

# Impact Of Geomorphology On The Urban Landuse A Case Study Of Shillong

By

MS. SUBRATA CHAKRAVORTY

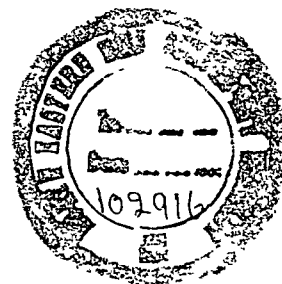
*DISSERTATION*

SUBMITTED

IN

PARTIAL FULFILMENT OF THE REQUIREMENT  
OF THE DEGREE OF  
MASTER OF PHILOSOPHY (M, Phil)

TO



DEPARTMENT OF GEOGRAPHY  
SCHOOL OF ENVIRONMENTAL SCIENCES  
NORTH EASTERN HILL UNIVERSITY  
SHILLONG - 14

(1991)

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## CERTIFICATE

This is to certify that the dissertation titled, "Impact of Geomorphology on the Urban Landuse - A Case Study of Shillong" submitted by Ms. S. Chakravorty towards partial fulfilment of the degree of Master of Philosophy (M.Phil) in Geography is a bonafide study to the best of my knowledge and belief. Ideas, concepts and quotations from other scholars have been duly acknowledged.

The dissertation may now be placed before examiners for due evaluation.

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## ACKNOWLEDGEMENT

I consider myself extremely fortunate to be working under Dr. R.K. Rai, Professor of Geography, North Eastern Hill University, Shillong. His guidance, untiring zeal and personal involvement to the problem has shaped the work to the present form. Through this I express my heartfelt gratitude to him.

I acknowledge with deep sense of gratitude the help rendered to me by Dr. A.C. Mohapatra, Head, Department of Geography, NEHU, Shillong.

Thanks are also due to Mr. A. Alam of Urban Development Office, Govt. of Meghalaya, Shillong and the Officer-in-Charge of Environmental Geology Section, Geological Survey of India, North Eastern Circle, Shillong for rendering all the necessary information which have helped in shaping the present work.

I am grateful to my parents for their encouragement to take up the present work and for its completion.

Thanks are also due to my teachers and friends for their valuable suggestions.

I am thankful to all the technical staff of the department for kindly extending their help and cooperation in this work.

SHILLONG  
The 30<sup>th</sup> Sept . 1991

  
Ms. SUBRATA CHAKRAVORTY

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**CHAPTER - I**  
**INTRODUCTION**

## INTRODUCTION

Geomorphology has been defined as the study of Land- forms and Landforms are encountered ~~by~~ *during* men's activities. Infact Man's very lifestyle - his living, working and playing on the land causes him automatically to become a Geomorphic agent and a force who can change the environment which he/she inhabits.

Thus an understanding of the ~~Geomorphology~~ *g/* of the area one is inhabiting perhaps becomes essential before any developmental process is undertaken as it tends to play a significant role in the landuse specially in hilly areas where topography tends to dictate to a great extent men's activities.

It is in this context in this study "The Impact of Geomorphology on the Urban Landuse of Shillong" has been undertaken which is characterised by rugged terrain.

As the twentieth century which has often been depicted as starting the "Urban Revolution"<sup>1</sup> where Urbanism

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1. D.R. Coates (1974) Benchmark Paper in Geology. Environmental Geomorphology and Landscape Conservation. Urban Areas Vol.II, Dowdsen Hutchinson and Ross INC. Stroudsburg, Pennsylvania., pp.10.

is becoming increasingly significant throughout the world resulting to a new anthropogenic landscape, an understanding of the ~~Geomorphology~~ specially of the hilly areas like Shillong shall perhaps help to make a judicious use of the landforms as a resource and give remedial policies which may attempt to preserve and rehabilitate the damaged terrain thereby bringing greater environmental and ecological harmony.

Thus the science of Geomorphology cannot be in this context treated only as an academic discipline but as a science which can perhaps solve the problems faced by the present day world. Geomorphology has thus become more applied in nature which may be having both a positive and a negative role in landuse development and planning.

In this context it may be mentioned that Urban Geomorphology is emerging perhaps as an important field of research. As ~~Geomorphological~~ research is being carried out in order to assist "Urban development in dryland"<sup>2</sup> and other parts of the world. In the dry ~~lands~~ of the Middle East, rapidly growing urban areas are threatened by ~~Geomorphological~~ hazards like "advancing sand dunes continuously

---

2. R.U. Cooke, D. Brundson, J.C. Doornkamp and D.K.C. Jones (1985)  
Urban Geomorphology in Drylands, Oxford University Press, pp.1-4.

threaten and occasionally overwhelm highways, suburban developments, and oasis settlements...."<sup>3</sup>

Similarly the hilly areas are prone to landslides, break off slopes, soil erosion and gully formation due to urban expansion which perhaps necessitates an understanding of the ~~geomorphological~~ processes in landscape development.

The slope characteristic, the relief of an area, the physio-chemical characteristics of the soil, the hydrological conditions and the subsurface Geology are some of the important parameters controlling landscape configuration and denudational history of an area (Agarwal 1990)<sup>4</sup>. These parameters in turn tend to determine the suitability for the location of constructional activities like settlements, roads, dams, etc.

See below!

Moreover the population explosion as faced by our country has resulted ~~to~~ ever increasing pressure of population on limited land resource specially in the urban areas where ~~land~~ has to be allotted for different urban activities which in turn necessitates ~~land~~ use planning. In the hilly

---

3. R.U.Cooke, D. Brundsden, J.C.Doornkamp and D.K.C. Jones, Op.cit., pp.1-4.

4. M.Agarwal (1989) Geomorphological Studies around Umiam Lake and adjoining areas, East Khasi Hills District, Meghalaya, M.Phil Thesis, Deptt. of Geography, NEHU, Shillong p.2.

areas where rugged terrain and slope characteristics perhaps acts as a constraint for developmental purpose, landuse planning becomes essential.

The Indian towns and cities have often grown in an unplanned way. The growth has been rapid with almost spontaneous and uncontrolled expansion that has been generated by population growth both natural as well as migrational from different areas in search of employment. This in turn poses serious environmental problems which calls for proper environmental planning.

Again each Urban Area has its own unique geomorphology which may play a significant role in the field of Urban Landuse specially in the hilly and rugged topographic areas amidst which a number of small and medium sized towns have sprung up. g/

The understanding of the landforms can play a significant role in the development of these hill towns of India where steep slope and rigorous topography tends to limit accessibility network, constructional activities for urban functions. h/ d/

Moreover due to unplanned nature of growth and defo-

# LOCATION MAP

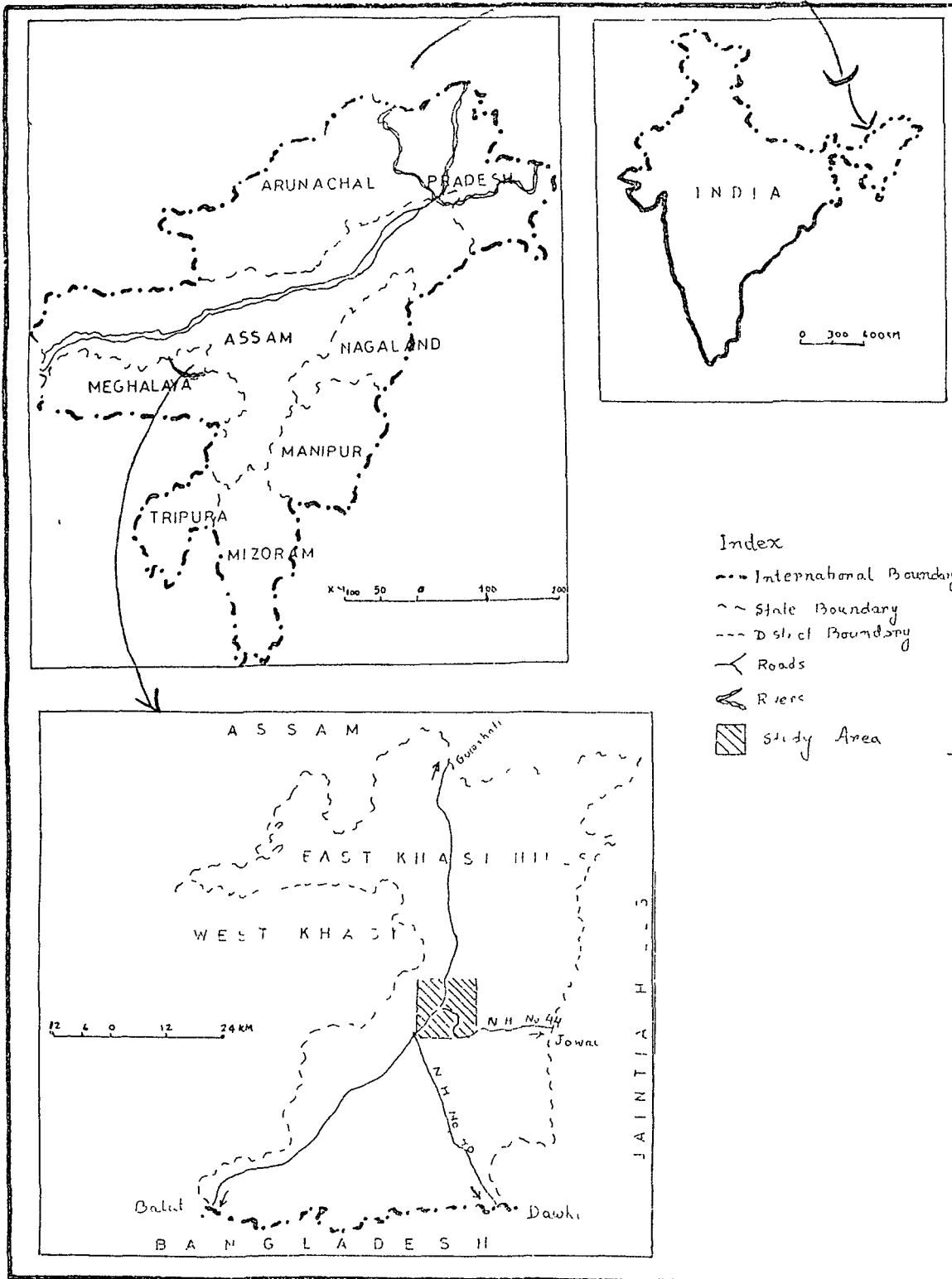


FIG 11

restation in steep slopes results <sup>o</sup>~~to~~ <sup>in</sup> soil erosion which increases run-off thereby bringing about an ecological imbalance.

It is in this context that the study has been undertaken for understanding the "Impact of Geomorphology on the Urban Landuse: // Case Study of Shillong."

#### Choice of the Area:

Shillong which is located in the East Khasi Hills district of Meghalaya (Fig.1.1) at an altitude of about //1500 metres on the average above mean sea level (M.S.L.) is one of the oldest, largest and fastest growing Hill Station of the country.

It is not only the State Capital but also the District Headquarter of the East Khasi Hills District of Meghalaya and is one of the most important city of North East India, // second only to Guwahati in its Regional importance.

Shillong has grown as an enclave in the midst of a rural society, catering to the administrative and educational needs of the surrounding areas. It is also an important Tourist centre and Health Resort as well as a Trade Centre.

The township of Shillong has grown in an unplanned way, whose history can be traced back to the year 1863-64 when the British shifted its ~~its~~ Headquarter of Assam Province from Cherrapunjee to Shillong. From a mere 1363 people in 1874,<sup>5</sup> Shillong has grown with a population size of 2,01,577<sup>6</sup> as per 1981 census. It has been designated as a class I city.

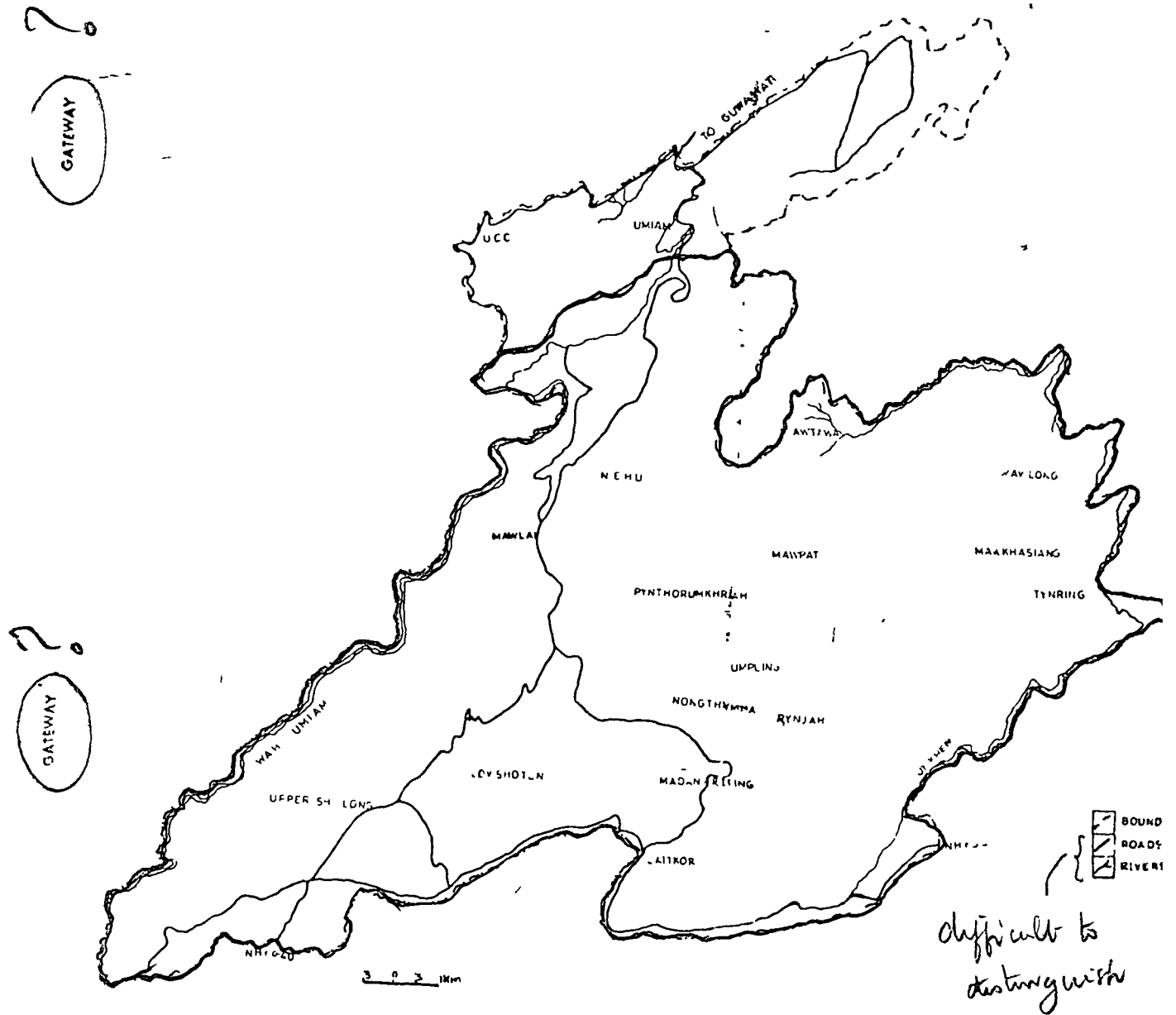
Being in a plateau area Shillong's developmental structure is controlled by rigorous topography, limitation of accessibility networks and constructional activities due to steep slopes. It is also subject to a series of Geographical constraints.

Thus the Geomorphological understanding of the Shillong Standard Urban Area which consists of the Shillong Municipality, the Cantonment, the townships of Nongthymmai, Mawlai, Pynthorumkhrah and Madan~~ting~~ as well as nine rural components viz. Nongmy~~nsong~~, Nongrah, Rynjah Lapalang, Mawklot Umlyngka, Lowshtun Umpling and Upper Shillong shall perhaps help in understanding the landuse in relation to slope morphology, distribution of population within the different localities of Shillong as well as settle~~ment~~.

5. Report from Urban Development Office, Government of Meghalaya, Shillong.

6. Census of India 1981, Series 14 Meghalaya Part II A&B.

Shillong Master Plan Area  
**STUDY AREA**



*Lettering of places not clear*

Fig. 12

distribution with the Geomorphology of Shillong.

#### Location of the Study Area:

The area of study falls in the Survey of India Topo-sheet No.78 0/14. The total area covers 20875 hectares of land bounded approximately by the Umroi Road in the north, the Laitkor Road which connects the National Highway Number 40 and 44 together in the ~~South~~, River Wah Umiam in the East and River Umkhen Wah Shella in the east (Fig.1.2).

*one of them must be west*

The study area is located between 25°32' North to 25°36' North latitude and 91°51' East to 91°56' East longitude.

#### Scope of the Present Work:

The main objectives of the present study are enumerated below:

- (i) The Impact of Geomorphology on the existing landuse.
- (ii) Whether ~~Geomorphology~~ has influenced the distribution of settlement and population within Shillong Standard Urban Area?
- (iii) Whether ~~Geomorphology~~ can play a rol<sup>e</sup> in the distribution and development of water supply within the different ~~Localities~~ of Shillong.

**Methodology:**

For the present study the <sup>m</sup>Method adopted has been based on application of morphometric techniques like ~~Average~~ slope, drainage frequency and density of the study area. It also includes cartographic and statistical analysis of the Primary and Secondary data, ~~field~~ investigation and survey of existing Literature.

**Limitations:**

Although every measure has been taken to make this study very feasible, yet it suffers from many limitations which are due to lack of proper data and other relevant informations~~y~~.

The most striking limitation is the non-availability of good base maps with detailed topography, lack of areal ~~photographs~~ <sup>aerial</sup> and toposheets which has led to a lot of setbacks.

**Plan of Work:**

For a better understanding and correlation of land-form characteristics and its influence on the Shillong Urban landuse, the distribution of population and settlement a chapter scheme has been adopted in the present study.

In the First Chapter the Research Problem has been

introduced. The location of the study area, its scope and ~~Methodology~~ adopted has been discussed. The limitations faced by the present study has also been discussed.

In the Second chapter an attempt has been made to examine Shillong in its ~~Environmental~~ setting. For this a detailed account of the ~~Geology~~, physiography, ~~Climate~~, soil and vegetation of Shillong has been discussed, ~~As~~ ~~Geology~~, physiography soil etc. tend to play an important role on the distribution of population and settlement as well as the landuse of Shillong. c/  
a/

In the Third chapter the evolution of Shillong from an unknown nomenclature in the midst of rural tribal society to the capital of Meghalaya ~~an~~ important city of North East India has been discussed. 2/

The process of urban growth in Shillong can be traced down to the period of 1863-64 when the British shifted its headquarter of Khasi and Jaintia hills from Cherrapunjee to Shillong. The favourable climate of Shillong in comparison to Cherrapunjee where there is very heavy rainfall and the topographic factors contributed for the selection of this new site, which today is the capital of Meghalaya having a population size of 2,01,577 as per 1981 census.

In the Fourth chapter an analysis of the average slope of the study area and its categorisation has been undertaken. It also deals with the fluvial morphology of the area. It describes the drainage analysis of the study area. How the average slope tends to influence the urban landuse of Shillong has also been discussed.

In the Fifth chapter the existing Landuse of Shillong vis-a-vis the ~~Geomorphology~~ has been discussed. How ~~Geomor-~~ *g/* morphology has influenced the distribution of settlement and population within the Shillong standard urban ~~Area~~ has *a/* been discussed.

Moreover civil amenities like water supply and how ~~Geomorphology~~ can perhaps play an important role in the distribution and storage of water has also been discussed.

The ~~Last~~ chapter has been an attempt to bring about a summary and general conclusion of the study.

CHAPTER - II

SHILLONG IN ITS ECOLOGICAL SETTING

## SHILLONG IN ITS ENVIRONMENTAL SETTING

### Introduction:

The city of Shillong is one of the most important cities of North East India. The city lies on the Meghalaya Plateau in the East Khasi Hills District which has an altitude of about 1500 metres above Mean sea level. Northeast

It is bounded on the south by the Shillong Range, on the north east by the Mawpat hills and on the east by the river divide of the Umkhrach and Umshing water divide. The city in its Environmental Setting can be discussed under the following heads.

### Geology:

The first Geological study of the Shillong Plateau was initiated by Oldham<sup>1</sup> in 1858 followed by a systematic Geological mapping of the region carried out by Medlicott (1869)<sup>2</sup> who inspite of all the limitations and heavy odds of the hostile terrain of the area has critically examined the Geological <sup>formations</sup> occurrence of the area.

- 
1. To Oldham (1858) "On the Geological structure of a portion of the Khasi Hills", Bengal Mem... Geol. Survey India, Vol.1, Pt-Z, Misc. Pub. pp.99-201.
  2. H.B. Medlicott (1869) "Geological Sketch of Shillong Plateau", Bengal Mem. Geol. Surv. Ind. Vol.7 Pt.7, pp.151-207.

Other Geological work in the area was carried out by Palmer (1923)<sup>3</sup> followed by Khedkar (1938-39)<sup>4</sup> and Ghosh (1936-39)<sup>5</sup> which led to the establishment of the stratigraphic sequence of the region. However, the compiled Geological framework of Meghalaya is given by Anon (1974)<sup>6</sup>, Murthy (1976)<sup>7</sup> and Mazumdar (1986)<sup>8</sup>.

The generalised stratigraphic sequence is given in the table 2.7. While the description of the different lithographic groups are as follows -

#### The Gneissic Complex

The Gneissic complex is exposed in the central and northern part of the Meghalaya Plateau and comprises mainly

- 
3. R.W. Palmer (1923) Geology of a part of the Khasi and Jaintia Hills, Assam", Rec. Geol. Surv. India, Vol.55, Pt.2, pp.143-168.
  4. V.R.Khedkar and P.N. Mukherjee (1938-39) Unpublished Progress Report Geol. Surv. India. Assam Circle.
  5. A.M.N. Ghosh (1936-39) General Report Rec. Geol. Surv. India. Vol.71, Pt.1; Vol.72 - Pt.2, Vol.73, Pt.1; Vol.74, Pt.1.
  6. Anon (1974) "Geology and Mineral Resource of the States of India. Geol. Surv. India, Misc. Pub. No.-30, Pt. 1. pp.124.
  7. M.N.V. Murthy (1976) Basement Controlled Volcanism Sedimentation and tectonics in Assam Plateau, N.E. India, Paper presented in Seminar on Geology N.E. India, Shillong.
  8. S.K. Mazumdar (1986). "The Pre-Cambrian Framework of part of the Khasi Hills, Meghalaya Rec. Geol. Surv. India, Vol.117, Pt.2, pp.1-59.

of schistose members as well as Gneisses of varying composition. However the most dominant constituent is Gneiss represented by biotite Gneiss, Biotite Granulite, Biotite ~~Kornblende~~ Gneiss, quartz sillimanite gneiss etc.

Structurally the Gneissic complex which has been called the "Archean Gneiss Complex" shows a very complex and polyphase folding currently with multistage ~~Metamorphism~~ as has been identified by Murthy<sup>9</sup> which are as follows.

- i) The earliest is an isoclinal phase of broad recumbent - reclined folds regionally having E-W axial surface.
- ii) The superposed tight isoclinal folds having ENE and NE axial surface.
- iii) The third phase is marked by broad N-S warps.

The dominant south surfaces within the complex show North East-South West, East-West, North-South, North West-South East strikes in different sections due to ~~the~~ complex folding. This gneissic complex was carbonised prior to the initiation of the Shillong Basin.<sup>10</sup>

---

9. M.V.N. Murthy, Op.cit.,

10. M. Agarwal (1989) Geomorphological Studies around Umiam Lake and adjoining areas, East Khasi Hills, Meghalaya, M.Phil Thesis, Deptt. of Geography, NEHU, Shillong, pp.20.

0  
Non ~~Per~~phyritic Nigmatitic Granitoids

This class of rocks occur throughout the Gneissic complex in all scales as vienlets, interpolial permeation, patches, lenses and small irregular bodies.

