

GEOMORPHOLOGY AND AGRICULTURE IN MEGHALAYA PLATEAU

**DISSERTATION SUBMITTED FOR THE PARTIAL FULFILMENT OF THE
DEGREE OF MASTER OF PHILOSOPHY**

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Shillong-793014
November, 1979.**

COMPUTERISED

Thesis

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This is to certify that the dissertation titled
"Geomorphology and Agriculture in Meghalaya
Plateau" of Mr. S.N. Patnaik, submitted for the
partial fulfilment of the degree of Master of
Philosophy, is a bonafide study to the best of
our knowledge. All the quotations, extracts and
ideas of other studies have been duly referred.

This dissertation may be placed before
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D E C L A R A T I O N

I hereby declare that with the exception of the guidance and suggestions received from my Supervisor, Dr. R.K. Rai, Reader in the Department of Geography, School of Environmental Sciences, NEHU, this thesis is my own unaided work. It is based on the research work carried out in the Department of Geography, NEHU and the field work undertaken during the period of my research.

Syama Narayan Patnaik
S. N. PATNAIK

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CHAPTER - I

INTRODUCTION

- * Objective
- * Salient Features of the Region
- * Earlier Investigations
- * Plan of Work

Geomorphology is the study of the origin and evolution of topographic features by physical and chemical processes operating at or near the earth's surface. The study of geomorphology is based on the principle that all landforms can be related to a particular geomorphic process or set of processes, and that all landforms thus developed may evolve with time through a sequence of forms dependent in part on the relative time a particular process has been operating. Underlying all geologic and geomorphic principles, and in fact all scientific principles is the concept of uniformitarianism¹, which states that the natural physical and chemical processes which operate today have operated in the past and will continue to do so in the future. Study of present phenomena which can be observed in operation allows extrapolation into the past to infer the origin of landforms which are the effects of past processes.

Geomorphology has today quite clearly and separately crystallised from a coagulated position between geology and geography. Now it stands fairly on its own principles and concepts and has developed its own methods and techniques. What is more, geomorphology plays a leading role in integrated surveys in which the geomorphologists work in useful collaboration with botanists, pedologists and agricultural scientists to evaluate the resources of the land. For agricultural planning, particularly, geomorphology plays a very important role. A study in the regional geomorphology helps in the various types of land

utilization for agriculture, horticulture, forest development, selection of sites for construction of dams, transport and communicational necessities. Last but not the least, geomorphology also helps in selecting sites for human habitations.

/ Certainly for centuries the landforms were treated very inadequately and superficially. Only during the 18th century did the development of surveying allow a correct and full descriptions of landforms and not until the 19th century did the development of geology lay the foundations for a more truly scientific way of thinking. The qualitative approach in geomorphology deals primarily with the understanding of phenomena which may or may not be based on numerical data. In particular, the qualitative approach attempts to draw together relationships between cause and effect. The quantitative approach in geomorphology, which developed comparatively recently, places much emphasis on measurement and gathering of numerical data. But it is always found that both the approaches are intricately interwoven with each other. Quantitative evidence may play an important role in investigation but each number is analysed qualitatively for relevance to the problem before being used.

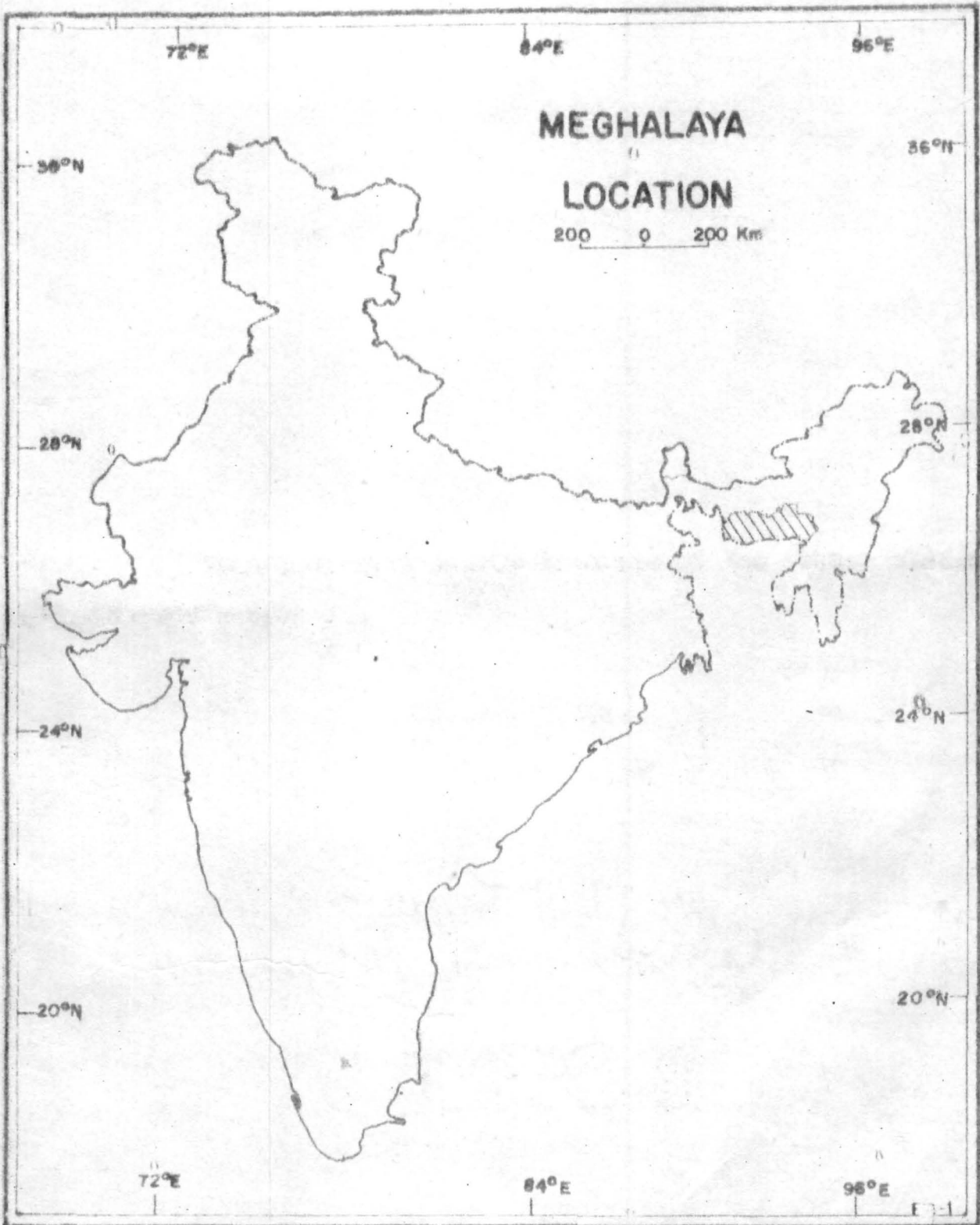
In India geomorphological studies are yet to be developed and studied on a wider scale. Of late, there has been a very little work done in this field of geomorphology. Most of the literatures available are based mainly on geological background. In India the branch is yet to be crystallised separately from general geography and geology. Geographers like S.P. Cha-

tterjee (1962)² and B. Basu (1944)³ have worked on physiographical divisions on the basis of structural and topographical differences. The reason for this limitation in geomorphology in India may be attributed to the lack of detailed geological and topographical maps and areal photographs. Recently some work has been made on geomorphology of different regions of India. Some of the important contributions include R.K. Rai's⁴ geomorphological studies in the Sonar Bearma Basin of M.P. His study is based on extensive field work and quarter inch toposheets. V. Subramanyam's⁵ techniques of geomorphologic analysis has been very helpful to the students of geology and geomorphology. Bimal Ghosh and Surendra Singh⁶ have worked out different possibilities of landuse in a village based on the geomorphology of the region.

Although some geomorphological investigations have been undertaken in different parts of the country and now many geographers and geologists are engaged in this field but unfortunately no work has been done in the North eastern region of India. So the study of geomorphology and its impact on agriculture is expected to throw some light for future planning of the region and it will certainly bring some new facts about the geomorphic history of the region.

SALIENT FEATURES OF THE MEGHALAYA PLATEAU :

An outlier of the peninsula, the vast plateau of Meghalaya extends between 25°N and 26°N latitudes and 90°E and



and $92^{\circ}45'E$ longitudes. The state, which came into existence on the 19th January 1972 covers an area of 22,549 Sq.Km. The plateau comprises predominantly of difficult hilly terrains with narrow valleys in between and strips of plain lands adjacent to Bangladesh in the south and west. In the north lies the great Brahmaputra valley of Assam and in the east of the plateau lies the detached Mikir Hills.

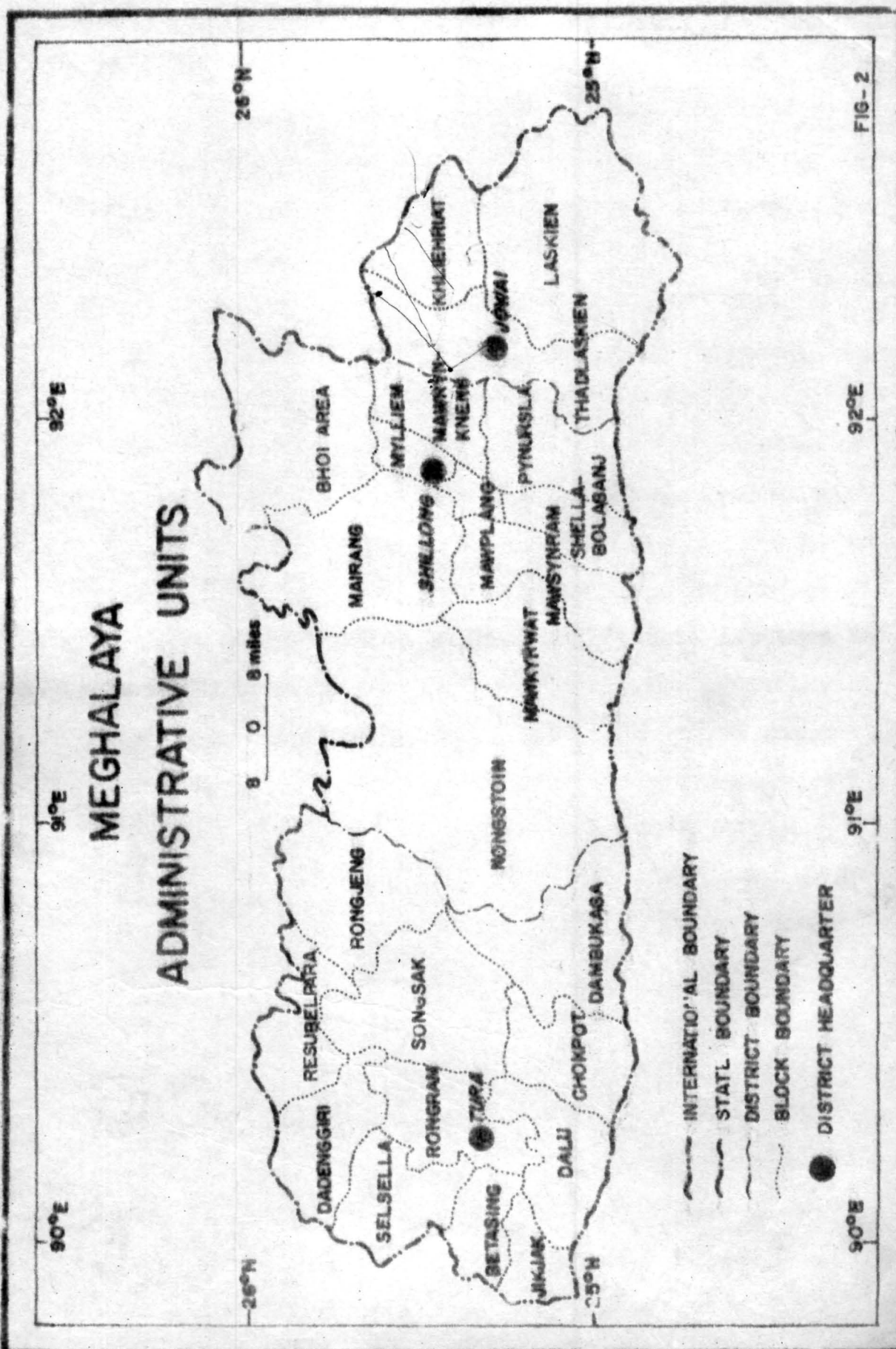
Physiographically, the Meghalaya plateau is remarkable due to its highly dissected and irregular terrain in the western and southern faces in contrast to the regular and steep fall of the southern face. The Mohekhola Adaguri range is the demarcating line between Garo and Khasi Hills. The central and eastern parts of Meghalaya are the true extensions of the Deccan plateau. The northern undulating hilly region gradually slopes down towards the Brahmaputra valley. There are two terraces indicating two peneplain surfaces in this region. One is from Khanapara to ^{Jorabat} Jorhat and the other from Burnihat to Nongpoh. The central upland zone consists mainly of rolling grassy downs, intersected with river valleys and dotted all over with soft rounded hills. A number of waterfalls and rapids in this region indicates a youthful topography. The southern face of the plateau is a vast structural platform. From Cherrapunjee the terrain has a gentle slope southwards and then falls to the Sylhet plain. The altitude varies considerably in the plateau. The Shillong peak in the Khasi Hills district is the highest known point which is 1961 meters above sea level where as the lowest elevations are to be seen generally on the western part of the state averaging as low as 100 meters.

The climate of Meghalaya is very much influenced by the seasonal winds. The climatic conditions vary from sub-tropical to the semi-temperate. The rainy season starts from April and lasts till the end of September. The northern hills being the rainshadow area gets lesser rainfall than the southern part of the plateau. The maximum rainfall is recorded in the Mawsynram - Cherrapunjee - Pynursla belt in the Khasi Hills district with an annual average of 11,741.7 mm. Shillong and Tura receives 2800 and 1800 mm. respectively. There is a wide variation in temperature distribution in the plateau. The temperature has a general trend increasing westwards. The following table shows the climatic variation in the Meghalaya plateau.

