere, but plying in Shillong, which do not figure in the recorded number of vehicles in Shillong; thus the increase in vehicular traffic in the 1985-89 period is likely to be well over 90%.

geography has generated much interest among geographers and there is a considerable amount of literature in the field, of which the important contributions are as follows :

Studies of Taaffe and Gauthier<sup>11</sup> and Eliot-Hurst<sup>12</sup> were of a general nature treating various methodological and conceptual issues. Kansky<sup>13</sup> analysed the structure of transportation networks using graph theoretic techniques in relation to regional characteristics of areas and forwarded a predictive model of network structure, while Ullman<sup>14</sup> developed the concepts of transferability, complementarity and intervening opportunity to explain variations in flows and linkages over economic space.

Apart from these, the literature has been grouped into the following broad categories :

- (a) studies concerned with transportation and developmental issues ; and
- (b) literature relating to transportation as problematic in spatial organisations.

---

11. Taaffe and Gauthier, op. cit., 1973.

12. M.E.Eliot-Hurst, "Transportation Geography", McGraw Hill Book Co., New York, 1973.

13. K.J. Kansky, op.cit., 1963.

14. Edward L.Ullman, " The Role of Transportation and the Bases for Interaction", in W.L.Thomas (ed) Man's Role in Changing the Face of the Earth, The University of Chicago Press, (1956), 867-71.

(a) The relationship between Transportation and Development :

That a positive correlation between transportation and the various aspects of development, (-whether understood in terms of socio-economic indicators like urbanisation, industrialization or increased regional accessibility etc) exists is easily understood and numerous studies have dealt with this relationship<sup>15</sup>

Gauthier (1968)<sup>16</sup> suggests 3 possible relationships between transportation and the development process, with transportation having :

- " (1) a positive effect on the development process - the expansion is directly productive activities being a direct result of providing improved transportation facilities ;
- (2) a permissive effect on the development process - because transportation does not independently produce directly productive activities or subsequent increases in the level of economic growth ;
- (3) a negative effect occurs when an overinvestment in transportation reduces potential growth in directly productive activity and consequently, leads to an absolute decline in the level of income per capita ."

---

15. Taaffe, Morrill and Gould (1963) op. cit.;

H.L.Gauthier, "Transportation and Growth of the Sao Paulo Economy", Journal of Regional Science, 8, (1968), p.1 -18

M.Jefferson, "Communication and Civilization", Annals, AAG., 23 (1933), p. 46 -47.

16. H.L. Gauthier, op. cit., 1968, p. 1 - 18.

Taaffe et al<sup>17</sup> in their study of transport development in Ghana and Nigeria have noted three factors behind the development of railways :

- (1) the need to connect coastal administrative centres to internal areas,
- (2) to make areas of mineral wealth accessible, and
- (3) to reach areas of potential agricultural export production.

The study of Kolars and Malin<sup>18</sup> supports the above conclusions. Moreover, Kolars and Malin observed close links between rail -line location and population distribution.

The study by Taaffe et al (1963) is also important as an idealized process of transport network development is presented. Among works of this nature mention may be made of those of Oluwole<sup>19</sup>, Burghardt<sup>20</sup> and Williams and Hayward<sup>21</sup>.

---

17. Taaffe, Morrill and Gould, op.cit. ,1963.

18. J.Kolars and H.Malin, "Population and Accessibility: An Analysis of Turkish Railroads", Geographical Review 60, 1970, pp. 229 - 46.

19. Oluwole Aloba, "Evolution of Rural Roads in Nigeria", Singapore Journal of Tropical, Vol.4, 1, 1983, pp.1 -10.

20. A.F. Burghardt, "The Origins and Development of the Road Network of the Niagara Peninsula, Ontario : 1770 -1851", Annals, AAG, Vol. 59 (1969), pp. 417 - 40.

21. G.J.Williams and D.F. Hayward, "The Changing Land Transportation Pattern of Sierra Leone", Scottish Geographical Magazine, Vol.89, No. 2, Sept 1973, pp. 107 - 118.

Berry<sup>22</sup> posits that factors of transportation " Mould patterns and specify limits to potential symbiotic relationship of producers and consumers, thereby influencing economic interchange."

Associated with the theme of transportation and different aspects of development are the works of Mukerji<sup>23</sup>, Kayastha<sup>24</sup>, Singh<sup>25</sup>, Bird<sup>26</sup> and Ramachandran<sup>27</sup>.

Mukerji (1974) examined the relationship between road transportation network structure and the levels of urbanisation in Rajasthan. On district level data he used indices like the alpha, beta and gamma indices and cyclo-matic number and the concept of aggregate transportation score ( ATS ) to determine levels of urbanisation, and established a positive correlation between transportation and urbanisation.

- 
22. B.J.L.Berry, " Recent Studies Concerning the Role of Transportation in the Space Economy ", Annals, AAG, Vol. 49 (1959), pp. 328 - 342.
  23. A.B. Mukerji (1974), "Road Transport Network Structure and levels of Urbanisation in Rajasthan", NGJI, XX(I)p.42-54.
  24. S.L.Kayastha, "Transport and Communication in the Himalayan Beas Basin", NGJI, IV,2, June 1960, p.105 - 114.
  25. I.D.Singh, "Patterns of Rail Traffic Flows in Rajasthan" NGJI, Vol. VXII, 2 & 3, June-Sept 1971, pp. 90-98.
  26. James Bird, "Road and Rail in the Central Massif of France", Annals, AAG, Vol. XLIV (1954), p. 1 -14.
  27. H.Ramachandran, "Transportation and Urban Attributes - A Study of Structural Relations", Annals of NAGI, Vol.1, No. 1, (1981) p. 48. - 68.

Kayastha (1960) tried to relate the existing transportation facilities with the economy of the Himalayan Beas Basin area, noting the role of road, rail and water transport and communication facilities (including Posts and Telegraphs, telephones) in breaking down the conservatism and isolation of the people. Bird (1954) studied the emergence of road and rail transport in the Central Massif of France in terms of the physical background and the regional economy.

Ramachandran (1981) has dealt with the relationship between transport and the space economy; the latter in terms of various urban economic attributes, in a study of the Coimbatore region.

Singh<sup>28</sup> studied the degree of accessibility of the transport network of North Bihar to determine its efficiency. Like Kayastha (1960)<sup>29</sup>, he attempts to relate the transportation facilities with the economic structure of the area. Other works more or less along similar lines are those of North<sup>30</sup>, Saxena<sup>31</sup> and Mehta<sup>32</sup>. While North's work is partially historical and focuses on changing spatial

---

28. D.N.Singh, "Patterns of Transportation Links in North Bihar, North of the Ganga", NGJI, XVI,2,1970,pp.161-174.

29. S.L.Kayastha, 1960, op.cit.

30. R.N. North, "Transport in Western Siberia : Tsarist and Soviet Development", Vancouver, University of British Columbia Press, 1979.

31. H.M.Saxena, "Road Transport Connectivity Pattern and Economic Development in Rajasthan", GRI,42,2,1980 pp. 183 - 187.

32. G.S. Mehta, "Roads and Area Development : A Study in Utilisation and Impact", IJRS, Vol.XVI,2,1984,pp.170-77.

relationships in Western Siberia (between 1580 and 1975) measured in terms of the impact of transport facilities and freight - traffic flows, Saxena computes road transport connectivity (using beta index, connectivity index and cyclomatic number) and levels of economic development (using indicators such as population density, per capita income, percentage of electrified villages etc.). Mehta examined the impact of road transport on the economy of a village in Almora.

(b) Transportation as Problematic in spatial organisation :

Another area of research in transportation geography has been that of transportation as a problematic in spatial organisation. Taaffe and Gauthier<sup>33</sup> have stressed that the geographer studies transportation as an aspect of the organisation of space. Under this theme studies pertaining to transportation networks, commodity flows, traffic flows, urban hierarchical structures measured in terms of commodity or traffic flows, transport investment etc have all been clubbed together.

Datta<sup>34</sup> has attempted to study the road network of National Highways in India (1961, 1971) taking the shortest

---

33. Taaffe and Gauthier (1973) op. cit.

34. Gauri Datta, "The Network Pattern of Indian National Highways From Major Urban Centres to the National Capital" GRI, Vol. 37, 2, (1975), pp. 121 - 131.

routes to Delhi. Over notable works relating to urban transport networks are those of Tarkhov,<sup>35</sup> Dawson<sup>36</sup>, Taaffe<sup>37</sup>, Snyder<sup>38</sup> and Wheeler and Thomas<sup>39</sup>.

Tarkhov (1986) has compared the spatial structures of Moscow and Leningrad, using public transport lines as indices of spatial structure to analyse their topological structures.

Dawson (1979) examines the impact of changes the road and rail networks upon landuse in the cities of Edinburgh and Glasgow. Taaffe (1962) used air traffic as an index of urban hierarchical patterns and compares air passenger linkages between American cities with gravity model expectations, while Snyder (1962) considers the vehicle movements to and from Montevideo as metropolitan linkages, using public and commercial transportation data to analyse the nodality of the city of Montevideo.

- 
35. S.A. Tarkhov, " A Comparative Geographical Analysis of the Structure of Urban Transport Networks in Moscow and Leningrad.", Soviet Geography, Vol. XXVII, 7, (1986) pp. 445 -455.
  36. Andrew H. Dawson, "Land and Transport in the Scottish City." Scottish Geographical Magazine, Vol.95,2, (1979)pp. 83-92.
  37. E.J. Taaffe, "The Urban Hierarchy : An Air Passenger Defination.", Economic Geograpy, Vol.38,1 (1962)pp.1-14.
  38. David E. Snyder, " Commercial Passenger Linkages and the Metropolitan Nodality of Montevideo", Economic Geography, 38,2 (1962) p. 95 - 112.
  39. James O. Wheeler and R.N.Thomas, "Urban Transportation in Developing Economies : Work Trips in Teguchigalpa, Honduras", Professional Geographer Vol.XXV,2,(1973),p. 113 - 120.

Wheeler and Thomas (1973) analyse the daily internal movement of people in Teguchigalpa, a city in an developing economy, highlighting the influence of transportation on urban structure.

Williams and Hayward<sup>40</sup> analysed the impact of the physiography and the economy on the surface transport network of Sierra Leone.

Strand<sup>41</sup> analysing the road links since 1945, to previously roadless settlements in Norway, debates the issue of whether roadless settlements should be connected by roads or not, pointing out that this should be considered in terms of both alternative costs (viz. those incurred in relocation of migrants and employment generation for them) and benefits.

While the studies mentioned above are works by scholars abroad, a number of works by India researchers in the field is available. Singh<sup>42</sup> outlined the evolution of the transport system in Allahabad and identified its requirement and inadequacies.

---

40. Williams and Hayward (1973), op.cit.

41. Sverre Strand, "Roadless Norway", Scottish Geographical Magazine, Vol. 100, 1 (1984), pp. 49-59.

42. U.Singh, "Growth of Transport and Communications in Allahabad", NGJI, 4, (1959) 188-204.

Singh and Kayastha<sup>43</sup> studying the road network and traffic flow in Dhanbad have noted the 'somewhat proportionate' growth of traffic and population and stressed the need for planning of the road network from a long range point of view. In a similar vein, Singh and Singh<sup>44</sup> have analysed the traffic problems of Varanasi forwarding suggestions for ameliorating the traffic congestion problem.

Apart from network analysis, the study of network flows has been another area of research. As Moonis Raza and Aggarwal<sup>45</sup> note; the analysis of flows involve ascertaining (a) the factors behind the flows, (b) discerning similarities in the flows of different commodities if any (c) predicting the nature and volume of flows, and (d) to posit the flows in terms of a general theory of development.

Smith<sup>46</sup> posited that commodity flow analysis were primarily concerned with : " 1. The deviations of flow

---

43. D.N.Singh and S.L.Kayastha, "Some Aspects of Transportation in Dhanbad", NGJI, Vol.XVIII, 2, (1972) 64-79.

44. R.L.Singh and U.Singh, "Road Traffic Survey of Varanasi", NGJI, Vol.IX, 3 & 4, (1963) 32 - 47.

45. Moonis Raza and Yash Aggarwal, "Transport Geography of India and the Regional Structure of the Indian Economy", Concept Publishing Company, New Delhi, 1986, p.7

46. R.H.T. Smith, " Concepts and Methods in Commodity Flow Analysis", Economic Geography, 46, (1970), pp.404-416.

volumes over individual routes

2. The efficiency of a given flow pattern,
3. The structure of commodity flows."

Raza and Aggarwal (1980)<sup>47</sup> made a commodity-wise analysis of the impact of distance-decay on commodity flows, while at a micro-level, Singh and Singh<sup>48</sup> analysed commodity flow patterns in Rajasthan.

Bhat and Gidadhubli<sup>49</sup> analysed commodity flows of selected commodities in India (1955 - 56 to 1967 - 68) and establishing inter and intra regional relationships among the (seven) different economic regions of India.

Raza et al<sup>50</sup> examined the dominance of the metropolitan centres in the Indian economy by analysing the commodity flows of Indian railways, noting the top-heavy structure of the national market with the large metropolises dominating the directions of commodity flows.

- 
47. Moonis Raza & Yash Aggarwal, "Distance Decay and Railway Freight Flows in India : A Preliminary Enquiry", IJRS, Vol. XII, No. 1 (1980) pp. 37 - 48.
  48. J.Singh and R.B.Singh, " Commodity Flow Patterns in Rajasthan - A Case Study ", in Essays in Applied Geography (eds), V.C.Misra, N.P.Ayyar and P.Kumar, University of Sagar Press, Sagar 1976, pp.289-299.
  49. L.S.Bhat and Gidadhubli, "Economic Regions and Regional Flows - A Case Study in the Flow Patterns and Trends in Selected Commodities in India", in Regional Development (ed) M.Raza, Heritage Publishers, New Delhi, 1988, pp.279-320.
  50. Moonis Raza, Y.Aggarwal & M.Dutta, "A Spatial Analysis of Metropolitan Freight Flows in India, GRI, Vol.42,4, (1980) pp. 323-341.

Other than commodity and traffic flows, geographers have worked on communication flows, tourist flows etc. Leinback<sup>51</sup> using data of telephone messages among exchanges in West Malaysia suggested that location in terms of the "core of modernization" could have a significant bearing on the magnitude of the distance exponent in the gravity model; with areas peripherally located (in terms of the core of modernization) displaying a higher friction of distance coefficient in a gravity analysis of telephone interaction, than areas located closer to the core. Williams and Zelinsky<sup>52</sup> analysed international tourist flows (using the transaction flow model). Literature in transportation geography at both national and international levels is being increasingly produced.

In the north-eastern region some works, particularly with reference to the Brahmaputra Valley, have been produced. Mention may be made of Deka's<sup>53</sup> study on road transport in the Brahmaputra Valley, and Medhi's<sup>54</sup> on railways

- 
51. T.R. Leinback, "Distance, Information Flows and Modernization : Some observations from West Malaysia", Professional Geographer 25, (1973), pp.7-11.
  52. A.V. Williams and W. Zelinsky, "On Some Patterns in International Tourist Flows", Economic Geography 46 (1970) pp. 549-67.
  53. D. Deka, "Regional Analysis of Road Transport in the Brahmaputra Valley - A study of its Development and Potentialities", Unpublished Ph.D. thesis submitted to Gauhati University, 1979.
  54. S.B. Medhi, "Impact of Railways on the economy of Assam with special reference to post-independence periods", D.Phil submitted to Gauhati University, 1972.

in Assam. Urban passenger transport issues have been analysed by Medhi<sup>55</sup> and Sharma<sup>56</sup>.

However, no studies have been attempted on any transportation issues in intracity situation and specifically on the city of Shillong.

- 
55. A.K.Medhi, " Problems of Urban Passenger Transportation : A Case Study of Vishwanath Charali", M.Phil thesis submitted to N.E.H.U., 1987.
  56. C.Sharma, " City Bus Service in the City of Guwahati: A Geographical Analysis", M.Phil Thesis, Gauhati University, 1988.

CHAPTER - IIDATA AND METHODOLOGY

## 2.1 Data

Keeping in view the objectives of the study, both primary and secondary sources of data have been utilised. These are as follows :

## 2.1.1 Secondary Sources :

Secondary information relating to the areal extent of the constituent units of Shillong Urban Agglomeration its population and growth rates etc. were derived from Census of India publications<sup>1</sup>. Information relating to the road network map of Shillong city have been obtained from maps collected from the Town and Country Planning Department, Government of Meghalaya, Shillong, and the Survey of India, North Eastern Circle, Shillong. Other materials such as road length statistics and traffic surveys along the National Highways etc. were obtained from the Public Work Department, Government of Meghalaya, Shillong, while statistics relating to the number of registered vehicles in Shillong, annual increase in number of vehicles etc. were obtained from the office of the District Transport Officer.

---

1. Census of India Publications include :

Census of India 1911, Vol. III Assam Part II,  
Census of India 1921, Vol. III Assam Part II,  
Census of India 1931, Vol. IX, Assam Part II,  
Census of India 1951, Vol. XII, Assam Part I-A and  
particularly Census of India, 1981, Series XIV, Meghalaya  
Part II-A and B.