Shillong Group

This overlies the Gneissic complex with an unconformity and comprises of variable quartzites with subordinate phyllites, sandstone, siltstone, quartz-sericite schist.

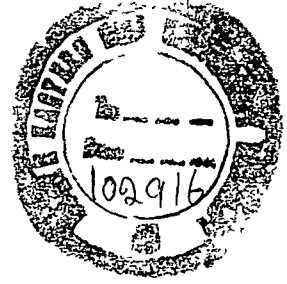
The Shillong group of rocks are weakly metamorphosed except at few places which show higher grade of metamorphism.

However in this variety of rocks the primary sedimentary structures are well recognizable such as bedding, lamination, current bedding, ripple marks etc.

The Shillong Group of rocks show a zone of subvertical dips with local reversals from west of Mawphlang upto Barapani, away from this zone the dips show gentle rolling disposition. Such folding represents "Intermediate crestal type folding" of Belousov (1962).<sup>11</sup>

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11. V.V. Belousov (1962) Basic Problems in Geotectonics, Mc. Graw Hill Co. New York, pp.809.



### The Khasi Greenstone

This group occurs as isolated bodies in the Shillong Group of rocks. These are intrusives both in the argillaceous and arenaceous facies of Shillong Group. The Khasi Greenstone are represented mainly by dolerite, epidiorite and amphibolite. The overall structural pattern of the Khasi Greenstone suggests a NE-SW axis sending dykes and appophyses in the Shillong Group of rocks.

### The Sylhet Trap

The Sylhet Traps are of the nature of Plateau flood basalts which is exposed in a narrow E-W strip around 80 km long and 4 km wide. This is found along the southern border of the Shillong Plateau. The maximum exposed thickness is about 500-600m.

The Sylhet Trap which has been considered equivalent to the Rajmahal Trap comprises predominantly of basalts, minor alkali basalts, rhyolite and acid tuffs. The thickness of this varies from 5m-7 metres and occur as flows with flow breccia at their top.

### Cretaceous-Tertiary Sediments

The Cretaceous-Tertiary sediments which occupy the southern part of the Meghalaya Plateau are thick and

extensive sedimentary sequence. It is considered to be physically continuous with the cretaceous-tertiary sediments of the Bengal Basin. These sediments are affected mostly by basement controlled faults.

The sediments are mainly sandstone and shales excepting for the three fossiliferous limestones which occur as -

- (i) Discrete outliers.
- (ii) A continuous narrow belt fringing the southern margin of the State bordering the Bangladesh Plains.

The Sediments here are divided into three major groups

- (a) Khasi Group
- (b) Jaintia Group
- (c) Garo Group.

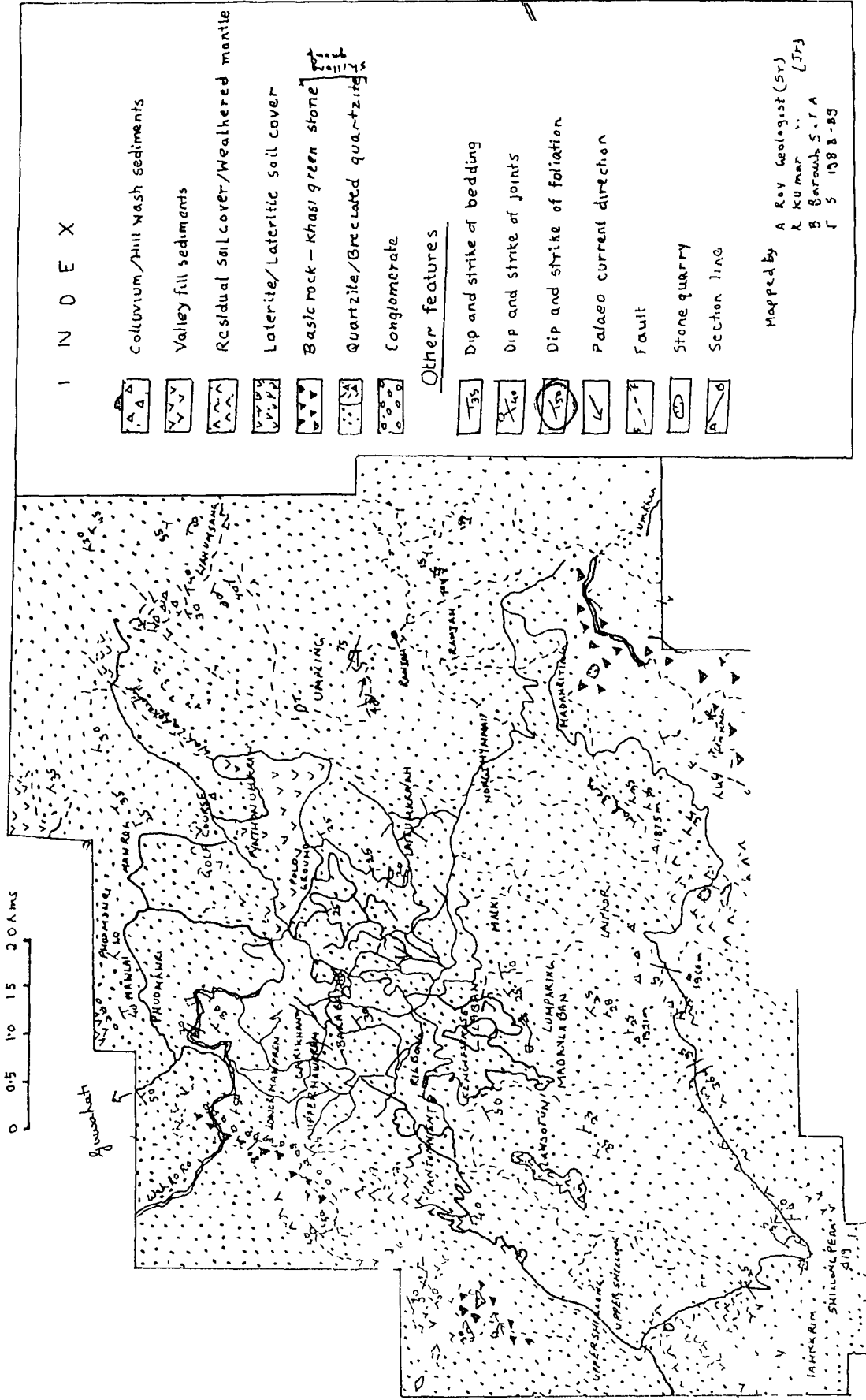
#### Local Geology of the Study Area

After discussing the Geology of Meghalaya it becomes essential to have an understanding ~~as to~~ the Geology of the study area.

The Shillong city has a predominance of the "Shillong Group of rocks" which comprise of sub-metamorphic facies of argillaceous and arenaceous members with a distinct superimposition in the argillites underlying the arenites<sup>12</sup>.

12. Interim Progress Report (1988-89) FS. Geol. Surv. India. North Eastern Region, Shillong, pp.4.

# GEOLOGICAL MAP OF GREATER SHILLONG



Source - GSI Rec 123 Pt IV

The argillites display a wide variation of composition from soft and shaly type to schists. While the quartzites has its base formed by Conglomerate bend with persistent litho character.

The entire Group i.e. Shillong Group of rocks lies over the basement of Gneissic Complex and the Geological succession of the different types of rocks is given in the table 2.2.

The other rock types include "the Khasi Greenstone" which is a basic rock and appears to be intrusives into the quartzites as concordant bodies occurring as linear lenses sharing weak metamorphism.<sup>13</sup>

The Shillong Group of rocks are finally overlain by the Mesozoic-Tertiary sediments especially towards the south of the study area.

Fig. 2.1 shows the Geology of the Greater Shillong Area where we see that there is predominance of the Shillong Group of rocks, while the Khasi Greenstone is concentrated in the southeastern section of the study area along the course of river Umkhen. Khasi Greenstone is also exposed

13. A. Roy, L. Kumar & B. Baruah (1988-89). Detailed Geological and Geomorphological mapping on the Greater Shillong Area with special reference to Environmental Aspects. East Khasi Hills District, Meghalaya, Geol. Surv. India, Report. Unpub. pp.6-12.

# GREATER SHILLONG SECTIONS ALONG FEW GEOLOGICAL TRAVERSE

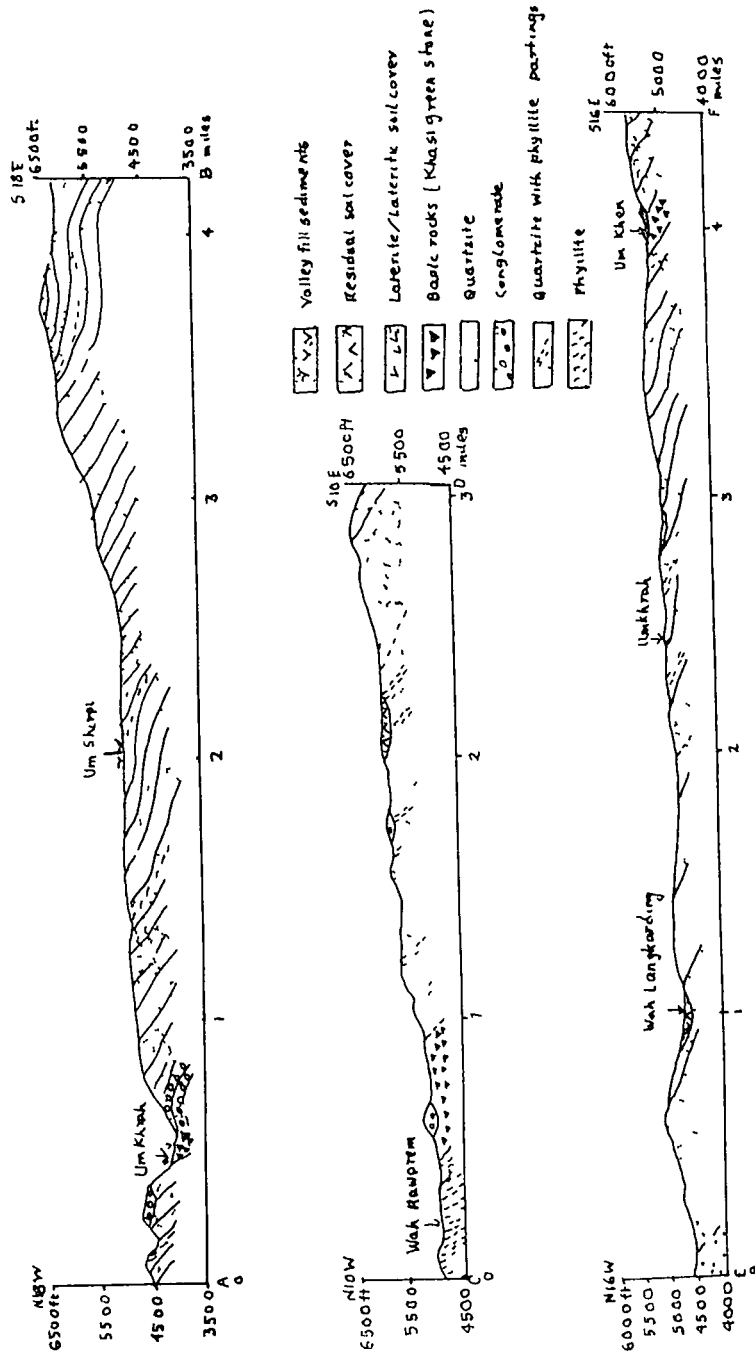


FIG 2 2

Table 2.1

Generalised stratigraphic succession of Meghalaya  
(modified after Anon 1974 and Mazumdar 1976)

Recent	Newer Alluvium (Thickness not known)	Represented by sand, silt and clay.	
----- Unconformity -----			
Pleistocene	Older Alluvium (Thickness not known)	Represented by Sand, clay pebble, gravel and boulder deposits.	
----- Unconformity -----			
Mid Pliocene	Dupi tila Group (approx. 1050m)	Represented by unclassified <u>molted</u> clays, <u>felspathic</u> stone and diamictite	
----- Unconformity -----			
Oligo-miocene	Caro Group	Chengapara Formation (approx. 700m)	Represented by sand, silt-stone clay and marble.
		Bagnara Formation (approx. 530m)	Represented by <u>felspathic</u> sandstone pebble diamictite, clay, silty clay.
		Simsang Formation: (1150 m)	Represented by Siltstone-sandstone alternations, sand.
Eocene	Jaintia Group	Kopili Formation (500 m)	Represented by shale, sandstone, marl.
		Shella Formation: (600 m)	Represented by alternation of sandstone limestone.
		<u>T</u> angpar Formation: (100 m)	Represented by Calcareous shale, sandstone, limestone
Upper Cretaceous	Khasi Group	Mahadek Formation: (150 m)	Represented by arkose (Glaucinitic)
		Bottom Coylomerate: (25 m)	Represented by Conglomerate arkose.
		<u>T</u> adukuta Formation: (150 m)	Represented by sandstone-conglomerate alternations.
----- Unconformity -----			

Table 2.1 contd.

Upper Cretaceous	Sang Valley Complex	Represented by <del>Cyroxenite</del> , serpentite, carbonatite, etc.
----- Unconformity -----		
Jurassic	Sylhet Trap	Basalt, alkali basalt, rhyolite, acid
----- Unconformity -----		
Permo Carboniferous	Lower Gondwana Group (approx. 200m)	Sandstone, Shale, Conglomerate, <u>Coal.</u>
----- Unconformity -----		
	<u>Porphyritic Granitoid</u>	These dot the Meghalaya Plateau. Those entirely within the Gneissic complex and those intrusive into the Shillong Group, are of the same age. Because of the South Khasi batholith transects both the older sequence.
----- Intrusive contact -----		
Proterozoic	Khasi Green stone	Basic sills and dykes mostly within the Shillong Group.
----- Intrusive Contact -----		
Proterozoic	Shillong Group	Formerly termed the "Shillong Series" They are a conglomerate-sandstone-siltstone-shale rhythm. Weakly metamorphosed in the northern parts. Metamorphised in proximity with Porphyritic Granitic <u>Phetous</u> . Occurs as a cover on older rocks. Strike persistently NE with open folds alternating with zones of steep dips.
----- Unconformity -----		
Archean	Nonporphyritic migmatite Granitoids.	They are a variety of textural and compositional types developed exclusively within the Gneissic complex where grade of metamorphism reaches amphibolite facies.
----- Diffused contact -----		

Gneissic complex      Formerly described as "Older Gneisses" or "Gneiss series." or "Archeans". A telescoped sequence of stratigraphic, deformational and metamorphic events which needs further elucidation, mostly show one phase of recrystallisation probably due to later metamorphism Augen gneisses pre-tectonic with respect to this phase of deformation and recrystallisation, are considered relicts of a still earlier orogeny.

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Source: Geological survey of India, N.E. Circle, Shillong.

**Table 2.2**  
Geological Succession of the Study Area

Geological Succession	Rock Types
Acid Intrusives	Porphyritic, Granites, Metabasalt, Metadiorite Amphipolite, Meta Gabbro.
Shillong Group	<ul style="list-style-type: none"> <li>a) Coarse grained granular quartzites.</li> <li>b) Intraformational Conglomerate.</li> <li>c) Quartz-sericite schist mica schist etc.</li> <li>d) Phyllite, carbon Phyllite, Phyllite with quartzite appearance.</li> </ul>
<del>Basal Conglomerate</del>	

The basement is of Gneissic complex.

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Source: Interim Progress Report (1988-89) Field Study. Geol. Surv. India. North Eastern Circle.

in the western and North <sup>W</sup>Western section of the study area. There is also predominance of Quartzites falling under Shillong Group of rocks.

*shown in/* Along the course of river Umshirpi there is presence of valley fill sediments as ~~suggested~~ *by* Fig.2.1 while residual soil cover is prevalent in and around Mawprem. Pologround and Golf course also has prevalence of valley fill sediments as it is a low lying area skirting the northern portion of city.

The distribution and description of the rock types presented in the study area can be enumerated as follows:

#### Phyllites:

These are reddish brown, pinkish to purple in colour and are fine grained with well preserved foliation and schistosity.

In the north they are exposed <sup>along</sup> on the entire length of Shillong Barapani Road with a thick weathered mantle.<sup>14</sup>

These Phyllites are having a varied composition ranging from carbon phyllites to silicified ones. The carbon phyllites are rarely in situ. Silicified composition of

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14. Ibid.

Phyllites found near the sheer zone usually impart a quartzite look.

The phyllites occur mainly within the core of the fold closures and also as partings within the quartzites.<sup>15</sup>

#### Quartz schist, quartz-sericite schist:

These are the well foliated light grey to white coloured rocks exposed along the National Highway number 40 and 44 both in the north as well as south of the study area.

The quartz schist and quartz-sericite schist are found overlying the Phyllites and exhibits an axial plane schistosity making an acute angle with the primary foliation in the direction of the dip of the strata. Impressions of the existing structural elements like lineations, slicken sides etc. are perfectly reflected with the plunged of fold axis varying 20°-30° towards SW.<sup>16</sup>

#### Quartzites:

The quartzites are hard compact massive light grey to buff coloured rocks exposed on the roads and quarry sections of the study area. These rocks are coarse to granular in nature with well preserved sedimentary structures

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15. Ibid

16. Ibid.,

These rocks show a low intensity of metamorphism except near the contact zone with granite where the intensity of metamorphism is comparatively high.

Towards the north and north east of Beado n Bishop falls as well as in the vicinity of the Phudmauri village the quartzites display an acute tendency of oxidation resulting to thick lateritic cover as shown in Fig.2.1.

Evidence of brecciation within these quartzites have also been witnessed in a denudational hill near Mawpat village as well as to the South east of Laitkor Peak on a nala section.<sup>17</sup> It has been observed that at some places the quartzites have been interbedded with phyllites, quartz schist and quartz-sericite schist.

#### Intraformational Conglomerate:

These occur as syndepositional pebble beds, usually found overlying the phyllites and interbedded with quartz-schist as well as quartzites. These rocks are mainly composed of flat elongated pebbles of one centimeter to about ten centimeter in size.<sup>18</sup>

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17. Ibid.

18. Ibid.

Fig.2.1 shows that this variety of rock is exposed in the south and south-western part of Beadon-Bishop falls.

f The Intra ~~C~~ Formational Conglomerate tends to show a foliation conformable to the bedding and matching intensity of metamorphism with the quartzites.

#### Basic Intrusives:

These occur as isolated lenticular concordant <sup>d</sup> bodies within the quartzites with very thick weathered <sup>h</sup> mantle

It is greenish to black in colour hence the name Khasi greenstone, whose texture varies from fine, medium to coarse grain. Its composition varies from basalt to dolerite, amphibolite to gabbroic.

The composition of the Khasi Greenstone varies from higher elevation to lower elevation as well as from north to south.

It has been observed that the amphibolites and the pyroxenes have been altered to chlorite and serpentine especially in the Umiam Nala section near the Umjajew village to the north of the study area.

The Khasi Greenstone has undergone metamorphism in many a place. It has been observed that when the Khasi Greenstone have come into contact with quartzites it has undergone occasional assimilation with the surrounding rocks due to contact metamorphism.

### Granites:

These are pink to light grey in colour and are coarse grained with porphyritic texture.

Xenoliths of quartzites are encountered with the granites indicating a later emplacement history of these acid intrusives. The evidence of the acid intrusives in the granites has also been observed at Lytlyngkot where it is found to be cutting across the regional schistosity.

Towards the south of the study area the quartzites along with granites shows a high intensity of thermal metamorphism.

The Shillong Group of rocks comprising of the Phyllites, Quartz schist, Quartz-sericite schist, quartzites, ~~Intra Permian~~ Conglomerate and the Khasi Greenstone which has been termed as basic intrusives usually show a low grade of metamorphism under green schist facies condition.

Structurally these rocks show a combination of monoclines to homochines and the type of folding in this area has been termed as the "Intermediate crest like folding" by S.K. Mazumdar (1976)<sup>19</sup> who opined that this

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19. S.K. Mazumdar (1976). A summary of the Pre-Cambrian Geology of the Khasi hills, Meghalaya, Geol. Surv. India, No.23, PT.2. Misc. Pub.

structural set up may be due to the re-activation along the fractures in the basement particularly below the zones of steep dips which to some extent can explain the numerous monoclinial bends in the Shillong Group of rocks.

Geologically Shillong thus presents an interesting study with varying rock types ranging from the Shillong Group of rocks which were laid down as a thick pile of sediments possibly on a secondary basin over the Gnessic complex and the basic silts and dykes have followed the weaker tensional cracks and margins.

The emplacement of ~~G~~ranites as intrusives into the Shillong Group of rocks may be considered as the end member of the tectonic phase.<sup>20</sup> These are definitely post depositional as suggested by the presence of quartzitic xenoliths embedded within the granites observed near Umroi (outside the study area) and also by the evidence that the quartzites have attained a higher grade of metamorphism and recrystallisation specially in areas having close proximity to granites.

The Shillong Group of rocks ~~tend~~ to show a persistent NE-SW trend with minor swings. There is also the presence of important primary sedimentary structure viz.

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20. A. Roy R. Kumar & B. Baruah (1988-89) Ext. Abstracts of Progress Report for field Season-1988-89. Geol. Surv. India. Records Vol.123-Part 4. Unpub. pp.12.

bedding plane, current bedding, ripple marks etc.

The distribution of individual members are aligned roughly towards NE-SW with variable dips thus following the regional strike.

On the basis of regional study three phases of deformation could be observed which may be defined as

- (i) The steeply plunging axis folded on a NE-SW plunging axis, which has been refolded on a NW-SE plunging axis and are represented by open folds, sub-parallel to bedding plane.
- (ii) Assymetrical to isolinal folds as encountered in the quartzites with its axial plane foliation sub-parallel to bedding, except near the fold closures.
- (iii) Broad open folds with northerly plunges where some of the joints and fractures are found parallel to the fold axis.

The structural pattern of the basic intrusives on the Khasi Greenstone suggests their emplacement in the Shillong Group of rocks after the first phase of deformation.

Geologically thus Shillong presents an interesting

study which in turn throws light on the geomorphology of the region which is perhaps intricately related with the urban landuse.

### Physiography:

Shillong and its suburbs falls on the Central upland zone of the Meghalaya Plateau. The Meghalaya Plateau is actually a part of the Peninsular Plateau of Southern India separated from it by the Garo Rajmahal Gap.

The Plateau is mainly composed of Pre-Cambrian rocks which have undergone acute folding and are steeply dipping with an overturned fringe of Mesozoic and Tertiary sediments. It stretches in an east-west direction abutting between the alluvial plains of Bangladesh in the south and Assam plains in the north.

The plateau characteristics is more pronounced in the southern part of the area which has numerous rises and steep wall descending into the Bangladesh plains.

The Shillong Range and Laitkor Range situated in the southern part of the city of Shillong is the highest part of the Plateau. Some individual peaks like the Shillong Peak (1960m) and Laitkor Peak (1940m)<sup>21</sup> above mean sea

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21. A. Roy. R. Kumar & B.Baruah (1988-89), Op.cit., pp.10.

level are situated here which acts as a water shed.


The Meghalaya Plateau has a chequered evolutionary history of emergence. Over 2000 million years ago, a large part of the area was a landmass upto the present day Himalayas, Upper Assam and perhaps the Bengal Tripura area. About 472 million years ago, the eastern part of the Khasi hills became a basin of sedimentation in which were deposited the sandstones and the shales of the Shillong series.<sup>23</sup>



Thus started the evolutionary history of the Meghalaya Plateau which experienced coal bearing sedimentation of the Gondwana marines in the fresh water west of the Garo hills about 250 million years ago.

During Jurassic times about, 150 million years ago, the southern part of the Plateau experienced volcanism, through east-west fissures, along which the southern block ~~under~~ and the northern block rose.