TABLE - I

Districts	Average Maximum	Average Minimum	Rainfall
1. Garo Hills	34°C	14°C	1800 mm(Tura)
2. Khasi & Jaintia Hills	24°C	12°C	2800 mm(Shillong)

The plateau has red soil mostly with a lot of laterite formations. The soil is deficient in phosphoric and potash contents but rich in nitrogen and organic matter⁷. In the central plateau the soil is predominated by red soil and in the northern border areas there is a typical upland loam and old and new alluvium soils. The southern areas have sandy gravelly and shaly soils because of heavy rainfall and other geological



In the last 70 years, the state of Meghalaya has recorded a population growth of 97 percent. During the decade of 1961-71, the Jaintia Hills recorded a growth of 38.6 percent, the Garo Hills 32.4 percent and the Khasi Hills has recorded a growth of 29.3 percent against the average growth of 31.5 percent for the state as a whole. On account of great variations in the land-population ratios in different areas, the geographical and population centres do not coincide. The density of population per sq.km. in 1971 was 45 persons, having risen from 35 persons in 1961. The urban population of the state forms about 14.54 percent to the total population.

In 1961, about 52.8 percent of the population were workers (males 58.3; females 49.7). In 1971 this declined to 44.2 (male 53.2; females 34.6). About four-fifth of the total population are engaged in primary activities (69.15 percent as cultivators; 9.88 percent as agricultural labourers and only 2.66 percent in livestock). In the interior areas of Garo Hills, Nongpoh, rural Jowai and Dowki more than 95 percent of the population are engaged in primary activities, elsewhere, it varies from 70 to 90 percent.

Although the economy of the plateau is almost entirely dependent on agriculture, 85 percent of the state's land surface has been classified as barren and unsuitable for agricultural use under the prevailing traditional practices. The plateau falls broadly into three agro-climatic regions: (a) areas bordering Bangladesh; (b) the central plateau and (c) the sub-

tropical regions bordering Assam. The southern border area stretches downwards from where the central plateau ends towards the plains of Bangladesh in the south. It is the main region where tropical and sub-tropical fruits are grown. The central plateau is the highest region in the state averaging between 900 to 2000 meters of elevation where high altitude paddy, maize, millets, potatoes etc., are grown. The sub-tropical regions bordering Assam is dominated by paddy and maize as the principal crops.

EARLIER INVESTIGATIONS :

There has been a very little work done on the north-eastern region of India as far as geomorphology is concerned. The most important and relevant of these is by J.P. Singh⁸. He has worked on the physiographic evolution of Meghalaya. His study is based mainly on the geological structure of this region. He has also tried to distinguish the cycles of erosion which seem to have worked out to produce the present day landscape in the plateau. R. L. Singh's⁹ work on the Meghalaya - Mikir Region is also an important contribution to the geomorphological study of Meghalaya. The extensive mapping and surveying done by the Geological Survey of India needs no elaboration. But still this region needs the detailed geomorphological study to know more about the region.

PLAN OF WORK :

In order to have a clear vision of the impact of geo-

morphology on the agricultural pattern in Meghalaya, the work has been divided into two main parts. The first part deals with the general geomorphology of the region, which consists of three chapters. The second part deals with the agricultural situation of the region, which consists of two chapters.

The second chapter includes a detailed discussion on geology of the plateau as observed and depicted by different geologists. The chapter also includes the geomorphic characteristics of the region in relation to the geology and physiography. In general, this part deals with four main sections - stratigraphy, structure and structural relationship, geological history and the geomorphic features.

Chapter three deals with the geomorphic processes that have been operating in the region with the geological time scale. The geomorphic processes have been dealt separately under mechanical and chemical weathering, the drainage system, and the fluvial cycle of erosion and finally an attempt has been made to distinguish the different cycles of erosion which continued through time.

Chapter four deals with the various morphometric analysis which helps to understand the drainage and other characteristics empirically. This part has been divided into three sections under slope analysis, drainage morphometry and multiple relations among morphometric properties. Under the drainage morphometry included calculations of the drainage frequency.

Different drainage pattern have also been distinguished in this section.

The chapter five deals with the general agricultural situation in Meghalaya including the factors effecting the agricultural pattern. In this chapter the land use pattern has also been discussed for the two time periods of 1971-72 and 1975-76 and finally the intensity of cropping is also discussed within this chapter.

The sixth chapter also deals with the agricultural pattern, but in a detailed manner. It has been divided into four sections; the cropping pattern, the crop combination regions, the agro-climatic regions and lastly an attempt has been made to analyse the problems and prospects of the region in regard to agriculture.

The last or the seventh chapter deals with a summary of all the chapters in brief and a correlation between geomorphology and agriculture in the plateau. An effort has been made qualitatively to find out a meaningful relationship between agriculture and different geomorphic characteristics such as relief, slope, geology, and fluvial characteristics.

It was found necessary to illustrate and supplement the statements and discussions in the thesis by figures and photographs which helped us in a great deal to visualise a clear picture of the natural configuration of the region. The necessary materials for the thesis was collected mainly

from the field. Other important sources include publications of memoirs and records of the Geological Survey of India, toposheets of various scale published by the Survey of India, Census reports of the districts as well as of the state, some latest publications on geomorphological literature, and other published or unpublished reliable sources.

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CHAPTER - II

GEOLOGY AND GEOMORPHIC FEATURES

- * Stratigraphy
- * Structure and Structural Relationship
- * Geological History
- * Geomorphic Features

STRATIGRAPHY

The stratigraphy of Meghalaya shows the following rocks of different geologic periods :

1. Archaean Gneissic Complex
2. Shillong Group of rocks
3. Lower Gondwana rocks
4. Sylhet Traps
5. Cretaceous - Tertiary sediments and
6. Quaternary and recent deposits

The Archaean Gneissic Complex :

The core of the plateau is an ancient mass of gneiss much intruded by a coarse granite. The Archaean gneissic complex is exposed in the central and northern parts. The rocks are believed to be the north-eastern extension of the Indian Peninsular block, separated from it by the Garo - Rajmahal trough fault.

The rocks are composed predominantly of Para - and ortho - gneisses, migmatites and meta - sedimentary bands. They comprise mainly biotite - gneiss, biotite - granite, amphibolite, calc - granulite, banded magnetite - quartzite, sapphirine - cordierite granulite, magnetite - grunerite granulite,

MEGHALAYA

GEOLOGY

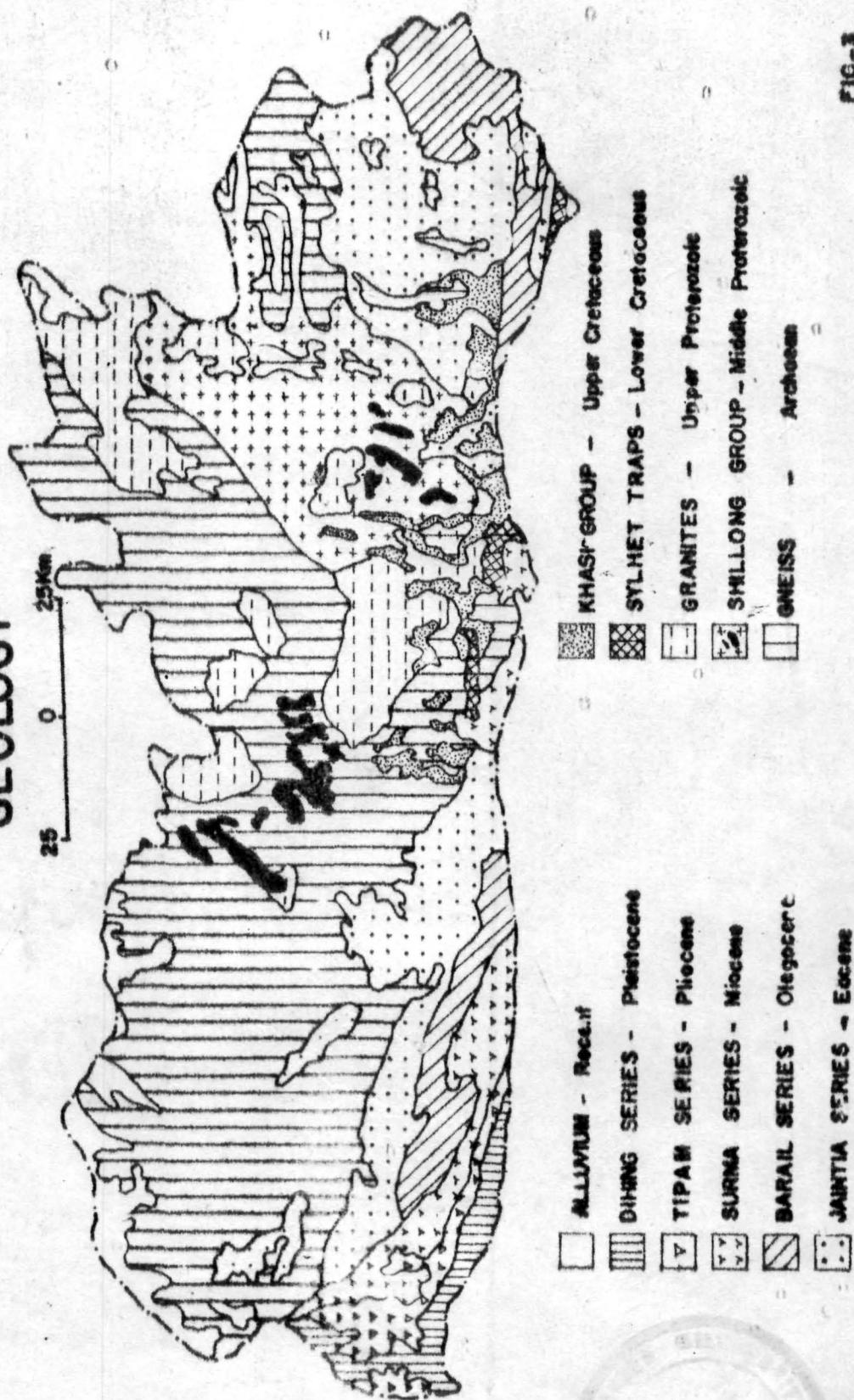


FIG-3

quartz - dumortierite - tourmaline schists, etc. Some of the schistose rocks comprising biotite - schist, quartz - sillimanite schist, meta - basite, biotite - cordierite granulite, red schist, etc. occur as detached remnants over the older gneissic complex around Sonapahar. Possible presence of an unconformity is recently postulated between these two groups of rocks. The mafic rocks within the Archaean include (a) Ortho-amphibolite, and (b) Meta - dolerite and meta - pyroxenite. They show mostly concordant and partly discordant relationship with the associated gneisses.

The older gneiss is uniform in character, white to light grey in colour but occasionally pink (for example, in Nongstoin), usually fine, but sometimes medium in texture, and distinctly banded. It is essentially a microcline granite with abundant biotite and the feldspar dominating the quartz. A certain amount of plagioclase in typical and hornblend may occur in addition to the biotite. Magnetite is always strongly developed, and small granules of apatite are sometimes found. In places the gneiss contains much muscovite. The bands in much of the rock are scarcely more than $\frac{1}{8}$ th inch apart, but in Nongstoin a coarser variety has been noted, variation in the amount of biotite causing alterations of acid and basic bands.

Shillong Group of Rocks :

The Shillong series, occupying a moderately large area around especially south and east of Shillong is the predominant type among the Shillong group of rocks. They are composed of a

considerable thickness of well bedded quartzites, locally conglomeratic and frequently micaceous and of an unknown thickness of highly crumpled and foliated mica schists, hornblende schists, chlorite schists, granulites and amphibolites, with occasional bands of shale or slate. These two types are not indiscriminately associated, and the argillaceous is thought to constitute an older sub-division, the main line of junction between the two groups follows the general NNE-SSW strike and affords no sign of unconformity. On the whole, micaceous schists is the predominant rock of the shillong series and is in places intimately associated with the gneiss. The argillaceous stage includes some soft and shaly beds. For several miles the base of the quartzite stage is a conglomerate band about 100 ft. thick, the basal layers of which are coarser and have a more earthy matrix than the upper. This band is made up almost exclusively of quartz pebbles ranging upto 4 inches in diameter, some of the other pebbles are of coloured quartzite. Some of the quartzites are said to show current bedding. In the Khasi Hills, the strike of the beds is E - W, with a general southerly dip along the northern portion and a northerly dip among the southern exposures. In both stages there is a distinct general increase in metamorphism from north to south, marked also by the development of granite veins. The argillaceous beds show thermal metamorphism along their contact with igneous intrusions. Along the southern boundary of the shillong beds, there is a steep plane of contact between the highly altered sedimentaries and an accumulation of bedded igneous rock known as the Sylhet trap, supposed to correspond to the trap of the Rajmahal hills and therefore, to be early Jurassic age. Bradshaw² speaks of the shillong series in the Khasi

and Jaintia hills as typically arenaceous and comparatively youthful in aspect when undisturbed; at the shattered and in contact with the granite or epidiorite the Shillong beds become quartzite schists, mica schists and phyllites.

Intrusive into the gneiss as well as into the older rocks is a granite which is exposed over an area of nearly 30 sq. mile around Myllem and is known in consequence, as the Myllem granite. It consists of a structureless aggregation of large porphyritic, flesh coloured microcline, with subordinate acid plagioclase and orthoclase, quartz and biotite, the latter sometimes inter-grown with hornblende, common accessories are apatite, zircon, crystals of magnetite of considerable size and abundant sphere. The quartz usually shows strain shadows. This rock is often seen intruded along the bedding planes of the quartzite, elsewhere, however, it cuts obliquely across the strike of the shillong series, and contains pieces of the quartzite and schists. The dip and strike of the shillong quartzites along the granite boundary are quite independent of the granite, and the contortions, in the quartzites must have been effected before the granite was introduced. Veins of the granites are to be seen magnifying through the khasia greenstone or epidiorite, xenoliths which have been caught up by the acid intrusions.