### 2.1.2 Primary Sources :

Data relating to traffic flow at selected nodes of the network was collected from fieldwork. The traffic survey was conducted in the following manner, seventeen major nodes were selected, each representative of the seventeen units of the city<sup>2</sup>. At each of these nodes (point locations or road intersections) a traffic count was taken for a minimum period of fifteen minutes, at different peak hours - once during the morning peak period and once during the evening peak period. Generally, the morning peak period was identified as being between 8.30 to 10.30 A.M., with the evening peak traffic been calculated between 3.30 to 5.30 P.M.

This period of peak traffic flow, would vary from area to area depending upon its prime function. Thus, the time of enumeration is different in the case of educational areas from administrative or market areas. Correspondingly, the evening peak period at Don Bosco and Dhankheti, (both educational areas) were taken as varying between 2.45 to 3.15 P.M., due to the 3 o'clock termination time of school; whereas for Police Bazar - a shopping-cum-administrative area, the peak traffic period was between 5.00 to 5.30 P.M.

---

2. The Shillong Urban Agglomeration comprises of the six townships of Shillong Municipality, Shillong Cantonment, Mawlai, Madanryting, Pynthorumkhrah and Nongthymmai. The Municipality is divided into twelve wards - taking these twelve wards and the remaining five towns the study area is divided into seventeen units.

In order to iron-out any irregularities that may have crept into the traffic survey, the surveys at each point were conducted twice for each peak period (morning/evening), at different times on different working days. For example, if the evening survey on day 1 was conducted proceeding from point A to point E from 3 P.M. to 5 P.M.; the survey order was reversed on day 2, proceeding from point E towards point A during the same time period, with a traffic count for a minimum of 15 minutes per location. At busy junctions where traffic load was too heavy to be accurately conducted by a single person, three or four enumerators simultaneously counted traffic flow on different roads emanating from the junction;.

The traffic flow count was enumerated under the following categories : 1) Buses, 2) Cars and Jeeps, 3) Trucks and 4) two wheelers. (There are no non-motorised vehicles in Shillong, except a few pony carts used to transport goods).

## 2.2 Methodology

On the map of Shillong, 61 nodes were selected representing the different localities of the city, but with a bias towards the important wards of Shillong Municipality - more nodes being selected from wards like Laitumkhrah, Malki, Police Bazar and Bara bazar, than

those from peripheral areas of the Shillong Urban Agglomeration (SUA) such as northern part of Mawlai, Madanryting and Pynthorumkhrah. This selection process was based on the population concentration of the area and the availability of functions - retailing or administrative etc. in the area, which is important from the point of view of traffic flow.

These 61 nodes of the network were idealized in the form of a graph comprising of points (nodes or vertices) and lines (edges, arcs or routes), using graph theory - a branch of topology, dealing with abstract configurations, to study a simplified version of the more complex reality.

Garrison<sup>3</sup> observed that two types of indices prove useful : 1) those dealing with properties of the network as a whole; and

2) those describing individual elements of the network.

#### 2.2.1 Analysis of Aggregate Network-Characteristics

Considering the indices dealing with properties of the whole network first, i.e., with the connectivity of the network<sup>4</sup>, the following indices have been used :

- 
3. W.L.Garrison (1960) : "Connectivity of the Interstate Highway System", Regional Science Association, Papers and Proceedings, 6, 121-137.
  4. Taaffe and Gauthier, op.cit., p.105, ("The degree of connection between all vertices is defined as the connectivity of the network").

- (1) alpha Index ( $\alpha$ )
- (2) Gamma Index ( $\gamma$ )
- (3) Beta Index ( $\beta$ )
- (4) Cyclomatic Number ( $\mu$ ).

The indices used belong to the category of planar graphs, i.e., graphs in which no edges, (arcs/roads) intersect except at vertices (nodes).

The Alpha Index is a ratio of the measure of the number of actual circuits to the maximum number of circuits which could exist in a given network<sup>5</sup>. The formula for calculating it is as below :

$$\alpha = (E_n - V_n + G_n) / (2V_n - 5) \dots\dots 1$$

where,

$V_n$  is the number of vertices,  $E_n$  is the number of edges and  $G_n$  the number of sub-graphs in the system.

Multiplying the alpha Index by 100 gives it a range of 0 - 100, thereby affording a percentage interpretation.

The Gamma Index is the ratio of the number of edges in a network, to the maximum number of edges possible in the network<sup>6</sup> and is expressed by the formula :

---

5. W.L.Garrison and D.F.Marble (1962), "The Structure of Transportation Networks", U.S.Army Transportation Command, Technical Report, 62,- II, p. 24 - as cited in R.G. Chorley and P.Haggett, (eds), Models in Geography, Methuen and Co., London (1967), p.634.

6. Taaffe and Gauthier, op.cit., 1973.

$$= \frac{\text{actual edges}}{\text{maximum edges}} = \frac{e}{3(v-2)} \dots\dots 2$$

where, e = number of edges, v = number of vertices.

Network connectivity as measured by the Gamma Index evaluates the degree to which the network deviates from an unconnected graph and approximates a fully connected one. Like the Alpha Index, it is expressed as a percentage when multiplied by 100.

The Beta Index is a simple measure of network connectivity and is computed using the formula<sup>7</sup>:-

$$\beta = \frac{e}{v} \dots\dots 3$$

where, e and v represent the edges and vertices of the network respectively.

If the Beta Index is zero, as is theoretically possible, the network system would be absent.

Values less than 1 indicate disconnected or poorly connected networks, while a value of 1 indicates a simple connected graph with minimum connectivity and only one circuit; values greater than 1 (with a maximum limit of 3.0) indicate higher values of connectivity<sup>8</sup>, and a complicated network structure.

---

7. R.G.Chorley and P.Heggett, "Network Analysis in Geography", Edwin Arnold, London 1969, p. 32 - as cited in A.B. Mukherjee, op.cit., 1973.

8. M.H.Yeates, "An Introduction to Quantitative Analysis in Economic Geography", McGraw Hill Book Co., New York, 1968, p.115.

The Cyclomatic Number is one of the fundamental indices of graph theory and is written as<sup>9</sup>:-

$$\mu = e - v + p \dots\dots\dots 4$$

where,

e = edges, v = vertices and p = non-connected sub-graphs.

Highly connected graphs have higher cyclomatic numbers, and in conjunction with the alpha index, provides a sensitive measure of network connectivity<sup>10</sup>.

#### 2.2.2 Analysis of Nodal Characteristics

The indices noted above are useful for measuring the connectivity of the network as a whole. However, a geographer is not interested solely in considering the aggregate characteristics of the network, but also in "identification of the spatial structure of the component node-linkage associations of the network"<sup>11</sup> and in understanding the individual nodes in terms of their importance, functions or accessibility with the rest of the nodes/network.

Here again, graph theory provides a convenient means of measuring the accessibility or importance of

9. Chorley and Haggett (1969) as cited in A.B.Mukherjee, op.cit., 1973.

10. Ibid, p.44

11. Taaffe and Gauthier, op.cit., 1973, p.116.

individual nodes of the network. In order to determine nodal accessibility, the network is abstracted as a graph and information on the relationship between the various pairs of nodes is entered into the different cells of the matrix.

At the simplest level, cell entries may record the presence or absence of a direct connection or linkage between a pair of nodes in the network<sup>12</sup>. This presence or absence of connectivity between nodes can be called a connectivity matrix or a binary matrix, since the cell entries are either 1 or 0. The value 1 indicating the presence of a direct connection between a pair of nodes, and 0 indicating the absence of direct connection between a pair of nodes. The difference between the connectivity matrix and the alpha or Beta Indices lies in the level of analysis; thus while the alpha index describes total network connectivity, the connectivity matrix is connectivity between a pair of nodes and not for the whole network.

The size of the connectivity matrix is 61 x 61, and the summation of the individual rows of the matrix produces a sub-total of the connectivity of the node represented by that particular row. The sum of each row is equal to the total number of direct connections from that node to

---

12. Taaffe and Gauthier, op.cit., 1973, p.117.

the remaining nodes, and has been defined as the Degree of a Node<sup>13</sup>.

However, a particular node may have good accessibility in terms of the rest of the nodes via indirect connections, although it may not have many direct connections. An indirect connection is a linkage between two nodes which passes through one or more intermediate nodes. Clearly, indirect connections are also important in determining the connectivity of nodes vis-a-vis the rest of the nodes.

The indirect connectivity between pairs of nodes can be determined by matrix multiplication of the rows of the matrix by the columns of the same matrix<sup>14</sup>. Multiplying row one by column one the value of the first element is derived, multiplying row one by column two the second element of the first row of a new matrix, which is a squared matrix, (square of the direct connectivity matrix) is derived. In this process multiplying all the columns by each of the rows of the connectivity matrix finally results in the squared matrix which is a matrix of indirect connectivity. This process of matrix multiplication can continue and the power of the matrix can be raised to the nodal diameter of the network<sup>15</sup>; however

---

13. Taaffe and Gauthier, op.cit., 1973.p.119

14. Ibid, p.120

15. The diameter of the matrix is defined as the shortest path between the farthest two nodes of the network; shortest path in terms of minimum number of nodes crossed in reaching the one farthest node from the other.

in the present study only the first level of indirect connections, obtained by raising the power of the binary connectivity matrix to two, has been considered. The first level of indirect connectivities implies the linkages between the two nodes via a third.

The binary connectivity matrix and the squared matrix referred to above deal with the connectivity characteristics of the network.

Another nodal characteristic is the centrality of a node and its relative accessibility. This follows from its connectivity characteristics in terms of distance travelled in reaching the  $j^{\text{th}}$  nodes from the  $i^{\text{th}}$  node. To this end, a matrix of the actual distance from the  $i^{\text{th}}$  node to the remaining  $j^{\text{th}}$  node has been constructed. Summing along the rows provides the total distance travelled to reach the  $j^{\text{th}}$  nodes from the  $i^{\text{th}}$  node. This aggregate travel distance<sup>16</sup> of a node, is a measure of the centrality and relative accessibility of that node, and the higher the accessibility of a node, the lower the distance travelled and vice-versa.<sup>17</sup>

The aggregate travel distance, derived as above, has been treated as an accessibility variable and using

---

16. H.Ramachandran, op.cit., 1981.

17. Ibid, p.55.

factor analysis techniques (in this case principal component analysis<sup>18</sup>), an attempt is made to interpret aggregate characteristics of the network, and also in analysing the importance of the individual nodes by generating an eigen vector. The nodes have classified into high, medium, low-medium and low accessibility groups on the basis of the eigen vector and accessibility isolines have been drawn.

In the present study, principal component analysis has been used not for making an index, but to find out if there is any underlying feature being represented by the actual distance matrix.

Another matrix, along much the same lines as the actual distance matrix above, recording straight line distances ( i.e., crow flies distance ) between nodes was represented. In this matrix each element records the direct distance between the  $i^{\text{th}}$  and the  $j^{\text{th}}$  node. Summation along the rows gives a vector representing the direct distance from the  $i^{\text{th}}$  node to the remaining  $j^{\text{th}}$  nodes. This vector expressed as a ratio of the actual travel distance vector gives the tortuosity index<sup>19</sup> or tortuosity ratio of the nodes of the network.

---

18. M.G.Kendall's method of Principal Components has been used; M.G. Kendall, "A Course in Multivariate Analysis, Griffin, London (1957).

19. J.P. Cole and C.A.M. King, "Quantitative Geography " John Wiley and Sons Ltd., London (1968), p. 563.

Interaction between population of different areal units takes place in various ways. This could be in the form of commuting, work trips, shopping trips or telephone calls etc. For the present study vehicular traffic has been taken as an index of spatial interaction within the Shillong Urban Agglomeration. As stated earlier, traffic survey was conducted at seventeen nodes of the study area. The fifteen minute surveys were converted to one-hour peak periods and the entire day's traffic considered as comprising of two such peak periods interspaced by a trough traffic period, with the latter taken as fifty per cent of the average of the morning and evening peak periods. As the survey took into account various types of vehicles, different weightages have been allotted to them. After the passenger traffic was calculated, an approximate figure for pedestrian movement (based on observation) as fifty per cent of passenger traffic was calculated to derive the estimated interaction figure of a unit with the remaining units during a day.

At the second level, estimated interaction figures between the seventeen units has been calculated using the gravity model on projected figures for 1991 and 2001. Gravity models are the mostly widely used types of interaction models and are mathematical formulations used to analyse and forecast spatial interaction<sup>20</sup> and have been used not only in areas of human geography such as traffic

---

20. K.E.Haynes and A.S.Fotheringham, "Gravity and Spatial Interaction Models", Sage Publications Inc., Beverly Hills,

and commodity flows, retailing and urban analysis etc. but in new fields such as archaeology<sup>21</sup> and linguistic geography.<sup>22</sup> The gravity model is not without limitations and its mechanical use can produce inaccurate results, thus modifications to the basic model and careful use of exponents on population in the model are required. In the present study the gravity model has been used in forecasting expected interactions between the seventeen divisions of the Shillong Urban Agglomeration.<sup>23</sup> The area, population size, decadal variation etc. of these seventeen areal divisions was collected from the Census of India publications.<sup>24</sup> For 1971 relevant data was used from the 1971 Census of India.<sup>25</sup>

On the basis of the growth rate of population between 1971-81, the population sizes of the six townships of the Urban Agglomeration was projected for 1991 and 2001.

---

21. J.R.Clark, " Measuring the Flow of Goods with Archaeological Data ", Economic Geography, 55, (1979), pp.1-17.

22. H.Trudgill, "Linguistic Geography and Geographical Linguistics", Progress in Geography 7, (1975)pp. 227-252.

23. Please refer to footnote 2 of this chapter.

24. Census of India, 1981, Series XIV, Meghalaya, Part II A&B.

25. Census figures for Madanryting and Pynthorumkhrah are not available, as these two towns were added to the Shillong Urban Agglomeration only in 1981.

Next the seventeen units were classified on the basis of the predominant economic activity of the unit, into commercial, administrative, educational and residential areas; and different weightages were allotted to them. These weightages were used in the gravity model on the populations, (projected for 1991 and 2001). For calculating the distances between the seventeen units, a central location or major intersection in each of the units was selected, and treated as the distances between them, although most of the divisions possess common boundaries. The results of the estimated interactions for 1991 and 2001 thus obtained have been compared with the estimated interaction during 1990, and the relationship statistically tested. A detailed discussion on the above is given in Chapter IV.

CHAPTER III  
NETWORK STRUCTURE

3.1. Introduction

In the present chapter the structural characteristics of the intra-city road network (topological) of the city of Shillong will be considered. Broadly the study of three different characteristics has been attempted:

- (a) the aggregate characteristics of the network,
- (b) the connectivity characteristics of the network, and
- (c) the accessibility characteristics of the network.

The city of Shillong is an agglomeration of six townships contiguous to one another and in integrated functional relations so that the entire agglomeration functions as one city. The overall population of the agglomeration which was 174,703 in 1981 is expected currently to cross 300,000. Since the city is located largely on an undulating valley area at about 5000 feet above MSL, it has over time spread out over a large geographical area. Although Shillong Municipality extends over 10.36 square km, being situated along the axial transport routes of the city, it has a high population density. The city is highly inter-connected within, with reasonably well-surfaced roads and practically the entire city is accessible to vehicular traffic. However, the major traffic flows are along the axial routes interconnected with the national highway No. 40 and No. 44 which passes through the city, connecting Shillong with Guwahati to the north and Cherrapunjee, Howai and Silchar to the South.

The main areas of the city have many localities connected with the main avenues by lanes and by-lanes. For the



purpose of the present study, it was not possible to include the nodes and roads of the entire network of the city, which is extremely complex and often detailed information is not available. For simplicity, 61 major nodes have been selected from the whole network for the present study, as shown in fig. 3.2.

### 3.2 The aggregate characteristics of the Network

Four indices have been used to analyse the aggregate characteristics of the network. These are the alpha, beta, gamma indices and the cyclomatic number<sup>1</sup>.