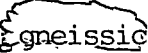
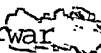
Just after the ceassation of volcanism, the rate of sinking of the southern blocks increased resulting in the invasion of the sea deposits of the Upper Cretaceous sediments about 110 million years ago. This movement was

23. S.N.Sarkar, A.A. Polkanov, E.K. Gerling, and F.V. Chukrov (1964), "Pre-Cambrian Geomorphology of Peninsular India", Int. Geol. Congress. Twenty Second Session, India. New Delhi, In. M.V.N. Murthy's, "An Outline of Geomorphological Evolution of the Assam Region", pp.10.

rapid first and then slowed down during Eocene times.<sup>24</sup>  
 During Paleocene times  portions of the Meghalaya Plateau became basins of fresh water. Here sedimentation occurred at different phases. Again during different ~~Geolo-~~ geological times some areas experienced upliftment while others experienced depression resulting to a varied topography which is ~~Geologically~~ geologically complex.

The Meghalaya Plateau thus experienced emergence, submergence and peneplanation in different ~~Geological~~ geological periods as a result of which there is presence of the younger  sediments of  Tertiary and Mesozoic age in the southern part of the Plateau.

The general slope of the area has maintained a persistent northward gradient<sup>25</sup> which is indicated by the drainage lines which tend to follow the initial slope of the area.

The prevailing rocks of the Meghalaya plateau have more in common with the  gneissic and  Dharwar rocks of Bengal and Bihar than those of the more neighbouring Himalayan sequence as found in the states of Nagaland, Mizoram etc. or the alluvial tracts of Assam valley. The strike in the

24. P.C. Panda (1983) Geomorphology and rural settlements in Khasi and Jaintia Hills Meghalaya. Ph.D. thesis. Geography Deptt. NEHU Shillong, pp.55-59.

25. A. Roy, R. Kumar & B. Baruah (1988-89) Op.cit., pp.10.

foliation of the Gneiss of the Plateau is much the same as that of the Chotanagpur gneiss of Bihar and Bengal. A further resemblance is seen in the marine transgression which has affected the southern sides of the plateau in the Cretaceous deposits, much of which now lie undisturbed upon the older rocks as do similar deposits along the Coromondal coasts of the Peninsular.<sup>26</sup>

The ancient (Pre-Cambrian) peneplaned surface of the plateau is still preserved, with marks of different cycles of denudation. In the central and northern parts it is hidden beneath the Mesozoic traps along the central southern fringe and Cretaceous-Tertiary and Post-Tertiary depositions over the southern, south-eastern and south-western parts.

Since Pre-Cambrian to the end of Miocene the region has experienced earth movements which has left its imprints. Thus the city of Shillong lies in the earthquake belt and today's "Shillong Plateau is a horst which has been uplifted during the post-Mesozoic era to its present height."<sup>27</sup> The region exhibits numerous faults, fractures and troughs indicating active volcanic activities. It is in this background that the city of Shillong is situated in the central upland zone of the Meghalaya Plateau which contains the

26. O.H.K. Spate (1967), India and Pakistan, Methuen and Company Ltd., III Ed., pp.15.

27. S.K. Mazumdar (1976) Morphogenetic evolution of the Khasi hills Meghalaya, Geol. Surv. India. No.30, p.III, Misc. Pub. pp.208-213.

remnants of ancient peneplain surfaces thus preserving several traces of erosional cycles. The presence of many rapids and waterfalls in and around Shillong suggests that there is also the presence of a youthful topography in an ancient pre-cambrian shield which is perhaps due to recent upliftment of the area.

The uppermost part of the Shillong Plateau consists of a mildly undulating plateau top of limited width stretching roughly along east-west direction and having an altitude of 1800-1900 metres above mean sea level<sup>28</sup> where Shillong Peak and Laitkor Peak is situated forms the southern boundary of the Shillong city.

While the Pologround or the Umkhrach valley skirts the northern edge of the city and is situated at much lower level than the city proper. The general altitude of Shillong city varies from 1490 M to 1524 M above mean sea level.

It is towards the north of Upper Shillong as suggested by Fig.1.2 most of the localities of Shillong lies. The topography comprises of rolling hills and valleys having varying relief. It is also characterised by the presence of low relief hillocks with gentle undulating valleys, moderate relief hills having escarpments on two sides in

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28. Report from Urban Development Office, Govt. of Meghalaya, Shillong.

Mesa/butte landforms depending on the magnitude is also found here. ?

The Plateau between Laitkor and Barapani exhibits three structural terraces. This may be partly attributed to the fold movements and partly to the later block movements which has been suggested by abrupt scarps. Infact a conspicuous scarp exists between Laitkor Peak and Shillong town.<sup>29</sup>

The main drainage of Shillong is constituted by two rivers viz. Umshirpi and Umkhrah which roughly determines the municipal boundary of the city.

These two rivers which join near the Beadon and Bishop falls to form the Wah Ro-Ro a tributary to Wah-Umium which marks the western boundary of the study area.

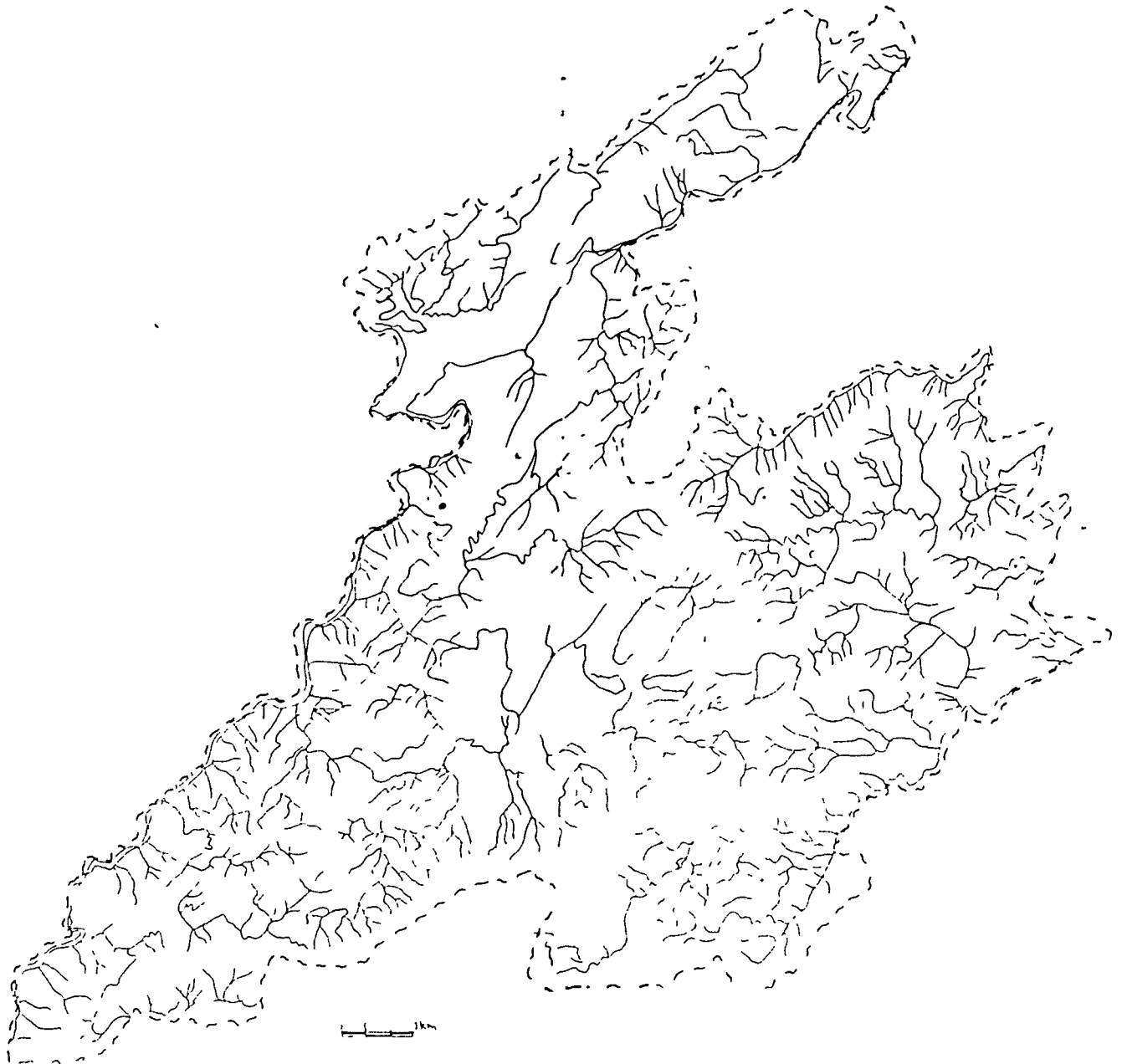
The numerous nalas in the northern and eastern part of the city are actually the tributaries of the Umkhrah river, which starts as the Umpling river from near about Umpling towards the eastern side of the city. The Umkhrah river passes through the northern sector of Shillong whereas the Umshirpi follows a course towards the south.

On the course of the Umkhrah towards the eastern

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29. A. Roy, A Kumar & B. Baruah (1988-89), Op.cit., pp.11.

Shillong Master Plan Area  
**DRAINAGE MAP**



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Fig 2'3

section lies the Spread Eagle falls. From the Phudmawri the Umkhrah river takes a northwesterly direction and flows towards Beadon and Bishop Falls.

The river Umshirpi starting from the Crinolines Falls in the Lumparing area takes a northwesterly direction and joins the river Umkhrah near the Bishop falls in lower Mawprem.

The drainage pattern is sub-parallel to dendritic in nature as suggested by the drainage map of the area (Fig.2.3). The streams tend to follow the joints and faults of the area which is reflected by almost straight stream courses.

There is also presence of numerous 'V' shaped gullies in this area which is controlled by Northeast-Southwest and Northwest-southeast trending joints having thick vegetation cover.

Major streams have cut deep gorges which are often narrow and have a depth of more than 600m.

#### **Climate:**

The climate which is an aggregate of weather conditions prevailing over a long period of time at a given place is a dynamic factor of natural environment. It changes

with varying magnitude in time and space. Climate is not only a local phenomenon but is also controlled by global atmospheric circulation which is governed by the sun's black spots and energy budget of the Earth.

Before any geomorphological study of Shillong is conducted it is perhaps necessary to have an understanding of the climate for climate too is an important factor determining the process of development of landforms and how it is used.

The climate of Shillong is controlled by the seasonal winds i.e. South west and North east monsoonal winds as well as altitude of the area.

The Shillong range lying to the south of the study area and extending in west to east direction across the path of the South West monsoon winds plays a significant role in governing the weather conditions of the area. Due to Shillong's location on the northern leeward side of the range it is in the rainshadow zone, thus there is relatively less rainfall here than Cherrapunjee-Mowsynram area which is only around 50 km from Shillong, as it lies in the windward side towards the southern edge of the Meghalaya Plateau.<sup>30</sup>

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30. Z. Hussain (1984) "Some Ecological observation on climatological Data of Shillong - 1970-81", Shillong 1971-81, North Eastern Council for Social Science Research, Research India Pub. Calcutta, pp.11-24.

The climate of the study area can be described as a typical mountainous monsoon climate with sufficient rains in summer.

Geographically the climate of Shillong can be classified under the humid sub-tropical climate, Characterised by high rainfall mostly during summer.<sup>31</sup>

According to Koppen's empirical classification of climate, with some minor modification the climate of Shillong can be classified under C climatic scheme known as Humid Mesothermal climates.<sup>32</sup>

On the basis of Temperature and Precipitation the climate of Shillong comes under Amk (Z. Hussain)<sup>33</sup> designation of Koppen's scheme where

C = warm temperate rainy climate with mild winter.

m = Monsoon regime of Precipitation with short dry season compensated for by heavy rains during rest of the year.

k = mean annual temperature below 18°C warmest month above 18°C Centigrade.

All these characteristics are found in the climate of Shillong in the nature of cold dry winter. Heavy rains

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31. Ibid., pp.11-24.

32. Ibid.,

33. Ibid.,

# SHILLONG RAINFALL AND TEMPERATURE

1981 - 1990 (Average)

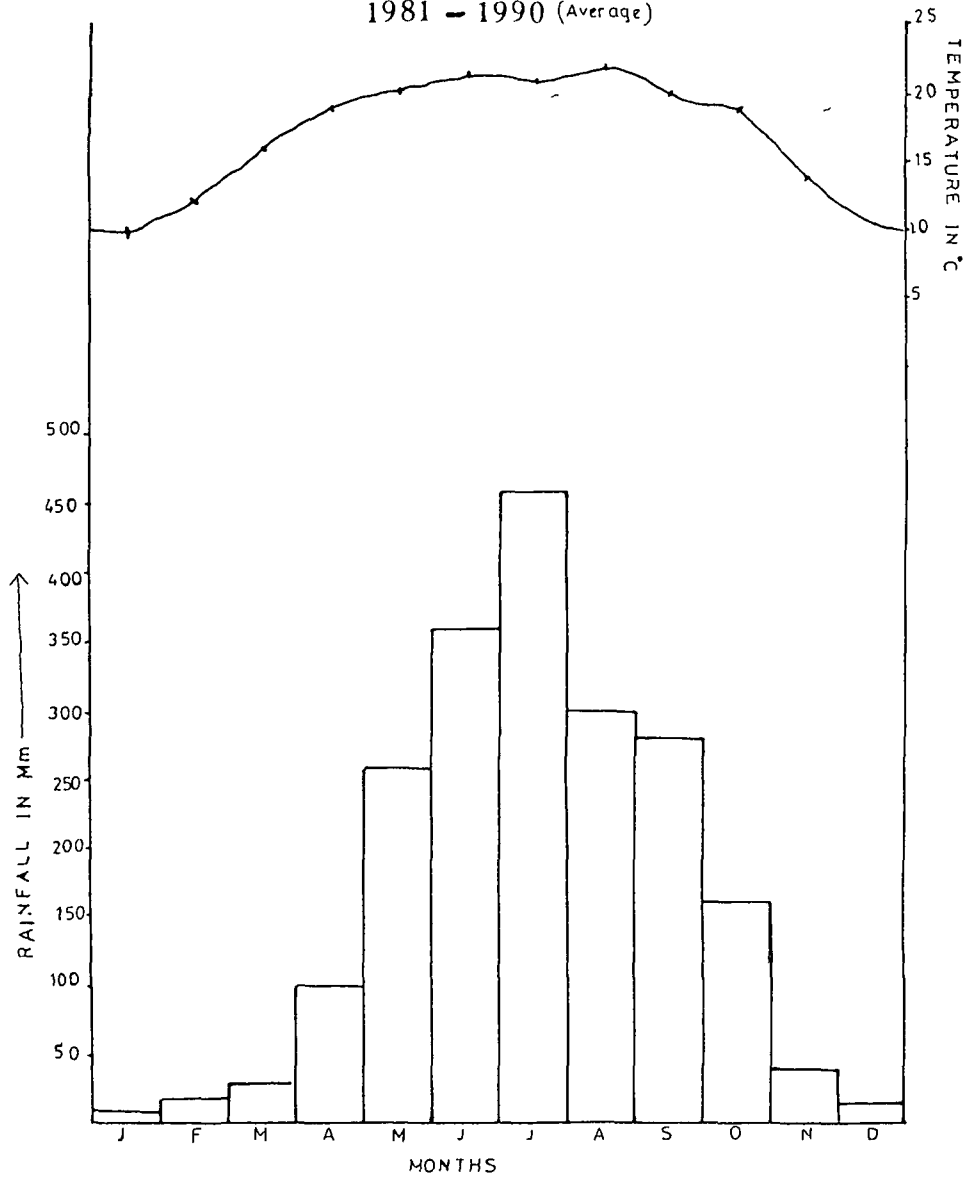




FIG - 2.4

during June-August as well as mean annual temperature ranging less than 18°centigrade. The temperature of the warmest month being above 18°centigrade around 20-25°centigrade.

Table 2.3 and 2.4 give<sup>s</sup> the average monthly temperature and average monthly rainfall respectively.

The seasons of the study area are as follows:

Spring Season - March to middle of May is also known as the Pre-monsoon season when the average rainfall is about 100-150mm. The temperature is also moderate with maximum average temperature around 20°centigrade and minimum average temperature around 12°centigrade.

Summer Season - <sup>It</sup> Which starts around Middle of May and lasts till September <sup>and</sup> is also known as  the Rainy  Season when the city comes under heavy rainfall. The months of June and July record the highest rainfall <sup>is</sup> indicated in the table 2.4 as well as the Fig.2.4.

In fact in 1982 the month June recorded the highest rainfall of 622mm. While in 1983 the month of July recorded the highest rainfall of 827mm which 1984 the monthly of July had a rainfall of ~~85.8m~~ as indicated in Table 2.4.

858 mm .

TABLE 2.3 Average monthly temperature of Shillong, 1981-1990 (in degree Celcius)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Average Annual	% variation from the av. of the decade
1981	8.87	10.86	14.84	15.74	18.91	21.54	21.91	21.65	20.92	17.99	14.93	11.09	16.60	-2.70
1982	10.95	11.54	14.84	18.55	20.32	21.14	21.82	22.53	20.63	17.26	13.32	10.26	16.93	-0.76
1983	9.22	10.79	15.03	18.53	19.13	21.35	21.55	21.17	19.58	18.75	14.78	10.32	16.68	-2.23
1984	8.73	12.26	17.74	19.97	20.04	21.21	20.64	21.74	19.23	18.13	13.97	10.68	17.03	-0.18
1985	10.38	10.71	17.78	19.81	19.15	21.57	21.04	21.89	20.56	18.45	13.34	12.37	17.25	+1.11
1986	11.62	11.47	16.93	18.50	18.58	21.62	21.47	21.70	19.48	16.13	13.80	11.95	16.94	-0.70
1987	11.85	13.10	15.55	18.66	20.38	21.56	21.52	20.87	20.84	17.69	15.24	12.42	17.47	+2.40
1988	10.61	13.32	15.85	20.09	19.77	21.28	21.67	21.49	20.89	18.41	15.01	11.86	17.52	+2.70
1989	8.13	10.63	15.53	20.02	20.96	21.48	21.19	21.78	21.30	19.22	13.94	11.32	17.13	+0.41
1990	9.60	12.26	13.94	17.46	19.48	21.52	21.85	21.59	20.61	17.39	16.20	11.78	16.97	-0.53
Average of the decade	10.00	11.69	15.80	18.73	19.67	21.43	21.47	21.74	20.40	17.94	14.45	11.41	17.06	

Source: Meteorological data Recording Centre Bar Jhar Guwahati.

TABLE 2.4 Monthly rainfall in Shillong, 1981-1990 ( n mm)

Year	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Total Annual	% variation from the av. of the decade
1981	35.50	20.00	68.00	127.00	369.50	242.50	489.00	269.00	176.00	16.50	0.00	87.50	1900.50	-10.27
1982	5.50	1.00	62.00	142.75	170.50	622.00	328.75	369.25	320.25	52.75	70.50	2.00	2147.25	=1.38
1983	4.00	36.00	41.50	118.00	223.50	195.50	827.00	396.50	439.50	241.50	7.00	12.50	2542.50	+20.04
1984	16.50	2.50	18.00	97.60	142.50	316.00	858.00	309.75	305.00	114.50	2.50	35.50	2218.35	+ 4.74
1985	7.00	23.60	8.00	64.50	386.00	347.00	363.50	321.00	203.50	33.50	11.50	0.00	1769.10	-16.48
1986	0.00	16.00	20.00	82.00	189.50	184.00	154.80	182.00	288.00	342.50	45.00	5.00	1508.80	-28.77
1987	2.50	41.25	79.50	105.00	115.00	540.00	619.00	292.50	390.50	77.50	40.00	14.00	2316.75	+ 9.38
1988	7.00	18.00	46.50	168.10	575.20	561.00	512.00	572.25	196.00	211.50	220.50	0.00	2988.05	+41.08
1989	13.50	41.75	74.75	32.20	170.00	315.25	839.50	160.75	273.75	282.70	12.00	4.85	2221.00	+ 4.86
1990	2.25	21.75	50.00	193.50	280.75	278.75	142.85	148.50	207.50	235.20	5.50	1.50	1568.05	-25.97
Average of the decade	9.38	22.19	46.83	103.07	262.25	360.20	513.44	302.13	280.00	160.82	41.45	16.29	2118.05	

Source: Meteorological Data Recording centre Borjhar Guwahati.

Post Monsoon season - The post-monsoon or the retreating monsoon season is experienced during the month of October-November when the rainfall gradually decreases. The nights became chilly with average monthly temperature ranging from around 13°-20°centigrade.

Cold Season - The cold season or winter season sets in during mid November beginning of December and lasts till February.

The coldest months are experienced during December and January when the ground temperature sometimes reaches sub-zero level in the early morning resulting <sup>in</sup> ~~to~~ ground frosting.

Fig. 2.4 represents the average rainfall for a decade from 1981-90 as well as the average temperature for the same decade. It is seen from the graph that the hottest months are June, July and August when average monthly temperature is slightly above 21°centigrade.

The maximum rainfall is recorded for the decade 1981-90 in the month of July when it is 513.44mm as indicated in table 2.4 as well Fig.2.4.

#### **Natural Vegetation:**

Meghalaya is one of the richest and interesting

botanical province of the Indian subcontinent which supports a dense natural cover of forests, probably because of climatic and physical features which is extremely diversified.

The Meghalaya forests could well be called the "Genetic treasury of the wild".<sup>34</sup> The natural vegetation by virtue of their location at different altitudes with variation in climatic condition has resulted to a variety of flora and fauna in the state which can be divided into three groups viz.

by  
in

- (i) Mixed evergreen forests in the southern parts.
- (ii) The rolling grassland and the pine forests.
- (iii) Grasslands with scattered pine trees which have been observed in the higher altitudes.

The hill tops are smooth with shallow sub-soil supporting the growth of several grass species.<sup>35</sup>

Shillong which lies in the East Khasi hills District of Meghalaya is extremely rich in natural vegetation.

*Pinus khasia* is the principal flora of the Shillong urban complex.

The *Pinus khasia* has fair to poor water retaining

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- 34. P. Chakravorty (1982) Studies on the Fungal Diseases of Certain Forest trees of Meghalaya - Ph.D. thesis, Deptt. of Botany, NEHU, Shillong.
  - 35. A.S. Rao (1968) "Vegetation of the Khasi and Jaintia Hills, ~~Proc.~~ Proc. of the Congress Symp. I.G.U., Guwahati, pp.95.

capacity and is found at an altitude varying from 950 metres to 1850 metres.<sup>36</sup> As the average altitude of Shillong is around ~~#~~1500 metres above mean sea level almost all the area is covered by Pine forests.

Shrubs are more prevalent on slopes with the veneer of soil where lateritic crusts have been formed.

The Pine and Thuja forests cover around sixty per-cent<sup>37</sup> of the total forested area.

Bamboos of *Bambusa palida* and *Dendrocalamus hamiltoni* species are also found within the city of Shillong.

Forests of the study area occupy around 1220.40 hectares of land accounting for 11.76 percent of the total study area. Out of this only ~~Eight~~ percent of the forests of Shillong is under state control,<sup>38</sup> while the rest is classified as Private forests and Raid forests.

The forest cover of Shillong is reducing due to the destruction of the natural vegetation because of rapid urban expansion causing pressure of population on land. The demand for wood in various industries like plywood, furniture making etc. has had its toll on the forests of Shillong as there is indiscriminate felling of trees.

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36. Report from Urban Development Office, Govt. of Meghalaya, Shillong. Unpub.

37. Ibid.,

38. Ibid.,

Moreover due to the lack of sound plan and programme as well as scientific management of the forests the natural vegetation of Shillong is under threat which may have a serious repercussion on the ecological balance of the city.

The need of the hour is perhaps a proper management of the natural vegetation of the area where the understanding of the geomorphology of Shillong perhaps becomes essential as deforestation in the steeper slopes leads to more of soil erosion and loss of soil nutrients. This in turn results to the development of furrows, gullies and badlands which in turn results <sup>in</sup> to lateritic crusts which is harmful for luxuriant Pine forests.