The Sylhet Trap

The Sylhet Traps are of the nature of plateau basalts, exposed in a narrow east-west strip of 80 km. long and 4 km. wide along the southern border of the shillong plateau,

the maximum exposed thickness is 550-600 m. They apparently overlie the eroded Pre-Cambrian basement are themselves overlain non-conformably by the upper-cretaceous - eocene sediments. The sediments and the lavas form a monocline, becoming a flexure southwards, the sediments at the crest of the flexure in the Therrighat - Shella sector with its last - west axis changes along its trace westward to a high angle reverse fault through normal and vertical faults (Dowki fault) and marks the exposed limit of the Sylhet Traps to the south. To the north the trap at Therrighat are in contact with the gneisses, granites or anillong group of rocks along an east-west fault, termed the Raibah Fault. Immediately, south of this fault the Traps dip at 45° - 50° to the south. At the southernmost limit, they again dip at 10° - 35° along the monocline or at 50° against the Dowki Fault (e.g. Ummgri river section). Laterally they plunge together with the sediments southwest along the Jadukuta river, to the east, the last exposure of the traps is seen in the Dowki river.

The sylhet traps comprise predominantly basalts and minor alkali basalts, rhyolites and acid tuffs. The basalts occur as flows and are 5 - 7 m. in average thickness. Andesites are absent. Many of the basalt flows show flow - breccias at their top and comprise various textural types, viz. non-porphyrite, micro-porphyrite or mega-porphyrite. The alkali basalts occur as flows in the Umiew gorge and in the Dwara gorge. They comprise mostly phenocrysts of diopside a few altered and resorbed hornblende in a groundmass of augirine augite, augerine, euhedral

nepheline, magnetite and interstitial isotropic patches of a feldspathoid mineral resembling analite. Secondary minerals filling the vesicles are calcite, quartz and zeolites.

Both within the flows and also in the immediately adjoining Archaean rocks to the north, basalt dykes are common; within the Trap area the dykes occur as swarms. They trend between $N75^{\circ}E - S75^{\circ}W$ to $S85^{\circ}E - N85^{\circ}W$ and are intruded post-lava. They are of a single compositional type. The basalt dykes are found in the Archaean of Khasi and Garo Hills trending between $NNE - SSW$ and $NE-SW$ in most cases coincident or nearly so with the grain of the country rock. There are some unusual alkali lamprophyre dykes in the Archaeans of NE Garo Hills, probably belonging to the same period of the igneous activity.

Lower Gondwanas of Western Garo Hills

Lower gondwana rocks, recognized at Singrimari in the Garo Hills, consist of pebble bed, sandstone and carbonaceous shale with streaks and lenses of coal and impressions of *Vertebraria indica*. The sandstone dips westwards and is intruded by dykes of dolerite.

The lowest beds of the calcareous facies of the eocene has been termed by Fox as the Tura stage. They include sandstones and shales and thin seams of coal. This stage is now believed to include the Cherra-sandstone, a band of hard, coarse sandstone, and the various outcrops of thin coal occurring in and near the Garo Hills. These were previously thought to be of cretaceous age. These beds rest with no marked discordance on the

cretaceous but overlap on to the gneiss and other metamorphic rocks. At the base is commonly found Kaolin and occasionally laterite. The Tura beds are followed by mummulite limestones (Sylhet limestone stage) which show considerable lateral variation, shales and even sandstones are locally developed. The fauna is fairly rich and shows affinities with the Kirthar fauna of Bangladesh.

Cretaceous Tertiary Sediments :

The oldest fossiliferous sediments of Meghalaya belong to the cretaceous system predominantly seen in the plateau. These sediments occupying the southern part of Meghalaya are thick and extensive and are considered to be continuous with the cretaceous - tertiary sediments of the Bengal Basin³. These sediments are affected mostly by basement controlled faults.

These continuous sediments, about 300 m thick, mainly comprise of sandstones and mudstone or shale, excepting for the three well defined fossiliferous limestones and occur as (i) discrete outliers, and (ii) a continuous narrow belt fringing the southern margin of the state bordering the Bangladesh plains. Here the sediments are divided into two groups: (a) the Khasi Group and (b) the Jaintia Group. The Khasi group is a distinct arenaceous facies consisting of the oldest Jadukuta Formation followed by the predominantly conglomeratic Mahadek Formation. The Jaintia Group is a calcareous facies (shelf facies) and has been divided into three formations viz; the Langpar, the Shella and the Kopili formations.

Quaternary and Recent Deposits :

The Tertiary rocks along the southern and western borders of Garo Hills in isolated areas and along the southern fringes of Khasi Hills are overlain by isolated patches of Older Alluvium. Along the northern fringes of the Garo Hills district also one finds such patches. These deposits consist of beds of assorted pebbles with coarse, loose sand and brownish clay. The pebble beds, at places, occur in irregular repetition. These rocks usually form exceptionally flat-topped low hillocks and mounds with red soil cover.

Recent Alluvium is found in the river valleys on the northern foot hill region of Garo & Khasi Hills along the western border of Garo Hills and southern foot hill region of Garo and Khasi Hills.

The Alluvium consists of fine silty sand and light to dark greyish clay with rare pockets and layers of coarse sand and shingles. The fine sand at places contains abundant minute flakes of mica and when extremely fine, resembles the weathered loose silt stones as seen around Manikachar in the Garo Hills.

STRUCTURE AND STRUCTURAL RELATIONSHIP :

The present height of the plateau owes its origin to the upliftment of the block during the Jurassic times. The tectonic history of the plateau began with the effusion of plateau basalts (the sylhet traps) through fractures and faults in

the basement, and uplift and subsidence of adjacent basement blocks⁴. These were followed by upper cretaceous - tertiary sedimentation into the relatively down thrown portions along the faults. These faults tend along the direction of NW-SE and E-W in the north western part of the Garo Hills, E-W in the south Khasi Hills and NE-SW in the eastern margin of Khasi Hills. The tectonic force has been vertically dominated and controlled by differential movements along these basement fractures⁵.

Basement deformation is evident in the gneissic group of rocks. Various rock types of this group are intricately folded and show a high degree of flowage indicative of high mobility of rocks due to deep burial. In some of the areas, evidences of cross folding are present. The foliation trend of the rocks seems to be mostly NE-SW in the western part and E-W in the southern part of the Khasi Hills.

The Shillong group of rocks usually show broad open folds with a few steeply dipping zones, apparently due to faulting. Some rocks of the shear zone shows evidences of sulphide (mostly pyrite) mineralization⁶. The general trend of the rocks is NE-SW. The western margin of this group is remarkably straight having no outliers to the west of this contact.

The first major tectonic event in the region started in the Jurassic period. This is marked by the Sylhet Traps which occur along a 80 km. long and 4 km. wide narrow strip, exposed in gorges along the southern margin of the plateau. Their contact

with the crystallines to the north is a fault, the Raibah Fault, which apparently determined the limits of the Traps during their effusion.

The Dowki fault in the southern fringe of the Khasi Hills is a predominant structural lineament which comprises at least four E-W running normal faults and at places becoming reverse faults. The upthrown side of these faults is to the north and the system represents a major plane of dislocation. In the southern fringe of the Jaintia Hills one of these faults continues further east to the North Cachar Hills and then joins the Disang Thrust.

The E-W lineaments in the western part of the plateau in the Garo Hills are represented by monoclines and faults among which the Dapsi Reverse fault at the base of the Tura range is most spectacular. The Tura range, a horst is bounded to the south by the Dapsi upthrust. In the Garo Hills there is ample evidence to indicate activity along a number of E-W, N-S, and NW-SE basement faults throughout the tertiary period.

A rectilinear drainage pattern in the NE-SW, NW-SE, and E-W directions is a distinctive features of the Shillong plateau. Some of them appear to represent faults, many of them are master joints and fractures and the whole pattern has been developed due to upliftment of this horst in the tertiary period.

The Shillong plateau which is looked upon as a disconnected portion of the peninsular India, seems to be in some ways

similar to the salt range of the west. However, there are remarkable contrasts between the two tracts. While the salt range includes a comparatively complete sequence of rocks from early Palaeozoic to early Tertiary, the Shillong plateau is made up largely of Pre-cambrian rocks acutely folded and steeply dipping with overturned fringe of Mesozoic and Tertiary sediments.⁷ The Shillong plateau, therefore is best regarded as geologically part of the Indian peninsula cut off therefrom by the intervening spread of the Ganges and the Brahmaputra Alluvium. The prevailing rocks of the plateau have more in common with the gneissic and Dharwar rocks of Bengal and Bihar than those of the more neighbouring Himalayan sequence. There is a further resemblance seen in the marine transgression which affected the southern shores of the plateau in the cretaceous times and which left cretaceous deposits much of which lie undisturbed upon the older rocks⁸.

GEOLOGICAL HISTORY

Till the Pre-Cambrian times, the Archaean basement of Meghalaya, a remnant of the northeasterly extension of the Indian peninsula, remained a landmass experiencing earthmovements leading to complete folding and fracturing of the ancient rocks. During this time the central part of Meghalaya, now covering the eastern Khasi and Central Jaintia Hills districts, developed into a trough over which the sediments of the shillong group of rocks were laid down. The sediments, later uplifted and folded experienced low grade metamorphism as a result of granite(Myllem granites) and basic/ultrabasic(Khasi greenstone) intrusions.

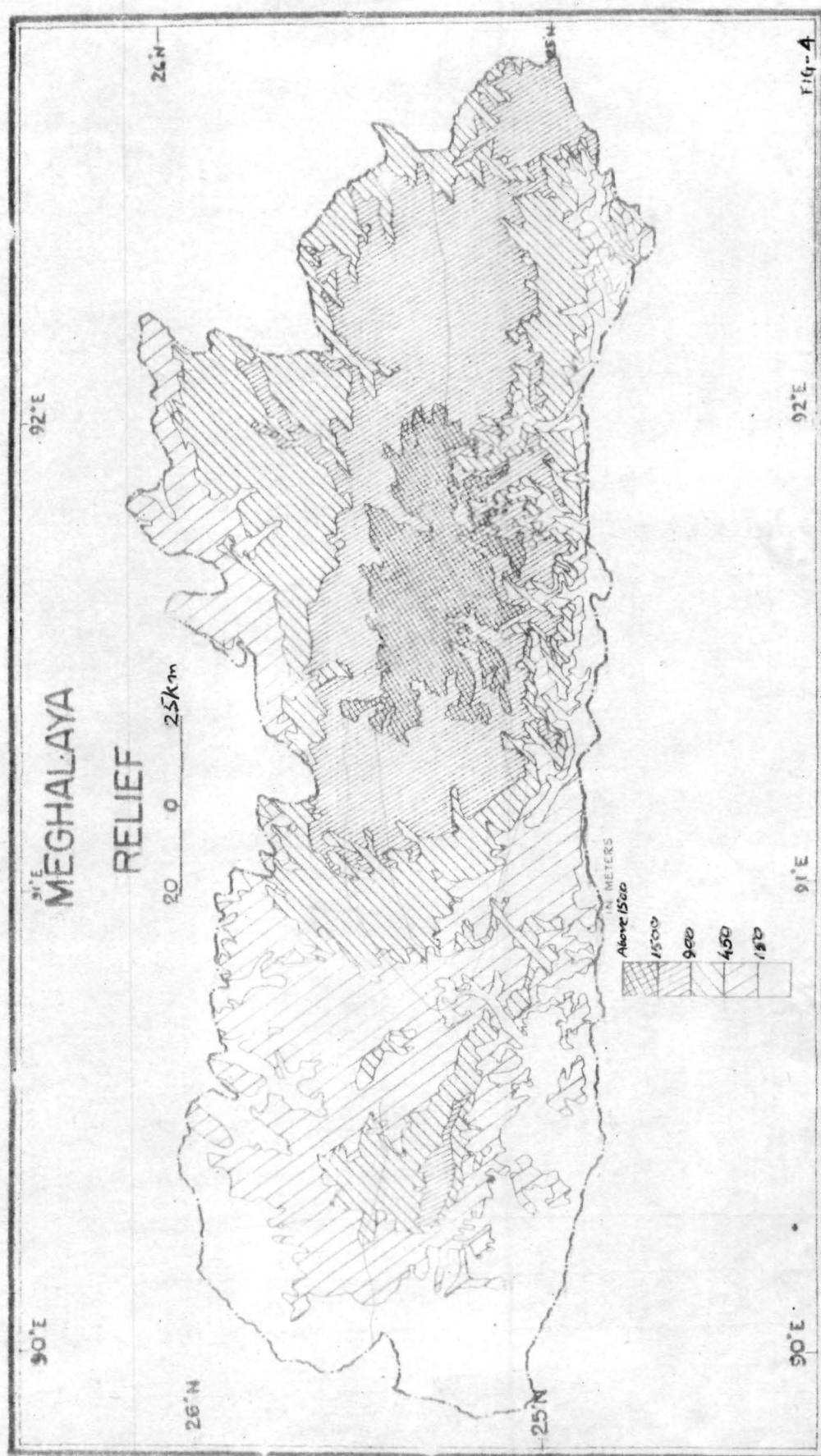
The post Pre-Cambrian landmass experienced peneplanation till the Jurassic times resulting into the formation of a flat levelled surface preserved over the plateau till today. By the end of Jurassic the southern margin of the Khasi Hills experienced eruption of plateau basalts, the sylhet traps, through East-West fissures, i.e. Raibah Fault, along which the southern block subsided and the northern block upheaved. The rate of sinking of the former increased, soon after the cessation of the volcanism, resulting into the marine invasion and deposition of the upper cretaceous sediments over a rapidly down sinking basin. The rate of subsidence gradually slowed down towards the Palaeozoic - Eocene times during which the area attained a stable shelf condition and the calcareous formations of the Jaintia group were deposited. The part of the plateau covering the Khasi block was still experiencing upliftment of the northern block resulting into the deposition of only the oldest (low sylhet) sandstones and limestone beds over the plateau and the younger ones (the middle and upper sylhet sandstones and limestones) along the southern fringe of the plateau. The eastern Jaintia and Garo blocks, respectively to the east and west, remained landmass till mid-eocene and experienced progressive down sinking later initiating the deposition of the coal bearing sandstone followed by limestone of the Khasi Hills. Since then, the sedimentation continued uninterruptly over the submerged southern part of the Garo hills and southern and eastern fringes of the Khasi and Jaintia hills till the end of the Oligocene period when the Barail range, the south of the Jaintia hills stood up as a landmass.