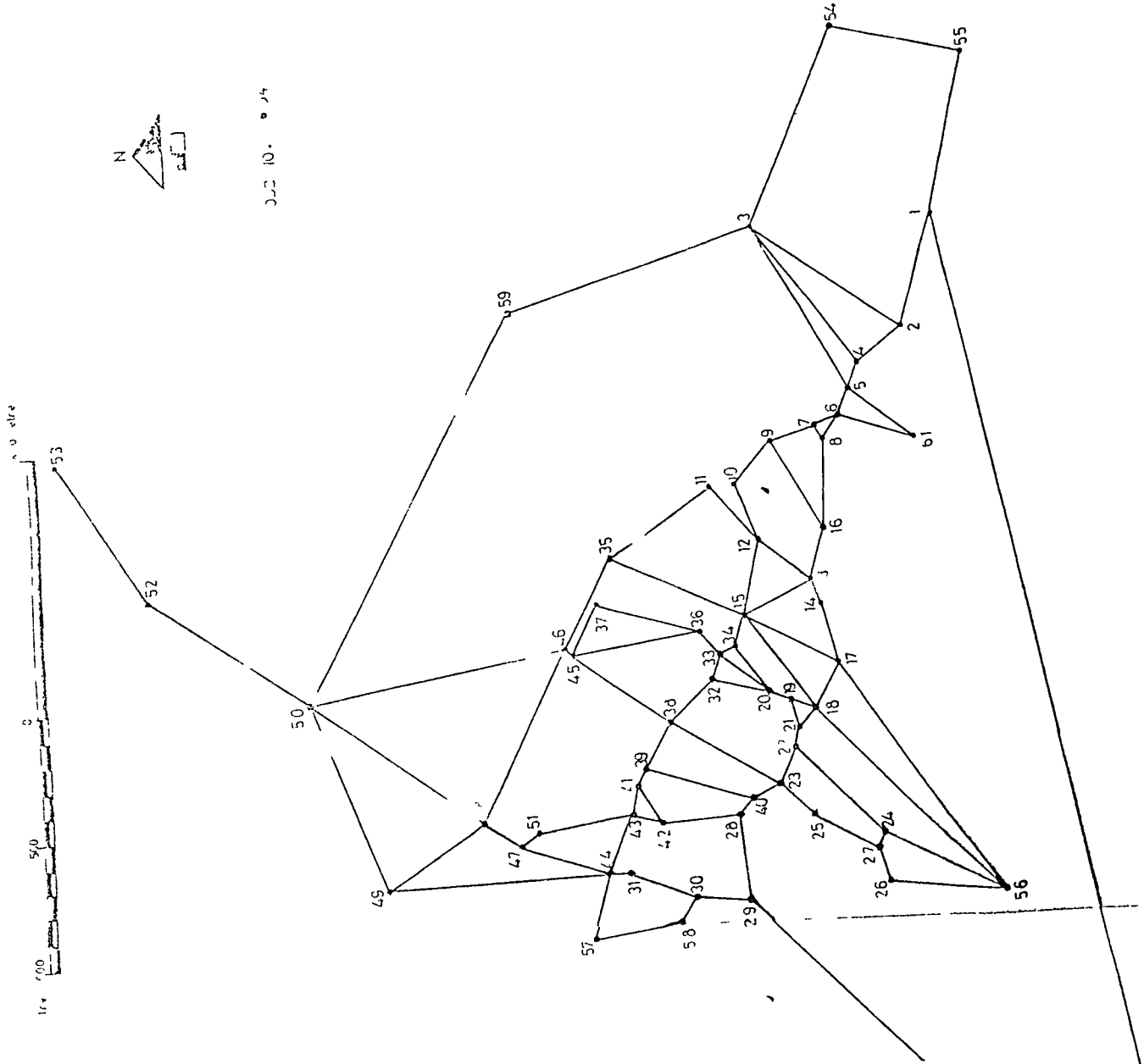
The Alpha Index : The Alpha Index is a ratio between the actual (existing) number of circuits and the maximum number of circuits which could exist in a given network. The range of the alpha index is from zero to one. A value tending towards zero would indicate a minimally connected network, while a fully connected network would be represented by a value of one, or a value tending towards unity. This range can be converted to a percentage interpretation by multiplying by 100.

In the present network, the alpha index works out as  $\alpha = \frac{97 - 61 + 1}{2 \times 61 - 5} \times 100 = 31.62\%$ . The value of 31.62% indicates a low to medium connected network for the city. The number of existing circuits is only one third of the total possible circuits that could exist in the network.

---

1. These nodes are discussed in Chapter - II, in section 2.2.1.

TOPOLOGICAL ROAD NETWORK OF SHILONG



- 1. APOKADAM POLICE BUS STOP
- 2. POLICE BUS STOP
- 3. BAZAR
- 4. JAIL STOP
- 5. JAIL STOP
- 6. JAIL STOP
- 7. JAIL STOP
- 8. JAIL STOP
- 9. JAIL STOP
- 10. JAIL STOP
- 11. JAIL STOP
- 12. JAIL STOP
- 13. JAIL STOP
- 14. JAIL STOP
- 15. JAIL STOP
- 16. JAIL STOP
- 17. JAIL STOP
- 18. JAIL STOP
- 19. JAIL STOP
- 20. JAIL STOP
- 21. JAIL STOP
- 22. JAIL STOP
- 23. JAIL STOP
- 24. JAIL STOP
- 25. JAIL STOP
- 26. JAIL STOP
- 27. JAIL STOP
- 28. JAIL STOP
- 29. JAIL STOP
- 30. JAIL STOP
- 31. JAIL STOP
- 32. JAIL STOP
- 33. JAIL STOP
- 34. JAIL STOP
- 35. JAIL STOP
- 36. JAIL STOP
- 37. JAIL STOP
- 38. JAIL STOP
- 39. JAIL STOP
- 40. JAIL STOP
- 41. JAIL STOP
- 42. JAIL STOP
- 43. JAIL STOP
- 44. JAIL STOP
- 45. JAIL STOP
- 46. JAIL STOP
- 47. JAIL STOP
- 48. JAIL STOP
- 49. JAIL STOP
- 50. JAIL STOP
- 51. JAIL STOP
- 52. JAIL STOP
- 53. JAIL STOP
- 54. JAIL STOP
- 55. JAIL STOP
- 56. JAIL STOP
- 57. JAIL STOP
- 58. JAIL STOP
- 59. JAIL STOP
- 60. JAIL STOP
- 61. JAIL STOP

RD: ROAD  
INT: INTERSECTION

Beta Index : This is a simple measure of network connectivity. The value of the beta index is positively related with the degree connectivity of the network. The beta index ranges from 0 to 3.0 for planar graphs, with index values less than 1 indicating poorly connected (or even disconnected) graphs, the value of 1 indicating the presence of a single circuits and values higher than 1 representing complicated network structure.<sup>2</sup>

The Beta Index for the Shillong road network is

$$\frac{97}{61} = 1.59.$$

This indicates a complex network structure with more than a single circuit and a high degree of interconnection between the nodes. However, there is ample scope for greater linkages between nodes as some nodes have poor connections, reflected by the beta value in terms of the highest possible beta value - which works out to be only 53% (i.e.,  $\frac{1.59}{3.0} \times 100 = 53\%$ ).

Gamma Index : This index is the ratio of the number of edges existing in the network to the maximum number of edges that could exist in the same. Thus, the gamma index evaluates the degree to a given network deviates from an unconnected graph and approximates a fully connected one<sup>3</sup>

$$\gamma = \frac{97}{3(61-2)} = \frac{97}{177} = 54.8\%$$

---

2. Kansky, op.cit. 1963, p.16

3. Taaffe and Gauthier, op.cit., 1973, p.104

The gamma value of 54.8% indicates a medium to high level of connectivity and although it tends towards a well connected graph, in order to be fully connected its edges would have to be increased by almost 80% (180% of existing 97 edges = 176.4, approximating 177 in the gamma value calculation above).

The Cyclomatic Number : The Cyclomatic Number is defined as the maximum number of fundamental circuits in the graph, for connected graphs.<sup>4</sup>

The cyclomatic number is positively correlated with levels of economic development<sup>5</sup> and highly developed countries possess highly connected transportation networks.<sup>6</sup> However, in the case of intra-city transport networks, the cyclomatic number is likely to be influenced by factors such as population distribution, economic activities of the population, size and status of the urban centre etc.

The cyclomatic number for this study is

$$\begin{aligned}\mu &= 97 - 61 + 1 \\ &= 37\end{aligned}$$

This is indicative of a complicated network structure with as many as 37 fundamental circuits in the

---

4. Kansky, op.cit., 1963, p.12  
 5. Mukerji, op.cit., 1974, p.44  
 6. Kansky, op.cit., 1963, p.12

network. The number of circuits would be greater if the number of edges were higher. For instance, if the beta index was 3.0, the resulting cyclomatic number would be significantly higher :

$$= \frac{e}{v} = \frac{x}{61} = 3.0, x = 183.$$

Applying this new number of edges to the cyclomatic number we get :  $= 183 - 61 + 1 = 123$ . The number of existing fundamental circuits, i.e., 37, would increase more than three-fold in the present network, if it was fully connected. Thus although the number of fundamental circuits is high and the structure complex, the network is not structurally high connected and the cyclomatic number is only a third of its maximum.

### 3.3 The Connectivity Characteristics of the Network

The process of reduction of the actual road network to a topological network, not only provides aggregate characteristics and indices thereof, which have been outlined earlier but also the topological (mathematical) relations of the connectivity structure of the network. A simple mathematical reduction of connectivity, between the nodes of the network can be represented by presence of an actual direct connection as one, and absence of such a connection by zero<sup>7</sup>. In this process a matrix

---

7. Taaffe and Gauthier, op.cit., 1973, p.117

of the order of the nodes of the network ( 61 x 61, in this case) can be generated representing all the connected or unconnected nodes of the network by a simple binary matrix.

By a simple row summation process, a vector can be generated representing the total direct connections of the  $i^{\text{th}}$  node with all the  $j^{\text{th}}$  nodes. In the ideal situation, the maximum such connections would tend to be 1 less than the order of the matrix, i.e.,  $61 - 1 = 60$ .<sup>8</sup> However, there could be great variations between the different nodes and their connectivities depending on their economic and accessibility significance. For example, it is expected that either the C.B.D. areas are highly connected or the C.B.D. areas emerge where a high level of model connectivity exists.

Table 3.1 provides information on the direct and indirect connections of all the 61 nodes

Table 3.1

Direct and Indirect Inter-nodal Connections

Node No.	Name of the Node	Direct Connections	Direct Connections Quartile classes	Indirect Connections	Indirect Connections Quartile classes
(1)	(2)	(3)	(4)	(5)	(6)
1.	Allogodam P.B.H.	3	II	7	I
2.	Nongthymmai B.S.	3	II	11	III
3.	Umpling Bazar	5	IV	14	III
4.	Jellishop	3	II	12	III
5.	Jingkieng B.S.	4	III	14	III
6.	Jingkieng-Fire Brigade Int.	4	III	13	III
7.	F.B.-Nagaland House Rd.Int.	3	II	9	II
8.	Fire Brigade	3	II	9	II
9.	Laitumkhrach P.B.H.	2	I	5	I
10.	Laitumkhrach Police Point	2	I	7	I
11.	Upland Rd. - Redhill Rd. Int.	2	I	10	II
12.	Don Bosco Square	5	IV	19	IV
13.	Loeto, Dhankheti	4	III	15	III
14.	Law College, Dhankheti	2	I	8	I
15.	Old Jowai Road	6	IV	26	IV
16.	Risa Colony Rd.	2	I	7	I
17.	Malki B.S.	4	III	17	IV
18.	Barik B.S.	5	IV	20	IV
19.	State Library -Civil Hosp.Int.	3	II	12	III
20.	I.G.P's Office	4	III	13	III
21.	Civil Hospital	3	II	11	III
22.	Civil Hosp.-Bowell Rd. Int.	3	II	11	III
23.	General's Point Laban	3	II	10	II
24.	Patricia Rd. -Laban	3	II	10	II
25.	Lady Kerr Welfare Centre	2	I	6	I
26.	Circuit House	2	I	7	I
27.	Patricia Rd.-Amzad Ali Rd.Int.	3	II	7	I
28.	Petrol Pump near Anjalee	3	II	8	II
29.	Military Hospital	3	II	8	II
30.	J.S.Rd. -Lukier Rd. Int.	3	II	7	I
31.	Distrist Council's Office	2	I	8	II
32.	A.G.Office-Kacheri B.S.	3	II	13	III
33.	A.G. Office	4	III	14	III
34.	N.E.C. Secretariat	3	II	14	III
35.	Bishop Cotton Rd.McCabe Rd.	5	IV	21	IV
36.	Camel's Back Rd.	4	III	15	III
37.	Bivar Rd. -Bishop Cotton Rd.	2	I	8	II
38.	Police Bazar Police Point	5	IV	16	IV
39.	Bouchier Rd.Police Bazar Int.	3	II	10	II
40.	Arunachal Secretariat	3	II	9	II

Continued on following page

(1)	(2)	(3)	(4)	(5)	(6)
41. Police Point -Barabazar Bata		2	I	7	I
42. City B.S. - Barabazar		2	I	7	I
43. Barabazar Police Point		4	III	11	III
44. Lower Mawprem Rd. NH 40 Int.		5	IV	13	III
45. Polo Rd.- Jail Rd. Int.		4	III	15	III
46. Polo Rd.- Bishop Cotton Rd.Int.		4	III	18	IV
47. Welsh Mission Hospital		3	II	11	III
48. St. Joseph's Convent, Jaiaw		4	III	15	III
49. G.S. Rd. Iewrynghep		3	II	14	III
50. Long Round Rd. -Jaiaw Rd. Int.		5	IV	15	III
51. Riatsamthiah		2	I	7	I
52. Shillong Polytechnic		2	I	6	I
53. NEHU Campus - Mawlai		1	I	2	I
54. Happy Valley B.S.		2	I	7	I
55. Happy Valley Rd.		2	I	5	I
56. Madan Laban-Kench's Trace Int.		4	III	14	III
57. Beadon Falls Rd. Junction		2	I	7	I
58. Jhalupara Rd. Junction		2	I	5	I
59. Lalchand Basti		2	I	10	II
60. Air Force Base - Upp. Shillong		2	I	6	I
61. Motinagar P.B.H.		2	I	8	II

\* P.B.H. - Police Beat House  
 B.S. - Bus Stop  
 Int. - Intersection

In order to classify the column representing direct connectivity into quartiles, the table 3.2 was constructed :-

Table 3.2 : Direct Connectivity Quartile Classes

No. of Direct Connections	Frequency	Cumulative Frequency
1 - 2	21	21
3 - 4	32	53
5 - 6	8	61

Dividing the series into quartiles we get  $Q_1, Q_2$  and  $Q_3$  as :

$$Q_1 = L_1 + \left( \frac{N/4 - C}{f} \right) \times h$$

$$Q_2 = L_1 + \left( \frac{N/2 - C}{f} \right) \times h$$

$$Q_3 = L_1 + \left( \frac{3N/4 - C}{f} \right) \times h$$

helps in identifying the level and pattern of indirect connections between nodes as well as the aggregate indirect connections of the  $i^{\text{th}}$  node of the network. For example, two nodes of the same level of direct connectivities, say one each, might possess very high degrees of indirect connectivities, while nodes with high level of direct connectivities may possess low degrees of indirect connectivities.

Table 3.1 also provides the aggregate indirect connectivity vector, generated through the row-summing process. By classifying this vector into quartile classes one can identify the various degree of indirect connectivities of different nodes as well as gauge the relationship between the indirect and the direct connectivities.

From column 5 of table 3.1., the following is derived :

Table 3.3

No. of Connectivities	Frequency	Cumulative Frequency
5	1	1
5 - 8	17	18
8 - 11	14	32
11 - 14	11	43
14 - 17	12	55
17 - 20	3	58
20	3	61

using this table, the indirect connectivity vector has been classified into quartiles as :

$$Q_1 = 5 + \left( \frac{15.25 - 1}{17} \right) \times 3 = 7.51$$

$$Q_2 = 8 + \left( \frac{30.5 - 18}{14} \right) \times 3 = 10.68$$

$$Q_3 = 14 + \left( \frac{45.75 - 43}{12} \right) \times 3 = 14.69$$

With the first quartile 7, second quartile 7 - 10, third quartile 11 - 15 and 15<sup>+</sup> as the fourth quartile. The nodes in the fourth quartile class are those of 12, 15, 17, 18, 35, 38, 46. Of these nodes, apart from node number 35, all of them are located either at the C.B.D. area of the city, (i.e, the Barabazar - Police Bazar area) or along the two axial transport routes of the city along the two national highways of NH.40 and NH.44. Node 35 and 46 are located in the commercial area of Polo Bazar.

In general it may be said that nodes with higher degree of indirect connectivities seem to be located at the C.B.D. and commercial ( shopping or bazar ) areas, as location along transport routes within the city indirectly implies location at commercial or tertiary areas, because subsidiary shopping centres exist along these transport routes.

This is true in the case of the nodes falling in the third quartile category as well. Nodes 2 - 6, 13,

indirect

connectivity. The node number 56 is an exceptions to this, as it is peripherally located yet possesses a relatively high degree of connectivity. Barring this observation, the connectivity of nodes, conforms to the C.B.D. and transport route factors.

### 3.4 Tortuosity Index

The tortuosity ratio or detour index is the ratio between the actual shortest distances between the nodes of a network and the direct distances ( theoretical, straight line distance) between the same<sup>10</sup>. This simple measure is calculated as :

$$\text{Tortuosity Index} = \frac{\text{Shortest Actual Distance between nodes of Network}}{\text{Direct Distance between nodes}} \times 100$$

The multiplications by 100 giving the index a percentage interpretation.

For the present study, the shortest (actual) distances between pairs of nodes was recorded in the distance matrix, while a similar matrix enumerating the direct distances (irrespective of the presence of routes) between pairs of nodes was constructed. The summation of the rows of both the matrices produces a column vector for each matrix. These column vectors of the two matrices when expressed as a ratio (as in the Tortuosity Index Computation above) give the Tortuosity Index.