**CHAPTER - III**  
**EVOLUTION OF SHILLONG**

**Introduction:**

Before going into analysis of how geomorphology can be applied for the Urban Landuse of Shillong, it is perhaps necessary to have an understanding as to how the township of Shillong grew up. This in turn necessitates a historical perspective of the study area which may become essential in order to understand the present landuse and how Geomorphology plays a negative or a positive role in the existing Landuse.

**Shillong Under the British:**

The process of urban growth of Shillong can be traced down to the period of 1863-64 when the British shifted the headquarters of Khasi and Jaintia hills from Cherrapunjee to Shillong.<sup>1</sup>

Before 1864 Shillong was an unknown nomenclature. Its present area was then covered by deep forests with Laban a small village and certain small hamlets under the United Khasi state of Shillong. It was in that year that Shillong became the administrative village for the Khasi and Jaintia hills.

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1. B. Pakem (1984) "An Introduction" Shillong 1971-81, N.E.Council for Social science Research, Research India Publication, Calcutta pp.1-10.

# SHILLONG - HISTORICAL GROWTH

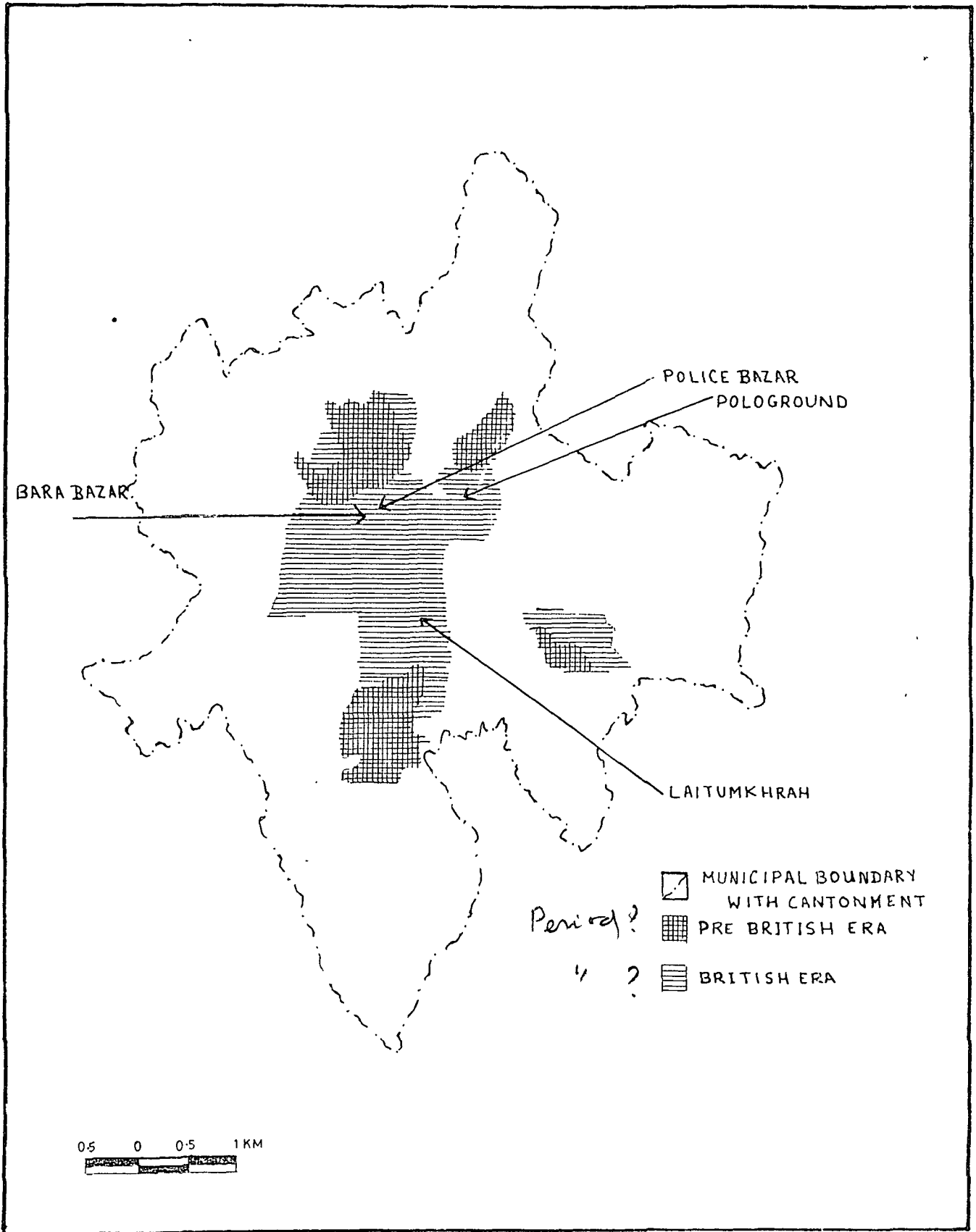


FIG 31

Thus the evolutionary history of ~~the~~ Shillong, being principally an administrative satellite centre of the British Raj has till date preserved its characteristic of an administrative centre essentially being service oriented.

Being located at <sup>About</sup> 1500 metres above mean sea level its location between the Brahmaputra valley in the north and the Surma Valley in the south provided an ideal setting for the British administrators, planters and other fortune seekers. Moreover the temperate climate of Shillong so akin to the climate of Britain perhaps attracted the British as they found a relief from the oppressive climate of the Plains. Thus Shillong grew up as an enclave with urban functions in the midst of rural tribal society.)

The varied topography and the scenic beauty as well as the hospitable people provided enough of variety in its socio-economic spectrum. The variety has become its uniqueness and therefore today Shillong has developed as the premier centre for educational and cultural activities in the Region perhaps second only to Guwahati.

(?!) (Shillong derived its name from a person named "Shyllong" who discovered God at the highest Peak.<sup>2</sup> The

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2. J.P. Singh (1980) Urban Land Use Planning in Hill Areas, Inter India Publication, pp.192.

urban centre evolved around the weekly market centre called "Iewduh" i.e. present Barabazar.

With certain events like the acquisition of the Dewani of Bengal by the East India Company in 1765 A.D.<sup>3</sup> and the Yandaboo Treaty in 1826 A.D.<sup>4</sup> the Shillong Plateau and Khasi and Jaintia Hills came under the British rule.

For the selection of the sanitorium and cantonment for the British military stationed in this Region, Cherrapunjee was selected by the British in 1829.

Due to inclement weather conditions of Cherrapunjee, as the highest rainfall <sup>in</sup> ~~of~~ the world is recorded here, as well as the need for better water supply facilities. Central location with the advantage of military post and civil station as well as easy accessibility favoured the shifting of the Headquarters of the District of Khasi and Jaintia Hills to Shillong from Cherrapunjee. Thus a committee of Enquiry was appointed, which comprised of Colonel Richardson<sup>5</sup> the Commanding Officer of the British troops stationed at Cherrapunjee as well as B.W.D. Morton the Deputy Commissioner of Khasi and Jaintia Hill District.

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3. Govt. of Meghalaya Report.

4. Govt. of Meghalaya Report.

5. D.R. Syiemlieh (1989). Our City, North East India History Association Decennial. X Annual Conference. Deptt. of History, NEHU, Shillong, pp.19.

This team after studying the surrounding areas like Sohrarim, Mairang, Laitlyngkot and Nonkrem selected the large open space to the north-east and east of the Shillong Peak as a favourable location for the future headquarter<sup>6</sup>. But it was found that the area does not have sufficient water supply in all seasons of the year, thus such a location may not be suitable to sustain a large population.

Finally it was decided that the best location might be the northern slopes of the Shillong Range and the plateau of Iewduh which is the present market centre of Shillong and is now in the heart of the city.

Geomorphology perhaps played a significant role in the selection of the site for the setting up of the British administrative centre even as early as 1863-64 as indicated in the preceding paragraphs.

However the suggestion to shift the civil and military station or the headquarter of the Khasi and Jaintia Hills from Cherrapunjee to Shillong was first mooted by Rowlatt, the Principal Assistant Commissioner in September 1860 following an enquiry by the Military Department for the settlement of non-commissioned officers in the Khasi hills. The enquiry led to the proposition that a Sanatorium

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6. Ibid.,

for the European Residents of Assam and the District Civil Station should also be located close to the intended settlement for the troops.<sup>7</sup> Thus Shillong was chosen as the station by Rowlatt, who principally had in mind the central location of Shillong between Sylhet plains in the south and Assam valley in the north, which would be more easily accessible from both north and south than the existing base at Cherrapunjee.

Thus an agreement between the British Government and the Syeim of Myllem and the Chief of Khyrim viz. Raja Melay Sing and Raja Rabon Sing respectively, on whose state the proposed site was located was signed on 8th December 1863.<sup>8</sup>

The following Government  bears the fact.

"I Melay Sing having, on behalf of myself and my Muntrees and all others concerned, ceded the Raj rights and Title in the land at Shillong known as the Shillong lands: The Raj land south of Om Soorpee, known as Kurkongton Nongseh land; the land near Youdoe known as Shillong Labang land: hereby renounce all right and title thereto, resigning the same to Her Majesty the Queen of England, with the

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\*King or ruler.

7. Ibid.,

8. Ibid.,

trees, water and all things thereon or therein and hereby acknowledged to have received in full satisfaction therefore the sum of Rupees 2000 (two thousand) from Leutenant Colonel Haughton, Governor General's Agent, North East Frontier.

Youdoe  
the 8th December 1863.

(sd) Melay Sing & His Mark

(Sd) Raja Rabon Sing & His Mark

**Source:** Government Document - "Agreement with the Chief of Moleem, 1863".


By this agreement the local Chieftains ceded to the British one thousand six hundred and twenty six (1626) acres of land for Rupees two thousand as token payment. However an additional seven hundred and fifty nine (759) acres of land was purchased from individual properties.<sup>9</sup>

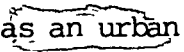

With the transfer of the headquarters from Cherrapunjee to Shillong which covered the base of Shillong Peak included within its ambit Sadew village, Nongkhsheh village Mawkhar, Laban and Laitumkhrah village.

In the year 1866 the then Lieutenant Governor-General of Bengal, Sir John Peter Grant sanctioned the transfer of the Deputy Commissioners establishment from Cherrapunjee

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9. Ibid.,

to Shillong. In the same year Colonel Hopkins who was the Commissioner of Assam and Agent to the Governor General of India strongly advocated in  favour of Shillong as the future Headquarter of Assam Province. Accordingly on March 20, 1874 Shillong was declared the Capital of Assam Province<sup>10</sup> which had a population of about one thousand three hundred and sixty three (1363 people)<sup>11</sup>.

However it must be mentioned that Shillong  as an urban  centre grew up without much planning thereby creating numerous problems in the field of settlement, sanitation, road and transportation.

In 1878 the need was felt to formally declare Shillong as a station. The areas taken from the Syiem and the lands purchased from owners, together with some of the neighbouring villages was constituted into a station under the Municipal Act. The Town affair was managed by the Deputy Commissioner.

As the town was growing steadily it was necessary to acquire more land, thus the British Government by other agreements took on perpetual lease from the Syiem of Mylliem those portions now known as European Ward, Police Bazar,

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10. Ibid.,

11. Report from Urban Development Office, Govt. of Meghalaya, Shillong, Unpub.

Jail Road and the present cantonment.<sup>12</sup> The Lachumiere hill was added to the township in 1895.<sup>13</sup>

It is seen that even in those days settlements sprung up in those areas of the present city which had a moderate slope and in areas which could be easily accessible. Thus the steep slopes of Laban Lumpering area inspite of being the sites of the earliest settlements in the area did not grow at a faster rate as the rest of the area. It was only with the rise of population and the tremendous population pressure on land that these areas were encroached upon by urban functions.

In 1901 the total population of the township was 9621.<sup>14</sup> Shillong Municipality was established in 1909, new areas such as Laitumkhrah, Hopkinson Estate, Malki, Mawprem, Laitkor forest were included under the Municipal boundary just after two years i.e. 1911 the population recorded at Shillong was 13639 people showing a growth of +4018 and an increase of about 41.76 per cent (as per table 3.1) from the previous census.

The population growth before Independence is represented by table 3.1. Thus the township was growing at a very fast rate as indicated by the table 3.1.

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12. Ibid.,

13. Ibid.,

14. Census of India 1981. Provisional population total Meghalaya Series-14.

TABLE 3.1 Population growth of Shillong before Independence  
(1901-1941)

Year	Population	Increase or decrease	Percentage of increase or decrease	Remarks
1901	9,621	-	-	
1911	13,639	+4018	+41.76	
1921	17,203	+3564	+26.13	Shillong Municipality Area
1931	23,536	+9333	+54.25	
1941	38,192	+11656	+43.93	

**Source:** Census of India 1981, Provisional Population Total Meghalaya Series - 14.

### Shillong after Independence

After Independence of India in 1947, a new thrust of horizontal and vertical expansion was experienced by Shillong, due to large immigration and influx of refugees from the then East Pakistan the present Bangladesh. Expansion of residential buildings, administrative buildings took place. Vacant land in Laitumkhrah, Laban, Malki etc. were occupied. Proper planning especially in case of residential expansion was not done at this stage as settlements grew up on steep slopes and rugged terrain by the sides of the main line of communication without paying much heed to the ~~Geomorphology~~ of the area, which had had an adverse effect on the ecological balance of the city. In 1951, Shillong had only two parts, the Municipality and the Cantonment which recorded a total population of 58,512.<sup>15</sup>

By 1961, the townships of Nongthymmai and Mawlai had developed and formed two census towns of the Shillong Urban Agglomeration. Due to unrestricted residential expansion, changes in Municipal boundary the surrounding areas like Happy Valley, Umlyngka, Upper Shillong, Nongkesh, Lowsotun, Madanrting, Pynthorumkhrah, Nongmynsong and Umpling developed urban characteristics in their morphological and economic set up.

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15. Ibid.,

In 1981 Madanrting and Pynthorumkhrah were included under the Shillong Urban Agglomeration as indicated by Fig.3.2.

In 1970 when the new state of Meghalaya was created and Assam's capital was shifted to Dispur, Shillong automatically became the Capital of Meghalaya.

Shillong though established mainly for administrative purposes has through time achieved a certain degree of specialization to its function.

It has emerged as an important educational centre of the North-East where there is a full fledged central University besides a number of good schools and colleges catering to the needs of the neighbouring states.

Shillong is also emerging as an important trade centre of the North-East and its position can be regarded as only second to that of Guwahati. It is perhaps operating as an important nodal centre as the National Highway No.40 and 44 passes over the heart of the town linking it up with the state of Assam, Mizoram and Tripura.

Due to its varied functions and high rate of Urbanisation the population of Shillong has increased at a rapid pace as indicated by table 3.2. This has resulted to

TABLE 3.2 Population growth of Shillong Urban Agglomeration  
(1961-81)

Urban Units	Total Population			Decennial growth	
	1961	1971	1981	1961-71	1971-81
Shillong Municipality	72439	87659	107673	+21.01	+22.85
Cantonment	2988	4730	6653	+58.32	+40.66
Mawlai	8528	14260	20280	+67.21	+42.22
Nongthymmai	10084	16103	21563	+59.69	+33.91
Pynthorunkhrah	-	-	10735	-	-
Madanrting	-	3-13	6160	-	-
Shillong Urban Agglomeration	94039	122752	176064	+30.53	+43.43

Source: Census of India 1981 and final tables for 1961 and 1971. Provisional population total Meghalaya series - 14.

development of new settlements under Urban areas. Certain important characteristics emerge from the table 3.2.

The growth of population is higher in 1961-71 decade than 1971-81 decade in all four constituents except Shillong Municipality. The reason may be the large scale outmigration resulting from shifting of capital from Shillong to Dispur.

But however the overall growth rate is higher in 1971-81 decade as indicated in Table 3.2.

However owing to the topographic limitation of the city as Shillong is situated in a plateau characterised by rugged topography and steep slopes as well as the complexity of land ownership,<sup>16</sup> the city's expansion is not possible in all directions, particularly in the establishment of housing colonies etc. Therefore the inner city areas are already highly concentrated and traffic density are fairly high on the road network of the city.

In case of the size of population the relative dominance of population of Shillong Municipality is closely manifested. The share of urban population of Meghalaya is very less which is 18.12 percent as against 23.73 percent

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16. K. Holoi, "Land Ownership in Khasi Hills", Hill Geography, Vol.II, No.1. pp.11-17.

# SHILLONG URBAN AGGLOMERATION

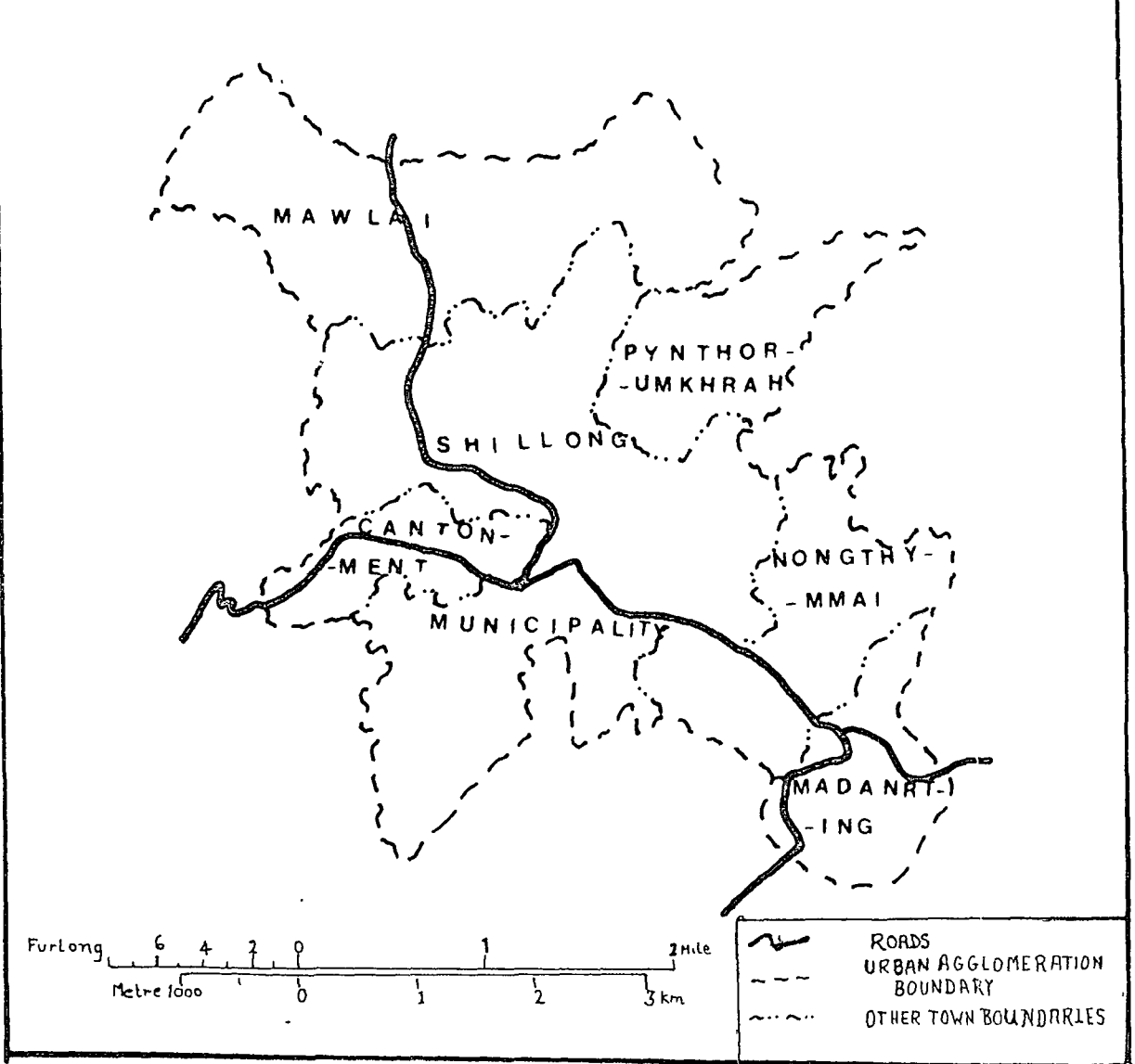


FIG 32

of the National average. However Shillong Municipality has the largest share (48.71 percent) of the urban population of the state. This had led to high density of population with around 10,500 persons per square kilometre causing strains and stresses to the urban infrastructure and quality of life in general.<sup>17</sup>

Shillong is an important tourist centre known for its scenic beauty with its undulating topography and rolling grassland rich in vegetation is the largest hill station of the country.

Fig.3.1 shows the growth of Shillong before the British Era, after the British Era and its boundary indicates the present Municipal Boundary along with the Cantonment of Shillong.

Thus today's Shillong is expanding at a very fast rate and taking within its ambit the peripheral areas. Fig.3.3 shows the standard urban area which includes the Municipality, Cantonment the townships of Mawlai, Nongthymmai, Madanrting, Pynthorumkhrah as well as nine rural components.

Not only is the city embracing Laitkor Peak itself,

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17. H.B. Mahanta (1986) "Continuity and Change A Geographical Analysis of the Urban fringe of Shillong Urban Agglomeration - A Case study of Mawsbuit", M.Phil Thesis, Deptt. of Geography, NEHU, Shillong.

# SHILLONG STANDARD URBAN AREA

1989

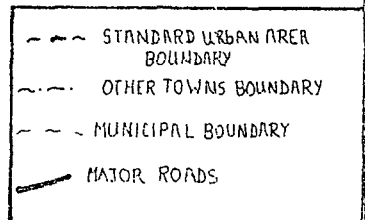
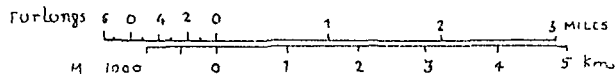
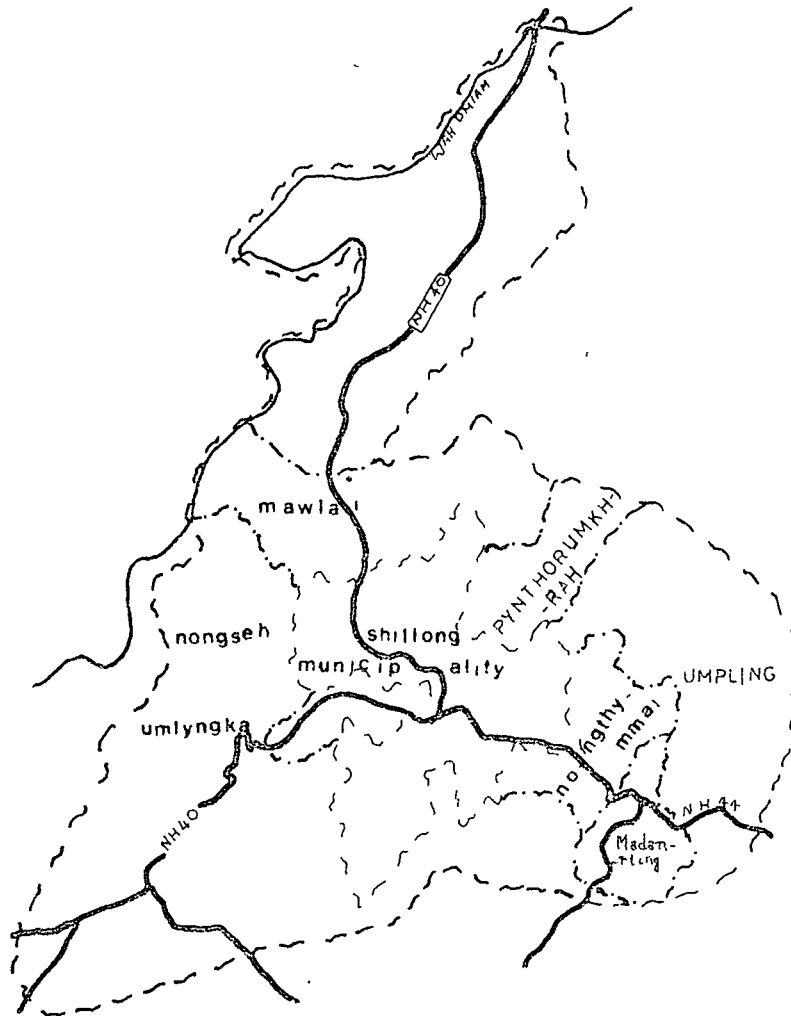


FIG 33

it is marching on the opposite side of the Plateau, but most spectacularly it is engulfing the roadside villages along the National Highway No.44 towards Guwahati and is now reaching towards Umsning.<sup>18</sup>

Infact according to the Shillong 1991 Master Plan of the Meghalaya Urban development office the boundary of the Standard Urban Area extends from Umroi Road in the north to Laitkor Road connecting National Highway No.40 and 44 in the south, and Umkhen Wah Shella upto Tynring village in the east to Wah Umiam in the West.<sup>19</sup>

Thus ~~urbanisation~~ urbanisation is spreading rapidly in Shillong and its population is becoming more cosmopolitan in nature which is not only affecting the social condition but the economic lifestyle of the people.