The sedimentation continued uninterruptedly during the Miocene period over the southern and western part of the Garo Hills and southern fringe of the Khasi Hills, the Jaintia block became uplifted and remained a landmass. The major upliftment of the plateau as a whole started at the end of the Miocene resulting into the formation of land locked shallow water lacustrine basins along southern fringe of the Khasi and Jaintia Hills. The Pliocene (Dupi Tila) sediments were deposited in these basins. The sub-recent older alluvium deposits along southern border of the Khasi and Jaintia Hills and southern and western part of the Garo Hills are fluviatile deposits along old river valleys.

GEOMORPHIC FEATURES

The Meghalaya plateau represents a remnant of an ancient plateau of the Pre-Cambrian Indian Peninsular shield, uplifted to its present height of about 600-1800 m above mean sea level. The plateau, though now a part of the north-eastern ranges is actually an extension eastward of the massive block of the Peninsular India lying to the east of the Great Gap in the Archaean terrain, subsequently filled up with alluvium deposited jointly by the rivers of Ganga and Brahmaputra.

During the Mesozoic and early Tertiary times, this plateau was practically submerged under the encroaching sea and it was uplifted slowly from the bed of the sea at the time the Himalayas rose from the floor of the Tethys.⁹ The slow and free orogenic movements helped the sedimentary beds retained their



horizontal character and gave rise to structural platforms well developed in the Cherrapunjee area. The central and eastern parts along with the Surma valley in the south, the state appears as an imposing table land, bordered by a great scarp and sloping steeply towards the plains (Plate - 1).

The plateau like character of this tract is well developed on the west and east of Shillong itself. The culminating ridge, north of the hill station, is some 1900 meters above mean sea level, but the general altitude of the plateau is about 1500 meters. Southwards, the ground slopes gently to elevations ranging from 1200 to 1320 meters and then plunges steeply to the plains except where foothills intervene. In most places, the plateau rises like the the sloping wall of a great fortress, 1200 meters from the plains of Sylhet, which are only some 50 meters above sea level. This wall is not a scarp face, but is the steep dip-slope of a monoclinial fold¹⁰. It is broken through by impassable river gorges or canons which may be between 700 and 1100 m. deep with a considerable breadth at the top (Plate - 2). Between the gorges rise the flat topped remnants of the old plateau.

The evolutionary history of the plateau involves emergence, submergence, and peneplanation with several phases of erosion, sedimentation, diastrophism, intrusion and movements of land and sea. It contains marks of peneplanation on its bare face which ranges from the Pre-Cambrian to Recent and sub-Recent periods.¹¹ The higher parts of the plateau preserve marks of the Gondwana surface, while later cycles are traced below them¹².

Plate No.1



Plate No.2



The highly dissected and irregular terrain in the western and northern faces makes the geomorphic features, characteristics in this region. In contrast, the southern face is characterized by the regular and steep fall down to the Barak-Surma plain through a faulted face. The plateau may be divided into two broad physiographic division based on the geomorphic characteristics.

1. The Western Hilly Tract and
2. The Central and Eastern Plateau.

The Western Hilly Tract : This hilly tract coincides with the Garo Hills district of Meghalaya and covers about 8,180 sq.km. At the southern foot of this extensively dissected tract lies the Surma plains with their marshes and meandering streams. The highest elevation is 1412 m., the Norkek peak situated 13 km. southeast of Tura on the Tura Range. The Moheskhola Adaguri Range is the demarcating line of the western and central part of the plateau. The Tura Range and the Simsang valley are the most important geomorphic features in the Garo Hills. The Tura range extends from the Tura town to Siju, a distance of 50 km. The hills in the north of the Tura range including the Arbela hills running parallel to the Tura Range are low but gradually increase in height until they reach the latter in the south. The range is a typical horst bounded by two fault lines and it is along the northern fault line that the Simsang river flows eastwards for about 45 km. before turning south through a gorge, separating the Tura Range from the Kylas Range and ultimately coming down to the plains near Baghmara. Here it is known as the Somes-

wari river. The Kylas hill which lies east of the river, called Chitmang¹³ by the Garos, stands out as an abrupt hog back mass towering above most of the hills in the vicinity. The rest of the area of the hilly tract consists of a tumbled mass of hills, whose general tendency is to run north and south with several low peaks between 450 and 600 m.

The Central and Eastern Plateau :

Covering an area of about 14,375 sq.km. the central and eastern plateau, coincides with the Khasi and Jaintia district of Meghalaya. It is characterised by its senile topography and flat skyline. Geomorphologically it may be subdivided into three sections.

1. The Northern Undulating Hills
2. The Central Upland, and
3. The Southern Hills.

The northern section has an undulating topography, hill after hill rising almost to the same height and extending to the Brahmaputra. The accordant summits of these hills vary between 170 and 820 m. There are two terraces indicating two peneplain surfaces, one from Khanapara to ^{Jorabat} Jorhat and the other from Burnihat to Nongpoh. The northern hills are separated from the more higher central upland by an important fault line. The alignment of the hills from Nongholi to Burnihat is from NW-SE. Above 490m most of the hillocks are conspicuous by their flat top character.

The east-west running central upland of the Khasi Hills

covers about 5000 sq.km. which is demarcated by a 1500 m contour line as its outer limit. This zone consists mostly of rolling grassy downs, intersected with river valleys and dotted all over with soft rounded hills. The upland contains remnants of several peneplained surfaces, ranging in height from 1500 to 1900 m, thus preserving the several traces of erosional cycles in this part. The Shillong hills contain the highest peneplained surface, trending ESE-WNW, over which streams meander before plunging into the deep valleys of the Umiam and the Umkhen. The region has a youthful topography which is evident by the presence of many rapids and waterfalls in the neighbourhood. A typical granite topography is to be seen to the south of the shillong hills around Mylliem. Farther south occurs a vast structural platform on which stands Cherrapunjee. This part of the central plateau is built of gently dipping sandstones of the cretaceous age, and over its edge the magnificent Mawsmai waterfalls add to the scenic beauty (Plate - 2). Small, rounded limestone hills of the Eocene age are found scattered all over the Cherra plateau, some of them contain small cave deposits too.

From Cherrapunjee the terrain has a gentle slope southwards for about 7 km. and then falls rapidly to the Sylhet plain, the ground slope conforming to the high dip of the sedimentary rocks. Towards the Surma valley the abrupt slope in many places has given rise to deep precipices due to heavy rainfall.

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CHAPTER - III

GEOMORPHIC PROCESSES AND FLUVIAL CYCLE OF EROSION

- * Weathering
- * Climate and Weathering
- * Mechanical Weathering
- * Chemical Weathering
- * Fluvial Geomorphic Cycle
- * Drainage Systems
- * Stages in the Cycle of Erosion

The geomorphic processes are all those physical and chemical changes which effect a modification of the earth's surficial form. A geomorphic process may be epigenic or exogenetic and hypogenic or endogenetic. But the most common geomorphic processes are weathering, mass wasting and erosion which are generally exogenetic processes. Other geomorphic processes originate within the earth's crust and are thus designated as endogenetic. Diastrophism and vulcanism belong to this class of geomorphic process. However, for the present study only the exogenetic processes have been taken into consideration which confine physical and chemical weathering only. It has been also attempted to assess the importance of fluvial geomorphic cycle in the Meghalaya plateau.

WEATHERING :

The disintegration or decomposition of rocks is generally referred to as weathering. It is a collective or group of processes at or near the surface of the earth. Weathering may be regarded as of two distinct kinds, according as the rock is disintegrated without chemical alterations (Mechanical or physical weathering) or rotted and decomposed (Chemical weathering). Though both the types of action commonly cooperate in producing the mantle of rock waste, each has its region of optimum activity.

The various factors which influence weathering are :

1. Climate,
2. Petrological and lithological characteristics of rock types,
3. Structure and
4. Vegetation.

CLIMATE AND WEATHERING :

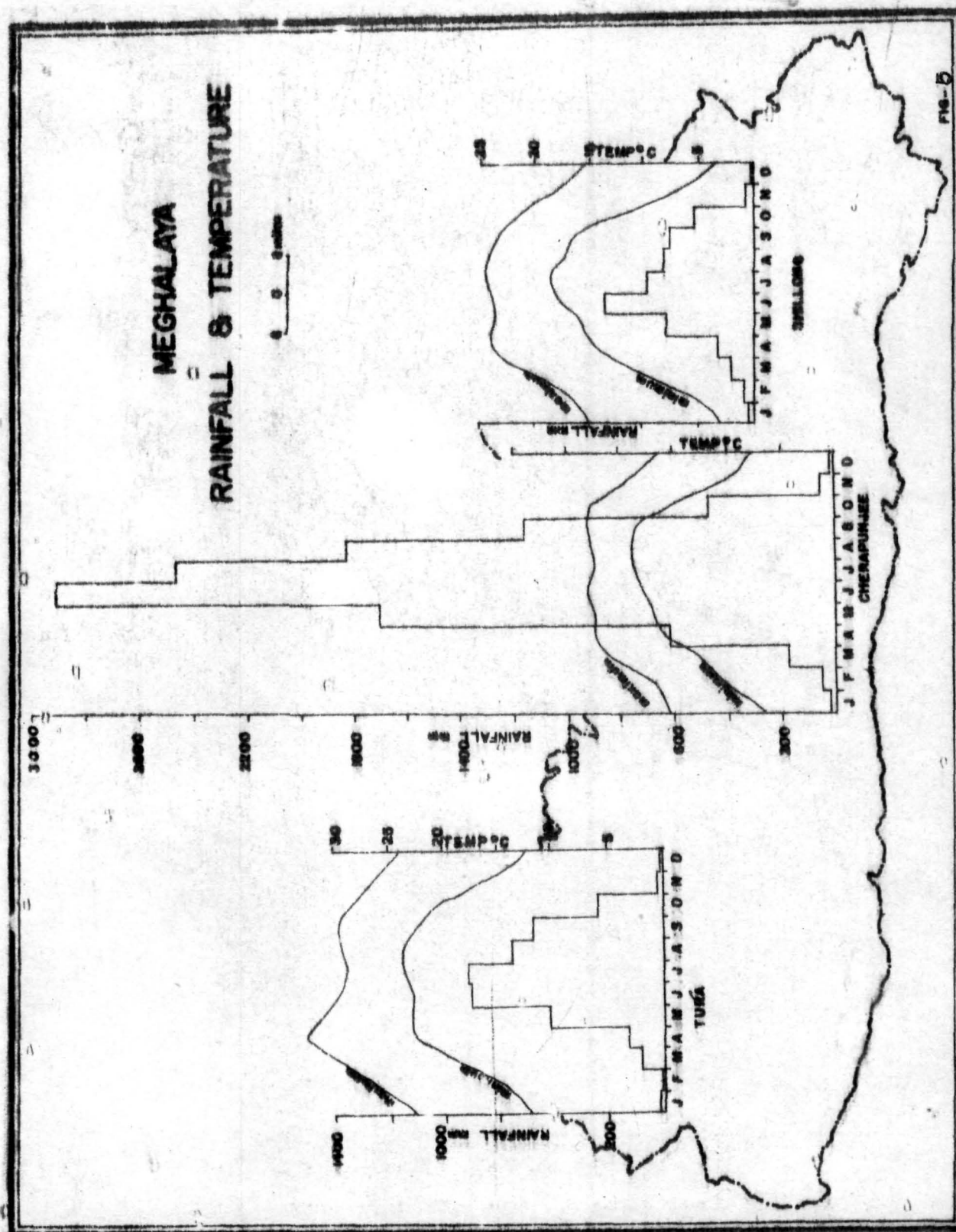
The major climatic factors of temperature, rainfall and humidity determine not only the rate at which weathering proceeds but also whether chemical or mechanical processes predominate.

It is worthwhile to mention here that the area under study is quite vast to have a detailed field observations. However, an attempt has been made to identify those weathering surfaces where climatic factors might have played a significant role.

TEMPERATURE : The Table - II, which shows the temperature variation in Tura (Garó Hills), reveals that there is a steady rise of maximum temperature of 23.6°C in January to 32.5°C in April. The temperature is fairly high throughout the summer beginning from March to October. It can be seen that the variation between the maximum and minimum temperatures is remarkable throughout the year. The minimum temperature varies from 12.3°C in January to 23.3°C in August.

TABLE - II

	JAN	FEB	MAR	APR	MAY	JUNE
Max°C	23.6	26.4	29.9	32.5	31.0	29.3
Min°C	12.3	14.9	18.7	22.1	22.9	22.7
	JULY	AUG	SEPT	OCT	NOV	DEC
Max°C	28.9	29.3	29.5	28.9	26.5	24.7
Min°C	23.2	23.3	22.7	20.3	16.3	13.5



In contrast, the data (Table - III) for Shillong (Khasi & Jaintia Hills) show that the temperature decreases eastwards. The mean maximum in this district is highest in the months of July and August (24.1°C) and lowest in January (15.5°C). The same months record the highest and lowest minimum temperatures also. The mean minimum temperature varies from 3.6°C in

TABLE - III

	JAN	FEB	MAR	APR	MAY	JUNE
Max°C	15.5	17.1	21.5	23.8	23.7	23.7
Min°C	3.6	6.4	10.5	14.1	15.5	17.4
	JUL	AUG	SEP	OCT	NOV	DEC
Max°C	24.1	24.1	23.6	21.8	18.9	16.4
Min°C	18.1	17.8	16.6	12.9	7.7	4.5

January to 18.1°C in July. It can thus be seen that the temperature variation is more in the Khasi and Jaintia Hills district than the Garo Hills.

RAINFALL : There is a marked variation between the eastern and western parts of the plateau as far as rainfall is concerned. The Table - IV shows that the annual rainfall in the Garo Hills is 3331.6 mm of which more than two third are received in the four months from May to August. The rainfall in the eastern part in Shillong, shows an annual of 2417.3 mm. The most remarkable feature is that the rainfall in the winter months is more in Shillong than in Tura. The rainfall at Cherrapunjee (Table - IV) which is located in the structural platform on the south is as high as 11,418.7 mm while Shillong being located only 50 Km. to the north

with a rainshadow effect gets only 2417.3 mm. The high rainfall in Cherrapunjee - Mawsynram region is due to the fact that the southwest monsoon laden with great amount of moisture from the Bay of Bengal blows over Bangladesh and is suddenly cut by the cliffs of the tableland in the south with an average elevation above 1200 meters which juts out like a peninsula into the surrounding gorges about 600 meters deep on either side and as a result the monsoon having reached the heads of the gorges ascends vertically upwards and causes very heavy rainfall.