---

10. Cole and King, op.cit., 1968.

Table 3.4

Actual Shortest Distances and Direct Distances

Node No.	Shortest Actual Distance	Direct Distance	Tortuosity Index (In %)	Node No.	Shortest Actual Distance	Direct Distance	Tortuosity Index (In %)
1.	277.84	204.07	136	31.	173.77	119.28	146
2.	228.01	162.62	140	32.	145.78	92.13	158
3.	255.55	180.78	141	33.	142.49	92.24	154
4.	201.28	143.57	140	34.	141.57	92.29	153
5.	193.83	137.16	141	35.	184.93	111.81	165
6.	186.18	131.08	142	36.	146.35	94.34	155
7.	181.75	128.65	141	37.	182.98	107.90	170
8.	182.46	126.74	144	38.	143.56	96.05	149
9.	193.82	120.61	161	39.	157.20	95.43	165
10.	174.79	107.89	162	40.	146.70	102.30	143
11.	188.89	112.25	168	41.	148.37	103.58	143
12.	161.21	102.57	157	42.	166.98	104.29	160
13.	150.95	105.56	143	43.	160.58	108.04	149
14.	148.60	103.12	144	44.	171.99	121.53	142
15.	146.13	92.82	157	45.	178.63	109.40	163
16.	163.16	112.02	145	46.	178.61	110.38	162
17.	136.82	104.31	131	47.	194.71	131.14	148
18.	132.23	98.77	134	48.	211.74	139.03	152
19.	139.33	91.20	153	49.	252.38	171.63	147
20.	138.61	90.51	153	50.	314.19	179.84	175
21.	134.04	98.39	136	51.	191.45	125.06	153
22.	132.72	101.01	131	52.	382.15	232.11	165
23.	180.85	99.19	182	53.	447.72	281.76	159
24.	180.85	126.28	143	54.	415.05	260.95	159
25.	161.47	111.59	144	55.	369.10	257.08	144
26.	198.95	137.47	145	56.	272.76	168.47	162
27.	180.51	127.20	142	57.	196.15	143.84	136
28.	165.84	106.74	155	58.	190.03	129.74	146
29.	172.05	123.57	139	59.	381.25	182.71	209
30.	176.21	122.24	144	60.	493.06	328.51	150
				61.	191.79	142.12	135

Source : Computed by researcher.

In this study, the tortuosity index for all the nodes of the network have been considered.

Table 3.4 shows the tortuosity index of the different nodes. It can be seen that the Tortuosity Index ranges from 131% to 209%, although nearly  $4/5^{\text{ths}}$  of the values lie in the 131-161 range. Since the city is an unplanned city, originally meant for a few thousand people, the road network does not exhibit any sort of pattern and all the roads are winding roads, albeit to differing degrees, and the tortuosity index is higher than unity in all instances, the minimum being 130% of the shortest direct distance.

Although no specific patterns emerge from the index values, it can be noted that lower index values indicating straighter routes or more direct routes, are located along the main traffic routes, viz. nodes 1-8, 13, 14, 16-18, 21-22, 24-27, 38-41 and 43-44.

However, two short segments of the main traffic routes -viz. the Laitumkhrah and the - Policebazar - Kacheri - IGP segments have higher tortuosity indices.

Lower tortuosity indices are evident in the centrally located nodes ( cf. Fig.                    ). Thus, nodes

17-22 are centrally located and have relatively lower tortuosity indices ( and hence more direct routes); conversely the peripheral nodes of the network, 45-46, 50, 52-54, 56 and 57 have relatively higher tortuosity scores.

There are, however, exceptions to the above, for example, nodes 55 and 60, are located in the periphery of the network, but still have low/good tortuosity index values; while nodes 32-34 are located adjacent to the central part of the network, yet have fairly high tortuosity scores.

Some nodes, e.g., 36,38,40,41,43-44, have relatively low tortuosity scores. This could be attributed to either/ both the following :

(i) location along the major traffic routes,  
(ii) central location in terms of the accessibility to the rest of the nodes, while all these nodes lie along the major traffic routes, nodes 38,40 and 41 are located within the 150 Km. line; nodes 36,43 and 44 within the 180 Km. line.

However, nodes 32-34 are exception to the above in that they are not only centrally located but also situated on the major traffic route, yet possess only medium

tortuosity scores and not low tortuosity scores as would be expected. The Tortuosity scores do not correlate with population density or with areas with concentration of economic activity as in the case in inter-city tortuosity indices, but can be linked with location of nodes in terms of accessibility to the remaining nodes, and location along the main traffic routes of the network.

### 3.5.1 Accessibility Mapping

Within one integrated network, as in the present case, it is possible to find each node is either directly or indirectly connected with all other nodes even though the travelling distance might increase considerably. In order to determine the centrality of a node and its relative accessibility, a matrix of the actual distances between the  $i^{\text{th}}$  and all the remaining  $j^{\text{th}}$  nodes has been represented in a square matrix<sup>11</sup> of 61 x 61 dimension.

Summing up all the actual distances along the rows provides a vector representing the aggregate distance of the  $i^{\text{th}}$  node vis-a-vis the rest of the nodes, as if a traveller was making trips to all the  $j^{\text{th}}$  nodes in turn. By classifying this vector we can understand a preliminary

---

11. This is the actual distance matrix referred to in 3.4 of this chapter.

accessibility characteristic by accepting the logic that the greater the aggregate distance, the lower is its accessibility and vice versa.

Column 2 of Table 3.4 shows the aggregate distance of all the 61 nodes. This vector has been plotted on a map. From the map, it can be seen that in terms of (least distance) accessibility, nodes 17-22 are the most centrally located and accessible set of nodes. Interestingly, all these nodes lie along the major transport routes of the city. Adjacent to this core group of nodes are the nodes of the Police Bazar and Barabazar area, which is the C.B.D. of the city of Shillong. Nodes 32,33,34 and 38 fall in this area, with offices like the N.E.C. Secretariat, Meghalaya Treasury, D.C.'s Office, GPO, CTO, Legislative Assembly, banking and financial institutions and a host of retail centres, located around them. These nodes are bounded by the 150 Km. isoline.

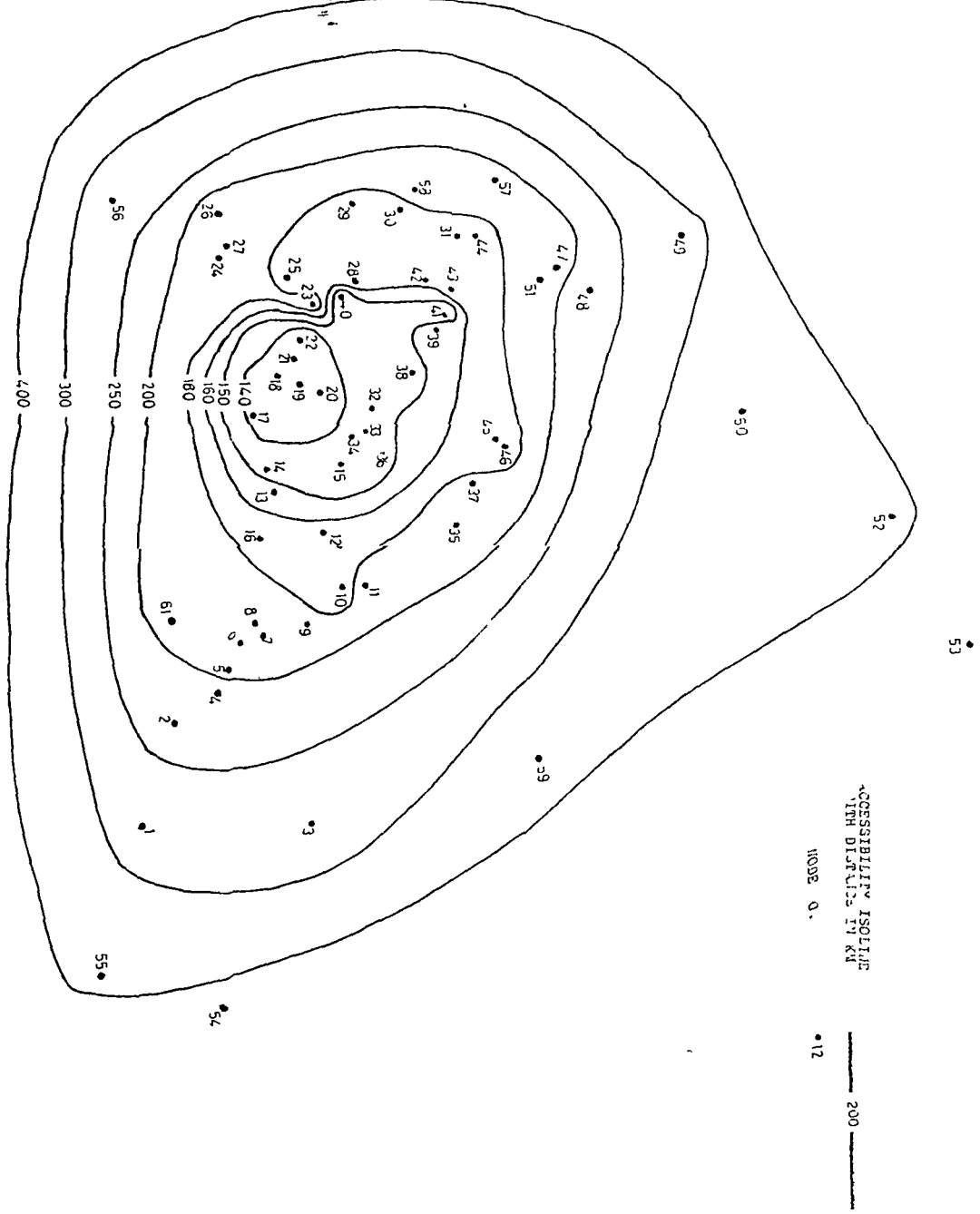
The remaining nodes of the C.B.D. area, i.e., nodes 39,41,42 and 43 have accessibility scores ranging between 148 Km. to 167 Km. Some residential areas and educational areas also have high accessibility, viz. nodes 13-15 which is the Dhankheti - Lachumiere area.

The medium accessibility nodes with distances between 160 Km. to 200 Km., lie to the north-east, north and northwest of the 17-22 node core area of the network, i.e., in the Laitumkhrah - Dhankheti- Lachumiere area,

# SHILLONG

## TRAFFIC ACCESSIBILITY BY ACTUAL DISTANCES

1. U.M.E.      14. OLD JOGAI RD  
2. RONGHYM TI BUS STOP      15. HAZARDEY RD  
3. UPELING BAZAR      16. HAZARDEY RD  
4. JELIASHOR      17. HAZARDEY RD  
5. JINGKING BUS STOP      18. HAZARDEY RD  
6. JINGKING-PINE BRIDGE INT.      19. HAZARDEY RD  
7. PINE BRIDGE-BAKALAND HOUSE RD      20. HAZARDEY RD  
8. PINE BRIDGE      21. HAZARDEY RD  
9. LAI LAI-BAKALAND POLICE STATION      22. HAZARDEY RD  
10. LAI LAI-BAKALAND POLICE STATION      23. HAZARDEY RD  
11. UPELAND RD-REDHILL RD INT.      24. HAZARDEY RD  
12. UPELAND RD-REDHILL RD INT.      25. HAZARDEY RD  
13. UPELAND RD-REDHILL RD INT.      26. HAZARDEY RD  
14. LAI LAI-BAKALAND POLICE STATION      27. HAZARDEY RD  
15. OLD JOGAI RD      28. HAZARDEY RD  
16. HAZARDEY RD      29. HAZARDEY RD  
17. HAZARDEY RD      30. HAZARDEY RD  
18. HAZARDEY RD      31. HAZARDEY RD  
19. HAZARDEY RD      32. HAZARDEY RD  
20. HAZARDEY RD      33. HAZARDEY RD  
21. HAZARDEY RD      34. HAZARDEY RD  
22. HAZARDEY RD      35. HAZARDEY RD  
23. HAZARDEY RD      36. HAZARDEY RD  
24. HAZARDEY RD      37. HAZARDEY RD  
25. HAZARDEY RD      38. HAZARDEY RD  
26. HAZARDEY RD      39. HAZARDEY RD  
27. HAZARDEY RD      40. HAZARDEY RD  
28. HAZARDEY RD      41. HAZARDEY RD  
29. HAZARDEY RD      42. HAZARDEY RD  
30. HAZARDEY RD      43. HAZARDEY RD  
31. HAZARDEY RD      44. HAZARDEY RD  
32. HAZARDEY RD      45. HAZARDEY RD  
33. HAZARDEY RD      46. HAZARDEY RD  
34. HAZARDEY RD      47. HAZARDEY RD  
35. HAZARDEY RD      48. HAZARDEY RD  
36. HAZARDEY RD      49. HAZARDEY RD  
37. HAZARDEY RD      50. HAZARDEY RD  
38. HAZARDEY RD      51. HAZARDEY RD  
39. HAZARDEY RD      52. HAZARDEY RD  
40. HAZARDEY RD      53. HAZARDEY RD  
41. HAZARDEY RD      54. HAZARDEY RD  
42. HAZARDEY RD      55. HAZARDEY RD  
43. HAZARDEY RD      56. HAZARDEY RD  
44. HAZARDEY RD      57. HAZARDEY RD  
45. HAZARDEY RD      58. HAZARDEY RD  
46. HAZARDEY RD      59. HAZARDEY RD  
47. HAZARDEY RD      60. HAZARDEY RD  
48. HAZARDEY RD      61. HAZARDEY RD  
49. HAZARDEY RD      62. HAZARDEY RD  
50. HAZARDEY RD      63. HAZARDEY RD  
51. HAZARDEY RD      64. HAZARDEY RD  
52. HAZARDEY RD      65. HAZARDEY RD  
53. HAZARDEY RD      66. HAZARDEY RD  
54. HAZARDEY RD      67. HAZARDEY RD  
55. HAZARDEY RD      68. HAZARDEY RD  
56. HAZARDEY RD      69. HAZARDEY RD  
57. HAZARDEY RD      70. HAZARDEY RD  
58. HAZARDEY RD      71. HAZARDEY RD  
59. HAZARDEY RD      72. HAZARDEY RD  
60. HAZARDEY RD      73. HAZARDEY RD  
61. HAZARDEY RD      74. HAZARDEY RD  
62. HAZARDEY RD      75. HAZARDEY RD  
63. HAZARDEY RD      76. HAZARDEY RD  
64. HAZARDEY RD      77. HAZARDEY RD  
65. HAZARDEY RD      78. HAZARDEY RD  
66. HAZARDEY RD      79. HAZARDEY RD  
67. HAZARDEY RD      80. HAZARDEY RD  
68. HAZARDEY RD      81. HAZARDEY RD  
69. HAZARDEY RD      82. HAZARDEY RD  
70. HAZARDEY RD      83. HAZARDEY RD  
71. HAZARDEY RD      84. HAZARDEY RD  
72. HAZARDEY RD      85. HAZARDEY RD  
73. HAZARDEY RD      86. HAZARDEY RD  
74. HAZARDEY RD      87. HAZARDEY RD  
75. HAZARDEY RD      88. HAZARDEY RD  
76. HAZARDEY RD      89. HAZARDEY RD  
77. HAZARDEY RD      90. HAZARDEY RD  
78. HAZARDEY RD      91. HAZARDEY RD  
79. HAZARDEY RD      92. HAZARDEY RD  
80. HAZARDEY RD      93. HAZARDEY RD  
81. HAZARDEY RD      94. HAZARDEY RD  
82. HAZARDEY RD      95. HAZARDEY RD  
83. HAZARDEY RD      96. HAZARDEY RD  
84. HAZARDEY RD      97. HAZARDEY RD  
85. HAZARDEY RD      98. HAZARDEY RD  
86. HAZARDEY RD      99. HAZARDEY RD  
87. HAZARDEY RD      100. HAZARDEY RD



Oakland area and the Barabazar - Mawprem areas respectively. Most of these nodes are located along the NH.40 and NH.44 routes, with the Kench's Trace - Laban nodes 24-27 being the only exception.

The remaining nodes are nodes of low accessibility and are these nodes located outside the 200 Km, isoline on the map. These nodes are largely situated in the peripheral areas of the city.

The above analysis suggests that the centrality and relative accessibility of nodes corresponds closely with the geometrical centre of the city and accessibilities of nodes decreases as one proceeds outwards from the centre, in approximately concentric circles, as is evident from the map.

### 3.5.2 Accessibility by Factor Analysis

Using the actual distance matrix, stated as earlier, if one is allowed to interpret the matrix representing a number of variables, ( $M = 61$ ) each node and its actual distance with the rest of the nodes appearing as an accessibility variable, then with the help of factor analysis techniques (principal component analysis<sup>12</sup> in this case) it is possible to :

---

12. M.G.Kendall's method of Principal Components has been used; M.G.Kendall, (1957), A Course in Multivariate Analysis, Griffin, London.

(i) understand one or two aggregate characteristics by explaining the significant eigen roots of the matrix, and

(ii) the eigen vectors corresponding to the significant eigen values would indicate the order of importance of the individual nodes, since the weight vector would correspond to each of the corresponding accessibility variables representing the individual nodes.

By factor analysis technique the first five eigen values were derived. The values and their corresponding percentage explained variations are given in table 3.5.