We thereby see in the Shillong of the present decade a repetition of the processes of the earlier decades when the little civil station so reminiscent of the colonial outpost of the British expanded to include Jaiaw and Laitumkhrah on its periphery.<sup>20</sup>

During the sixties Shillong included within its ambit

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18. Cajee (1984) "Shillong the Transition from village to Town to city" Shillong 1971-81, North Eastern Council for Social Science Research, Research India Publication, Calcutta, pp.20-24.

19. Report from Urban Development office, Govt. of Meghalaya, Shillong.

20. T. Cajee (1984), Op.cit.,

"Mawlai" which as the name implies was three miles from the town centre and "Nongthymmai" - which as its name indicates was once a "New Village".<sup>21</sup>

Thus the transition of Shillong from the Colonial outpost to the Capital of Meghalaya, a state under the Republic of India, within a span of one hundred and twenty eight years is indeed unique.

Today's Shillong is a fullfledged city which acts as an important nodal centre of the North Eastern Region.

The growth of Shillong however has perhaps been taking along the main traffic arteries, rather than giving a bias to geomorphological conditions of the area. The National highways which reach in three directions North, South East and south west has been the areas of settlement development thereby leading to a fringe development.<sup>22</sup>

As this process of fringe development continues, perhaps during the 21st century the expanding city of Shillong shall include within its ambit the outlying villages of Smit, Mawpat, Umroi and Mawiong.<sup>23</sup>

Urbanisation is thus being thrust upon the peri-?

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21. Ibid.,  
 22. Ibid.,  
 23. Ibid.,

Page 60  
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peri-urban villages without paying much attention to the geomorphology of the area which is having a serious toll on the loss of luxuriant vegetation cover especially on the steep slopes thereby causing soil loss through erosion and development of lateritic crusts as well as increased run-off which in turn has activated landslides.

Moreover the traditional socio-economic condition of the local people has been disrupted as there has been superimposition of urban oriented landuse in these peripheral villages.

On observation it is seen that the Shillong's development by and large is following the familiar pattern of other Indian towns; mainly consisting of three zones, which can be divided into the inner city with two more concentric sub-urban zone i.e. the present Greater Shillong and the outer transition zone respectively.<sup>24</sup>

The outer ring has an elongated apex along the National Highway No.44 towards Guwahati (Fig.3.3<sup>b</sup>) as this appears to be the direction of the fastest growth.

This fact may be explained with the help of geomorphology characteristics towards the south the rugged terrain of Shillong Range retards the growth of the city whereas

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24. Ibid.,

there is scope for expansion towards the north and north east of Shillong where topography is relatively plain giving enough scope for developmental purpose, like construction of roads, settlements.

**CHAPTER - IV**  
**SLOPE ANALYSES AND DRAINAGE ANALYSIS**

## SLOPE ANALYSES

### Introduction

Slope is a function of relief inclination usually shown in degrees. Although numerous literature has been built on the subject of slope by geomorphologists yet it becomes extremely difficult to define precisely the term 'slope'.

According to L.C. King (1962) slopes are fundamental elements of the landscape' while Fairbridge (1968)<sup>2</sup> is of the view that slopes in its broadest sense, is an element of the interface between lithosphere and either hydrosphere or atmosphere.

Slopes are therefore the upward or downward inclination of the surfaces of landscape measured in degrees with respect to horizontal. Often, slope is also measured in grade or gradient.

Thus the term slope as used throughout the <sup>1</sup>science of ~~Geomorphology~~, designates some small element or area of the landsurface which is included from the horizontal<sup>3</sup> and is perceptible to the eye.

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1. L.C. King (1962) Morphology of the Earth, Oliver and Boyd Edinburg, pp.699.
  2. R.W.Fairbridge (ed.) 1968). The Encyclopedia of Geomorphology, Encyclopedia of Earth Science Series, Vol.III, Reinholds Book Corp. New York, pp.1295.
  3. A.N.Strahler (1971) Physical Geography, Wiley Eastern Pvt. Ltd. New Delhi, pp.395.

Slopes have been a favourite subject for research not only by ~~geomorphologists~~ in their analysis of landforms, but also slopes have been intensely studied by Agricultural and Civil Engineers and by soil conservationists.<sup>4</sup>

As Shillong is a hill station the study of slope which to a large extent may have a role in determining the landuse pattern has to be analysed intricately. Thus the need for the study of form and evolution of the hill slope becomes essential.

The study of hill slope form and evolution may under ideal conditions be a simple process. However in the form and evolution of slope the underlying lithology, structure, ~~geologic~~ history and climate tend to complicate the interpretation of slopes.

Due to these complications the technique of soil mechanics, hydraulics and rock mechanics may be invaluable in many situations, but the complexity of the field situation precludes the development of generalisation applicable to all slopes.<sup>5</sup> Hence the rigour attained in studies of River Morphology, in which many ~~emperical~~ relationships and Laws have been discovered has yet to be achieved in slope studies. At present it also seems unlikely that hill

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4. S.A. Schumm and M.P. Mosley (1966) Slope Morphology (Ed), p.1.

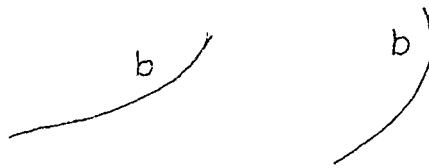
5. P.C. Panda (1983) Geomorphology and Rural Settlements in Khasi and Jaintia Hills Meghalaya, Ph.D. Thesis, Deptt. of Geography NEHU, Shillong.

ELEMENTS OF SLOPE  
 (AFTER YOUNG 1964)

a CONVEX



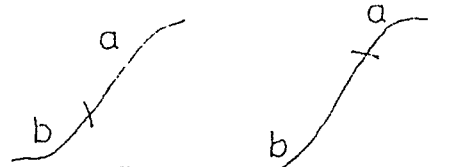
b CONCAVE



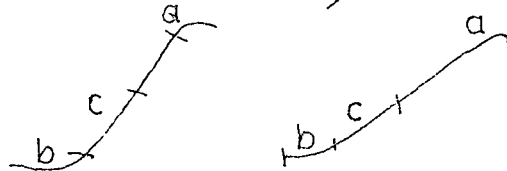
c STRIGHT OR RECTILINEAR



Convex - Concave Slope  
 without stright element



Convex Concave Slopes  
 with stright element



COMPLEX SLOPE

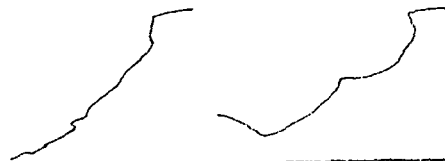


FIG-4'1

slopes may be the result of operation of different processes at different rates (Schumm 1966).<sup>6</sup>

Commonly slopes are classified in terms of slope profile which is a slope belt of unit width extending from drainage divide at the upper extremity, down to a lower terminus which is commonly a stream channel or a natural discontinuity such as a terrace, pediment or cliff (M. Agarwal 1989).<sup>7</sup>

A slope profile usually consists of a variety of forms (Fig.4.1) whose segments may vary from concave upward, convex upward, straight or rectilinear as well as complex. The point where the slope changes its profile is termed as 'break-in-slope'.

The primary aim of slope analysis is to identify the slope elements of an area. According to King (1957)<sup>8</sup> there are four elements in a fully developed hill slope (Fig.4.2) viz.

- (i) Crest or ~~waving~~ slope: which is the upper part of the slope profile and is usually convex. Weathering and soil creep are the main processes which forms this convexity.

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6. S.A. Schumm (1966) The development and Evolution of Hill slopes, J. Geol. Edited 14(3), pp.98-104.  
 7. M. Agarwal (1989) Geomorphological studies around Umiam Lake and Adjoining Areas, East Khasi Hills, Meghalaya, M.Phil Thesis, Deptt. of Geography, NEHU, Shillong.  
 8. L.C. King (1957) The Uniformitarian nature of Hill slope. Trans. Edinb. Geol. Soc. Vol.17, pt.1, pp.102.

ELEMENTS OF FULLY DEVELOPED HILLSLOPE  
 (AFTER KING 1957)

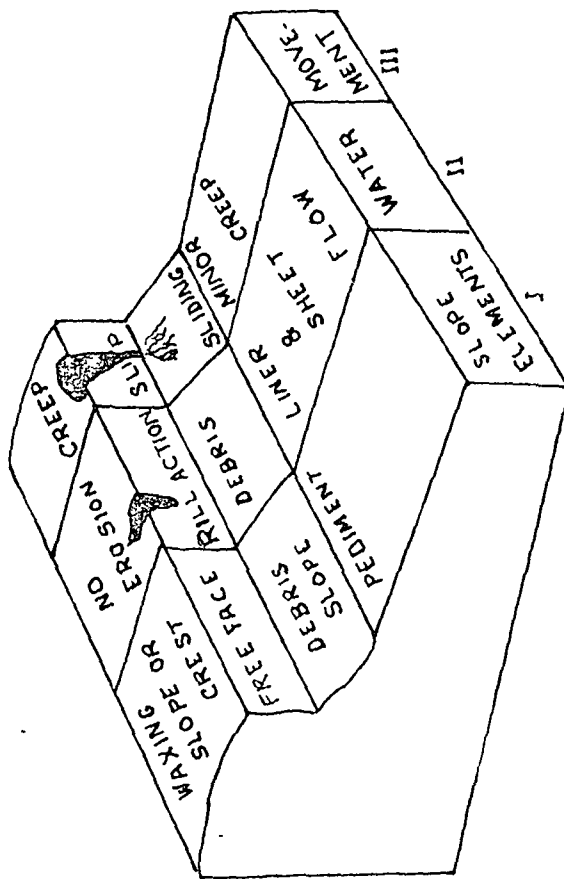


FIG 4.2

- (ii) Scarp or Free Face: This is usually present just below the crest slope and is the most active element in back wearing caused by rillwash and landslides.
- (iii) Debris slope: This is found immediately below the Free Face. It is formed due to the scree or talus fallen from the scarp above and hence the name debris slope.
- (iv) Pediment or Wanning slope: This is generally formed by the accumulation of debris from higher slopes. This is produced by surface wash and is a broad concavity extending from the base of the other elements to the stream or alluvial plains.

The study of slope elements in an area helps one to have an understanding of the evolution of landform in that area.

Again the analysis of slope helps one to assess the stability of different types of slopes under a given set of conditions. To assess the areas liable to landslides and thereby check these landslides from occurring as far as possible. As slopes are ubiquitous elements of the land surface which exert a tremendous control over constructional activities besides development of soil, loss of soil by soil erosion, mining operations and agricultural practices.

All these necessitates perhaps a detailed analysis of slope of an area before the chartering of any developmental programmes. The gradient of the land surface over an area can be analysed from a slope map.

The method of preparation of a slope map was used as early as 1890 by S. Finsterwalder and thereafter by K. Peuckes, J. Tricart, J. Muslin who used an extremely laborious and complicated formula by measuring the total length of all the contours with an episometer.<sup>9</sup>

C.K. Wentworth criticized the earlier formula and simplified it in 1930. G.H. Smith (1935) Riasz and Henry (1937) Robinson (1948) attempted with other methods to determine the average slope of an area.<sup>10</sup> However all these methods are not free from criticisms.

#### Methodology used for Average Slope of the Study Area.

In order to determine the Average Slope of the study area the C.K. Wentworth Method was found suitable which has been used here. This method which is widely accepted one in presenting the slope morphology is the most convenient technique of average slope determination for the preparation of slope zone map. For this the whole study

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9. As referred to by F.J. Monkhouse & H.R. Weikinson (1967) Maps and Diagrams. Methuen and Company Ltd. London.

10. Ibid.

area has been divided into one X one mile grids and the number of contour crossing per sq. mtr i.e. per sq grid is counted.

The average slope is then determined by following the formula.

$$\tan \theta = \frac{N \times I}{3361}$$

when N = Number of contour crossing per grid.

I = Contour Interval

3361 is constant

Tan  $\theta$  representing the angle of slope in degrees.

It has been observed that the study area has slope values varying from 0-28°. This slope values have been categorised into 5 groups or classes ranging from 5° and below to 20° and above with a class interval of 5°.

Table 4.1 reveals a clear picture of the average slope distribution of the area; it has been observed that the five classes of average slope can further be divided into Gentle slope, Moderate Slope, Moderately steep and steep slope.

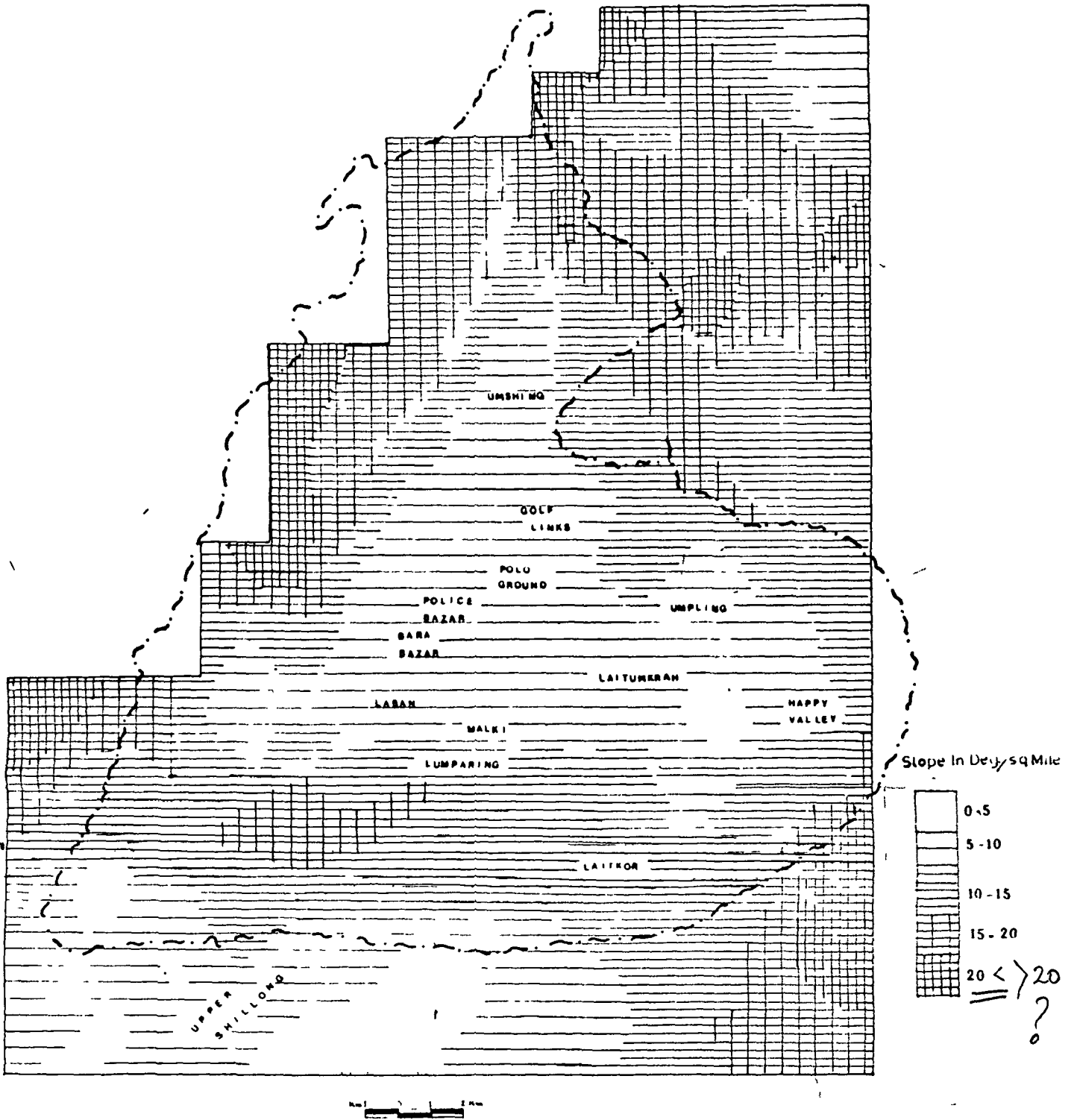
Table 4.1 which has been represented in Fig.4.4 (a&b) reveals a clear picture of the distributional pattern of

TABLE 4.1 Frequency distribution of slope

Slope in degrees	Frequency of grids	Percentage of total frequency	Cumulative percentage of frequency	Remarks/ Broad Categories
0-5°	6	3.87	3.87	Gentle Slope
5-10°	63	40.65	44.52	Moderate Slope
10-15°	39	25.16	69.68	Moderately steep slope
15-20°	37	23.87	93.55	
20° and above	<u>10</u>	<u>6.45</u>	100	Steep slope
Total	155	100		

In the preparation of the above table i.e. 4.1 "the quantitative nomenclature and quantitative limits of the categories have been adopted after Singh (1967), which is being presently followed in most of the Geomorphic studies in India.

SHILLONG STANDARD URBAN AREA  
 AVERAGE SLOPE MAP  
 WENTWORTH'S METHOD



frequencies according to the slope categories. It highlights that the category of moderately steep slope accounts for 49.03 per cent covering the maximum slope frequency, whose value ranges from 10-15° and 15-20°. Next comes the gentle slope of 5° to 10° which account for 40.65 per cent of the total slope frequency followed by steep slope of 20° and above which accounts for 6.45 per cent of the total slope frequency. The least share is taken by the gentle slope category ranging from 0-5° accounting for 3.87 per cent of the total slope frequency.

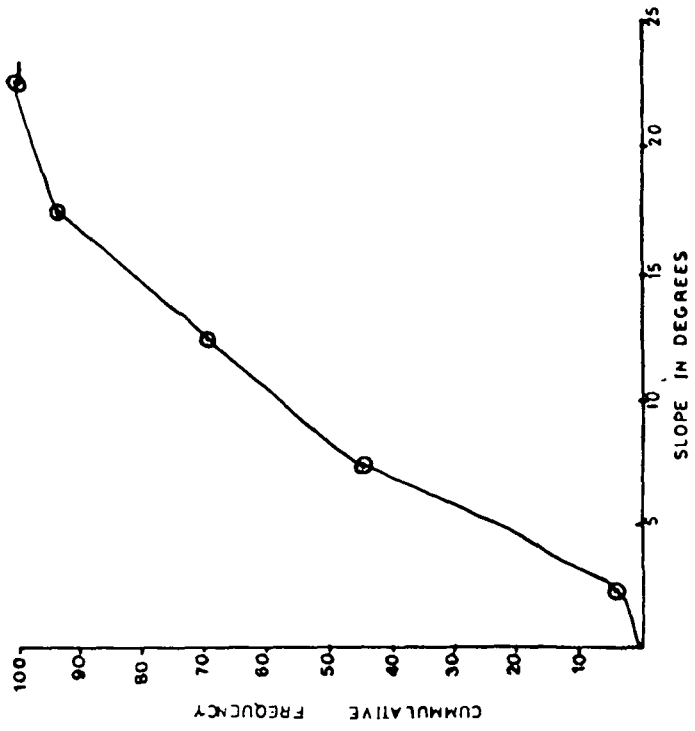
Thus the distribution of slope frequency clearly suggests that the study area is occupied mainly by slope gradient ranging from moderately steep to steep slope which suggests that there is perhaps a necessity for understanding the nature of slope before undertaking any constructional activities.

#### Analysis of Average slope of the Study Area.

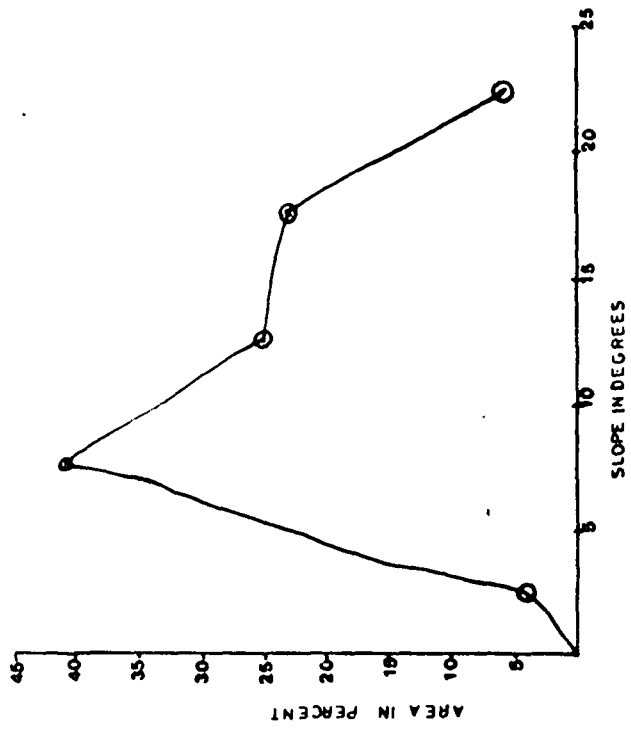
An analysis of the Average slope of Shillong (Fig.4.3) suggests that the maximum <sup>part</sup> of the study area is covered by moderate to moderately steep slope.

However an analysis of the broad categories of average slope becomes essential in order to have a clear insight into the average slope of the Study Area which has been discussed under the broad categories as follows:

# SLOPE DISTRIBUTION



b) SLOPE OGIVE



a) AREA SLOPE CURVE

Gentle slope (0-5 degrees): This slope category (Fig. 4.3) is mainly found to the south of the Study Area in Upper Shillong south of the Water divide.

This slope range is also observed within limited areas in Happy Valley, Pynth<sup>o</sup>rumkhrah, Pologround. The gentle slope category however has a very limited extent over the Study Area.

The soil overlying this category is usually of lateritic variety. This slope is suitable for cultivation as well as permanent settlement as it gives ample land with very gentle slope ideal for constructional activities. Thus Shillong being an Urban Area where land for constructional purposes is limited as it has a rugged topography these areas can be developed.

Moderate Slope (5-10 degrees): This slope surfaces indicates undulating uplands. However walking in this gradient needs or requires considerable effort~~s~~. These areas are well drained by small and large streams with its numerous tributaries.<sup>12</sup>

This slope category is found in patches to cover a large part of the study Area. This slope surface usually

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11. P.C. Panda (1983), Op.cit.,

12. Ibid.,

representy undulating uplands and includes pediment and hill slopes, Bouldery outcrops and rock surface with this soil cover are the main features of this category.

Moderate slope is found to be distributed over Upper Shillong i.e. towards the south of the Study Area as well as central part of the Shillong city covering the localities of Barabazar, Police Bazar, parts of Laban, Lower Malki, Golf Links, Umshing, parts of Mawroh, Pologround, Pynthorumkhrah, Laitumkhrah, Umpling, Rynjah as well as portion of Happy Valley, Madanrtingand Lower Nongthymmai.

This category of slope is good for housing purposes and other Urban functions. It has been observed that at this gradient, the slope is essentially a steep one where roads are risky for modern vehicles. However as a large section of the area of the Shillong city is having moderate slope the motorable roads have been developed in this area.