TABLE - IV

	JAN	FEB	MAR	APR	MAY	JUN
<u>Tura</u>	<u>11.9</u>	<u>7.5</u>	<u>72.1</u>	<u>131.1</u>	<u>402.4</u>	<u>708.7</u>
<u>Shillong</u>	<u>15.2</u>	<u>28.5</u>	<u>59.4</u>	<u>136.4</u>	<u>325.4</u>	<u>544.6</u>
<u>Cherrapunjee</u>	<u>19.8</u>	<u>37.3</u>	<u>178.9</u>	<u>605.2</u>	<u>1705.1</u>	<u>2921.5</u>
	JUL	AUG	SEP	OCT	NOV	DEC
<u>Tura</u>	<u>709.2</u>	<u>558.6</u>	<u>461.5</u>	<u>249.7</u>	<u>17.7</u>	<u>1.2</u>
<u>Shillong</u>	<u>396.9</u>	<u>334.6</u>	<u>314.9</u>	<u>220.2</u>	<u>34.9</u>	<u>6.3</u>
<u>Cherrapunjee</u>	<u>2456.7</u>	<u>1827.5</u>	<u>1167.7</u>	<u>447.4</u>	<u>46.7</u>	<u>4.9</u>

MECHANICAL WEATHERING :

Mechanical weathering is the breakdown of material by entirely mechanical methods brought about by a variety of causes. Some of the forces originate within the rock, while others are applied externally. The applied stresses lead to strain and thus ultimately disintegrating the rock surface. Various processes have been recognized as mechanical by Ollier (1969)¹, Thornbury(1971)² and Sparks(1971)³. Of these, however, only slaking and weathering caused by fire, are noticed in the area under study.

Alternate wetting and drying of rocks is a very important factor in weathering, a process known as slaking⁴. On the southern part of Meghalaya the cretaceous tertiary sediments show this type of mechanical weathering. Here one finds disintegration of the fine grained sandstones and mudstones into a number of large pieces of about equal size. A large variation in diurnal and monthly rainfall in this region helps in this process of slaking.

Blackwelder (1969)⁵ has pointed out that a good deal of thermal expansion and contraction of rock is caused by forest fires. Areas of higher relief in Meghalaya where extensive jhumming is practised, show spalls and flakes of rock which are produced due to exfoliation caused by unequal heating.

CHEMICAL WEATHERING :

The chemical decomposition of rocks comprises several processes which are usually concurrent, though one or the other may be dominant locally. The chief chemical weathering processes are hydration, hydrolysis, oxidation, carbonation and solution. Goldich(1938)⁶ has discussed the principle of mineral stability which states that the minerals in igneous and metamorphic rocks were at equilibrium under the conditions of temperature and pressure at which the rocks formed, but under the temperature and pressure conditions at the earth's surface some of the minerals are not the most stable minerals. He has given a general order of mineral stability in which the least stable mineral (calcite plagioclase) is at the top and the most stable (Quartz) at the bottom.

It is evident from the above order that quartz and muscovite are the common constituents of rocks composed of weathering residue. It will be seen from the geological map of Meghalaya that the region is widely occupied with igneous and metamorphic rocks. The exposed Archaeans in the central and north-eastern parts are believed to be remnants of chemical weathering processes. Abundant biolite and potash feldspar show that these rocks have been subjected to chemical weathering thoroughly.

The Shillong group of rocks are generally composed of quartzite - schists which show an interaction of mechanical and chemical weathering. On the southern border of the Shillong plateau the Sylhet Traps are exposed in a narrow E-W strip. They are

of the nature of plateau basalts. They comprise mainly of basalts and minor alkali basalts, rhyolites and acid tuffs. This is the region of intensive chemical weathering. The general chemical composition of the basalts show that the constituents like SiO_2 , Al_2O_3 , Fe_2O_3 , etc. are abundant. The Fe_2O_3 is very susceptible to water which undergoes the process of hydration which involves a conversion of limonite.



FLUVIAL GEOMORPHIC CYCLE :

A landscape has a definite life history during which it shows a series of gradual changes, whereby the initial forms pass through a series of sequential forms to an ultimate form. Landscape evolution is thus envisaged as a cycle which runs through a definite course of development. It is, therefore, of prime importance to recognise the stage of evolution attained in landscape development. But as in the case of a single valley, the process of sculpture stamps its character on the country, while rock characters, conveniently summed up under the term "structure", are also potent factors in determining form. We may say, then, following W.M. Davis, that "landscape is a function of structure, process and stage"⁷.

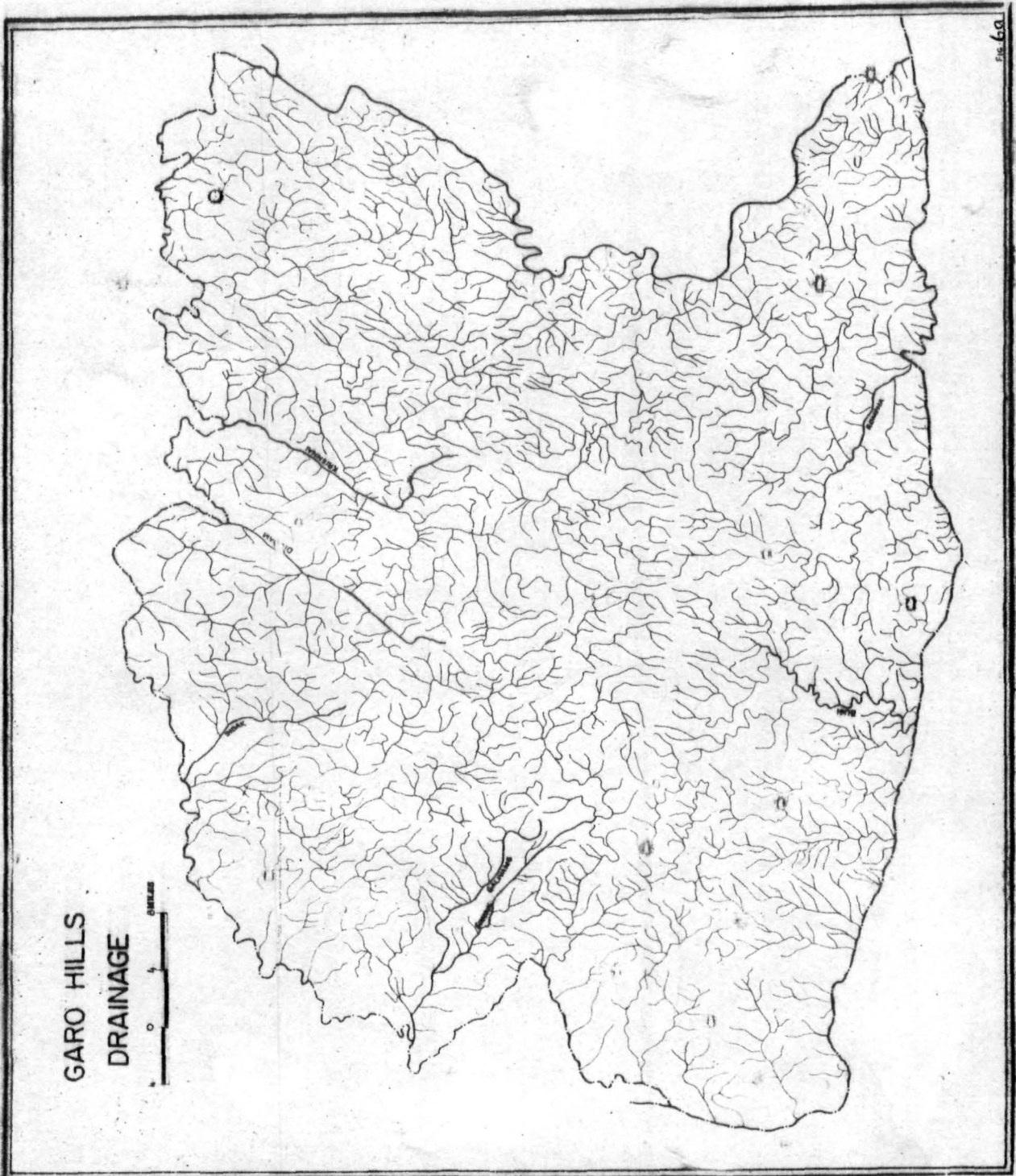
Throughout most of the world, runoff waters are the dominant geomorphic agency. So, in any geomorphological study fluvial cycle of erosion becomes the most important aspect.

DRAINAGE SYSTEMS :

With an average annual rainfall of 26889 mm, Meghalaya is drained by a number of consequent and subsequent streams with a large number of their tributaries. In order to have a clear picture of the drainage system we have divided the system into two : the Garo Hills and the Central and Eastern Plateau.

The rivers in the Garo Hills make two distinct systems separated by the Central Tura Range, one flowing to north towards the Brahmaputra and the other to the south to the Surma valley. The important rivers of the northern system includes the Kalu, the Ringgi, the Ajagar or Didak, the Krishnai and the Dudhnai. The important south flowing rivers are the Darrong, Bandra, Dareng and Simsang or Someswari. Of these, Someswari is the largest in the whole Garo Hills.

The drainage system of the central and eastern Meghalaya is to a great extent directed by the central upland zone which acts as a watershed from which the rivers flow down to the Sylhet plain in the south and Brahmaputra valley in the north. Of the northern group of rivers the important ones are the Khri or Umkhri, the Umiang and the Digaru while those of the southern system are the Kynchiang or Jadukuta, the Umiew - Umiang, Myngot and Myntdu.