Table 3.5

Eigen Values and Percentage Explained Variations

Eigen Value	Number of Variables	Percentage of Explained Variations
33.99	61	55.72
17.60	61	28.85
3.63	61	5.95
1.35	61	2.21
1.09	61	1.78

From table 3.5 it can be seen that the highest eigen value (now treated as the first principal component) explains 55.72% of variations in the data matrix. This value itself is highly significant since from an order of matrix of

Table 3.6  
Eigen Vector Values

Node No.	Name of the Node	Eigen Vector Values	Node No.	Name of the Node	Eigen Vector Values
1.	Allogodam P.B.H.	.176	32.	A.G.Office Kacheri B.S.	.953
2.	Nongthymmai B.S.	.322	33.	A.G.Office	.944
3.	Umpling Bazar	.245	34.	N.E.C. Secretariat	.936
4.	Jelli shop	.369	35.	Bishop Cotton Rd.-McCabe Rd.	.804
5.	Jingkieng B.S.	.404	36.	Camel's Back Rd.	.815
6.	Jingkieng -Fire Brigade Int.	.425	37.	Bigar Rd. -Bishop Cotton Rd.	.835
7.	F.B.-Nagaland House Rd. Int.	.458	38.	Police Bazar Police Point	.957
8.	Fire Brigade	.462	39.	Bouchier Rd. -Police Bazar Int.	.904
9.	Laitumkhrarh P.B.H.	.656	40.	Arunachal Secretariat	.945
10.	Laitumkhrarh Police Point	.767	41.	Police Point -Barabazar Bata	.833
11.	Upland Rd.-Redhill Rd. Int.	.839	42.	City B.S. - Barabazar	.862
12.	Don Bosco Square	.822	43.	Barabazar Police Point	.861
13.	Loretto Convent - Dhankhetti	.832	44.	Lower Mawprem Rd.- NH.40 Int.	.797
14.	Law College - Dhankhetti	.866	45.	Polo Rd. -Jail Rd. Int.	.822
15.	Old Jowal Rd.	.910	46.	Polo Rd. - Bishop Cotton Rd. Int.	.819
16.	Risa Colony Rd.	.736	47.	Welsh Mission Hospital	.716
17.	Walki B.S.	.911	48.	St. Joseph's Convent - Jaiaw	.650
18.	Barik B.S.	.970	49.	G.S. Rd. - Iewrynghep	.517
19.	State Library -Civil Hosp. Int.	.907	50.	Long Round Rd.- Jaiaw Rd. Int.	.267
20.	I.G.P.'s Office	.976	51.	Riatsamthiah Police Station	.762
21.	Civil Hospital	.974	52.	Shillong Polytechnic	.159
22.	Civil Hosp. -Bowell Rd. Int.	.977	53.	NEHU Campus - Mawlai	.075
23.	General's Point - Laban	.909	54.	Happy Valley B.S.	.008
24.	Patricia Rd. - Laban	.909	55.	Happy Valley Rd.	.142
25.	Lady Kerr Welfare Centre	.925	56.	Madan Laban - Kench's Trace Int.	.596
26.	Circuit House	.788	57.	Beadon Falls Rd. Junction	.778
27.	Patricia Rd.-Amzad Ali Rd. Int.	.902	58.	Jhalupara Rd. Junction	.811
28.	Petrol Pump Anjalee	.851	59.	Lalchand Basti	.055
29.	Miltary Hospital	.867	60.	Air Force Base -Upp. Shillong	.437
30.	J.S. Rd. - Lukier Rd. Int.	.851	61.	Motinagar P.B.H.	.534
31.	District Council's Office	.790			

\* P.B.H. = Police Beat House, B.S. = Bus stop, Int. = Intersection.

61 this explains more than 50% of variations in the data matrix. Therefore this eigen root itself is the principal cause, explaining the accessibility significance of the network.

By using the first principal component an eigen vector was generated which is summarized in table 3.6. The values are non-normalized. Using this vector, the nodes have been classed into high accessibility group, medium accessibility group, low-medium accessibility group and low accessibility group. On the basis of these values accessibility isolines have been drawn (fig. ).

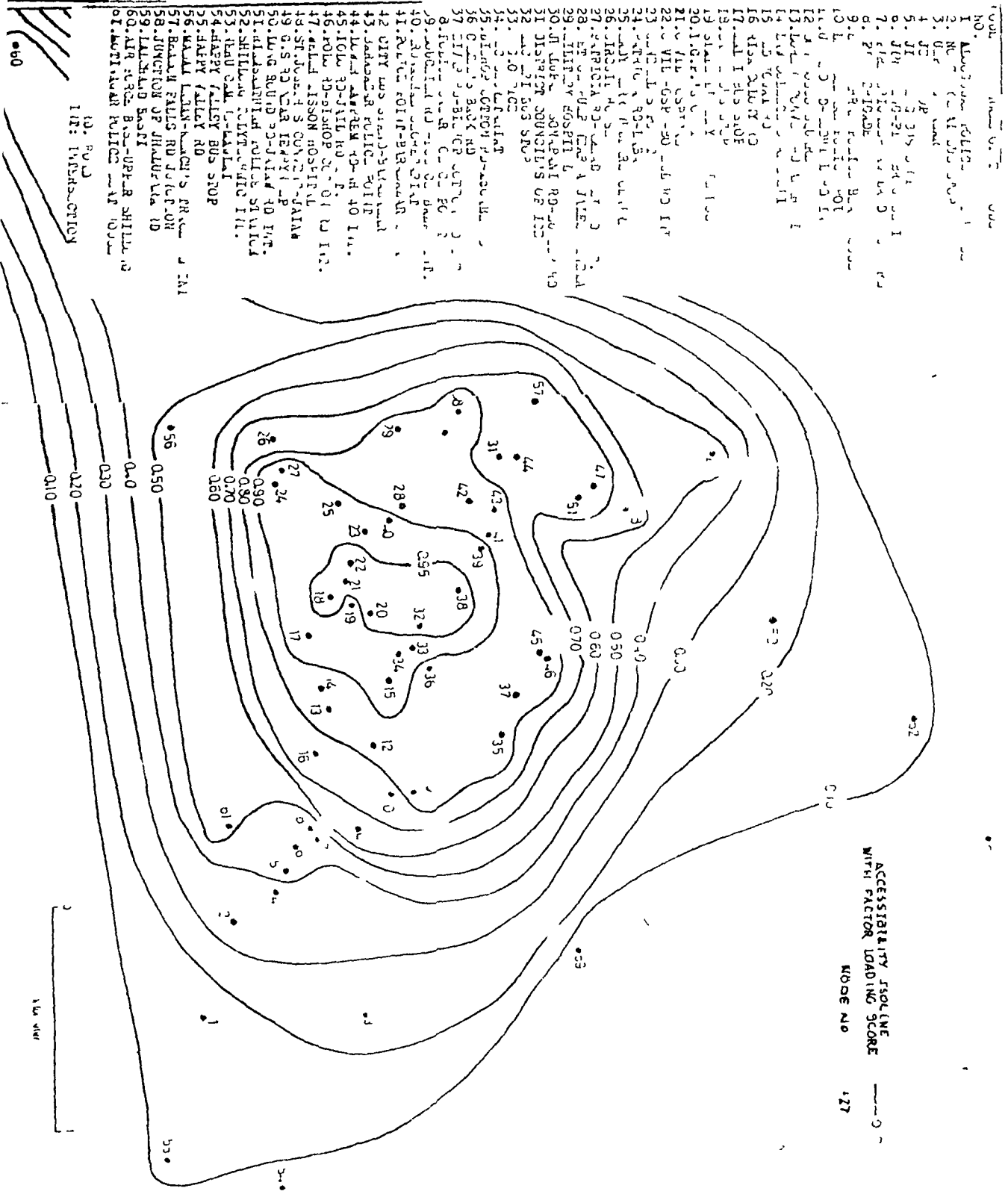
The 0.9 and 0.95 isolines indicate high accessibility, while the 0.7 and 0.9 isolines indicate medium accessibility. Values between 0.4 to 0.7 represent low-medium accessibility while values of less than 0.4 show low accessibility.

As expected, high accessibility scores are associated with the nodes located in the central areas of the city, conversely low accessibility scores with nodes located in the peripheral areas of the city.

In fact, there is a steady increase in the value of the eigen vector from -0.008 and 0.142 (nodes 54 and 55 in Happy Valley) to 0.910 in the case of node 15. This increase is evident from table 3.6. Nodes 1 to 15 show a sequential increase

# BY FACTOR LOADING SCORES

- 1. ALBANY POLICE
- 2. ...
- 3. ...
- 4. ...
- 5. ...
- 6. ...
- 7. ...
- 8. ...
- 9. ...
- 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. ...
- 38. ...
- 39. ...
- 40. ...
- 41. ...
- 42. ...
- 43. ...
- 44. ...
- 45. ...
- 46. ...
- 47. ...
- 48. ...
- 49. ...
- 50. ...
- 51. ...
- 52. ...
- 53. ...
- 54. ...
- 55. ...
- 56. ...
- 57. ...
- 58. ...
- 59. ...
- 60. ...



in the eigen vector as <sup>one</sup> proceeds from node 1, Allogodam, towards nodes 13, 14-15 of Dhankheti - Lachumiere. This trend of higher accessibility scores towards the centrally located nodes continues, and the highest set of values at  $0.95^+$  shows a clustering at the centre of the network. Nodes 18, 20, 21, 22 and 38 being the most accessible nodes of the network.

On all sides of these nodes are a group of nodes - viz., 15, 17, 23, 24, 25, 27, 33, 34, 39 and 40 which have accessibility scores ranging from 0.9 to 0.95. These two sets of nodes together constitute the high accessibility group of nodes. As noted above, these nodes are located in the geographical centre of the network. Moreover, they occupy the adjuncture of the two National Highway routes, NH.40 and NH.44, which serve as the main traffic routes of the city.

Nodes located in the C.B.D. area of Police Bazar and Barabazar fall either in the high accessibility group (e.g., nodes 32, 38 and 39) or in the medium accessibility group (viz. nodes 41, 42, and 43).

The low medium and low accessibility groups of nodes are located largely in the outer and peripheral areas of the city, as was the case in the distance accessibility of nodes (3.5.1).

1. In the aggregate characteristics of the network an analysis of the alpha, beta, gamma and cyclomatic number indices reveals a complex network structure with medium to high levels of connectivity and a high number of fundamental circuits. The network, however, shows only moderate development as the alpha index and the cyclomatic number represent little over 30% of the maximum potential development and the beta and gamma indices slightly more than 50% of the same.

2. The connectivity characteristics of the network analysed in terms of direct connectivity and first level indirect connectivity between nodes, show that higher connectivities exist in nodes located along the two axial transport routes of the city along NH.40 and NH.44 and in nodes located in the C.B.D. areas of the city. This could be due to the retailing and commercial centres being concentrated in both these locations (i.e., the CBD and in nodes along the National Highways).

3. The tortuosity scores show that all roads of the city are tortuous to varying degrees. This is largely because the city is unplanned and partly due to the hilly terrain. Nodes located in peripheral areas show greater tortuosity, than centrally located one.

4. The centrality and relative accessibility of the nodes of the network, measured by actual distance scores

and interpreting the accessibility variable using principal component analysis shows that in both instances, accessibility and centrality of nodes depend on their geographical location vis-a-vis the rest of the nodes and also in relation to the C.B.D. areas of the city.

CHAPTER IVTRAFFIC FLOW

## 4.1 Introduction

In the span of a century and a quarter, Shillong grown from infancy in 1862, when only a few settlements at Laban and the market of Iewduh existed, to its present population size of some two lakhs plus. Its tremendous and consistent growth in population has been accompanied by a corresponding diversification and expansion of its functional attributes as well as a rapid increase in road traffic. The growth of Shillong and its historical background is useful in forming a picture of its present set-up.

The history of Shillong started roughly in 1862, when the British attracted by its salubrious climate selected Shillong as the site for a 'station' for their troops. Acquisition of land from the Syiem (King) of Myllem in December 1863 put Shillong on the map as a 4.19 square mile tract comprising of Shillong (Upper Shillong 3.13 square miles), Iewduh (Civil station - 0.54 square miles) and Iewduh (Cantonment - 0.52 square miles)<sup>1</sup>.

Since then, the history of Shillong has been a continuous process of steady and sustained accretion of population, a result of the sequential enhancement of **its** administrative status.

---

1. K.D.Saha, "The Study of Community-wise Distribution and the Growth of population in Shillong", in B.P.Goswami (ed) Cultural Profile of Shillong, Anthropological Survey of India, Calcutta, (1979), p.4-31.

The processes of urban growth got under way with the shifting of (a) the district headquarters from Cherrapunji to Shillong and (b) the seat of military administration from Gauhati to Shillong, in 1864.

In 1874, when Assam was made a separate province and Shillong its capital, the forces of urbanisation were given a further boost. At about this time in 1872, the population of Shillong was estimated at 1363, although it was probably slightly higher.<sup>2</sup>

By late 1875, the first unmetalled cart track was opened to pony and bullock carts between Gauhati and Shillong. In 1878 with the acquisition of more land, Mawkhar and Laban were added to the existing areas of Jail Road, Police Bazar and European Quarters, Shillong was declared a 'station'. Its population was, at that time 2149.<sup>3</sup> The following years saw more and more new areas being brought under the station, viz. Lachumiere in 1885, Kench's Trace and Laitumkhrach during 1900-1910, and Jhalupara, Jaiaw, Mawlai and Nongthymmai soon after.

Separation of Assam from East Bengal saw Shillong being made provincial headquarters of Assam in 1912.<sup>4</sup> This resulted in a large number of government offices, quarters for government staff, medical centres etc. coming up in the town, along with a large

- 
2. The Report on the Census of Assam, 1881, Part I, p.32 notes a "Small Underestimate of the Population (of Shillong) in 1872."
  3. Assam Chief Commissioner's Proceedings, Home, January, 1882, Assam Municipal Report 1880-81, as stated in K.D.Saha, op.cit.
  4. Shillong was the capital of Assam since 1874 till 1905; however, between 1905 to 1911, it ceased to be capital of the province, which was joined in East Bengal. After 1912 it continued as capital of Assam till the creation of the new state of Meghalaya.

influx of migrant population into the town. With independence there was a further expansion of government departments and a corresponding population growth in the town. This also led to new localities being added to the town- Motinagar, Bhagyakul, Forest Colony and New Colony being such areas. An inflow of population from high density areas like the Brahmaputia Valley, Bihar, Bengal and Uttar Pradesh took place. Much of the migrant population were employed in government departments, and others in the business and commercial sector.

The granting of statehood to Meghalaya in 1972 made Shillong the state capital and the establishment of NEHU in 1973 further aided the growth of Shillong, partly countering the out-migration of large numbers of people to Assam.

A large number of central governments organisations like ICAR, GSI, Survey of India, Botanical Survey of India, Zoological Survey, Anthropological Survey, CWC, NEEPCO, NEC, AGO have contributed its continued growth, and the decadal growth rate of 42.32% actually took place entirely in the second half of the decade.

Table 4.1 shows the population growth of Shillong from 1881 onwards;

Table 4.1  
Shillong - Population Growth

Year	Population	Decadal Increase ( in % )
1881	4,288	-
1891	7,900	84.23
1901	9,621	21.78
1911	13,639	41.76
1921	17,203	26.13
1931	26,536	54.25
1941	38,192	53.92
1951	58,152	53.20
1961	1,02,398	75.00
1971	1,22,752	19.88
1981	1,74,703	42.32

Source : n.1, chapter II.

From the table, the constant growth of Shillong, with a rapid initial growth, followed by a relative trough growth period (1901-1921) and then a period of high growth (1931 onwards) is evident. Only during 1961-71 decade has the growth been low; during this period the population of Cantonment declined by nearly sixty per cent. The growth during the last decade took place largely during the latter half, as noted earlier, and in effect the decadal variation would be much higher, which could inflate the 1991 population size.

#### 4.2.1 Population and Vehicular Increase

Today Shillong is one of the premier cities of north-east India, second in importance only to Guwahati. Its major functions are administrative, educational and commercial and trade.

In terms of its administrative functions, the city has a plethora of central and state government offices, regional offices of public sector undertakings, banks etc. As far as education is concerned the city has a large number of schools, and colleges located in it, along with two polytechnics and a University. In fact, Shillong was stated to have four times more educational institutions per square kilometer than any other town in India.<sup>5</sup> The city offers a wide range of wholesaling and retailing facilities, with the major commercial area confined to the Barabazar -Police Bazar area.<sup>6</sup> The city is also a tourist centre with its picturesque landscape, numerous waterfalls, artificial lakes and an 18 -hole golf course, and attracts domestic as well as international tourists.

Along with population increase and functional diversification of the city, the vehicular traffic in the city has been rapidly increasing. Table 4.2 shows the number of registered vehicles in Shillong and their annual increase.

Table 4.2

Annual Increase in Registered Vehicles in Shillong

Year *	Trucks & Tractors	2-wheelers & 3 wheeler	Buses	Cars, Taxis, Jeeps and Trailers	Others	Total	Annual Increase (In %)	Total Increase (In %)
1985	2036	2516	571	5617	95	10835	-	
1986	2452	2925	639	7058	110	13184	21.68	
1987	2710	3643	674	7627	112	14766	12.00	
1988	2960	4020	732	8312	117	16141	9.31	
1989	4339	4771	1005	10558	144	20817	28.96	92.13

\* year ending 31st March.