Moderately steep slope (10-15 degrees and 15-20 degree)  
Maximum part of the Study Area falls within this category accounting for about 49.03 per cent of the total slope frequency. Here the slope are fairly steep and walking uphill in this area needs much effort.

The analysis of Fig.4.3 shows that this category of slope is very widely distributed within the Study Area

covering the Localities of Lowsotun, Kenchestrance, Bishnupur, Lumparing, Laitkor, parts of Upper Shillong, Happy valley, Mawpat, Alugudam, Madanrting, the township of Mawlai Upper Nongthymmai. Thus the eastern, northwestern, some portion of south and central part has a slope gradient of 10-20 degrees.

Here due to constructional activities as a result of Urban expansion and pressure of population on land, there has been a high rate of deforestation which in turn has accelerated soil erosion as well as minimised percolation of water which in turn has resulted ~~to~~ increased rate of run off with higher velocity whose impact is hazardous. This has resulted ~~to~~ the development of furrows<sup>w</sup>, bad lands and gullies, which ~~has~~ <sup>have</sup> been observed in the localities of Lumparing, Alugudam and Laitkor where the loss of nutrients of soil has led to the formation of lateritic crust in these areas.<sup>13</sup> This category of ~~slope~~ ranging from 10-20 degrees is a formidable obstacle for road traffic; inspite of its steepness the levelling of the ground for habitation is possible here.

Steep slope (20 degrees and above): This fifth category of slope unit having 20 degrees and above has been

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13. Report from Urban Development Office, Govt. of Meghalaya, Shillong, Unpub.

categorised as very steep slope. A slope of this order makes a straight descend<sup>t/</sup> extremely hard, but however one can walk up to a desired goal with some difficulty in a round about circuit. The extent of steep slope within the study area is limited (Fig.4.3). This category of slope gradient is found in patches in the south<sup>o</sup> eastern, western and a small portion of North<sup>o</sup> western part of the study area covering a portion of Mawlai, Madanrtng, Mawprem. poir

In this category the gradient of slope is a formidable obstacle in road development as well as levelling of ground for habitation which becomes extremely difficult.

This category of slope range is mainly occupied by forests. ~~Physical constituents like slope, soil, moisture, content as well as forest litter~~ helps in the growth of thick natural vegetation.

However <sup>9</sup> due to loss of this vegetation cover as a result of Urban expansion in these areas, has accelerated high rate of run-off which in turn has led to soil loss and gully formation. The first and second order streams tend to dominate these areas. Rill and gully erosion has been enhanced here which in turn has promoted rock fall as there is no binding matrix.<sup>14</sup>

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14. Ibid.,

The angle of slope has both ~~Geomorphic~~ and economic significance, the nature of lithology, processes of erosion, nature of ~~tectonic~~ movements, climate of the region all seems to play a very important role in determining slope into straight, concave or convex surface. Debris accumulation ~~is~~ a common feature associated at the base of the steep slope.

#### Limitation:

In the preparation of the average slope map (Fig. 4.3) ~~it should be remembered~~ that the slope units selected to express geographical significance are not rigidly true to angular scale. It is only a generalised picture. As for example a slope instead of being uniform may be concave or convex or it may be marked by knicks associated with rock functions, falls and rapids etc. (which is found in large numbers in and around Shillong city). These irregularities have been overlooked in drawing the average slope map of the Study Area.

#### Influence of slope on Urban Activities and Vice-Versa

The slope categories of Shillong ~~is~~<sup>are</sup> having a great influence on the Urban Landuse. For the future expansion of the city an understanding of the slope of the unbuilt area is perhaps necessary for the proper development of the city.

For this the five categories of slope may further be scrutinised and useful information may be gathered on the basis of slope sub-units for micro-regional studies. A knowledge of slope gradient is indispensable for the construction of metalled roads and other constructional activities. In fact slope play an important role in determining how far and how fast development can proceed.

An analysis of slope is therefore essential as the "Science of Geomorphology has a straight and direct concern with slope form and their evolution and origin. All these are the functions of climatic, lithological, tectonic, temporal and structural factors."<sup>15</sup>

The processes of denudation, geological complications or structure and stage have produced marked variations of slope within the Study Area. The slope morphology of Shillong has been affected by different denudational processes as well as sheetwash, gully erosion and rock fall with some cases of landslides has altogether played an important role in the development of the slope morphology of the area. Moreover cultural activities which has determined the existing landuse of the Study Area like construction of roads and houses have influenced the slope development of Shillong.

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15. H. Prasad (1988) "Mussourie and its Environs - A Study in Applied Geomorphology", Amarwati Pub. Varanasi U.P., India.

ey

## DRAINAGE ANALYSIS

### Introduction

The significance of drainage in the evolution of the Landscape has long fascinated ~~Geomorphologists~~, hydrologists as well as ~~Geologists~~. Probably nothing else so "epitomises<sup>S</sup> the history of a region's physiography as the history of its river."<sup>16</sup> For rivers and valleys have a special place in the development of Landforms which made W.M. Davis remark that "Landscape is a function of its structure process and time."<sup>17</sup> ~~While~~ talking about his normal cycle of Erosion.

Shillong situated in the humid tropical climatic<sup>18</sup> regime of the world where chemical weathering is a dominant process of landscape development, drainage tends to constitute one of the most important element of surface ~~Geodynamics~~.

In the absence of ~~the~~ wind action it is the frost actions~~s~~ and running water which perhaps acts~~s~~ as the main agents of erosion in shaping the relief and the development of the present landscape found in and around the Shillong city which in turn plays~~s~~ an important role in the landuse

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16. N.W. Fenneman (1938), Physiography of the Eastern United States, McGraw Hill, New York, Preface (iv).

17. W.D. Tharnbury (1969), Principles of Geomorphology, 2nd Ed., pp.17.

18. P.C. Panda (1983), Op.cit.,

pattern found in the Urban Area.

It should be remembered that the progressive dissection and degradation of the higher lands is mainly caused by fluvial action. A landscape has a definite life history during which it shows a series of gradual changes, whereby the initial form pass through a series of sequential forms to an ultimate form. Thus landscape evolution is envisaged to a cycle which runs through a definite course of development.

The importance of structure, <sup>/</sup>geology and lithology of the area should not be underestimated while discussing about the development of the landscape which influence the operation of the fluvial cycle.

Again the relationship between slopes and the flowing water is equally significant. A steep gradient allows a greater speed of flow which in turn helps the stream to scour its course deeply. A zigzag or meandering course rarely occurs on a steep gradient except when it is produced by excessive overloading or due to the physical obstruction in the streams. It is again the slope which determines the velocity required for the transportation of all the load supplied to the streams from upper courses.

An analysis of slope becomes essential in order to understand the drainage of an area and the analysis of

drainage becomes essential in understanding the evolution of landscape. Throughout the world run offs are perhaps the most dominant ~~Geomorphic~~ agent which has helped in shaping of a particular landform.

#### Fluvial cycle of Shillong:

In any ~~geomorphological~~ study the fluvial cycle of erosion tends to become one of the most important elements to be investigated. It helps one to understand the erosional features produced under the action of heavy rainfall which influences stream action specially in Shillong to a considerable extent.

During the rainy ~~seasons~~ the streams which flow with higher velocity brings ~~about~~ ~~gully~~ erosion and rills particularly along the joint planes and fissures of the rocks which ~~is~~ <sup>are</sup> noticed in and around Shillong specially in the steep slopes where deforestation has been active viz. Upper Nongthymmai, Lumpering, Kenchestrance, Bishnupur where slope is steep ranging from 10-15° and 15-20°.

According to the cyclic theory the influence of ~~geo-~~logic structure on relief is most marked during the stage of maturity. But in a region of ~~Youthful~~ topography as is the case of Shillong it has been observed that the streams gradually penetrate the underlying rock strata

and are engaged in deepening their valleys by headward erosion.

The Shillong Plateau which mainly consists of rolling grassy downs, intersected with river valleys and dotted all over with rounded hills contains remnants of ancient peneplain surfaces which has a height ranging from 1500 metre - 1800 metre above mean sea level.

The presence of many rapids and waterfalls within Shillong like the Elephant falls at Upper Shillong Crinoline falls at Malki, Beadon, Bishop falls indicate that the area has certain youthful characteristics.

A glance at the drainage map (Fig. 2.3) of Shillong shows that Upper Shillong to the South West of the Study Area and Laitkor towards the south East of the Study Area acts as a water divide where elevation is maximum. It is drained mainly by two rivers Wah Umiam in the west and north West and the river Umkhen, Wah Shella which flows from the Laitkor in a north Easterly direction.

As the Study Area receives very high rainfall to the tune of 2400mm per year on the average, it is the running water which is perhaps the most effective agent which has sculptured landforms of the region. Drainage lines which constitute the most prominent form or channel of

the runnings/ water in its attempt to shape the landform of the area which necessitates a systematic analysis and interpretation of drainage characteristics.

These have been studied here under the following aspects with the help of various quantitative techniques:-

- (i) Drainage pattern
- (ii) Drainage frequency
- (iii) Drainage Density

#### **i) Drainage Pattern:**

Drainage pattern refers to the particular design or plan which the stream courses collectively form. The study of drainage pattern often reveals a very delicate and intricate adjustment with structure and lithology of an area. Hence the knowledge of the drainage pattern of an area may throw considerable light on the structure and lithology of the underlying rocks as well as the initial slope of the area.

It has rightly been remarked by A.A. Miller (1965) that "the pattern of drainage is one of the most revealing features of landscape and casts light in the rock type structure, stage in drainage evolution."<sup>19</sup>

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19. A.A. Miller (1965), The Skin of the Earth, pp.75.

The drainage map (Fig.2.3) reveals the hierarchy of rivers from the source to its master stream. Rills, rivulets, streams and rivers outline a geometrical plan. These streams in general, do not organize at random. Their hierarchy traces their history to reflect the stage of their development. Rivers cut hard and soft rocks over the surface and exhibits an organisation of drainage lines over quartzites, phyllites, conglomerates etc. The river alignment is also guided by master and minor joints of the rocks and the drainage pattern is closely adjusted to joints, cleavage, bedding plane as well as slope of the area.

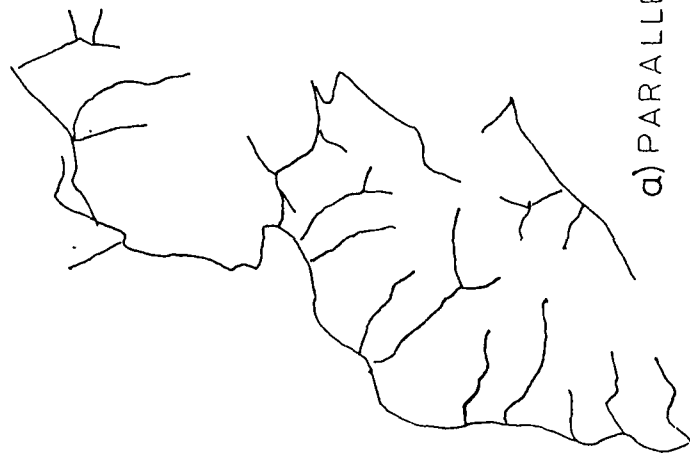
The main types of drainage pattern in the Study Area are -

- (i) Dendritic
- (ii) Parallel.

Dendritic Pattern: It refers to the type of drainage produced when a consequent stream receives a number of tributary streams, which in turn are fed by smaller tributaries at less than  $90^\circ$  angle thereby the whole forming a free like pattern or dendritic pattern.

It is seen from the geology map (Fig.2.1) of the Shillong city that the underlying rock strata has a very

DRAINAGE PATTERNS



a) PARALLEL



b) DENDRITIC

FIG 4.5

complex ~~Geological~~ structure. Thus there is very little chance for the development of dendritic pattern because of the varied geological structure.

Towards the eastern section of the Study Area in the Localities of Mawpat, Mawlong, Ritshywat, Umpling, where quartzites are found in abundance, ~~exhibits~~ <sup>s</sup> a dendritic pattern of drainage formed by the river Umkhrah and its tributaries.

Parallel Pattern: Regional slope plays a significant role and to some extent joints and cracks also helps in the development of parallel drainage pattern. The average slope map of the Shillong city (Fig.4.1) exhibits a wide variation in regional slope varying from 0-20° and above.

The slope increases from north to south and finally in the south the slope is very steep in the Upper Shillong and Laitkor area which acts as a water shed. Here a few patches of parallel pattern of drainage are noticed (Fig. 4.5b) specially in the southern part which flow parallel to the steep slope. The rivers Umshirpi, Wah Ro Ro, Wah Umiam and Umkhen along with its tributaries exhibit a parallel pattern of drainage.

The most important drainage pattern in and around Shillong is thus parallel to sub-parallel drainage pattern

which has been formed because of the underlying rock strata which has numerous joints and fractures as well as the initial slope of the area which is dominated by ridges and valley topography.

**ii) Drainage frequency:**

Drainage frequency refers to the ratio of the total number of channels of all orders in a basin to the area of the whole basin. Horton (1945)<sup>20</sup> introduced stream Frequency (FS) as the number of streams segments per unit area.

Melton (1958)<sup>21</sup> analysed in details the relationship between drainage density and stream frequency both of which make up the drainage texture of an area which in turn is affected by climate, structural characteristics of the rocks, Relief, Infiltration capacity and vegetation of an area.

Stream Frequency or Drainage Frequency is computed by the formula

$$F_u = ( \sum l ) / A_u$$

20. R.E.Horton (1945), "Erosional Development of Streams and their Drainage basins : Hydrological approach to Quantitative Morphology", Geol. Soc. American Bull., No.56, pp.285.

21. M.A. Melton (1958) "Geometric properties of Mature Drainage and their Representative Phase in an E4. Phase Space", Journal Geol. Vol.66, pp.35-45.

where  $F_u$  = Drainage Frequency in No./Km<sup>2</sup>.

( 1)u= Sum of the total number of streams of all order.

$A_u$  = Total area of drainage basin in Km<sup>2</sup>

### Methodology:

In the present study the entire drainage map has been ~~divided~~ into X number of grids and the number of channel segments gridwise are recorded. The value obtained by using the formula

$$FS = \frac{N}{A}$$

where FS = Stream frequency.

N = Total Number of streams per unit area.

A = The Unit Area.

gives directly the stream frequency per sq.km. The distribution of drainage frequency is given in Table 4.2.

### Analysis:

It is seen from the table 4.2 the distributional pattern of drainage frequency (Fig.4.6) which has been broadly categorised as Low frequency or coarse frequency, Moderate frequency a medium frequency, Moderately high frequency and High to very high frequency.

Table 4.2 further reveals high concentration of drainage frequency in the category of Moderately high where

TABLE 4.2 Drainage Frequency Distribution

Drainage frequency per sq.km.	No. of grids of occurrence	Percentage of total frequency	Cumulative percentage	Remarks
below 2	10	5.85	5.85	Course frequency
2-4	32	18.71	24.56	
4-6	46	26.90	51.46	Moderate frequency
6-8	23	13.45	64.91	
8-10	30	17.54	82.45	Moderate high frequency
10-12	20	11.70	92.15	
12 and above	10	5.85	100	High & very high frequency

Course

TABLE 4.3 Drainage Density Distribution

Length of streams per unit area (Km <sup>2</sup> )	No. of grids of occurrence	Percentage of total density	Cumulative percentage	Remarks drainage density
below 2	23	13.45	13.45	<u>Course</u>
2-4	37	21.64	35.09	
4-6	28	16.37	51.46	Moderate
6-8	31	18.37	69.59	Moderately high
8-10	24	14.04	83.63	
10-12	25	14.62	98.25	High to very high (fine)
12 and above	3	1.75	100	

*Course*

# SHILLONG MASTER PLAN AREA DRAINAGE FREQUENCY

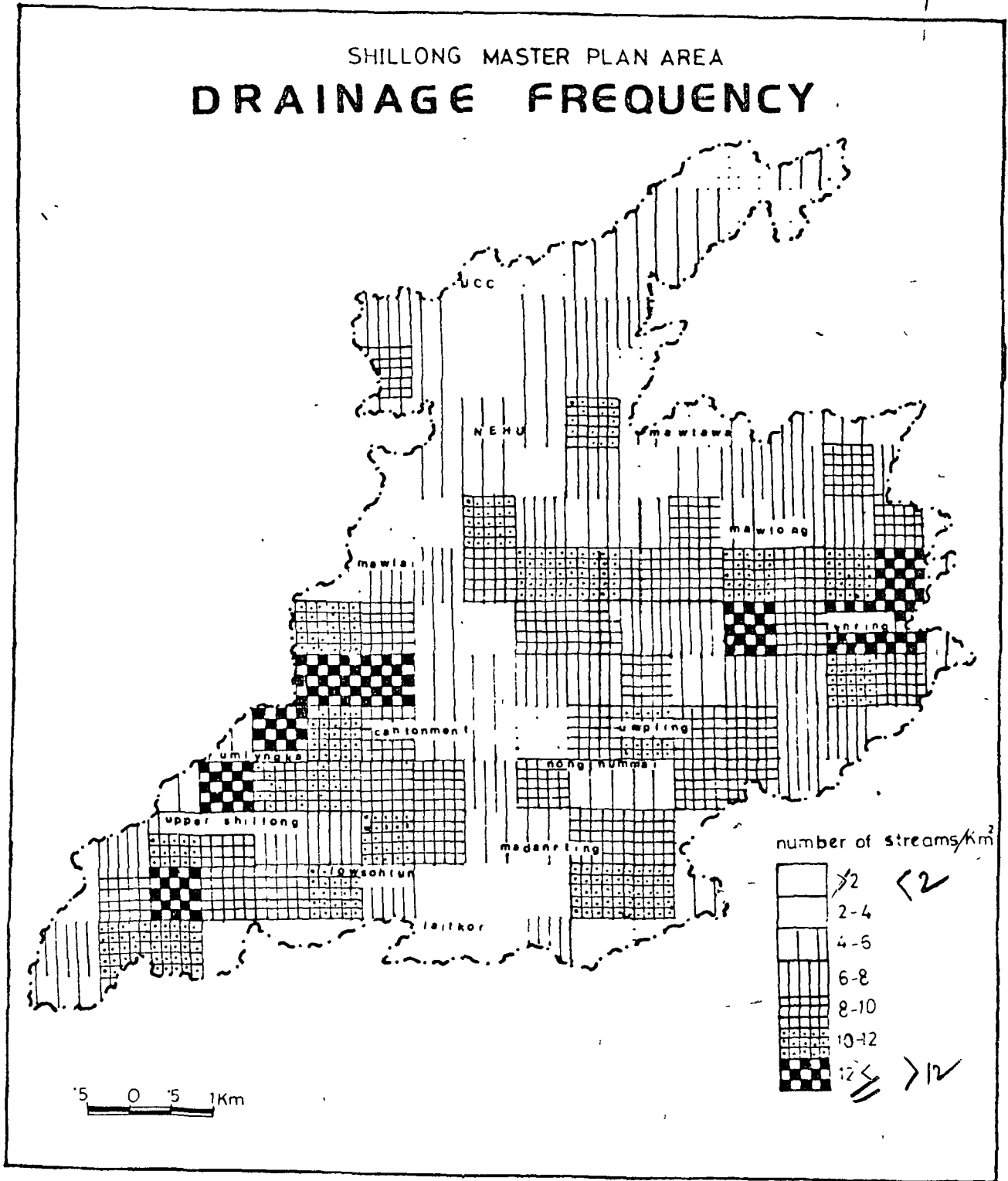


Fig. 46

drainage frequency per sq.km ranges from 4-6 and 6-8,   
 a) Accounts for a share of 30.99 per cent of the total drainage frequency.

The second highest number of stream frequencies fall in the Moderate frequency class i.e. 4-6 streams per sq.km. accounting for 26.90 per cent of the total followed by Coarse frequency i.e. below 2 and 2-4 streams per sq.km. accounting for 24.56 per cent of the total stream frequency.

The remaining 17.55 per cent of total drainage frequency are observed in the high to very high drainage frequency category ranging from 10-12 and above 12 streams per sq.km.

Fig.4.6 gives the spatial distribution of the drainage frequency of Shillong.

#### **Coarse Drainage Frequency (0-2, 4-6 per sq.km)**

This category of drainage Frequency occurs in patches over the study area, mainly towards Barapani, Rangmen, Umden in the North. Mawlai and NEHU Campus towards the west as well as in the extreme south in the Plateau area of Upper Shillong and Laitkor. This type of drainage frequency is also found towards the east of Mawlynri, Mawlong in the east of the Study Area.

This indicates there is lack of relief and absence of impermeable rocks which has given rise to coarse or low drainage frequency. Moderate Drainage frequency (4-6 per sq.km) develops over areas of low relief and absence of impermeable rock strata and it is observed (Fig.4.7) that areas usually adjacent to the areas of coarse drainage frequency tend to show Moderate drainage frequency as is seen at Mawlai, i.e. the northern sector of the Area, Lowsoh<sup>tu</sup>, Pomlu etc. towards the south<sup>e</sup>astern and southern part of the Area as well as Mawsbhut, Mawpdang towards the east of the Area.

Moderately high drainage Frequency (6-8, 8-10 per sq.km) occurs in patches mainly in central part of the Study Area e.g. in the localities of Pynthorumkhrah, Umpling Rynjah, Mawlynri, Nongthymmai, Umlyngka, Cantonment, Upper Shillong. These areas are having high relief with dissected hills and permeable rock strata.

High to very high drainage frequency (10-12, 12 and above per sq.km.) occurs adjacent to the areas of moderately high Drainage frequency, these areas are perhaps having permeable rock strata where infiltration capacity is high. These areas are also having relatively a higher relief with dissected terrain which has facilitated drainage frequency.

The Study Area thus has a concentration of Moderately high to very high high drainage frequency, because the area receives high amount of rainfall and the climate indirectly affects the stream frequency by its control over the amount and type of vegetation. This in turn has an influence on the amount and rate of surface run-off.

### Drainage Density

It simply refers to the ratio between cumulative channel lengths of channel segments of all orders and the area of basin. Numerically it is defined by the relation  $D_u = (L) u / A_u$  where

$D_u$  = Drainage density in  $m/Km^2$

$(L)u$  = Sum of total lengths of streams of all order in Km.

$A_u$  = Total area of drainage basin in  $Km^2$

The expression  $D_u$  gives the average density of streams in the area, theoretically the value should always come more than 1. However to know the variation of drainage density in the area, density has been computed per sq. km. and variation mapped.