KHASI HILLS

DRAINAGE

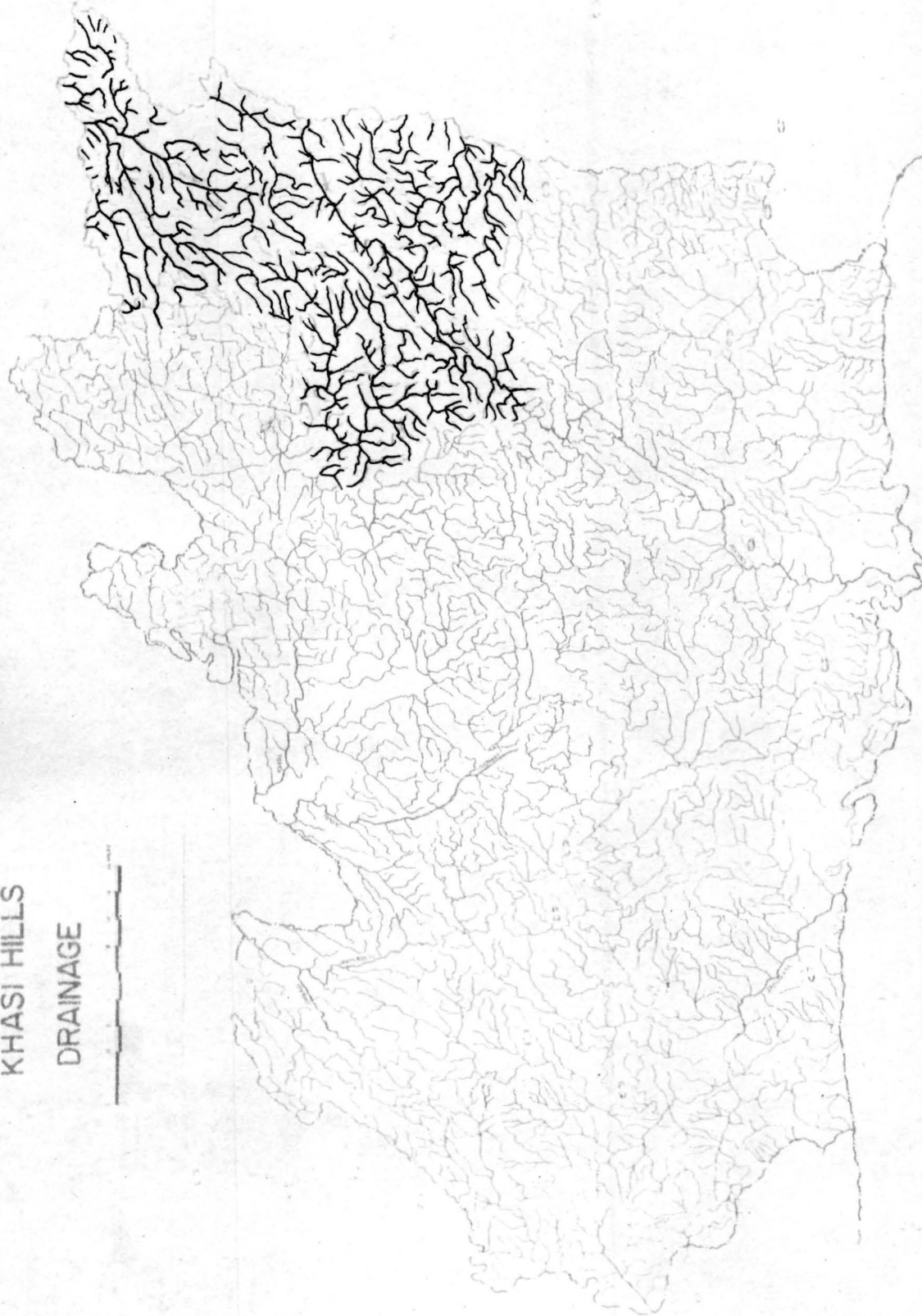


FIG-6b

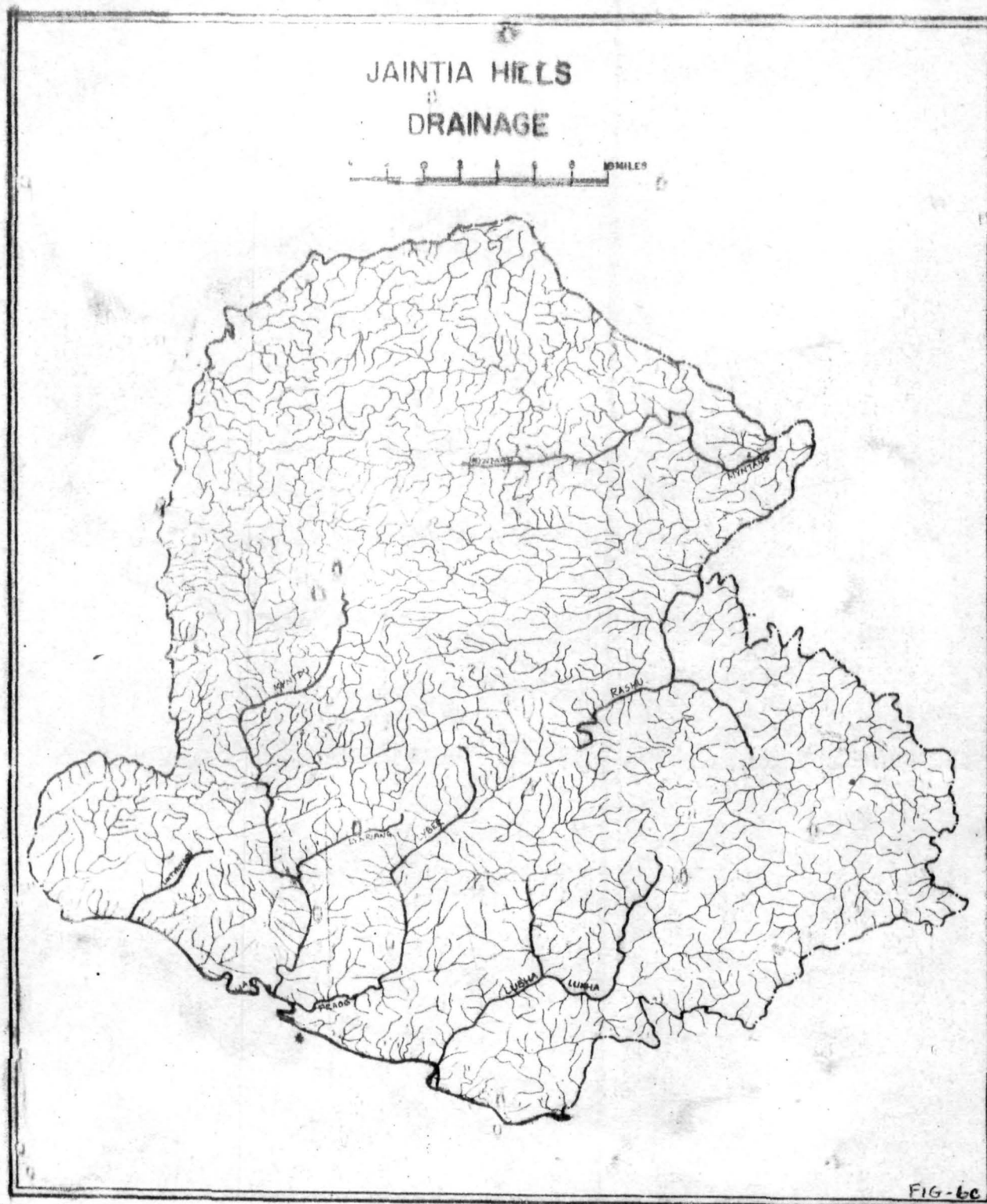


Plate No.3



Plate No.4



Plate No.5



STAGES IN THE CYCLE OF EROSION :

It has already been mentioned that operation of the erosional agents such as rivers leads to an orderly sequence of landform development. An attempt has been made here to identify the stages in the fluvial cycle of erosion in Meghalaya. It will be seen from the analysis later that the rivers of Meghalaya are in different stages of the cycle.

Numerous short tributaries and gullies extending themselves by headward erosion in the Garo Hills show that the cycle of erosion is still in its youthstage. The Someswari, the Krishnai, the Dudhnai rivers show a 'V' shaped profiles which confirms the above statement (Plate - 3). It will be seen from the drainage map of the Garo Hills that the interstream tracts are extensive and poorly drained. In addition, the prominent water-falls are the most typical of early youth stage. In case of the Someswari and Bingi rivers, at their upper courses, one will find conspicuous meanders reveals the fact that these streams are in a transition zone towards maturity.

A glance at the eastern and north-eastern portion of the Khasi Hills would reveal that this part is drained more extensively and densely than any other part of the district. A number of waterfalls around Shillong such as the Sweetfalls (Plate - 4), the Elephant falls (Plate - 5), the Mawsmal falls of Cherrapunjee (Plate - 2) prove an absolutely youthful topography in this region. The plates show that in the river the valley deepening is more conspicuous than their widening (Plate-3)



Plate No. 7



Plate No. 6

The stream divides are generally broad and poorly defined.

In the Jaintia Hills one finds that most of the region is drained by a number of short tributaries. Most valleys are 'V' shaped and there is a general lack of flood plain development. Inter-stream areas are extensive and drained only by a parallel streams which is rather irregularly drained.

The above regional picture shows that the general topography of Meghalaya is in a youthful stage except for some parts in the Garo Hills where one finds characteristics of maturity. Thus the study of the drainage characteristics and topography shows that the region has been uplifted in recent past, so the streams have again acquired energy to deepen their valleys. The streams are actively engaged in headqard erosion. Thus it appears that the region presents a multicyclic landscape (Plate - 6).

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CHAPTER - IV

MORPHOMETRIC ANALYSIS

- * Slope Analysis
- * Drainage Analysis
- * Multiple Relations Among
Morphometric Properties

Like other branches of geography, the study and objective of geomorphology have changed considerably since the end of the second world war. Today the emphasis is placed more on the study of the precise angle and composition of slopes, measurement of the denudational processes acting upon them and the mathematical properties of drainage basins.

The morphometric methods which have been used for the present analysis include the study of the characteristics and nature of average slope of the region, some drainage characteristics, such as stream frequency and drainage pattern and finally there has been an attempt to correlate the various morphometric characteristics of ten sample drainage basins within the plateau. These methods have been helpful not only to identify the different erosional surfaces, but they also provide materials to reconstruct a systematic geomorphic history of the region. By studying the processes quantitatively, the complexity of landform becomes more clear.

SLOPE ANALYSIS :

An analysis of slopes is very important for a better understanding of the processes of landform evolution. Very rarely do we find areas on the earth's surface that are absolutely level. All landform is composed of slopes, sometimes of a slight gradient and sometimes of a very complex nature. Geomorphology is concerned with landform and so, an understanding of the processes which control slopes must form an important element of study.

Some slopes, such as actively eroding sea cliffs, or the free faces of high valley sides, may consist of bare rock. A slope may be formed by a covering of weathered rock resting on bed rock. Another type of slope consists of bedrock, forming the basal slope, covered by a weathered rock, often including a surface layer of soil. There are three important factors which influence the development of slopes :

- a) The earth's surface has relief and hence slopes because a variety of internal endogenic processes have raised parts of it to considerable elevations above sea-level. The initial slopes caused by such movement will depend on the rapidity of the uplift and the material which is being raised. Many of the older theories of slope development envisaged separate periods of uplift followed by slope and river development.
- b) Both the weathering and transport of materials on slopes are affected by climate. In considering slopes it is important to realise the influence of ages of glaciation and periglaciation. Throughout most of British Isles slopes are the result of quaternary glaciation and periglaciation¹. The slopes may be mantled by material deposited there by glaciers and present a form quite unlike the bed rock profile they underlie.
- c) The activity of the stream at the base of the slope is important. It removes the material conveyed to it from the surrounding slopes. It sometimes moves around the bottom of

the valley and undercuts its banks. Thus the slipping of material on slopes and the removal of sediment from stream banks are but parts of a continuum involved in drainage basin dynamics.

- d) Man has had a considerable influence on slope development through agricultural and industrial activities.

Method of Study

Several methods have been suggested by Raisz and Henry, Smith, Wentworth and others to determine the average angle of slope. In the present study we have adopted Wentworth's method of average slope determination. It is a general and random method and hence, is simple.

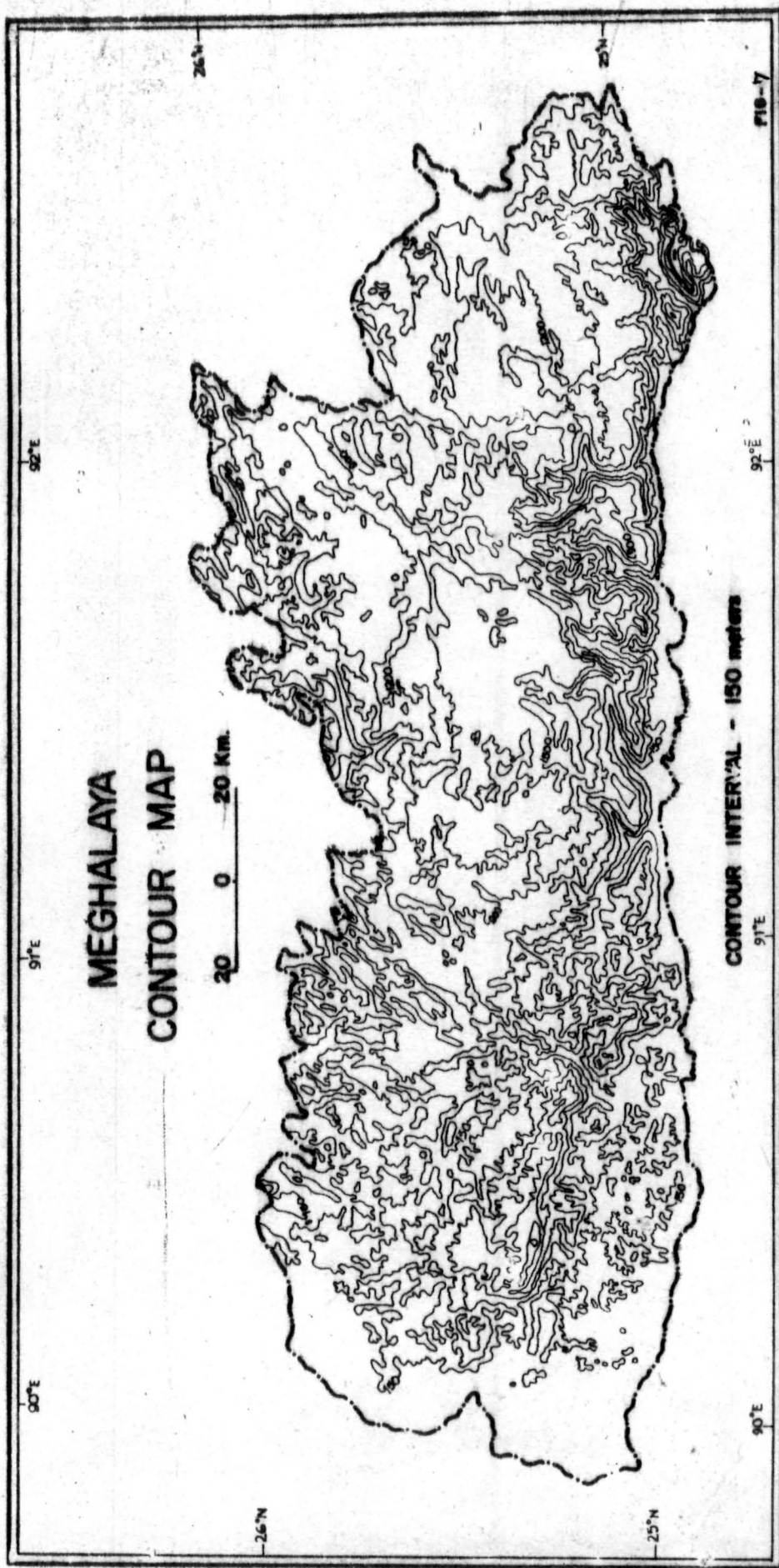
First of all a contour map of the region is prepared from the toposheets of scale 1 : 1,000,000. The region is then divided into grid of straight lines at right angles at one centimeter distance. The total length of grid lines of each square is measured in miles and the number of contour crossings for each square is counted. Then by applying the following formula the angle of slope is determined :

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

Where, N is the average number of crossings

I is the contour interval, and

θ is the angle of slope.



In this case θ gives the average angle of slope for the whole area. As the angle of slope varies from one part of the area to the other, the average angle of slope in each square is determined independently using the same formula.

The values of the angles of slope in degree and then written down on each square and then, isolines are drawn in order to show the areas of equal angle of slope. Then, a chloropleth map is made to depict the variations in the angle of slope over the different parts of the region.

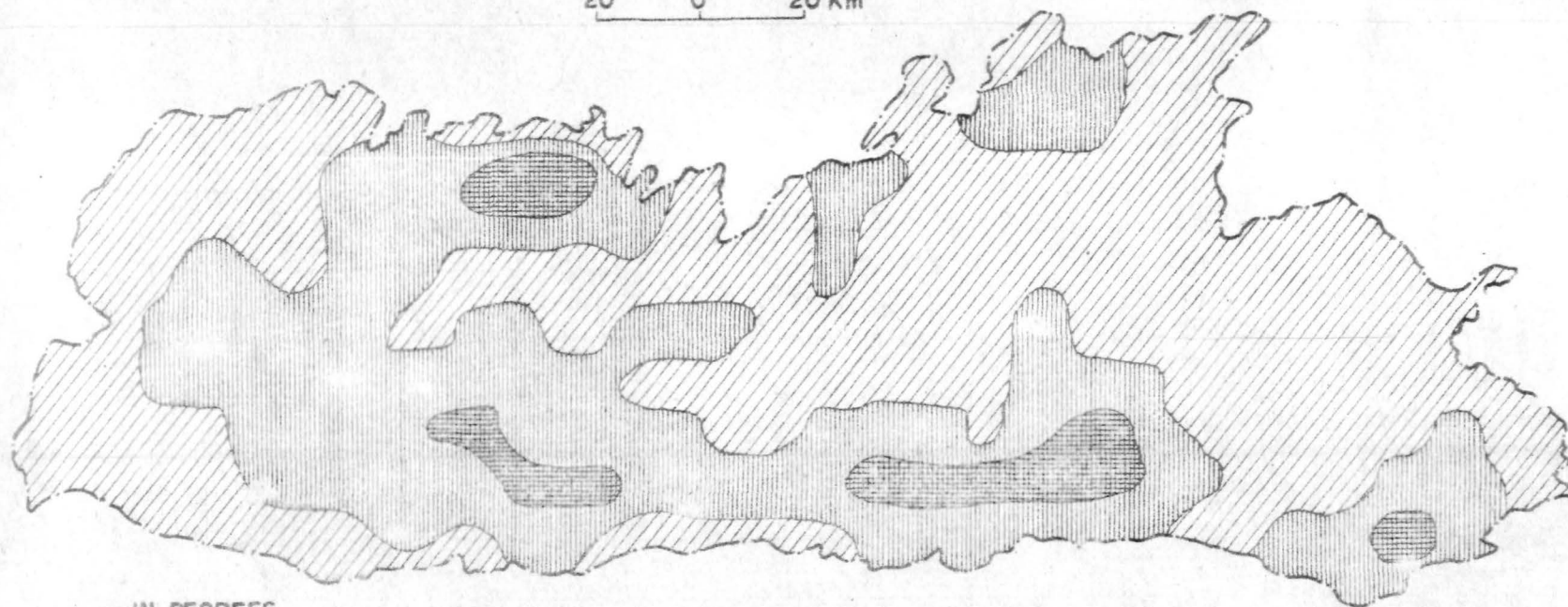
For the study of average slope it is always better to have a detailed map on 1 inch to 1 mile or even upto 1 inch to 4 mile scale. That will give a better picture of the variation in the slope. But because of non-availability of detailed topographic sheets of the state the present study of average slope is based on 1 : 1000,000 sheet. So, with such a small scale map one cannot expect a very good analysis of the slope. Here an attempt has been made to visualise a general picture of the average slope in the region. Since the contour interval is 150 meters, the slope map gives the variation in slope of only major relief features.