Source : District Transport Office, Shillong.

As evident from the table, the number of vehicles registered in Shillong has increased rapidly over the years and touched the 20,000 mark in early 1989. The rate of growth during the 1985-89 period is a staggering 92%, and with the trend likely to continue unabated, the traffic could add further stress to the road network of the city, which, as seen earlier, has limited connectivity.

As to what proportions the traffic problem may assume, can be estimated by projecting the population figures for the coming years; as population increase, interaction levels and vehicle ownership are inter-related facets of the issue.

Table 4.3 shows the projected populations for 1991 and 2001 for the Shillong Urban Agglomeration and its constituent units, based on the 1971-81 growth rates.

Table 4.3  
Projected Population of Shillong

Agglomeration/ Town	Population 1981	Area (Sq.Km)	Density (Sq.Km.) 1981	Popula 1991	Densi- ty (Sq.Km) 1991	Popu- lati 2001	Density (Sq.Km.) 2001
Shillong Urban Agglomeration	174,703	25.40	6878	248,637	9789	353,860	13931
Shillong Municipality	109,244	10.36	10545	136,140	13141	169,658	16376
Cantonment	6,620	1.84	3598	9,265	5035	12,967	7047
Nongthymmai	21,558	2.93	7358	28,862	9851	38,640	13188
Mawlai	20,405	6.14	3323	29,197	4771	41,778	6804
Madanryting	6,165	2.11	2922	8,773	4158	12,486	5918
Pynthorumkhrah	10,711	2.02	5302	15,243	7546	21,694	10740

The population projections for all the units except Pynthorumkhrah and Madanryting which were added to Shillong in 1981, (and hence decadal growth rates are not available) are based on their 1971-81 growth rates. These two newly added towns projected population are based on the growth rate of the agglomeration as a whole.

Table 4.4 shows the projected population figures of the twelve wards of Shillong Municipality. The 1991 and 2001 projections are based on the 1971-81 growth rates.

Table 4.4  
Ward-wise Population Projections of Shillong Municipality

Ward No.	Name	Area (sq.km)	1971-81 Variation (%age)	1981 Popul ation	Density (sq.Km.)	1991 Popul ation	Density (sq.Km.)	2001 Popul ation	Density (sq.Km.)
I	Laitumkhrah	1.87	33.21	15620	8363	20807	11127	27717	14822
II	European	1.50	35.16	7604	5069	10277	6851	13890	9260
III	PoliceBazar	0.1	-16.30	2629	26290	3276 *	32760	4082 *	40820
IV	Jail Road	1.41	53.32	8235	5779	12626	8892	19358	13632
V	Mawkhar	0.31	0.78	8869	20609	11052 *	35652	15762 *	50845
VI	Jaiaw	0.57	13.52	10207	17097	11587	19978	13154	22679
VII	S.E.Mawkhar	0.29	21.09	8549	29479	10352	35697	12535	43224
VIII	Mawprem	1.08	40.37	18408	16888	25839	23705	36270	33275
IX	Kench'sTrace	0.66	71.24	6266	9352	10730	16015	18374	27424
X	Laban	0.33	0.35	5903	17361	7356 *	21635	10491 *	30856
XI	Lumparing	1.59	11.13	8150	5094	9057	5661	10065	6290
XII	Malki	0.60	26.57	8804	14673	11170	18617	14138	23563
Av/Total		10.36	24.62	109244	10545	144129	13912	195836	18993

\* based on average growth rate of Shillong Municipality.

Source : 1981 Data from Directorate of Urban Affairs, Govt. of Meghalaya, Shillong and 1991 & 2001 computed by Researcher.

An analysis of tables 4.3 and 4.4 shows that the population of the Shillong Urban Agglomeration could reach the 2.5 lakh mark by 1991 and cross the 3.5 lakh mark by 2001. Since these estimates are based on the 1971-81 growth rate, estimates for 1991 and 2001 are conservative estimates and the population could grow to larger sizes, gives the fact that the 1971-81 growth took place mostly during the latter part of the decade.

When the ward-wise picture is considered, the wards of Police Bazar and S.E. Mawkhar (i.e. Barabazar) could be the problem areas with densities per square kilometer as high as 43,000. The case of Mawkhar, where the projected population density reaches 50,000 per square kilometer, (being based on the average growth rate of the Municipality) could be an exaggerated projection, as this ward registered a growth of less than one per cent in the 1971-81 period.

However, it is clear that even conservative estimates as above, present a rapid growth scenario with the 1981 population of the city doubling itself by the turn of the century. Add to this the corresponding increase in vehicular and increased travel trips and the chaotic picture of Shillong is completed.

#### 4.2.2 Activity Classification

A broad activity classification has been attempted at the ward/town level. Broad in the sense that the ward or town

has been classified into either of the following : (a) Commercial (b) educational (c) administrative (d) residential, categories on the basis of the major function of that unit; thus although a given ward may possess shopping areas, administrative centres, educational institutions etc., it has been classified as residential, if most areas or the major function of the ward is residential.

For example, Laban ward has been considered as residential although services other than residential (such as educational and commercial) do exist, but are not of prime importance. Similarly, the ward of Laitumkhrach has been considered as commercial-cum-educational, as both these activities dominate. With the large number of schools and colleges and the array of commercial activities along the Laitumkhrach-Dhankheti-Malki main road.

The following is the activity classification, based on the above procedure and on available census data<sup>7</sup>.

Table 4.5  
Activity Classification

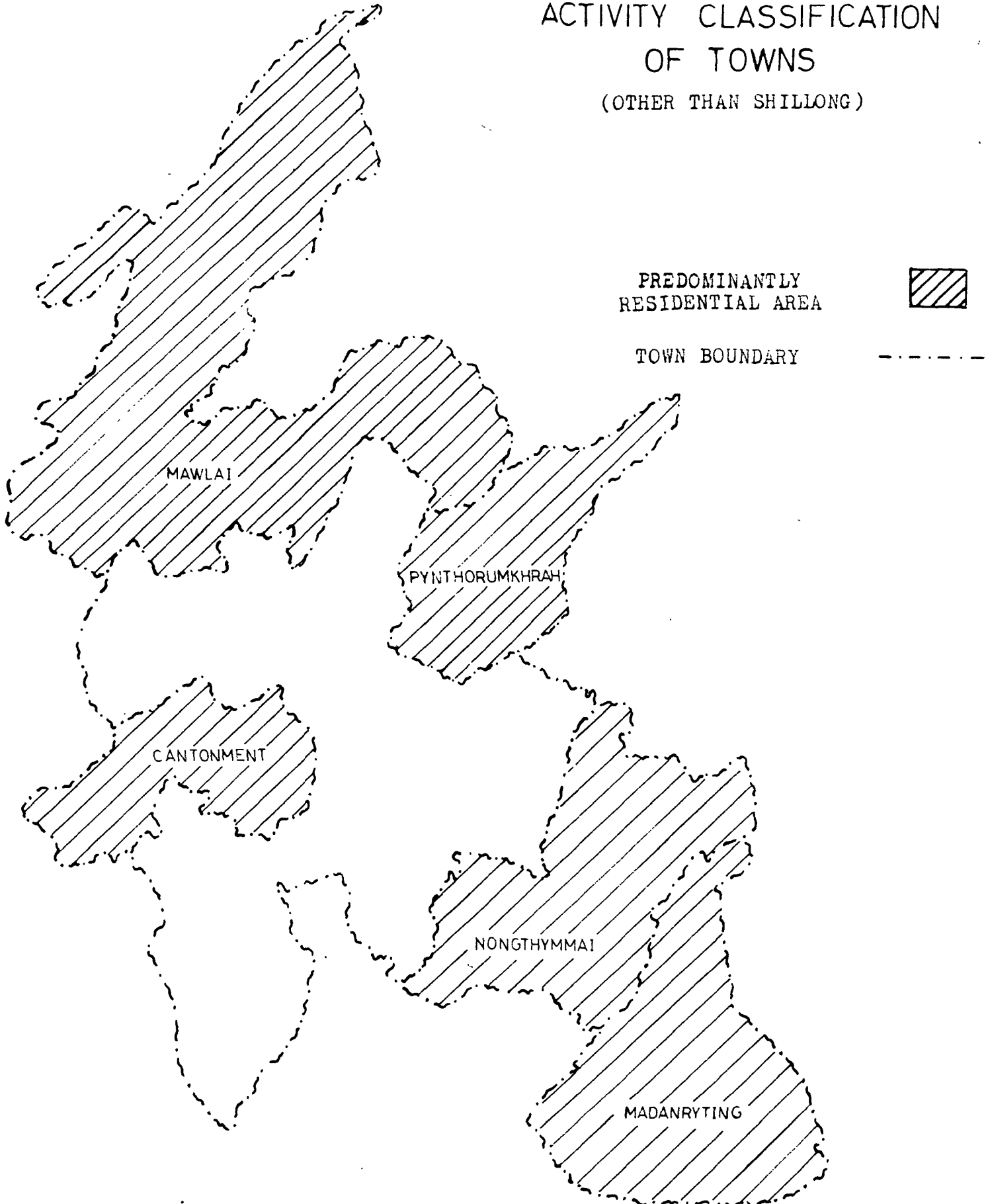
Town/Ward No.	Name of Ward/Town	Major Activity
(1)	(2)	(3)
I	Laitumkhrach	Commercial-Educational
II	European	Administrative
III	Police Bazar	Commercial
IV	Jail Road	Residential





(contd...p. )

7. District Census Handbook, East Khasi Hills District, Census of India, Series XIV, Part II A & B.

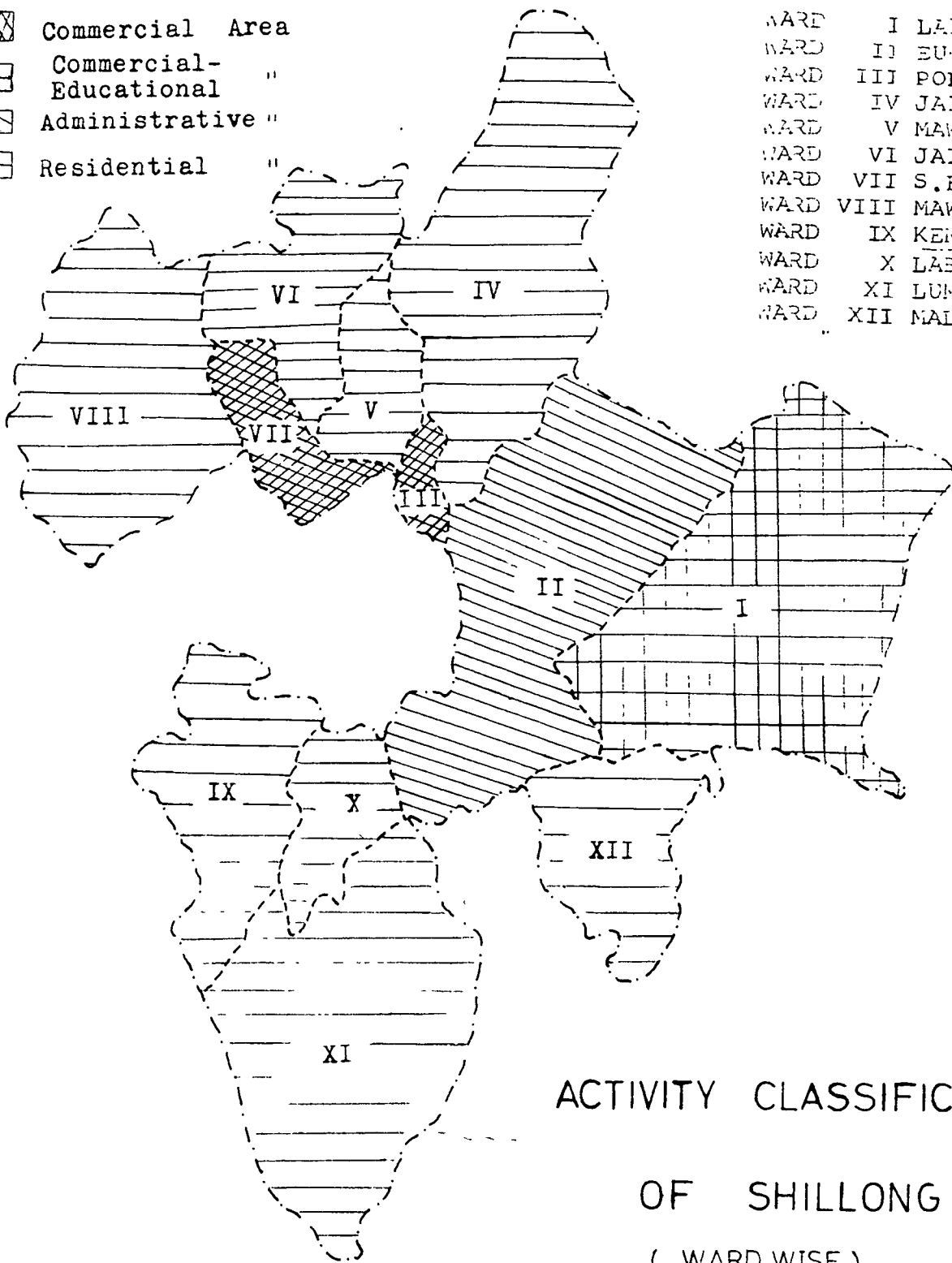
# ACTIVITY CLASSIFICATION OF TOWNS

(OTHER THAN SHILLONG)



-  Commercial Area
-  Commercial-Educational "
-  Administrative "
-  Residential "

- WARD I LAITUNKHRAM
- WARD II EUROPEAN
- WARD III POLICE BAZAR
- WARD IV JAIL ROAD
- WARD V MAWKHAR
- WARD VI JAIAM
- WARD VII S.E. MAWKHAR
- WARD VIII MAWPREM
- WARD IX KENCH'S TRACE
- WARD X LABAN
- WARD XI LUMPARING
- WARD XII MALKI



ACTIVITY CLASSIFICATION  
OF SHILLONG  
( WARD WISE )

not to scale

table 4.5 continued.

(1)	(2)	(3)
V	Mawkhar	Residential
VI	Jaiaw	"
VII	S.E. Mawkhar	Commercial
VIII	Mawprem	Residential
IX	Kench's Trace	"
X	Laban	"
XI	Lumparing	"
XII	Malki	"
	Mawlai	"
	Cantonment	"
	Madanryting	"
	Pynthorumkhrah	"
	Nongthymmai	"

As seen from table 4.5 most of the wards and all the towns fall in the residential category by this classification -with commercial and administrative/educational areas confined to the wards of Laitumkhrah, European Ward, Police Bazar and S.E. Mawkhar.

#### 4.3 Interaction Levels and Gravity Estimates

The Gravity Model, borrowed from Physics and widely used in the social sciences and geography, has found acceptance largely because of its simplicity<sup>8</sup>. The model suggests that the force of attraction between two bodies is proportional to the product of

8. R.Abler, J.S.Adams and Peter Gould, Spatial Organisation : The Geographer's View of the World, Prentice Hall Inc. New Jersey, 1971, pp. 236-239.

their masses, divided by the distance between them, with the distance generally but not always squared<sup>9</sup>.

In human geography the gravity concept along with its variations have been used to analyse inter-city, inter-regional and intra-city flows, tourist flows, retailing etc.<sup>10</sup>

In the present study interactions between the seventeen areal divisions of the city, has been considered in terms of estimated interaction based on :

- (i) 1990 traffic flows ( based on survey data ),
- (ii) gravity model estimates on population projections for 1991 and 2001.

As stated earlier in Chapter II, traffic flow data was collected by a traffic count at seventeen major intersections of the city and conversion of the quarter hour surveys to peak hour estimate and then to daily estimates were made. Since the traffic survey took into account different types of vehicles with different passenger capacities, the following weightages were given:

Passenger buses	=	35 persons
Cars and Jeeps	=	4 persons
Trucks	=	3 persons
Two Wheelers	=	1.5 persons

---

9. J.P.Cole and C.A.M.King, op.cit., 1968, p.503.

10. The Gravity Concept has been discussed in Chapter II.

After daily passenger traffic levels were generated, pedestrian movement, taken as fifty per cent of the former, were calculated to derive the interaction level for one day. This was done at the level of interaction of a particular unit with the remaining units in one day.

Estimated interaction between the seventeen units is based on the gravity model, and the basic model used is as :

$$I_{ij} = \frac{W (P_i) \times (P_j)}{d^2_{ij}}$$

where,  $I_{ij}$  = interaction between the  $i^{\text{th}}$  and  $j^{\text{th}}$  centres,  
 $P$  = population masses of the  $i^{\text{th}}$  and  $j^{\text{th}}$  centres,  
 $d$  = distance between the  $i^{\text{th}}$  and  $j^{\text{th}}$  centres, and,  
 $W$  = a weight given to the population on the basis of the activity classification of the centres.

As the units of the study area have classified on the basis of their major activities in 4.2.2., the following weights have been allotted :

Commercial areas = 3  
 educational and  
 administrative areas = 2, and  
 residential areas = 1.

The basis of allocation of weights on the basis of activity is of course, purely subjective, but the logic is that the traffic generating capacity of commercial or educational areas are many times more than a purely residential area. Therefore, it is better to assign the highest weightage to the commercial area, medium

weight to educational and administrative areas and low weightage to residential areas.