The area has been divided into one X one Km grids and drainage density per grid of 1 sq. km. has been computed. The length of the channel segments have been recorded by roto-meter. The drainage density has been classified

# SHILLONG MASTER PLAN AREA DRAINAGE DENSITY

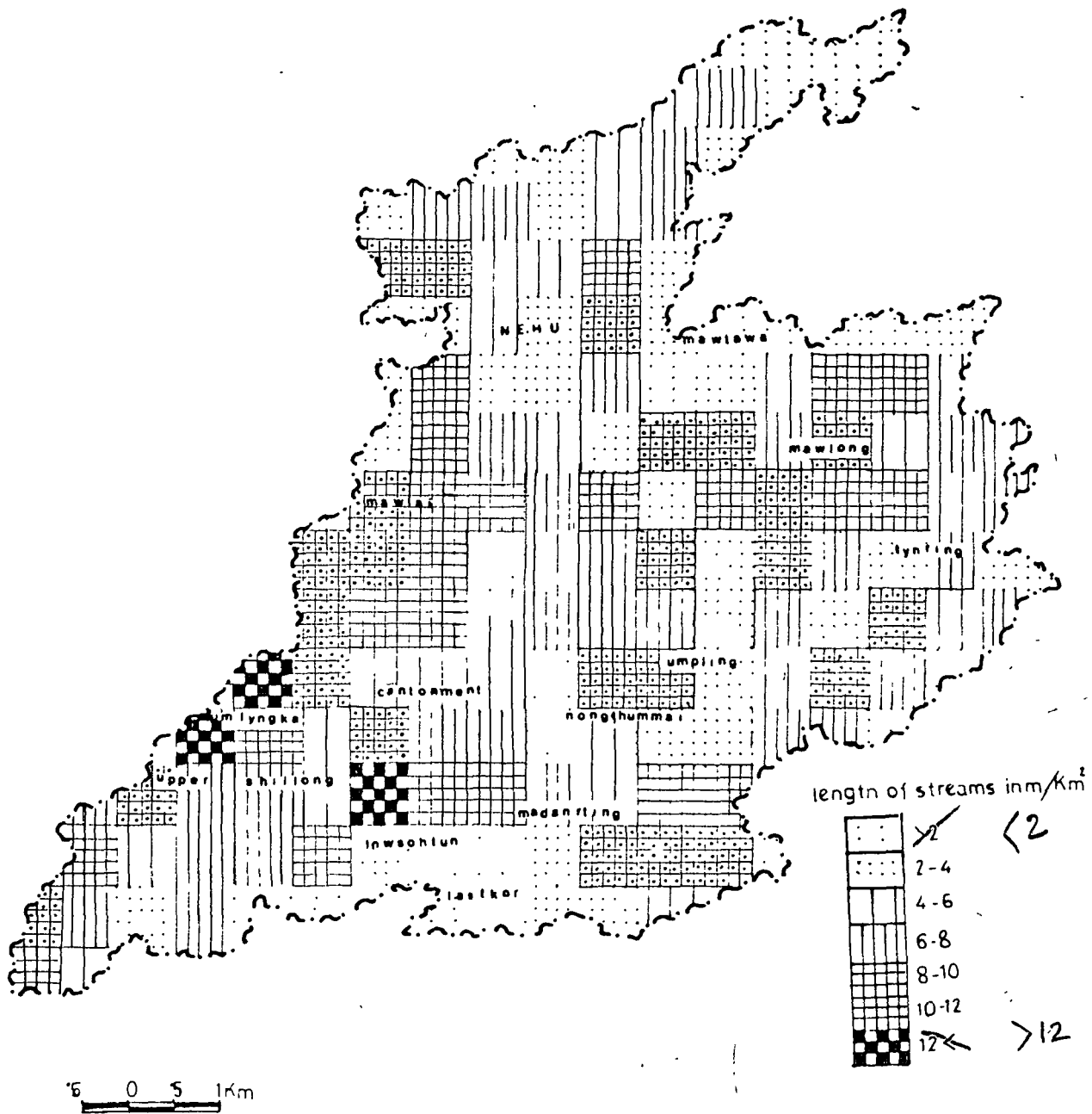


FIG 4 7

into seven groups Table 4.3 ranging from below 1 to more than 13 which has been categorised mainly into four categories.

Fig. 4.7 shows the distributional pattern of drainage density under different groups broadly classified as coarse drainage density, Moderate, Moderately high and high to very high drainage density.

Table 4.3 further reveals that there is high concentration of coarse or low drainage frequency which account for 35.09 per cent of the total followed by Moderately high i.e. drainage density varying between 6-8, 8-10 per sq.km. which account of 37.17 per cent of the total drainage density.

While the share of Moderate drainage density i.e. 4-6 per sq. km. and high to very high density of 10-12 and 12 and above per sq. km. is the same in the both the cases which is 16.37 per cent in each case respectively.

Fig. 4.7 gives the spatial distribution of the drainage density pattern of the study Area. It is observed that low density occurs in patches throughout the study area indicating that these river basins are located at regions of highly permeable subsoil with thick vegetational cover.

**CHAPTER - V**

**GEOMORPHOLOGY Vis-a-Vis EXISTING LAND USE PATTERN,  
DISTRIBUTION OF SETTLEMENT, POPULATION AND  
WATER SUPPLY**

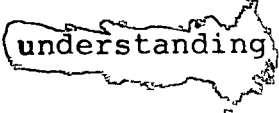
## EXISTING PHYSICAL STRUCTURE OF THE CITY AND PATTERN OF URBAN LANDUSE

### Introduction

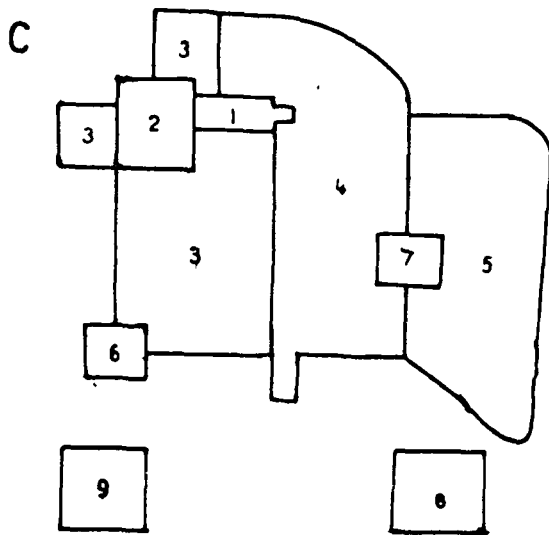
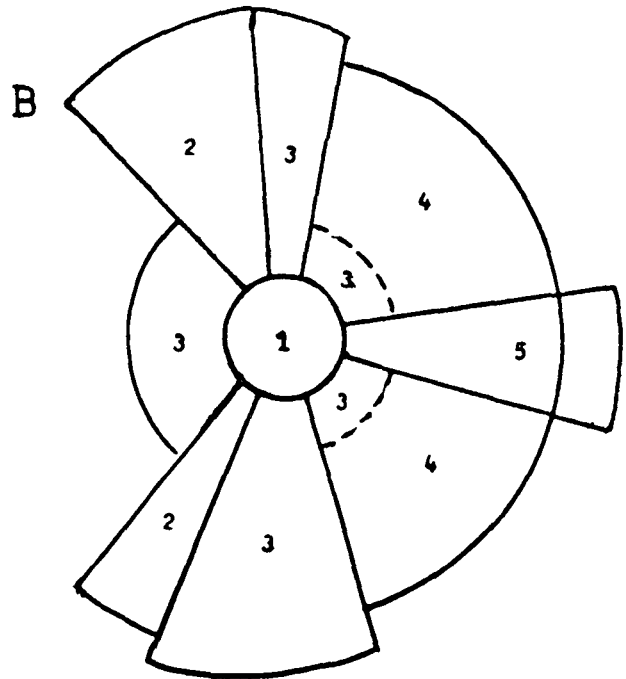
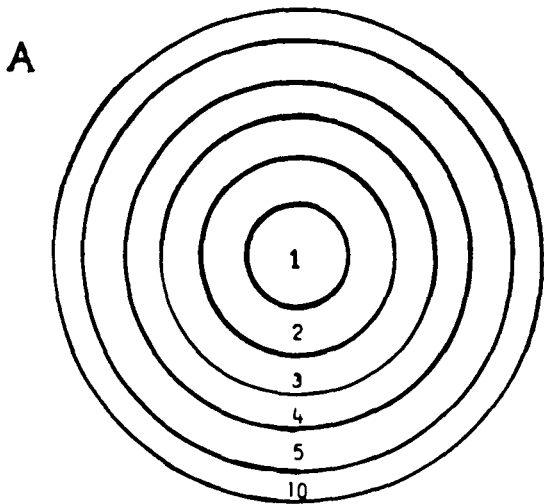
Due to the undulating topography with rugged terrain there is no continuity in the development of urban activities in the city of Shillong. The city which consists of Shillong Municipality along with the townships of Mawlai, Nongthymmai, Madanrting, Pynthorumkhrah and the Cantonment and nine rural components viz. Nongmynsong, Nongrah, Rynjah Lapalang, Mawklot Umlyngka, Lowsotun, Umpling and Upper Shillong consists of numerous localities situated at different altitudes above mean sea level and characterised by a varied topography varying from topographic lows to steep slopes.

The localities have been interconnected by good number of motorable roads as well as narrow walkways which presents a pattern of mixed landuse development in general within which the predominant land use can be identified in table 5.1.

### Urban Landuse Models

Before going into analysis of the impact of geomorphology on the urban landuse of Shillong it is perhaps necessary to have an  of the applicability of

# URBAN LANDUSE MODELS



- 1 CBD
- 2 WHOLE SALE LIGHT MANUFACTURING
- 3 LOW CLASS RESIDENTIAL
- 4 MEDIUM CLASS RESIDENTIAL
- 5 HIGH CLASS RESIDENTIAL
- 6 HEAVY MANUFACTURING
- 7 OUTLYING BUSINESS
- 8 RESIDENTIAL SUBURB
- 9 INDUSTRIAL SUBURB
- 10 COMMUTER'S ZONE

A. Concentric

B. Sector

C. Multiple Nuclei

the Urban Landuse Models in the internal structure of the city.

The internal structure of any city is unique in its particular combination of details.<sup>1</sup> Similarly in the city of Shillong there is a degree of order underlying the mixed landuse patterns, which can be explained with certain modification with the help of Theories of Urban Growth forwarded by Burgese (concentric Model) Homer Hoyt (Sector Model) and Harris and Ullman (Nuclei Model).<sup>2</sup>

As stated in Chapter III of the present study it is seen that the city of Shillong bears the legacy of the British administration as the city grew up as mainly the administrative centre of the Colonial power. Thus it had its birth from the functioning of the Government offices which in turn helped in the growth of various landuse zones which are the cornerstones of the theories of Urban Growth forwarded by the above mentioned writers.

The Classical concentric zone Model (Fig.5.1a) forwarded by Burgess in 1925 was based largely on his studies of Chicago region. "The model states that at any moment of time landuses within the city are organised into zones

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1. K.J. Chorley & P. Hagget (1976) "Socio Economic Models in Geography" Methuen and Co. Ltd. New Fetter Lane London, Ec4, Edt. pp.339.

2. Ibid., p.339-343.

differing in age and character and located in a definite order from the city centre."<sup>3</sup> He showed that a city generally consists of five concentric zones of Landuse keeping at the core of the centre the Central Business District (Fig.5.1a) which is the heart of the city's commercial, social, cultural and industrial life where transportation is well developed.

Surrounding the CBD\* is the transition zone of mixed Landuses in which deteriorating residential property predominates. The third zone consists of working class residential area where the conditions are somewhat better than in the slums i.e. the second zone. Surrounding this is the fourth zone consisting of large residential area. The last zone is the commuters' zone where sub-urban communities are found along the main lines of communication.

The Sector Model was forwarded by Homer Hoyt in 1939<sup>4</sup> after studying the residential areas of United States. He gave a theoretical explanation of land use in terms of wedge-shaped sectors radial to the city's centre along the main lines of transportation (Fig.5.1b). In his analysis he took different income group classes of a city and showed that they are generally found in distinct areas. In this

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3. Ibid. , pp.339.

\* Central Business District

4. Ibid. , pp.391.

theory Hoyt<sup>5</sup> mostly talked about the CBD and of the low, medium and high class residential areas. The theory contends that with the growing of the city's population, high rent areas move outward along one sector and these areas are generally located along the transportation lines.

The Multiple Nuclei theory of Urban Growth of Harris and Ullman (1945)<sup>5</sup> states that there are a series of nuclei in the patterning of the Urban Land Use rather than a single core used in other theories of Urban Growth. The reasons for creating different nuclei are -

- (i) The specialised requirement of certain activities.
- (ii) The tendency for certain activities to agglomerate.
- (iii) The repulsion of some activities by others to which it is linked.
- (iv) The difference in rent paying ability which force activities to cluster in separate districts within the city.<sup>6</sup>

Application of Urban Land Use Models in Shillong city.

Now if these theories of Urban Growth are to be applied in the present landuse of Shillong city taking into account the past growth of the city and renaming the Business

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5. Ibid., pp.342.

6. Ibid., pp.342.

zone of Burgess theory, "more particularly to a pure administrative zone and then by tailing off the industrial blue colour environment with due stress on the past records,"<sup>7</sup> The theory of Burgess perhaps could provide an explanation of the early phase of expansion of Shillong city.

If we presume Police Bazar - where agglomeration of Assembly Hall, Secretariat and other Government Offices are found as - zone Number one, it then gave rise to the Business zone i.e. Police Bazar, Barabazar area. The Second and the Third Zone covered the residential areas like Garikhana, Wahingdoh, Mawprem, Jail Road, Keating Road etc. The fourth zone definitely refers to the residential areas of Lachumiere, Malki, Laban, Rilbong, Kenchestrace etc.

Of course putting all these places under certain zones to explain the application of classical concentric zone theory may raise doubts in various quarters. Yet an attempt has been made in this study to relate the Land Use with the concentric zone theory.

The Fifth zone i.e. the commuters zone of Shillong in early stage of urbanisation might have been between Garikhana to erstwhile Mawlai Gate<sup>8</sup>. Today this zone can

7. Prof. N.N. Bhattacharya (1991), "Shillong 1991, A Critical Analysis on Geomorphology, Tectonic Movement and Urban Human Ecology" Paper presented in Seminar N.E. Council of Social Science Research, Shillong.

8. Ibid.,

perhaps be identified with Barapani in the north and Upper Shillong in the South of the Study Area.

In the application of Homer Hoyt sector Model theory of Urban Growth in the case of Shillong city we can perhaps take Bara Bazar and Police Bazar as the Central Business District. The low class residential areas could be Mawprem, Garikhana, Wahingdoh, Gualapatty forming a sector. Medium class residential areas could be Jail Road Pologround, Laban, Rilbong etc. and high class residential areas could be Lachumiere, Fruit Garden, Laitumkhrah, Nongrim Hills, Motinagar etc. forming a sector.

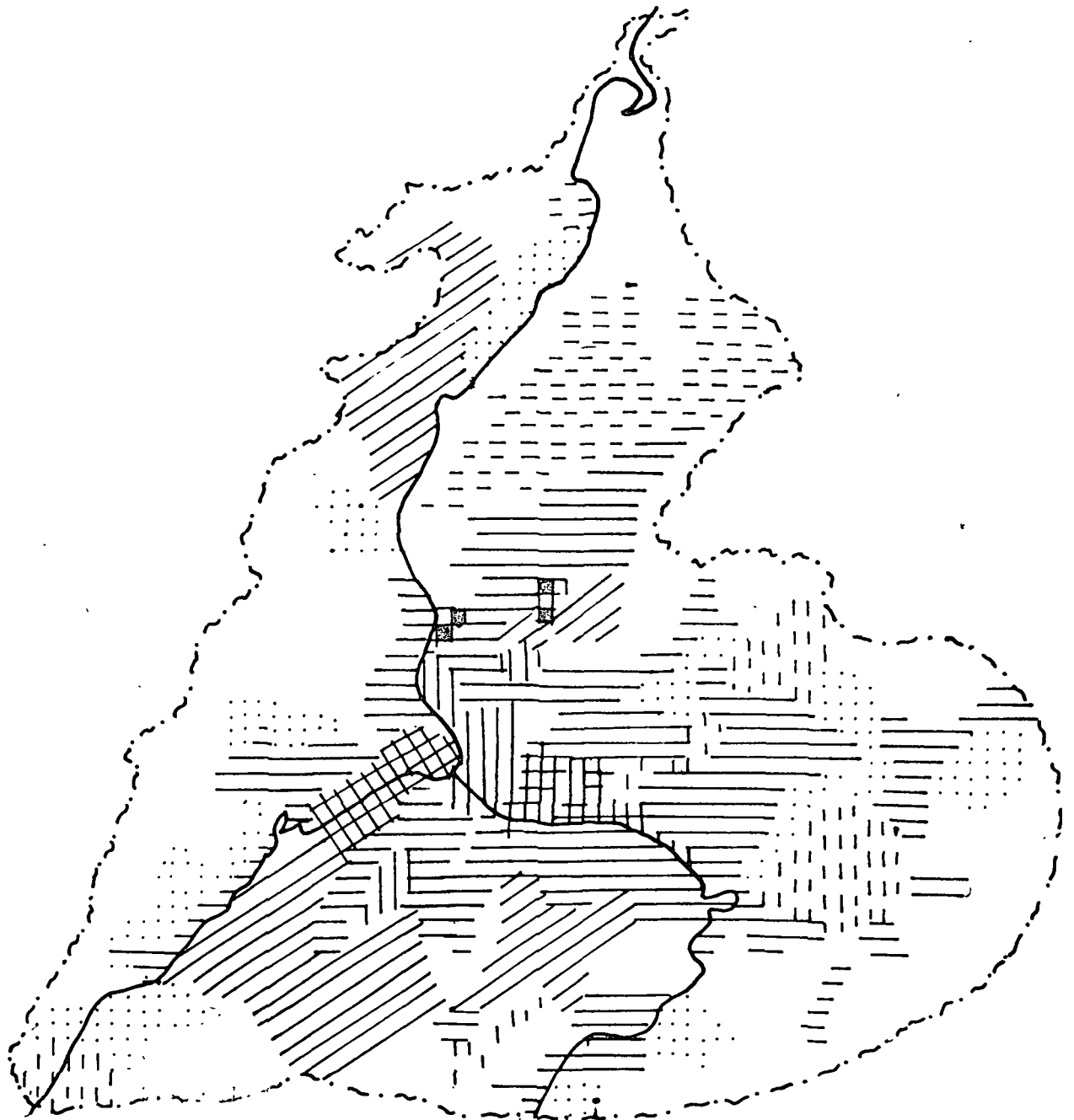
Coming to the application of Harris and Ullman's Multiple Nuclei theory in case of Shillong city one finds several nuclei specialising in different activities. In this context one may find the Barabazar, Police Bazar and Garikhana coming under one Nuclei, though originally these were different nucleus of certain specific activities. With passage of time these nuclei formed one nucleus because of the extension of trade centre from Barabazar to Police Bazar and due to generation of heavy traffic which made Garikhana to come under one nucleus.<sup>9</sup>

Due to high rent as well as non-availability of space in Central Business nucleus, business and other activities

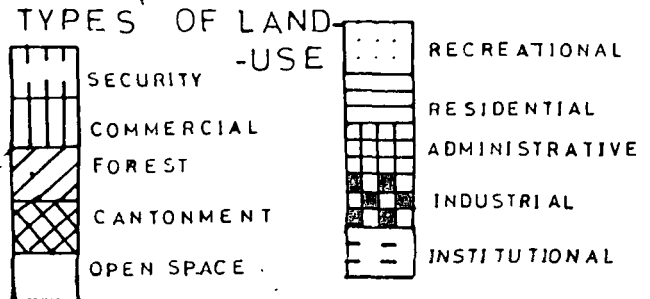
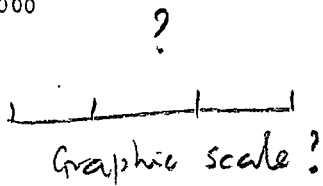
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9. Ibid.,

Shillong Standard Urban Area  
 EXISTING LAND USES



SCALE 1:20,000



SOURCE :- URBAN DEVELOPMENT OFFICE . GOVT OF MEGHALAYA .

FIG 52

started growing in different nuclei of the Shillong city - Like Laban Bazar developed with the help of high and middle class residential area influence of Rilbong, Kenchestrance, Oxford hill, Lumpering etc.

Laitumkhrah developed as a nucleus with the support of high and middle class residential areas of Lachumiere, New Colony, Risa colony, Motinagar etc. as well as the educational institutions situated in around Laitumkhrah Nongthymmai developed as a nucleus taking the base of educational centre like NEHU's\* Mayurbhanj campus.

#### **Impact of Geomorphology on Urban Landuse**

However no theories of Urban Growth can be applicable in its totality in explaining the expansion of Shillong city along the main lines of communication. Perhaps *Geo-g/* morphology may have had a role in the development of the different types of Land Uses within the city.

The development of the Central Business District at Barabazar and Police Bazar area perhaps may be due to the fact that these areas are more accessible as it is situated at lower elevations having moderate slope ranging from 5-10 degrees which is beneficial for urban functions.

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\*North Eastern Hill University.

Similarly the various nuclei of growth within the city like Laban Bazar, Laitumkhrah, Nongthymmai Bazar are also situated in areas having Moderate slope of 5-10 degrees. While Polo Bazar and Happy Valley are situated in areas having gentle slope of 0-5 degrees, which have also acted as a nuclei for the growth of the city.

According to Hoyt the high class residential areas tend to be located usually on well drained high ground and have established transportation network. In this context the areas identified as high class residential areas like Lachumiere, Fruit Garden, Laitumkhrah, Nongrim Hills, Motinagar etc. fall in areas of Moderate slope of 5-10 degrees on well drained high ground which have established transport network.

To some extent thus there has been an impact of ~~Geo-~~ morphology on the Urban Landuse of the Shillong City. However with rapid urbanisation Shillong has grown abruptly without much attention being paid to the underlying ~~Geo-~~ morphology characteristics of the region which has in turn resulted to environmental degradation.

It is seen that indiscriminate felling of trees in localities having steep slope of 15-20 degrees and above for constructional activities has resulted in heavy soil loss through erosion, gully formation and minimised the

percolation capacity. This has caused rapid run-offs thereby  
 resulting to bad land topography with high drainage density.

An analysis of table 5.1 showing the existing Land Use of Shillong indicates that the largest share of developed land is under residential occupation accounting for about 50 per cent of the developed land. Next comes Public and Semi Public Landuse under which institutional, security, administrative and cantonment areas account for 32 per cent of the developed land.

Transportation and communication account for about 15 per cent of the developed land. While the land under commercial use covers only about 1.1 per cent of the developed land. Industrial activities is almost negligible in the city as indicated by the low percentage of about .23 per cent of industrial landuse of the total developed land.

It is further observed from the Land Use map (Fig.5.2) that the major functional activities of the township including Public, Semi-Public activities, transport and communication and commercial activities have remained generally centred, while the settlements have sprung up all around without much of continuity. Concentration of main functional activities in a limited area of Barabazar, Police Bazar

TABLE 5.1 Existing Landuse of the Total Planning Area of Shillong

Total Planning Area	103737.6 hect.	100%	
Total Developed Area	4250.4 hect	40.97%	
Total undeveloped Area	6123.2 hect	99.03%	
<u>Land Use</u>	<u>Area in hector</u>	<u>% of developed area</u>	<u>% of planning area</u>
Residential	2133.20	50.19	20.57
Commercial	49.60	1.18	.47
Industrial	10.00	.23	.10
Transport and communication	670.00	15.76	6.46
Public and Semi-Public:			
a) Institutional	731.60	7.21	7.05
b) Administrative	44.40	1.05	.45
c) Security	390.00	7.18	3.76
d) Cantonment	189.20	4.45	1.82
Open spaces	<u>32.40</u>	<u>.75</u>	<u>.31</u>
Total developed area	4250.4	100%	40.97
Other Land uses:			
Agricultural	1038.40		10.01
Forest	1220.40		11.76
Vacant land	3864.40		37.26

Source: Urban development office.

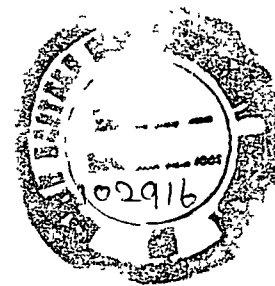


TABLE 5.2 Distribution of Settlements

Components	No. of occupied Residential <u>hguse</u> ✓	Percentage to the total
<b>Urban components</b>		
Shillong Municipality	21,289	55%
Nongthymmai	4,349	11%
Mowlai	3,539	9%
Pynthorumkhrah	2,244	6%
Shillong Cantonment	1,321	3%
Madanrting	1,181	3%
<b>Rural Component</b>		
Nongmynsong	744	2%
Nongraha	304	78%
Rynjah Laplang	418	1%
Mauklot	135	32%
Umlyngka	545	1%
Lowsotua	755	2%
Umpling	860	2%
Upper Shillong	<u>890</u>	<u>2%</u>
Total	38574	100

Source: Census of India 1981. Series 14, Meghalaya Part II, A&B.

Garikhana areas for the entire city along with residential occupation in these areas have resulted ~~to~~ congestion and overcrowding. <sup>in/</sup>

## IMPACT OF GEOMORPHOLOGY ON DISTRIBUTION OF SETTLEMENT AND POPULATION

### Introduction

Settlement studies form a traditional part of human Geography<sup>10</sup>. It has held a dominant place in the early writings of Brunhes (1925) and in reviews like that of Jones (1964). Settlements have often been viewed as a fundamental expression of Man-Land relationships between the physical environment and various aspects of human occupancy of the region.