A glance at the map (fig - 8) reveals some contrasting variations in the average angle of slope of the region. In general, lower angles are found along the margin of the plateau while the core and inner areas, except the Khasi Hills district show steeper regional slopes. In the Garo Hills the slope seems to increase from west to east. Western Garo Hills shows the

MEGHALAYA

AVERAGE SLOPE

20 0 20 Km



IN DEGREES



> 8



4-8



< 4

FIG-8

least average slope with less than 4 degrees. The central part has a slope which varies between 4 and 8 degrees and on the east it is as steep as 9 degrees. The highest elevation in the Garo Hills is the Norkek peak (1412 m) on the Tura range which shows steep slope of 7 to 8 degrees. The slope decreases southwards where in the plains near Baghmara it averages between 2 and 4 degrees. In the west the slope abruptly changes from 1 to 7 degrees. This variation in the average slope in the Garo Hills is mainly due to the lithological and structural characteristics of the rocks. A major part of this District is occupied by metamorphosed gneisses which are very susceptible to weathering and mass movement. In the west the abrupt change in the slope may be due to the fault surfaces at the base of the Tura Range.

A major part in the Khasi Hills district is occupied by gentler slopes of less than 4 degrees. The central upland zone which is a true plateau has the lower angles of slope while towards the south it rises to as high as 10 degrees. Towards the extreme north and south the average slope remains generally low. In this part of the plateau the variation in the average slope is a reflection of the relief of the region.

In the Jaintia Hills the average slope increases southwards. The southern areas has steep slopes, as steep as 11 degrees near Kheldam. In contrast, the northern slopes are much gentler averaging between 1 and 3 degrees.

The foregoing analysis of the average slope in the Meghalaya plateau leads to conclude the following facts.

The most important factor which is responsible for the varying slope characteristics in the plateau is mass movement. In the plateau which experiences heavy rainfall throughout most of the year, movement on the surface is caused directly by the action of the falling rain and surface run off. The excess material tend to be carried downslope by the force of gravity thus gradually steepening the slope. This may be the case in the southern part of the plateau where the average slope is comparatively higher.

Variation in the lithological composition of rocks also effects the average slope in the Meghalaya plateau. Areas of less resistant rocks show steeper slopes as in the case of southern Khasi Hills and eastern Garo Hills. The higher angles of slope in the southern part of Jaintia Hills may be due to the fault lines.

Soil erosion due to extensive jhuming practises, also helps in the variation of slope in the Meghalaya plateau.

DRAINAGE ANALYSIS

Interest in drainage basin morphometry has grown since R.E. Horton² drew attention in 1945 to certain basic laws. The work of Horton has been built upon and extended since then and

knowledge of the mathematical properties of drainage basins greatly extended. The channels of the drainage network and the landforms they drain are bound together in a close causal relationship. In 1900, W.M. Davis³ wrote, "rivers and valleys have a special place, for it is impossible to treat the development of landforms, or to describe existing forms in a rational manner, without constant reference to the valleys that have been worn in them and to the rivers by which the waste is washed along the channel in the valley floor". Thus, in any geomorphological study, drainage analysis becomes an important part. Here the drainage analysis includes the study of stream frequency and drainage patterns.

Stream Frequency

Stream frequency is one of the most important morphometric analysis of the drainage basins. It gives a picture of the number of streams per unit area.

First of all a drainage map of the region is prepared from the quarterinch toposheets (Sheet Nos. 7896, 78 J, 78 K, 78 N, 78 O, 83 B and 83 C). This map is then divided into a number of half inch squares representing 4 sq. miles on the surface. The total number of stream crossings are counted and plotted in the centre of the squares. These numbers represent the number of streams per 4 sq. miles. In order to simplify the analysis, all these figures are grouped into four classes which have been termed as coarse, medium, fine and very fine respectively :

(a) Less than 4 streams, (b) 4 to 8 streams, (c) 8 to 12 streams. Then a chloropleth map is drawn according to these class groups to study the spatial variation of stream frequency over the surface.

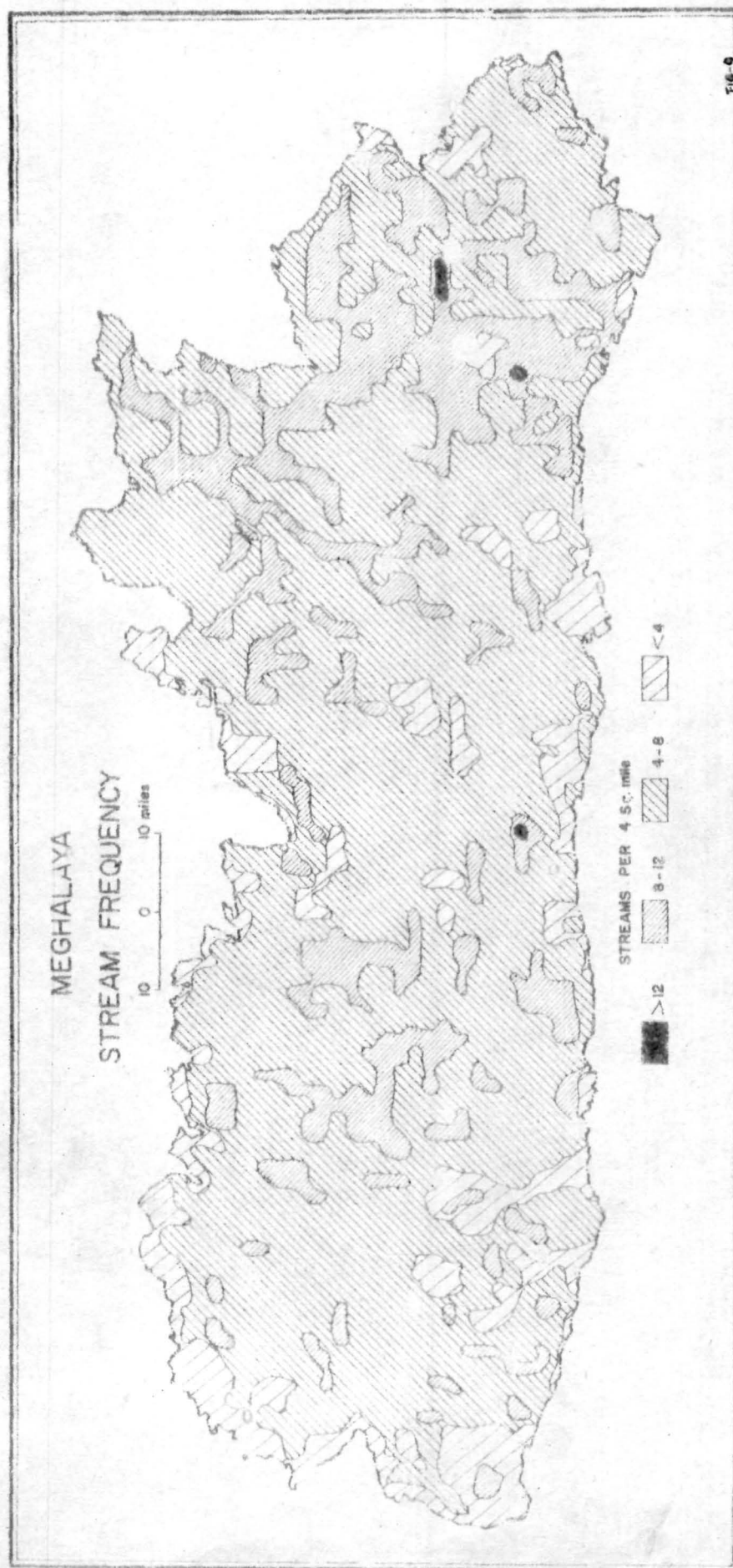
A glance at the map of stream frequency of Meghalaya would reveal that there are a number of variable factors involved in the variation. These factors may broadly be divided into two categories :

1. Environmental Factors,
2. Technical Factors

The most important environmental factors which have affected the drainage frequency of Meghalaya are as follows :

- a) Climate;
- b) Lithological and structural characteristics of rocks;
- c) Relief;
- d) Stages of development, and
- e) Vegetation.

A close examination of the drainage frequency map of Meghalaya (Fig-9) reveals that most of the area in the state is covered by the category of medium stream frequency, i.e., 4 to 8 streams per 4 sq.miles. A major area of the Garo Hills is occupied under this category. The other class groups of drainage frequency occupy in patches mostly on the marginal areas. In general one can see that the district of Jaintia Hills shows the maximum variation in stream frequency. The Khasi Hills dis-



trict shows moderate variation and the Garo Hills shows the least variation. The finer frequencies are found in the eastern side of the state while the lower values are to be seen on the western part. This explains that the drainage network in the Jaintia Hills is more complicated than the other areas which show a simpler drainage network.

It will be seen from the map that in the district of Garo Hills the south and eastern parts show higher stream frequency between 8 to 12 streams per 4 sq. miles which is termed as having fine texture as far as stream frequency is concerned. This area is drained by the Someswari river and its tributaries which is one of the largest river basins in the region as a whole. This river borders the district from the Khasi and Jaintia Hills district. The Bugi river basin on the southern part of the Garo Hills also displays medium to fine texture. The reason for this higher frequency of the streams in this district may be attributed to the fact that this part receives higher rainfall than the other areas of the district. Relief and physiography are the important factors controlling the drainage system, in turn, the stream frequency of this area. It is found that the district is separated from the Khasi Hills by the contour of 900 m which runs along the boundary approximately. A remarkable variation in the relief, hence an irregular terrain helps the streams to develop their network, thus showing a high drainage frequency.

There is a marked difference in the stream frequency in the district of Khasi Hills. It will be seen from the map

that the central portion of the district shows a lower frequency group while the frequency increases radially and finally on the border areas they show fine textures. A major part of the eastern half in this district is covered by fine texture. In the central district the frequency goes down to as low as no streams per four sq. miles. This variation may, again be mainly because of the relief structure. The district is a plateau surrounded by mountain ranges on all sides. The central plateau is as high as 1500 meters and the surrounding areas rise to less than 900 meters.

On the western margin of the region the basins of Ronga, Jadukata show high stream frequency. A glance at the drainage map (fig - 6) of Meghalaya would reveal that the eastern part of the district is covered by an extensively complex drainage network. The rivers, though small, have large number of tributaries most of them flowing eastwards. This part of the district shows a wide variation in stream frequency which varies from zero to eleven streams per four sq. miles. In the north eastern part there is a patch which has a frequency of over 12 streams per 4 sq. miles depicting a very fine texture over this area. In contrast, some areas of the central part has no streams absolutely. The Uiam river basin is the largest basin in the district which borders the Jaintia Hills district. In the south-eastern corner the frequency rises to as high as ten streams, having a fine texture, in the Umgot river basin. Climate plays a very important role in the region as far as the drainage frequency is concerned. The average annual rainfall in this district varies from 1585 mm in Upper Shil-

long to 11012 mm in Cherrapunjee⁴. Rains cover as many as 194 to 212 days in a year. Thus, it is the rainfall that accounts for the development of the drainage system in this district.

The district of Jaintia Hills shows the maximum variation in stream frequency. Some of the areas of this district have very high frequency - as high as 14 streams per four sq. miles. At the same time it has got some of the lowest frequencies ranging from 0 to 2 stream per sq. mile. A major part of the district is covered by fine textures. The eastern part is comparatively coarser than the west as far as stream frequency is concerned. Finer textures are found in the basin of Myntang river which flows from west to east. The Umken basin in the north also shows high frequency. The Myntdu river basin has the highest stream frequency - as high as 12 to 14 streams. The basins of Lyber, Lukha, Praog, etc. also have complex stream network giving rise to over 8 streams per four sq. miles. The southeastern part is not drained by any major rivers and hence these areas have got comparatively coarse stream frequency.

The relief and slope play very significant role in the stream frequency in this region. Drainage lines will develop in large number upon an irregular surface than upon one which lacks conspicuous relief⁵. It will be seen from the relief map(fig-4) that the relief gradually increases from the southeast to northwest. The southeastern part shows an average height of 900 meters. From the slope map(Fig - 8) it is found that this region of the state has a moderate slope which explains the lower stream frequency in this area. But in the central part there is a high

degree of slope which partially helps the streams to develop a dense network. The climatic conditions of this region also have wide implications on the variation in the drainage frequency. The stream frequency in the southern part is rather inconsistent which may be due to the presence of a number of faults and joints in this part.

Technical Factor :

The most important technical factor involved in determining the stream frequency is the scale of the map and the accuracy of mapping. It is obvious that larger the scale of the map, more will be the accuracy in the frequency of streams. For the present analysis the map chosen is of the scale; 1 inch = 4 miles. Since the study covers the whole of the state of Meghalaya, it would be difficult to proceed with a map of a larger scale. So, considering all these points the study has been done with the help of the quarter inch map.