For distance, a central point in each unit was taken to represent that unit. Thus, each of the seventeen units are represented by a point location, from which vis-a-vis the remaining units, distances have been calculated.

Now, using the gravity model the theoretical interactions between the units have been obtained. However, it may be noted that :

- (i) since traffic flow data in this study is between one unit vis-a-vis the remaining units, estimated interaction has also been calculated along these lines;
- (ii) since traffic flow data was enumerated during 1990, to get a more accurate perspective, the 1981 population figures were used to project 1991 and 2001 population, on which gravity model calculations were worked out, rather than using the 1981 population figures.

With the help of projected population figures for the 17 city units and distances between them theoretical gravity was estimated between all the  $i^{\text{th}}$  to  $j^{\text{th}}$  units. This results in a 17 x 17 square matrix (symmetric) with the principal diagonal as zero (or infinity ) represent the theoretical gravity between the same unit. By summing the matrix rowwise ( or column-wise) the total gravity potential of  $i^{\text{th}}$  unit vis-a-vis the rest of the  $j^{\text{th}}$  units were estimated. However, one peculiarity of the theoretical gravity is that the gravity quotient is true for the minutes

and time frame, it is true for the total interaction between the two masses for every instant of time. Since, it accounts for all type of interactions, the theoretical figures are invariably large. However, in the current study the main concern is the traffic interaction, chiefly passenger traffic. Therefore, some way a reciprocal constant can be found to reduce these figures to the human scale.

On the other hand, we have some knowledge about the actual level of traffic flow (as estimated by the survey) between the  $i^{\text{th}}$  unit and rest of the  $j^{\text{th}}$  units. Theoretically speaking the 'estimated passenger traffic' is someway related to the theoretical gravity of the system. One can symbolically name theoretical gravity potential as  $G(t)_i$  and the estimated passenger traffic as  $G(e)_i$ ,  $i$  representing the sum total of all gravity of  $i^{\text{th}}$  unit vis-a-vis the rest of the  $j^{\text{th}}$  units. Moreover,  $G(e)_i$  represent the passenger flow per day (as estimated). For simplicity, the figures can be kept as such with the justification that (i) instantaneous passenger flow is difficult to estimate in the system and (ii) the difference may arise in the value of reciprocal constant (say  $I/K$ ) only, therefore the overall validity of the relationship of the estimated to that of the theoretical remains the same, except for the degree of  $K$ .

$$G(e)_i = (f) G(t)_i$$

$$\text{and } G(e)^* = a G(t)^b$$

$$\text{or } \log G(e) = \log a + b \log G(t)$$

Table 4.6Estimated and Theoretical Interactions

Town/Ward	Estimated Interactions	Theoretical Interactions
	1990	( 10 <sup>6</sup> ) 1991
Mawlai	16470	656.41
Cantonment	25013	583.70
Nongthymmai	23855	699.98
Madanryting	8378	460.37
Pynthorumkhrah	9248	236.56
Laitumkhrah	43529	2070.67
European Ward	39402	2008.12
Police Bazar	54762	2430.29
Jail Road	10268	430.71
Mawkhar	15165	7722.56
Jalaw	19095	924.22
S.E.Mawkhar	43758	5405.91
Mawprem	28410	950.61
Kench's Trace	15285	1301.56
Laban	18690	1136.45
Lumparing	7245	260.14
Malki	35615	592.30

Where  $G(e)^*$  is the expected value of gravity estimated (passenger flow) solely dependent on the theoretical gravity,  $G(t)$  (independent variable) but for the double logarithmic relationship.

With such a regression model the actual relationship established is highly significant. The equation derived is as follows :

$$G(e)^* = -0.21 + G(e)^{3.91}$$

With  $R^2 = 0.504$

Using 't' test for b shows the estimated 't' of b is 3.91 at 0.01 level of significance at 16 (x-1) d.f. Compared to the theoretical (table) 't' value of 2.92, which is highly significant.

This equation is significant in two ways : (i) first this establishes the relationship of the estimated passenger traffic as dependent on the theoretical gravity potential (ii) secondly, the equation helps us to estimate the estimated passenger traffic between all the  $i^{\text{th}}$  and  $j^{\text{th}}$  units ( since this data is not available to us) by using the  $G(t)_{ij}$  figures in the equation and thereby deriving the estimated flow between all the  $i^{\text{th}}$  and  $j^{\text{th}}$  units in the system. Table 4.7 shows the cell-wise (unit-wise) estimated interaction between the seventeen units for 1991, and allows us to identify the units which show high interactions with one another.

Table 4.7

Estimated Interaction 1991

Town/Ward	Mawlai	Cantonment	Nongthymmai	Madanryting	Pynthor umkhrah	Laitumkhrah	European Ward	Police Bazar
Mawlai	x							
Cantonment	3524	x						
Nongthymmai	2737	1922	x					
Madanryting	3122	2292	10157	x				
Pynthor-umkhrah	1800	883	1873	895	x			
Laitumkhrah	4622	7268	5912	2809	6791	x		
European Ward	4487	4904	5020	2784	2741	14873	x	
Police Bazar	5475	4305	2769	1929	1696	6256	14944	x
Jail Road	4039	2467	2134	4475	1227	4203	4168	3600
Mawkhar	5692	3644	2237	2154	1290	4456	5455	6617
Jaiaw	1038	3016	1883	1681	1177	3573	3958	3411
S.E.Mawkhar	5398	3904	2030	3412	2452	4441	12146	13561
Mawprem	8064	6376	3123	2483	1902	5810	6906	6089
Kench's Trace	2671	3570	3182	2144	1767	4638	3970	2881
Laban	2015	3054	1981	1658	1191	3681	3224	2317
Lumparing	1808	2393	2065	815	1204	3760	1219	1967
Malki	2055	1859	3228	1344	1827	9610	6006	3473

continued on following page

Table 4.7 continued.

Town/Ward	Jail Road	Mawkhar	Jaiaw	S.E. Mawkhar	Mawprem	Kench's Trace	Laban	Lumpa ring	Malki
Mawlai									
Cantonment									
Nongthymmai									
Madanryting									
Pynthorumkhrah									
Laitumkhrah									
European Ward									
Police Bazar									
Jail Road	x								
Mawkhar	2470	x							
Jaiaw	2763	7193	x						
S.E.Mawkhar	4833	36395	9767	x					
Mawprem	2837	34580	5480	14440	x				
Kench's Trace	2518	2354	2128	4469	3804	x			
Laban	2010	1732	1515	3259	2794	19052	x		
Lumparing	1358	969	1249	1753	2109	5382	4296	x	
Malki	2762	2321	1577	4387	2925	2593	2527	2099	x

The highest interaction levels are projected between Mawkhar and S.E. Mawkhar (Barabazar) and between Mawkhar and Mawprem, reaching 36,395 and 34,580 respectively. S.E.Mawkhar or Barabazar is the C.B.D. area (excluding the Police Bazar part) of Shillong and the wards of Mawprem and Mawkhar lie to its west and east respectively. The high level of interaction between Mawkhar and Barabazar is explained by the latter's attractive power as a result of its commercial status, and also due to the fact that traffic from the Welsh Mission Hospital (located in Jaiaw, between Mawkhar and Barabazar) passes through Mawkhar en route to Barabazar. The main routes affected by this flow are the Jaiaw Road-Mawkhar Main Road and the Jaiaw Road-Riatsamthiah Main Road, both joining the Police Point at the Barabazar main junction. The affected nodes being 47-51-43.

Between Mawkhar and Mawprem the same two routes between nodes 47-51 and 43 are affected with an extension towards node 44 from node 43, i.e., along G.S. Road, and with a smaller section, along the Jhalupara-Sunapani Road and the Mawprem Road-NH.40 Intersection, coming under strain.

Another high interaction area is that between Laitumkhrah and European Ward on one hand and European Ward-Police Bazar on the other, both levels in the range of 15,000.

In the first case between Laitumkhrah and European Ward, this interaction is predictable considering that both these wards

are not only adjacent to one another, but also that Laitumkhrāh is a commercial-educational area while European Ward hosts a number of educational institutions and administrative centres. Moreover, both these wards recorded over 30 per cent growth during 1971-81. The roads affected by this high interaction could be either/both : (a) Laitumkhrāh Main Road along Loreto Convent, Malki Main Road upto Civil Hospital-State Central Library area (b) Laitumkhrāh Main Road-St. Edmund's College Road-Loreto Convent intersection.

By the high interaction between European Ward and Police Bazar, the roads affected would be (a) the Jowai Road from Lachumiere through the Main Road along Meghalaya Secretariat to Police Bazar (b) Old Jowai Road/ NEHU Administrative Building along the GPO/NEC Secretariat-Governor's House Road to Police Bazar.

The high interaction areas so far have been between commercial areas or educational or administrative areas. However, that between Kench's Trace and Laban falls into neither of these categories. Both these wards are largely residential areas, although there are a few schools in the Laban area and small markets in both Kench's Trace and Laban and two Colleges in the area. Partly this high interaction level (19000) is explained by the highest growth rate among the seventeen units of the study area, recorded by Kench's Trace (over 71%) during

1971-81. The Kench's Trace-Laban areas has a number of small roads which would be the potential problem roads. These are the Amjad Ali Road-Patricia Road-Bowell Road, the Rilbong-Amjad Ali Road, the Shankar Dev College Road-Kench's Trace Road-Laban Bazar Road routes.

Another high interaction area is the Nongthymmai-Madanryting area. This pair of units lie adjacent to one another and with the cost of living in the Shillong town (Municipality) area rising, the importance of Nongthymmai as a residential area (with its own market at Nongthymmai and Umpling Bazar) could increase substantially. The estimated interaction level of 10,000 would increase traffic along the Umpling-Nongthymmai Main Road-Allogodam-Happy Valley Road and the Jingkieng-Nongthymmai main Road-Allogodam-Happy Valley Road routes. Interestingly, apart from the Nongthymmai-Madanryting area (both of which are towns) all the other high interaction areas are between wards.

Table 4.8 shows the ratio table between the interaction estimates of 1991 and 2001.

From the table it is evident that in terms of proportionate increase of the level of interaction during 2001 over the level of 1991, certain pairs of units could record interactions as high as six times the 1991 level. The interaction of Mawprem with the towns of Mawlai, Cantonment, Nongthymmai,

Table 4.8

Ratios of 2001 Estimates to 1991 Estimates

Town/Ward	Mawlai	Cantonment	Nongthymmai	Madanryting	Pynthor Umkhrach	Laitumkhrach	European ward	Police Bazar
Mawlai	X							
Cantonment	2.00	X						
Nongthymmai	1.92	1.83	X					
Pynthor Umkhrach	1.17	1.15	1.09	X				
Madanryting	3.54	3.46	3.31	2.02	X			
Laitumkhrach	1.91	1.86	1.78	1.89	1.89	X		
European Ward	1.93	1.89	1.80	1.91	1.92	1.80	X	
Police Bazar	1.78	1.74	1.66	1.77	1.77	1.65	1.68	X
Jail Road	2.19	2.15	2.05	2.18	2.18	2.03	2.07	1.91
Mawkhar	2.04	1.96	1.91	2.02	2.03	1.89	1.92	1.77
Jaiaw	1.13	1.59	1.52	1.62	1.61	1.51	1.53	1.41
S.E.Mawkhar	1.73	2.30	2.19	1.72	1.74	1.95	1.63	1.51
Mawprem	2.08	5.89	5.63	5.99	1.99	1.86	1.89	1.57
Kench's Trace	2.45	2.39	2.29	2.43	2.43	2.28	2.31	2.13
Laban	2.04	2.00	1.90	2.03	2.03	1.89	1.92	1.77
Lumparing	1.59	1.55	1.48	2.34	1.58	1.48	1.50	1.38
Malki	1.81	1.68	1.69	2.34	1.80	1.69	1.77	1.57

Continued on following page.

Table 4.8 (continued)

Town/Ward	Jail Road	Mawkhar	Jaiaw	S.E. Mawkhar	Mawprem	Kench's Trace	Laban	Lumpa-ring	Malki
Mawlai									
Cantonment									
Nongthymmai									
Pynthor Umkhrach									
Madanryting									
Laitumkhrach									
European Ward									
Police Bazar									
Jail Road	X								
Mawkhar	2.18	X							
Jaiaw	1.74	1.62	X						
S.E. Mawkhar	1.85	1.72	1.72	X					
Mawprem	2.12	2.01	1.59	1.69	X				
Kench's Trace	2.62	2.44	1.83	2.07	2.40	X			
Laban	1.52	2.03	1.61	1.72	2.00	2.44	X		
Lumparing	1.70	2.41	1.26	1.34	1.56	1.90	1.58	X	
Malki	1.94	1.80	1.43	1.53	1.77	2.16	1.80	1.41	X

Pynthorumkhrah and Madanryting is projected as increasing between 1.99 to 5.99 times. This increase is just under six times between Mawprem and each of the townships of Cantonment, Nongthymmai and Pynthorumkhrah. This is all the more interesting as apart from Cantonment, Pynthorumkhrah and Nongthymmai are not adjacent to Mawprem.

Mawprem also records a fairly high ratio of about two with the wards of Jail Road, Mawkhar, Kench's Trace and Laban. This situation, wherein Mawprem records very high interactions levels (proportionately) with peripheral areas and high levels with residential wards and conversely relatively lower levels with commercial-administrative wards like Police Bazar, Laitumkhrah, European Ward and Barabazar could be due to higher saturation levels reached by the latter group of wards in terms of interaction, and hence some sort of a decreased possibility of interactions increasing by higher ratios of 1991 levels.

The case of Madanryting seems to conform to the above explanation, where it records high ratios of the 1991 interaction level with Mawlai, Cantonment and Nongthymmai (in the range of 3.3 to 3.5) and relatively lower levels with other areas - except of course with Mawprem as noted earlier.

Kench's Trace records moderately high ratios of the 1991 level of interaction, ranging between 1.83 to 2.45 with interaction ratio above 2.0 in all cases except with Jaiaw (1.83)

and Lumparing (1.9).

From the above analysis it would appear that areas which record significantly high ratios of 1991 interaction levels are largely those units which prior to 2001 were residential areas (or subsidiary commercial/administrative areas) compared to the other units and have scope for higher interaction, rather than attaining a sort of plateau or saturation level as in the case of the predominantly non-residential areas.

Table 4.9 shows the cell-wise interactions between the seventeen units of the Agglomeration for 2001. Since the 2001 estimate is a proportionate picture of the 1991 estimate, the most traffic-problem prone areas (or routes) are the same as in the case of 1991. However, the magnitude is of interest here.

Potential interaction between Mawkhar and Mawprem is as high as 69,500, corresponding with Mawkhar and Barabazar at 62,600. During 1991 the interaction between Mawkhar and Mawprem was 34580 which that between Mawkhar and Barabazar was higher at almost 36,400. This again conforms to the above explanation that interaction between predominantly non-residential areas increases at a decreasing rate compare to that between largely residential areas.

Other areas which could be problem areas are those between Kench's Trace and Laban (46,500 approximately), Madanryting-

Table 4.9

Estimated Interaction 2001

Town/Ward	Mawlai	Canton- ment	Nongthy- mmai	Madan- ryting	Pynthor umkhrah	Laitum- khrah	European Ward	Police Bazar
Mawlai	x							
Cantonment	7048	x						
Nongthymmai	5255	3517	x					
Madanryting	3653	2636	33620	x				
Pynthorumkhrah	4602	3055	2042	1808	x			
Laitumkhrah	8828	13552	10523	5309	12835	x		
European Ward	8660	9268	9036	5317	5263	26771	x	
Police Bazar	9745	7490	4597	3413	3002	10322	25106	x
Jail Road	8845	5304	4375	9756	2664	8532	8628	6876
Mawkhar	11612	7142	4273	4351	2619	8422	10474	11712
Jaiaw	1173	4795	2862	2723	1895	5395	6056	4809
S.E.Mawkhar	9338	8980	4446	5869	4267	8660	19798	20477
Mawprem	16773	37554	17582	14873	3785	10807	13052	9560
Kench'sTrace	6543	8532	7287	5210	4294	21381	9170	6136
Laban	4110	6108	3764	3366	2417	6957	6190	4101
Lumparing	2875	3709	3056	1907	1902	5565	1829	2714
Malki	3720	3123	5455	3245	3289	16241	10631	5453

Continued on following page

102415



Table 4.9 continued.

Town/Ward	Jail Road	Mawkhar	Jaiaw	S.E. Mawkhar	Mawprem	Kench's Trace	Laban	Lumparing	Malki
Mawlai									
Cantonment									
Nongthymmai									
Madanryting									
Pynthorumkhrach									
Laitumkhrach									
European Ward									
Police Bazar									
Jail Road	x								
Mawkhar	5384	x							
Jaiaw	4808	11652	x						
S.E.Mawkhar	8941	62600	16800	x					
Mawprem	6014	69506	8713	24404	x				
Kench's Trace	6597	5744	3894	9251	9130	x			
Laban	3055	3516	2439	6746	5588	46487	x		
Lumparing	2309	2335	1574	2349	3290	10226	6788	x	
Malki	5358	4178	2255	6712	5177	5601	4549	2960	x

Nongthymmai (33600), Cantonment-Mawprem (37,500), Laitumkhrah-European Ward (26800) and European Ward-Police Bazar (25100). The routes between these areas are those cited in the analysis of the 1991 interaction levels.