In the modern context the field of human Geography stresses more on Man - Man relationship<sup>11</sup> when taking about settlements, <sup>l</sup>for the importance of physical, <sup>^</sup>agents is overshadowed by the emphasis placed on various socio-economic factors.

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10. R.J. Chorley & Peter Hagget (Edt.), Op.cit., pp.303.

11. Ibid.,

However when talking about the Shillong city characterised by rugged terrain where land for settlement is limited ~~Geomorphology~~ <sup>A</sup> of the physical factors perhaps play a more dominant role in the development and distribution of settlements and population within the area.

Table 5.2 shows the distribution of the residential houses within the Shillong standard Urban area.

An analysis of the table (5.2) shows that the highest concentration of houses is in the Municipality area accounting for about 55 per cent of the total Residential houses. This may be because of the fact that these were the areas where the British set up the capital of Assam Province. Thus communication is well developed here and most of the urban functions have been concentrated within the Municipality. This in turn has attracted high population of about 1,09,244 as per 1981 census where the total area is only 10.36 sq.km. accounting for about 10,545 persons per sq.km.<sup>12</sup> The Shillong Municipal area is thus highly congested which in turn has necessitated the development of the surrounding areas. Here it may be mentioned that the small villages from which the township of Shillong had its birth did not grow at the same speed as some of the localities which came up later. It is seen that the original Khasi villages

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12. Census of India 1981 Series 14. Meghalaya Part A&B.

of Mawlai, Mawprem area as well as Malki, Laban (Fig.3.1) which were settled before the British came in 1863-64 have not grown at a very fast speed may be because of the rugged terrain and steep slope encountered in these areas.

The township of Nongthymmai situated at moderate to moderately steep slope accounts for 11 per cent of the total residential houses, whereas Mawlai situated at an average slope of 15-20 degrees and above 20 degrees has a share of about 9 per cent of the total Residential household, this may be because of the fact that the steep slope and rugged terrain of the area does not favour the development of settlement because walking up the steep slope becomes difficult. These areas thus inspite of being a place of early settlement ~~does~~ not have high density of residential houses or population.

Pynthorumkhrah inspite of having gentle slope has a low share of settlement of about 3 per cent of the residential houses, this may be because of the fact that the area is at a distance from the heart of the city. Madanrting and the rural components of the Standard Urban Area has a low share of settlement of less than 3 per cent perhaps because of its distance from the main centre of the city rather than the geomorphological characteristics of the area. Madanrting however is situated at steep slope of

8/ above 20 degrees where settlement becomes difficult. Besides ~~geomorphology~~ the communication lines have played a very important role in the distribution of settlements within the study area.

### Geomorphology vis-a-vis the existing settlements

If the average slope map is superimposed over the existing land use map to visualise the settlements of the Urban complex in relation to the average slope, it is seen that the settlements like Bishnupur, Kenchestrance, Lumpering, Upper Nongthymmai, Madanrting, Alugodam and many other localities in the north, east and west have come up on moderately steep to steep slopes of about 10-20 degrees. This in turn has had detrimental effect on the environment.

Constructional activities in areas of steep slope due to pressure of population on land has resulted in indiscriminate felling of trees thereby resulting ~~to~~ loss of valuable vegetation cover resulting ~~to~~ soil erosion and ~~gully~~ gully formation. The percolation capacity has also been minimised resulting to rapid run off having ~~a high velocity~~ a high velocity due to the steep slope.

Constructional activities and settlements which have sprung up along the banks of the streams of Shillong viz.

Umkhrah, Umshirpi, Demthring etc. has resulted <sup>o</sup>~~to~~ silta-  
 tion of these rivers which may later lead to flood hazards in  
 the study area.

Perhaps a ~~Geomorphological~~ <sup>a</sup> appraisal of the study  
 area can solve some of these problems faced by the city  
 of Shillong which had originally been planned by the Bri-  
 tish with an infrastructural facilities to sustain a few  
 thousand of population. But due to rapid urbanisation and  
 increase of population the city has grown in an unplanned  
 manner.

Under the pressure of population many localities  
 have come up without a planned framework of development  
 and without much attention for futuristic needs. It is  
 in this context that perhaps ~~geomorphology~~ may have a role  
 to play as the city is situated in a plateau characterised  
 by rugged terrain where land for settlement is limited.  
 Here ~~geomorphology~~ may play a role in the judicious use of  
 land and the future development of the area.

#### Population distribution vis-a-vis the Geomorphology of the area

Table 5.3 gives the distribution of population of  
 the main components of the Standard Urban Area.

An analysis of the table 5.3 shows that the Shillong

TABLE 5.3 Population Distribution within the Shillong Standard Urban Area.

Name of the component	Total population	Percentage to total
Shillong Municipality	109244	54.19
Nongthymmai	21558	10.69
Mawlai	20405	10.12
Pyinthorunkhrah	10711	5.31
shillong Cantonment	6620	3.28
Madanrting	6165	3.06
Rural Components		
Nongmynsong	3733	1.85
Nongraha	1,687	.84
Rynjah Lapalang	1852	.92
Mawklot	708	.35
Umlyangka	2677	1.33
Nongkseh	4399	2.18
Lowsotun	3841	1.91
Umpling	3632	1.80
Upper Shillong	4345	2.16
TOTAL	201,577	100

Municipality has the maximum concentration of population of 54 per cent. This is because as has already been stated earlier that majority of the settlements are concentrated here because the area enjoys easy accessibility to urban functions and good means of communication lines. Moreover most of the localities here are situated on relatively gentler slopes <sup>as in</sup> than <sup>the</sup> rest of the area. Perhaps the physical condition too <sup>has</sup> played an important role in the high density of 10545 persons per sq.km. in the area leading to congestion and overcrowding. The township of Nongthymmai accounts for 11 per cent of the total population which may be because of the fact that the area is situated at a steeper slope Mawlai having an average slope of 15-20 degrees account 10 per cent of the total population while the cantonment and Madanrting account for 3 per cent of the total population. The low share of Madanrting may be due to its distance from the main centre of the town as well as the steep slope characterised by rugged terrain. The rural components have a low share of population of less than 3 per cent which may be because of its distance from the heart of the city.

~~The township of Pynthorukhrah~~ in spite of being situated at a topographic low characterised by low relief and average slope of 5-10 degrees has a low share of population of about 5 per cent to the total. This may be because

of the fact that this township is isolated, far from the main lines of communication i.e. National Highway Number 40 and 44. Thus the townships of Nongthymmai and Mawlai inspite of being situated on moderately steep to steep slopes supports a higher percentage of population than Pynthorumkhrah perhaps because of their location along the main lines of communication. National Highway number 44 passes through Mawlai and National Highway. Number 40 passes through Nongthymmai. Moreover it has been observed that the settlements of Shillong has developed along the main lines of communication thereby resulting to a higher share of population in these areas.

Table 5.4 gives the distribution of population within the Shillong Municipality. An analysis of the table shows that the areas characterised by steep slope, and rugged terrain has a lower share of total percentage of the municipal population e.g. the localities of Rilbong Kenchestrance and Bishnupur supports 1.42 and 5.23 per cent of the total population respectively this may be because of rugged terrain and its distance from heart of the city.

Malki and Lumpering inspite of having a steep slope of 15-20 degrees is supporting a population size of 8.06 and 7.46 percent, this may be because of the fact that

these were the original Khasi settlement sites. Moreover Lumparing developed as a refugee colony where land was ceded by the Government to the erstwhile East Pakistan Refugees.

The localities of Laitumkhrah, Police Bazar, Barabazar situated at a gentler slope supports around 41.21 per cent of the total population of the municipality, this may be because of the availability of land with gentle terrain for various urban functions.

Mawkhar and Mawprem having a share of 8.11 per cent and 16.85 per cent of the total population respectively inspite of being situated on moderately steep to steep slopes has a higher share of population. This may be because of the fact that these too were areas of earlier settlements and they are also situated near the main lines of communication.

European Ward inspite of having moderate slope of about 5-10 degrees characterised by low gentle hillocks on which settlements have come up has a lower share of the municipal population of about 6.96 per cent which may be because of the fact that this area has a higher land rent value than the rest of the localities.

It is seen that the drainage of the study area is having negligible affect on the distribution of settlements

TABLE 5.4 Population distribution of the different localities within the Municipality.

Localities	Total population	Percentage to total
Laitumkhras	15620	14.30
Malki	8804	8.06
European Ward	7604	6.96
Police Gazar	8864	8.11
Mawkhar	8869	8.11
Kenchestrance and Bishnupur	5711	5.23
Barabazar	19756	18.08
Mawprem	18408	16.85
Laban	5903	5.40
Rilbong	1555	1.42
Lumpering	<u>8150</u>	<u>7.46</u>
Total (Shillong Municipality)	10,9244	100

Source: Census of India, Meghalaya Series 14 Part A&B.

and population of the area perhaps because of the fact that Shillong had its growth linked initially with the administrative activities of the Government. Settlements thus developed taking into consideration the distance from the Central Business District along the main lines of communication rather than being affected by the drainage lines or the slope of the area. This in turn has resulted ~~to~~ soil erosion, break of slopes and gully formation especially in those localities which have come up on steep slope viz. Alugodam, Lumpering, Bishnupur, Upper Shillong etc.

**Water Supply of Shillong vis-a-vis the topography of the area:**

A city in order to sustain itself must have an adequate water supply for its ever growing population. The demand for more water both for domestic and ~~Industrial~~ use increases as its population increases. The necessity for tapping the water resources both surface and underground becomes essential as well as a proper management and distribution of the water supply is also needed.

It is seen that "Urbanization and man's development of water as a resource, distort many aspects of the land-water ecosystem, a subject that falls within the realm of the geomorphologists."<sup>13</sup>

13. D.R. Coates (1974) "Editors Comment on Papers 4 Through 9" Benchmark Papers in Geology, Environmental Geomorphology and Landscape Conservation, Vol.II, Urban Areas, pp.58-68.

Thus various studies as to how ~~Geomorphology~~ can perhaps solve the problems of water supply has been conducted in the developed nations. Similar studies in our country too may solve the problems of water supply especially in a hilly area like Shillong where topography perhaps tends to play rather a negative role in the distribution and management of the water resource of the city.

In the study "Hydrology For Urban Land Planning - A Guidebook on Hydrologic effects of Urban Land Use (L.B. Leopold 1968)<sup>14</sup> the author has identified four effects of landuse changes on the hydrology of an area, which are "changes in peak flow characteristics, changes in total run-offs, changes in quality of water and changes in the hydrologic amenities ... Of all land-use changes affecting the hydrology of an area, urbanisation is by far the most forceful.<sup>15</sup>

Similarly urbanisation of Shillong at a rapid speed has also affected both the quantity and quality of water resource. Shillong<sup>16</sup> in spite of receiving very high rainfall of about 2400mm per year on the average yet is known as a water scarcity area.

14. L.B. Leopold (1968) "Hydrology for Urban Land Planning - A Guidebook on Hydrologic effects urban land use", U.S. Geol. Surv. Urc.554 Govt. Printing office Washington D.C. pp.1-18.

15. Ibid.,

The area is drained by the rivers Umshirpi, Umkhrah which joins together near Beaden, Bishop falls to form Wah Roro a tributary to the rivers Wah Umiam which marks the western boundary of the study area. Shillong is faced with water shortage for domestic purposes to the tune of 30 lakh gallons per day when compared to the total population of 201577<sup>16</sup> as per 1981 census having a requirement of 100 gallons per person per day. Water resources in Shillong includes a number of water springs and a few low discharge streams.<sup>17</sup>

Since the study area is situated very close to the water divide around the highest elevation of the Meghalaya Plateau viz. Upper Shillong and Laitkor peak having an elevation of about 1800m to 1920 metres above mean sea level, the discharge of water in the streams are meagre to very little. Moreover the streams are mainly of low order with very short length thereby having low discharge.

"The volume of run-off is governed primarily by infiltration characteristics and is related to the land slope and soil type as well as to the type of vegetation cover<sup>18</sup>. But in Shillong due to the pressure of population

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16. Census of India 1981, Series 14, Meghalaya Part II A&B.

\*W.H.O. norm

17. Report from urban development office, Govt. of Meghalaya, Shillong.

18. L.B. Leopold (1968), Op.cit.,

on land the steep slopes have come under settlement activating constructional activities which have promoted indiscriminate felling of trees thereby reducing the infiltration and percolation capacity which in turn has increased the rate of runoffs thereby causing water scarcity.

In fact it has been observed during recent years that at least seven springs in Laban-Lowsotun area and Upper Nongthymmai having an average slope of 15°-20 degrees has dried up perhaps because of the felling of trees for constructional purpose in these catchment areas. Thus the problem may necessitate a geomorphological understanding of the area.

The quality of water for drinking purpose is deteriorating which comes from the streams and springs of Shillong which are fed directly into the piped distribution system and stored in tanks to be distributed by the Shillong Municipality office and the Public Health Engineering Department, Government of Meghalaya.

The deterioration of the quality of water in the streams is mainly because of the fact that often there is dumping of waste and garbage in these streams. Moreover a number of stone quarries which are located over the steep slopes and by the sides of streams viz. Stone quarries at Nongthymmai, Rynjah, Pynthorumkhrah, Mawlai which are

TABLE 5.5 Source of Water Supply of Shillong Municipality and Public Health Engineering Department (1991 approximately)

Source	Capacity in gallons per day	Installed by
Wahrisa	1 lakh	SM*
Wahjalynnoh	1 lakh	SM
Umjasoi	2 lakh	SM
Crinoline	.80 lakh	SM
Wahdiengheng	.50 lakh	SM
Madan Laban	.50 lakh	SM
Patta Khana	.25 lakh	SM
Mawprem Tank	4,40,000 gallons	PHED
Barabazar Tank	2,90,000 gallons	PHED
Lachumiere	3,70,000 gallons	PHED
Mawlai Mawroh	1,30,000 gallons	PHED
Jail Road	10,700	PHED
Ganesh Das Hospital	40,700	PHED
Upland	60,000	

\*SM = Shillong Municipality

PHED = Public Health Engineering Department.

Source: Official Records of Shillong Municipality office and Public Health Engineering Department, Govt. of Meghalaya, Shillong.

located on banks of the Demthring and Wah Umkhrah have added to the pollution of water due to siltation. At least four public latrines are located by the side of the Umpling nala within 30 metres up-stream of the intake of Umpling water supply.<sup>19</sup> All these ~~is~~ <sup>are/</sup> having an adverse effect on the quality of drinking water of the city and perhaps ~~geo-~~ <sup>g/</sup> morphology can play <sup>a</sup> role in minimising the problem for proper slope management and selection of site for waste disposal at the ~~pediment~~ or waning slope rather than on the waxing slope may solve the problem to a large extent.

Table 5.5 gives an account of the main water sources of the Shillong Municipality and the township of Mawlai.

An analysis of the table 5.4 shows that the Shillong Municipality covering an area of 10.36 sq.km. @ catering to population size of 109244 as per 1981 census receives around 16 lakh gallons of water per day. However all the localities within the municipality do not receive an equal amount of water.

Though mismanagement and wastage of water through leaking pipes and water logged pools is responsible for the unequal distribution of water perhaps ~~geomorphology~~ <sup>g/</sup> too has had a role in this unequal distribution. It has

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19. Report from Urban Developed Office, Govt. of Meghalaya, Shillong.

been observed that the localities of Rilbong, Kenchestrence Bishnupur, Lumparing receives/ around 34 litres of water per head per day when compared to localities of Laitumkhrah, European Ward, Police Bazar, Barabazar, Mawkhar etc. which receive around 50-52 litres of water per head per day. This may be because ~~of~~ the former localities are situated at a higher altitude and steeper slopes ( $15^{\circ}$ - $20^{\circ}$ ) when compared to the latter. Perhaps the steep slope may have had an adverse effect on the distribution of water on the former localities.

In the selection of site of the water tanks it is perhaps necessary to have an understanding of the local topography of the area for a location of a tank on the waxing slope or the upper part of the slope may help in the easy distribution of water within the city.

In tapping the underground water it has been observed that the valleys and topographic lows are suitable for the construction of large diameter bore wells as well as open wells for these areas viz. Pologround, Mawroh, Pynthorumkhrah, Valleys of Mawpat, Mawlynrei have highly clayey deposits which have poor permeability and transmissibility<sup>20</sup> of water.

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20. Ibid.,

An understanding of the geomorphic features along with the underlying geology may be helpful in selecting sites for tapping underground water resource of the Study Areas. Infact the Geological Survey of India, North East Circle had carried on two exploratory drillings at Rynjah where the two bore holes of 62.55 metres and 72.30 metres respectively were dug up which penetrated the confined aquifers in fractured quartzites and turned out to be flowing wells, which recorded around 7540 litres to 5150 litres of auto flow of water per hour during the wet season and 720 to 306 litres per hour during the dry season.<sup>21</sup>

Hydrological studies by CGWB\* have revealed that the water level varies between 1 metre to 3 metres in topographic lows and within 10 metres depth in Upland areas with seasonal fluctuation to the tune of 3 metres and 8 metres respectively.<sup>22</sup> Thus geomorphological characteristics of the area may help in selecting the sites for tapping the ground water resource of the area besides the distribution which shall perhaps be beneficial in minimising the problem of water supply faced by the city.

However the problem needs a further micro level study

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21. Report from Geological Survey of India, North East Circle, Shillong.

\* Central Ground Water Board.

22. Report from Urban Development Office, Govt. of Meghalaya, Shillong.

in order to find the exact location of the tanks and distribution of water so as to minimise the negative role of the terrain in the supply and tapping of drinking water. Here the attempts is general which needs further investigation at a micro level to find the how far the topography plays a role not only in regards to water supply but also in relation to distribution of settlements and population of the study area characterised by rugged topography and steep slope.

**CHAPTER - VI**  
**SUMMARY AND CONCLUSION**

## SUMMARY AND CONCLUSION

### Summary

Physiographically Shillong is situated on the Meghalaya Plateau which represents the northeastern extension of the Indian peninsula separated from it by the Garo Rajmahal gap. The Plateau has a chequered history of geological evolution uplifted to its present height of about 600m-1900 metres above mean sea level during post-Mesozoic times. The city of Shillong has an average height of 1500 metres above mean sea level. The Shillong Peak and Laitkor Peak the highest part of the Meghalaya Plateau having a height of 1960 metres and 1940 metres respectively are situated on the southern part of the city which acts as a water shed.

Geologically the core of the plateau comprises of oldest rocks in the state, the Gneissic complex with Shillong group of rocks. The study area has a predominance of the Shillong group of rocks which comprise of sub-metamorphic facies of argillaceous and argillaceous members with superimposition. The Shillong Group of rocks comprise mainly of Phyllites, Quartz schist, quartz sericite schist, quartzites, Intra-formational Conglomerate and the Khasi Greenstone showing a low grade metamorphism. These are distributed throughout the study area.

The area slopes towards the north as the altitude lessens towards the north the Pologround skirting the northern edge of the Shillong city is situated at a lower elevation than the town proper.

The river Umshirphi and Umkhrah roughly determine the municipal boundary of Shillong. The climate of the study area can be described as a typical monsoon climate with heavy rainfall during summer and the mean annual temperature is below 18° centigrade while the hottest month records a temperature above 18° centigrade. The climate can be classed under CMk designation of Koppen's climatic scheme. The natural vegetation comprises of Pine Forests.

In the evolution of Shillong it is seen that the city had its birth with the establishment of the Headquarters of Khasi and Jaintia Hills by the British in 1863-64, which later became the capital of Assam Province in 1874. While selecting Shillong for the capital, the climate and topography were kept in mind by the British as well as its central location between Assam valley in the north and Sylhet plains in the south.

After Independence it was the capital of Assam till 1972 when it started functioning as the capital of Meghalaya. So the city of Shillong is an administrative centre initially created by the British in the midst of rural tribal

society, which later has turned into as not only an important Administrative Centre but also an important Educational Tourist and Trading centre. It is functioning as a nodal centre and is one of the most important cities of North East India.

The slope analysis reveals that there are mainly four categories of slope (below 5 degrees, 5-10 degrees, 10-15-20 degrees and above 20 degrees) and grouped as gentle slope, moderate slope, moderately steep slope and steep slope.

Most of the study area is covered by moderate slope to moderately steep slope, <sup>is</sup> while the gentle slope and steep slope occurs as small patches throughout the study area.

Felling of trees for constructional purpose on steep slope has resulted ~~to~~ break of slopes, soil erosion, gully-ing and bad land topography.

The Drainage analysis reveals ~~course~~, moderate, moderately high and fine drainage frequency and density varying between below 2 to 12 and above per sq. km. There are a large number of low order stream<sup>s</sup> in the area as it lies on a water<sup>s</sup>hed. The drainage pattern varies from Dendritic to sub-parallel. The areas having moderate slope viz. Police Bazar, Barabazar area has developed into the Central Business

District. 50 per cent of the total developed is under residential uses followed by Public and Semi Public land use accounting for 32 per cent. Transport and communication has a share of 15.76 per cent and the rest i.e. Commercial and Industrial have a share of less than 2 per cent each in all cases.

Urbanisation is having a tremendous impact on the study area and the Landuse in the fringe area is becoming more urban. Under pressure of population on land, steep slopes with altitude have been encroached for constructional purpose which has resulted to an ecological imbalance due to indiscriminate felling of trees which has encouraged minimisation of percolation capacity, break of slopes and rapid run-offs causing heavy soil erosion and gully formation prone to landslides.

The settlement and population distribution too have been affected by topography, concentration of settlements and population is found within the Shillong Municipality where the slope is moderate to moderately steep. However, settlements have sprung up along the main lines of communication irrespective of the steep slope and high altitude which has had an adverse effect on the ecological balance of the city.

In regards to drinking water supply topography tends

to play a negative role. The city of Shillong is not getting sufficient quantity and quality of water. Moreover the supply of water is not equal in all the localities. An understanding of the geomorphological characteristics may solve the problem to some extent for that however a micro level study is perhaps essential.

### Conclusion

From the present study the following conclusion can be drawn -

- (i) The area lies in a plateau characterised by gentle to steep slopes with undulating topography with valleys and hillocks.
- (2) The relief rises from north to south with the Umkhrah valley in the north at a lower level than town proper. The average altitude is about 1500 metres above sea level.
- (3) Shillong is the creation of British administration and till date it is an administrative centre besides being an Educational, Tourist and health resort. It is also emerging an important nodal centre of north east, where trade and commerce is flourishing.
- (4) There are four categories of slope. The drainage

density and frequency also varies from <sup>a</sup>course to fine showing four categories.

- (5) It is mainly the slope which to some extent has determined the land use pattern of Shillong. Distribution of settlement and population too may have a relation with the slope of the area. However, under the impact of pressure of population on land the steep slopes have come under constructional activities resulting to felling of trees which has minimised run-offs which has caused soil erosion and gully formation prone to landslides and slumping.
- (6) Topography tends to play a negative role in the distribution of water supply. This perhaps necessitates location of overhead tanks on the waxing slope. In order to increase the supply of water tapping of underground water in a scientific basis with the help of modern technology may solve to some extent the problem.

### **Recommendations**

To check further environmental degradation in the area, the following strategy may be undertaken:

- (1) Terrain characteristics should be taken into consideration in order to identify different hazard zones for rationalising landuse in the area.

- (2) Constructional activities on steep slope and felling of trees should be discouraged in order to minimise soil erosion and landslides.
- (3) Indiscriminate felling of trees should be stopped in the catchment areas so as to increase amount of water discharges in the streams.
- (4) Dumping of garbage on the banks of the streams should be banned.
- (5) Stone quarry sites on the banks of the streams should be banned and an alternative site for stone quarry should be identified.
- (6) Afforestation programmes should be undertaken specially on the steep slopes.
- (7) Decentralisation of urban function is also essential in order to minimise congestion in the Central Business District.

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