#### 4.4 Summary of Findings

1. The population of the Shillong Urban Agglomeration is rapidly increasing and is expected to reach the 2.5 lakh mark by 1991, and cross the 3.5 lakh mark by 2001 A.D. This means that the city's population could double itself in a period of twenty years (1981 population = 174,703), which in turn would lead to increased interaction and traffic flow along segments of the city's roads.

2. During 1991 increased traffic flow is likely to occur between Mawkhar-Marabazar-Mawprem areas and Laitumkhrah-European Ward-Police Bazar areas, i.e., between predominantly commercial (non-residential) areas.

3. During 1991 areas of relatively lower interactions are the residential areas.

4. The residential areas could record more rapidly increasing levels of interaction compared to the non-residential areas in the near future. This would include areas like Mawprem, Cantonment, Nongthymmai and Pynthorumkhrah, and Nongthymmai-Madanryting

areas, in cases recording interactions six times that of 1991.

5. While at present, the main CBD areas and subsidiary CBD area of Laitumkhrach-European Ward are the traffic problem wards, in the coming years, presently residential areas could also prove to be traffic problem areas.

CHAPTER - VSUMMARY AND CONCLUSIONS

5.1 Transportation constitutes one of the most vital organs of the modern economic system. It serves as a basic physical and economic infrastructure, as an instrument for the social and political integration of areas and by way of its requirements of infrastructure and equipments as a force for development. Present day society relies heavily on the transportation sector and the existence of the modern economic system involving large scale production and regional and product specialization, without an efficient transportation system is in-conceivable.

Urbanisation, the hall-mark of modern complex society, has its impact on transportation and with the rapid increase in the rate of urbanisation and the size of urban centres, intra-city movements of goods and people is gradually hindered upon. This is particularly true in the case of Third World Urban centres where due to a variety of reasons, including paucity of funds, no new infrastructural facilities are introduced to growing urban centres. With the result that such centres have to continue to make-do with limited transportational facilities in spite of rapidly increasing population and traffic flow, with the result that intra-city movements of people and goods become a problem. The case of the Shillong Urban Agglomeration conforms to this scenario and it is in this background that the present study of the road network and traffic

flow of Shillong was undertaken.

The main objectives of the study were :

(i) to study the structure of the road network and some aspects of the traffic movement in Shillong.

(ii) to identify the existing level of problems of the city's road network.

(iii) to forecast the level of problems the city is likely to face in the coming years, by way of forecasting and estimating the level of interaction/traffic flow in 1990.

5.2 The main findings of the present study are :

1. Shillong has rapidly developed over the last century and a quarter in terms of its population size, functional attributes etc. Primarily established by the British in the 1860s as a 'station' for their troops, its history has been a continuous process of steady and sustained accretion of population, a result of the sequential enhancement of its administrative status. From district headquarters in 1864 to state capital in 1972, the city's population has grown from a mere 4,288 in 1881 to 174,703 in 1981 and is currently expected to be in the range of 2.5 lakhs.
2. Although the structure of the road network of the city is complex, with a high number of fundamental circuits, the network shows only moderate development

as the alpha index and the cyclomatic number represent a little over 30 per cent of maximum potential for development; while the beta and gamma indices indicate less than 55 per cent of the same.

3. The connectivity characteristics of the network analysed in terms of direct connectivity and first level indirect connectivity between nodes show that higher connectivities exist for nodes located along the two axial transport routes of the city, along NH.40 and NH.44; and for nodes located in the Barabazar-Police Bazar CBD area of the city, and areas in close proximity to CBD areas, and subsidiary commercial/market areas.

Conversely, nodes with comparatively low connectivities tend to be located in the peripheral areas of the city, which are areas of residential functions with only small markets and negligible administrative/educational functions. This is true when both direct and indirect connectivities are considered.

4. All the roads in Shillong are tortuous and winding with tortuosity index scores varying between 131% to 209%. Generally the nodes located in the central areas of the city have more straight and less winding roads than those located in peripheral areas. This is true in the case of nodes located along the two national highways as well, although there are exceptions to this.
5. Centrality and relative accessibility of nodes of the network, measured in terms of (a) actual distances and (b) by interpreting this distance as an accessibility variable analysed using principal component

analysis, show that accessibility and centrality of nodes are higher in the geographical centres of the network and in the C.B.D. areas of the city, and gradually decline towards the peripheral areas.

6. The number of vehicle ownership in the city is rapidly increasing and the number of registered vehicles in Shillong increased by more than 92% between 1985-89. This must be seen in the light of the rapid population increase the city is currently experiencing, and is likely to experience in the coming years. Population projections based on the 1971-81 growth rates show that the city's population will reach 2.5 lakhs in 1991 and 3.5 lakhs by 2001.
7. During 1991 increased traffic flow is likely to occur in predominantly non-residential areas such as Mawkhar-Barabazar, European Ward-Police Bazar; while the residential areas would be the low-interaction areas, in terms of traffic flow.
8. There is a significant relationship between the estimated interaction in 1990 and the expected interaction (based on gravity model) in 1991.
9. The residential areas could record more rapidly increasing levels of interaction compared to the non-residential areas in the near future (2001). Hitherto residential areas like Hawprem, Cantonment, Nongthymmai, Pynthorumkhrah could record more rapid increases in interaction levels than the currently non-residential areas like the CBD area of Barabazar-Police Bazar and the developing CBD area of Laitumkhrah-European Ward.

### 5.3 Implications of the Findings

With increasing population, vehicle ownership and interaction levels rising sharply, (in some cases to levels six times those of 1991) by the turn of the century, traffic management in Shillong will be one of the city's major problems. This is partly inevitable considering the fact that the city was originally planned for a few thousand occupants, in contrast to the present scenario when the doubling time of the city's population could be as little as two decades (the 1981 population of 174,705 could reach 3.5 lakhs by 2001). This would lead to a sharp increase in travel trips, commuting etc. and this increased traffic flow would put tremendous stress on the city's road network.

Moreover, the fact is that, interaction levels (in terms of traffic flow, - already high in the CBD areas of Barabazar-Police Bazar and in the emerging CBD area of Laitumkhrah-European Ward will increase further. These areas then, will be the traffic-problem areas. However, more areas could join the list of problem areas, with the present residential areas having the potential of experiencing much rapidly increasing levels of interaction between 1991 and 2001. This is explained by, the sort of saturation level reached by the present non-residential areas in terms of potential interaction increase compared to the presently residential areas.

This brings us to the conclusion that the rapid increase in traffic will have to be tackled on a priority basis if the city's network is to function as a viable transportation medium. It is suggested that :

1. Road-width widening be taken up in the major roads of the city and along certain problem-prone segments such as those roads between Mawkhar and Barabazar and Mawprem-Barabazar as identified in the study.
2. If necessary, acquisition of land for this purpose should be taken up as soon as possible, as this could be legally a time taking affair. If however, land acquisition is delayed, improvement of the roads will take a long time and time is the crucial factor in view of the rapid population-interaction level increase.
3. Since traffic flow is generated by the CBD and commercial areas, the self-containment levels of the traffic origin areas needs to be increased so as to minimise the dominance of the former.
4. There is a need for dispersal of administrative and commercial areas to other parts of the city to decrease traffic along the axial transport routes/ NH.40 and NH. 44 routes.
5. Since the city serves as a thoroughfare to other states and important centres, a by-pass road needs to be constructed, so that diversion of goods-traffic passing via Shillong is possible. In this respect the Sohryngkham-Mawlynrei-Mawdiangdiang-Mawlong by-Pass road plan, already under consideration, should be taken up on a priority basis.

5.4 The major limitations of the study are :

- (i) The traffic count method used is rather crude, and the study would have been more accurate had cordon or screenline surveys been conducted on traffic routes at selected points been undertaken.
- (ii) This study also suffers from the limitation of having not considered all the nodes of the network, largely because of difficulties in calculations involving, say a 300 x 300 size matrix.

However, the study is important since not many studies on intra-city traffic flow are available and also because it serves as a pointer to one major problem area of the city, the growing traffic blockade of Shillong.

## BIBLIOGRAPHY

Books and Articles

- Abler, R., Adams, J.S., & Gould, P. : "Spatial Organisation : The Geographer's View of the world", Prentice Hall Inc., New Jersey, (1971).
- Berry, B.J.L. : "Recent Studies Concerning the Role of Transportation in the Space Economy", Annals of the Association of American Geographers, 49 (1959), 328-342.
- Bhat, L.S. and Gidadhuri : "Economic Regions and Regional Flows - A Case Study in the Flow Patterns and Trends in Selected Commodities in India", in Regional Development, edited by Moonis Raza, Heritage Publishers, New Delhi, (1988).
- Bird, J. : "Road and Rail in the Central Massif of France", Annals of the Association of American Geographers, 44(1954), 1-14.
- Burghardt, A.F. : "The Origins and Development of the Road Network of the Niagara Peninsula", Ontario: 1770-1851, Annals of the Association of American Geographers, 59 (1969), 417-440.
- Clark, J.R. : "Measuring the Flow of Goods with Archaeological Data", Economic Geography, 55 (1979), 1-17.
- Cole, J.P. & King, C.A.M. : Quantitative Geography, John Wiley and Sons Ltd., London (1968).
- Data, G. : "The Network Pattern of the Indian National Highways From Major Urban Centres to the National Capital", Geographical Review of India, 37,2 (1975), 121-131.
- Dawson, A.H. : "Land and Transport in the Scottish City," Scottish Geographical Magazine, 95,2 (1979) 83-92.
- Deka, D. : "Regional Analysis of Road Transport in the Brahmaputra Valley - A Study of its Development and Potentialities", Ph.D. Thesis (unpublished) submitted to Gauhati University, (1979).

- Eliot-Hurst, M.E. : Transportation Geography, McGraw Hill Book Co., New York (1973).
- Garrison, W.L. : "Connectivity of the Interstate Highway System", Papers and Proceedings, Regional Science Association, 6 (1960) 122-137.
- Gauthier, H.L. : "Transportation and the Growth of the Sao Paulo Economy", Journal of Regional Science, 8 (1968) 1-18.
- Haynes, K.E. and Fotheringham, A.S. : Gravity and Spatial Interaction Models, Sage Publications Inc., Beverly Hills, (1984).
- Jefferson, M. : "Communication and Civilization", Annals of the Association of American Geographers 23 (1933) 46-47.
- Kansky, K.J. : Structure of Transportation Networks : Relationships between Network Geometry and Regional Characteristics, Research Paper No. 84, Department of Geography, University of Chicago, Chicago, Illinois, (1963).
- Kayastha, S.L. : "Transport and Communication in the Himalayan Beas Basin", National Geographical Journal of India, 4, 2 (1960) 105-114.
- Kendall, M.G. : A Course in Multivariate Analysis, Griffin, London (1957).
- Kolars, J. and Malin, H.J. : "Population and Accessibility : An Analysis of Turkish Railroads", Geographical Review, 60 (1970) 229-246.
- Leinback, T.R. : "Distance, Information Flows and Modernization: Some Observations from West Malaysia", Professional Geographer, 25 (1973) 7-11.
- Medhi, A.K. : "Problems of Urban Passenger Transportation : A Case Study of Vishwanath Charali", M.Phil Thesis (unpublished) submitted to NEHU, 1987.
- Medhi, S.B. : "Impact of Railways on the Economy of Assam with special reference to post-independence periods", D.Phil, submitted to Gauhati University, 1972. ?
- Mehta, G.S. : "Roads and Area Development : A Study in Utilisation and Impact", Indian Journal of Regional Science, 16, 2 (1984) 170-177.

- Moavenzadeh, F and  
Geltner, D. : Transportation Energy and Economic Development: A Dilemma in the Developing World, Elsevier Science Publishing Company Inc., New York, (1984).
- Mukerji, A.B. : "Road Transport Network Structure and Levels of Urbanization in Rajasthan", National Geographical Journal of India, 20, 1 (1974) 42-54.
- North, R.N. : Transport in Western Siberia : Tsarist and Soviet Development, Vancouver, University of British Columbia Press, (1979).
- Oluwole, A. : "Evolution of Rural Roads in Nigeria", Singapore Journal of Tropical Geography, 4,1, (1983) 1-10.
- Ramachandran, H. : "Transportation and Urban Attributes - A Study of Structural Relations", Annals of the National Association of Geographers, India, 1,1, (1981) 48-68.
- Raza, M. and  
Aggarwal, Y. : "Distance Decay and Railway Freight Flows in India : A Preliminary Enquiry", Indian Journal of Regional Science, 12,1, (1980) 37-48.
- Raza, M., Aggarwal, Y.  
and Dutta, M. : "A Spatial Analysis of Metropolitan Freight Flows in India", Geographical Review of India, 42,4 (1980) 323-341.
- Raza, M. and Aggarwal, Y. : Transport Geography of India and the Regional Structure of the Indian Economy, Concept, New Delhi (1986).
- Rostow, W.W. : The Stages of Economic Growth, Cambridge University Press, Cambridge (1964).
- Saha, K.D. : "The Study of Community-wise Distribution and the Growth of Population in Shillong", in Cultural Profile of Shillong, edited by B.B.Goswami, Anthropological Survey of India, Calcutta (1979).
- Saxena, H.M. : "Road Transport Connectivity Pattern and Economic Development in Rajasthan", Geographical Review of India, 42,2 (1980) 183-187.

- Sharma, C. : "City Bus Service in the City of Guwahati : A Geographical Analysis", M.Phil Thesis (unpublished) submitted to Gauhati University, 1988.
- Singh, D.N. : "Patterns of Transportation Links in North Bihar, North of the Ganga", National Geographical Journal of India, 16,2 (1970) 161-174.
- Singh, D.N. & Kayastha, S.L. : "Some Aspects of Transportation in Dhanbad", National Geographical Journal of India, 18,2 (1972) 64-79.
- Singh, J. & Singh, R.B. : "Commodity Flow Patterns in Rajasthan - A Case Study", in Essays in Applied Geography, edited by V.C.Misra, N.P.Ayyar and P.Kumar, University of Sagar Press, Sagar (1976).
- Singh, J.P. : Urban Landuse Planning in Hill Areas : A Case Study of Shillong, Inter India Publications, New Delhi, (1980).
- Singh, R.L. and Singh, U. : "Road Traffic Survey of Varanasi", National Geographical Journal of India, 9,3&4 (1963) 32-47.
- Singh, U : "Growth of Transport and Communications in Allahabad", National Geographical of India, 4, (1959) 188-204.
- Smith, R.H.T. : "Concepts and Methods in Commodity Flow Analysis", Economic Geography, 46 (1970) 404-416.
- Snyder, D.E. : "Commercial Passenger Linkages and the Metropolitan Nodality of Montevideo", Economic Geography, 38,2 (1962) 95-112.
- Strand, S. : "Roadless Norway", Scottish Geographical Magazine, 100, 1 (1984) 49-59.
- Taaffe, E.J. : "The Urban Hierarchy : An Air Passenger Definition", Economic Geography, 38,1(1962) 1-14.
- Taaffe, E.J., Morrill, R. and Gould, R.R. : "Transport Expansion in Underdeveloped Countries : A Comparative Analysis", Geographical Review, 53 (1963) 503-529.

- Taaffe, E.J. and Gauthier, H.L. : Geography of Transportation, Prentice Hall Inc., Englewood Cliffs, New Jersey, (1973).
- Tarkhov, S.A. : "A Comparative Geographical Analysis of the Structure of Urban Transport Networks in Moscow and Leningrad", Soviet Geography, 27,7 (1986) 445-455.
- Trudgill, H. : "Linguistic Geography and Geographical Linguistics", Progress in Geography, 7, (1975) 227-252.
- Ullman, E.L. : "The Role of Transportation and the Bases for Interaction", in Man's Role in Changing the Face of the Earth, edited by W.L.Thomas, University of Chicago Press, (1956).
- Wadia, D.N. : Geology of India, London (1961).
- Wheeler, J.O. and Thomas, R.N. : "Urban Transportation in Developing Economies: Work Trips in Teguchigalpa, Honduras", Professional Geographer, 25,2 (1973), 113-120.
- Williams, A.V. and Zelinsky, W. : "On Some Patterns in International Tourist Flows", Economic Geography, 46,(1970) 549-67.
- Williams G.J. and Hayward, D.F. : "The Changing Land Transportation Pattern of Sierra Leone", Scottish Geographical Magazine, 89, 2 (1973) 107-118.
- Yeates, M.H. : An Introduction to Quantitative Analysis in Economic Geography, McGraw Hill Book Co., New Yrok (1963).

#### Government Publications

- Report on the Census of Assam, 1881, Part. I.
- Census of India, 1911, Vol. III, Assam, Part II
- \_\_\_\_\_, 1921, Vol. III, Assam, Part II
- \_\_\_\_\_, 1931, Vol. IX, Assam, Part II
- \_\_\_\_\_, 1951, Vol. XII, Assam, Part I-A
- \_\_\_\_\_, 1981, Series XIV, Meghalaya, Part II A&B.