Drainage Pattern

The process of tributary growth and "adjustment to structure"⁶ give much significant detail to water-sculptured landscape. Adjustment to structure refers to the adaptation of streams to the variations of rock character which underly them. The texture of the drainage network depends on the amount of rainfall and the proportion of runoff, i.e. the perviousness of the rocks. In general, in a basin, the drainage pattern is influenced by the slope, lithology and structure. The development of a particular drainage pattern is directly related to the

stages of the cycles of erosion.

There are four types of drainage pattern found in Meghalaya :

- a) Radial Pattern;
- b) Parallel Pattern;
- c) Dendritic Pattern; and
- d) Contorted Pattern.

RADIAL PATTERN : Most of the area in Meghalaya are drained in a pattern which is generally referred to as radial pattern. In this type of drainage pattern the streams flow from the central part to all the directions. This type of drainage pattern develops on flanks of domes and volcanoes where there is no effect of differing rock resistance⁷.

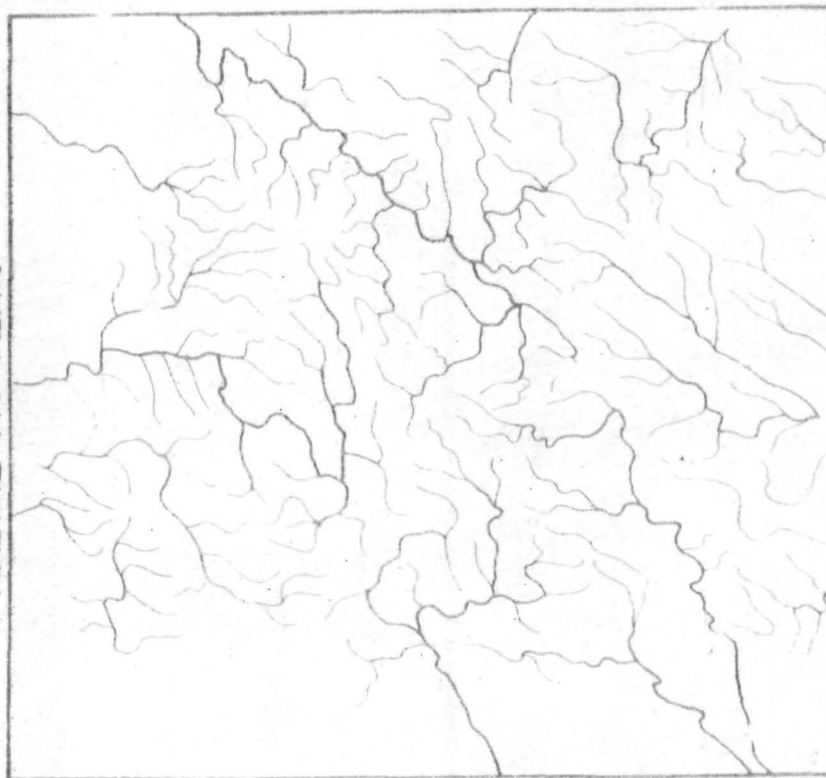
In the Garo Hills prominent radial pattern of drainage system are found in the southwest corner, southern margin and in some of the eastern parts. The southwestern corner is drained by the rivers of Rongkha, Daru, Sanda and their tributaries. The rivers of Bugi and Dareng and their tributaries drain the southern part and in the east, the rivers of Rongit, Dudhnai, Rongre, Someswari and their tributaries form a radial type of drainage pattern. In the southwest the Timam series and Chengpara formations of the Pliocene underlies the river system, while in the south the Surma series underlies the radial drainage system. It will be seen from the geological map (Fig - 3) of the state that these above mentioned rock formations are uniformly distributed

MEGHALAYA

DRAINAGE PATTERNS

4 0 4 miles

RADIAL PATTERN



PARALLEL PATTERN

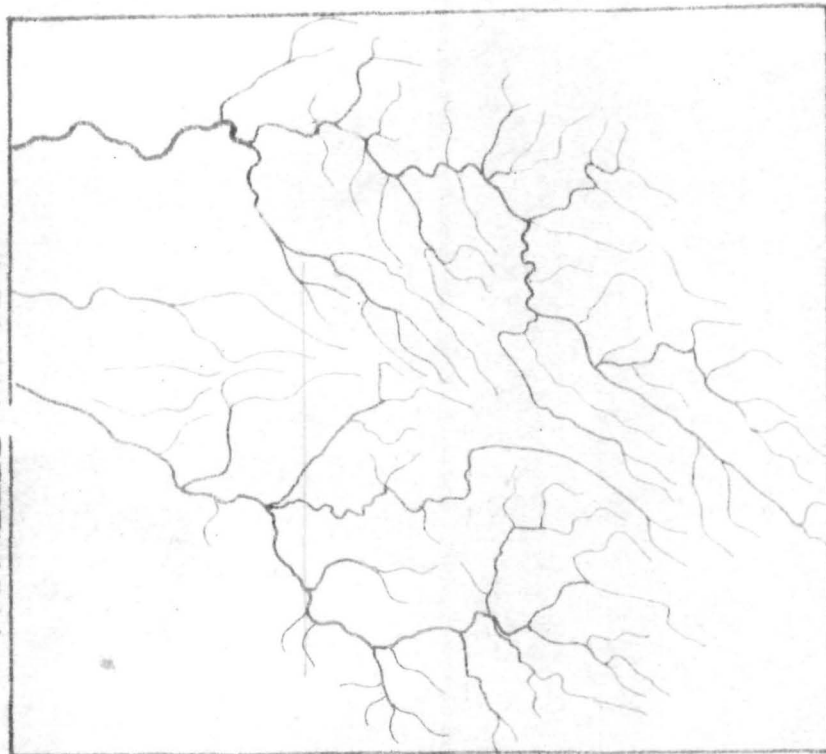


FIG-10

over these areas, thus helping the drainage system to develop in a radial pattern.

In the Khasi Hills district there is a wide distribution of radial type of drainage pattern. Most prominent areas are situated in the southwest, where the rivers of Someswari, Rongkhal and their tributaries drain the region. The lithological characteristics of the rocks underlying them are uniform and the relief consists of isolated mountains of great height. In the central part, the radial pattern is most prominent. This area has some isolated elevated highlands from which the streams could drain out towards all directions. A glance at the relief map (Fig - 4) would reveal that the district is traversed by a few contours in the central and eastern part. The land rises towards southwest where the contours are many and the topography seems to be very rugged. The drainage system is very complex in the central and eastern part of the district where some prominent radial types of drainage patterns are found.

In the Jaintia Hills the drainage system is predominated by radial patterns. This may be due to the presence of a number of isolated domes and peaks from where the rivers are directed to all the sides.

PARALLEL PATTERN :

Joints, cracks and regional slope play significant roles in the development of parallel types of drainage pattern. The

average slope map (Fig - 8) of Meghalaya shows that in the district of Garo Hills the average slope is maximum in the northeast and southeastern part. It will be seen from the drainage map (Fig - 6) that these are the areas in the Garo Hills where one finds parallel type of drainage pattern. In the north and northeast the streams flow in a southnorth direction and they are more or less parallel to each other. The rivers of Dudhnai, Rongronga, Krishnai, Didram, Rongsi etc. in the north display a parallel flow towards north. In some areas of the southeast also one finds the rivers flow almost parallel to each other. The average angle of slope is comparatively steeper in this part of the Garo Hills.

In the district of Khasi Hills one finds from the average slope map that there is a wide variation in the regional slope. The slope increases from north to south and finally in the south the slope is very steep forming an escarpment. A few parallel type of drainage pattern can be noticed in the southern part which coincides with the steep slopes. The rivers of Umiew and Umsohringkhiew and their tributaries in the south display a typical parallel drainage pattern. In the west, too, where the average angle of slope rises upto 9 degrees one finds patches of parallel type of drainage system.

In the Jaintia Hills the slope is very gentle which varies from 0 to 6 degrees in the northern part and on the south the slope is comparatively more. The drainage pattern is not systematic here and a few tributaries on the south run para-

MEGHALAYA
DENDRITIC PATTERN

1 0 4 miles

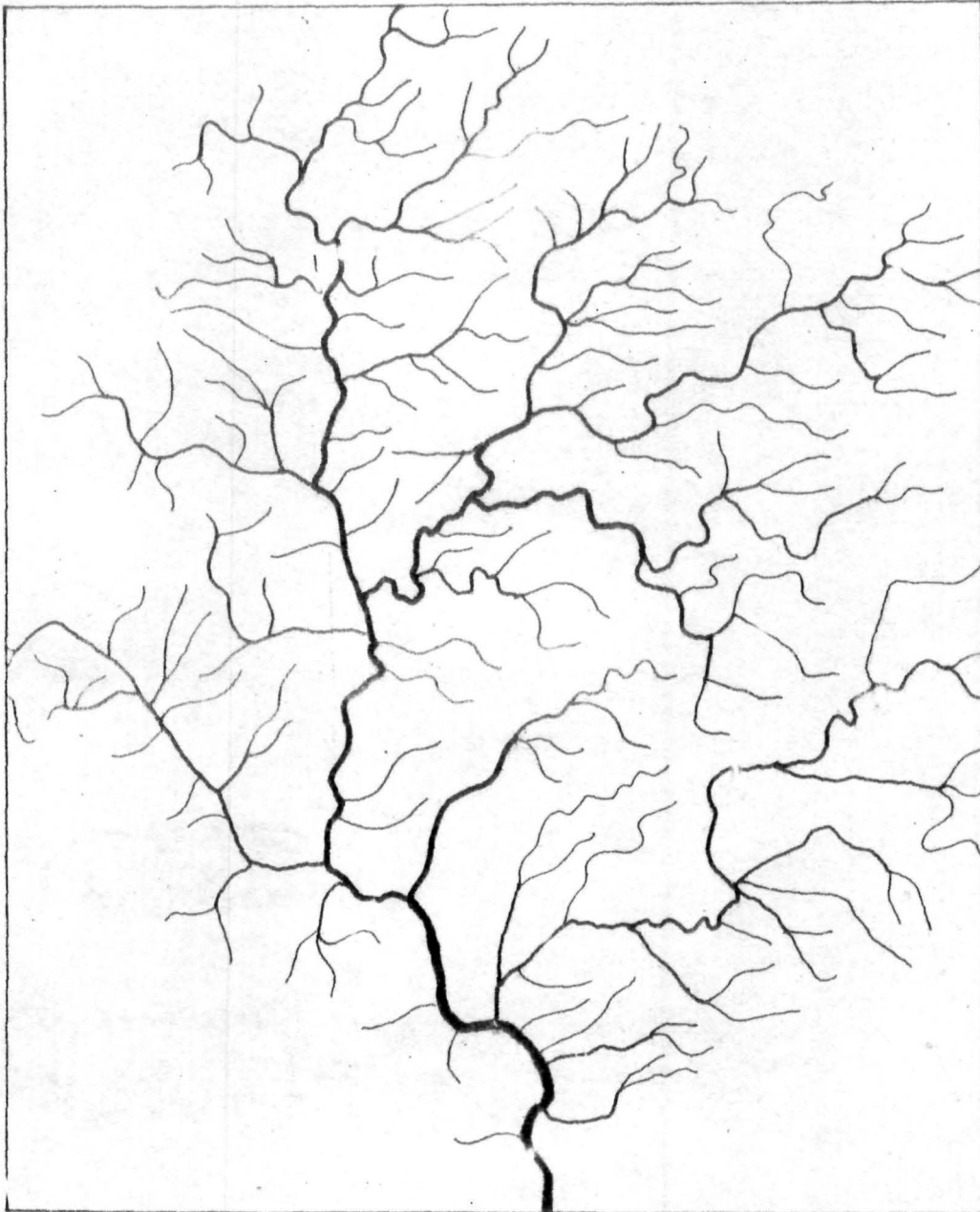


FIG-11

lled to each other.

DENDRITIC PATTERN

Dendritic type of drainage pattern occurs on rocks of uniform resistance to erosion and on gentle regional slopes. It will be seen from the geological map (Fig - 3) that the Garo Hills and Khasi Hills underlie a very complex geological structure while in the Jaintia Hills this variation is much less and has a simpler geological base. It is obvious that with a wide variation in the geological structure there is a little chance for the drainage system to develop a dendritic pattern. A glance at the drainage map (Fig - 6) displays a few patches of dendritic patterns in the districts of Garo and Khasi Hills. But there are quite a number of such patterns to be seen in the Jaintia Hills. The river of Umlunag in the south-eastern Jaintia Hills show a clear dendritic pattern. In Khasi Hills, Wahlaw river and its tributaries flow more or less in a dendritic pattern.

CONTORTED PATTERN

Schumm⁸ has recognized a pattern of drainage system which occurs in areas of complex geology, where dykes, veins, faults or metamorphic rocks control the pattern. This is known as contorted pattern. It will be seen from the geological map (Fig - 3) of Meghalaya that there are a very few parts in the whole region where there is a complex geology with faults and joints. On the southern margin of the state one finds a com-

plex geological structure. Most of the faults and joints are situated in this part of Meghalaya. The drainage map (Fig - 6) of the state reveals that the drainage system in the southern part displays an irregular pattern which may be referred to as contorted pattern.

MULTIPLE RELATIONS AMONG MORPHOMETRIC PROPERTIES :

The fluviially eroded landscapes are composed of drainage basins, and these provide convenient units into which an area can be subdivided. The development of a landscape is equal to the sum total of the development of each individual drainage basins of which it is composed⁹. Keeping this in mind we have analysed the geomorphic processes of the region by taking drainage basins as the units.

There are varying degree of complexity associated with geomorphological data. The simplest way is to analyse a single characteristic of certain landforms as analysed earlier in this chapter. They were measured and their proportions analysed through univariate statistics. In many instances, however the geomorphologists need to know the relations between two variables. This requires the use of bivariate statistics. But, when there are more than two variables to be analysed, it requires the use of multivariate statistics. In the present section an attempt has been made to study the relationship between the morphometric properties of 10 selected 5th order drainage

basins. Since it is not possible to measure the morphometric properties of all the basins in Meghalaya, the analysis was made to be based on a sample drawn from the total area.

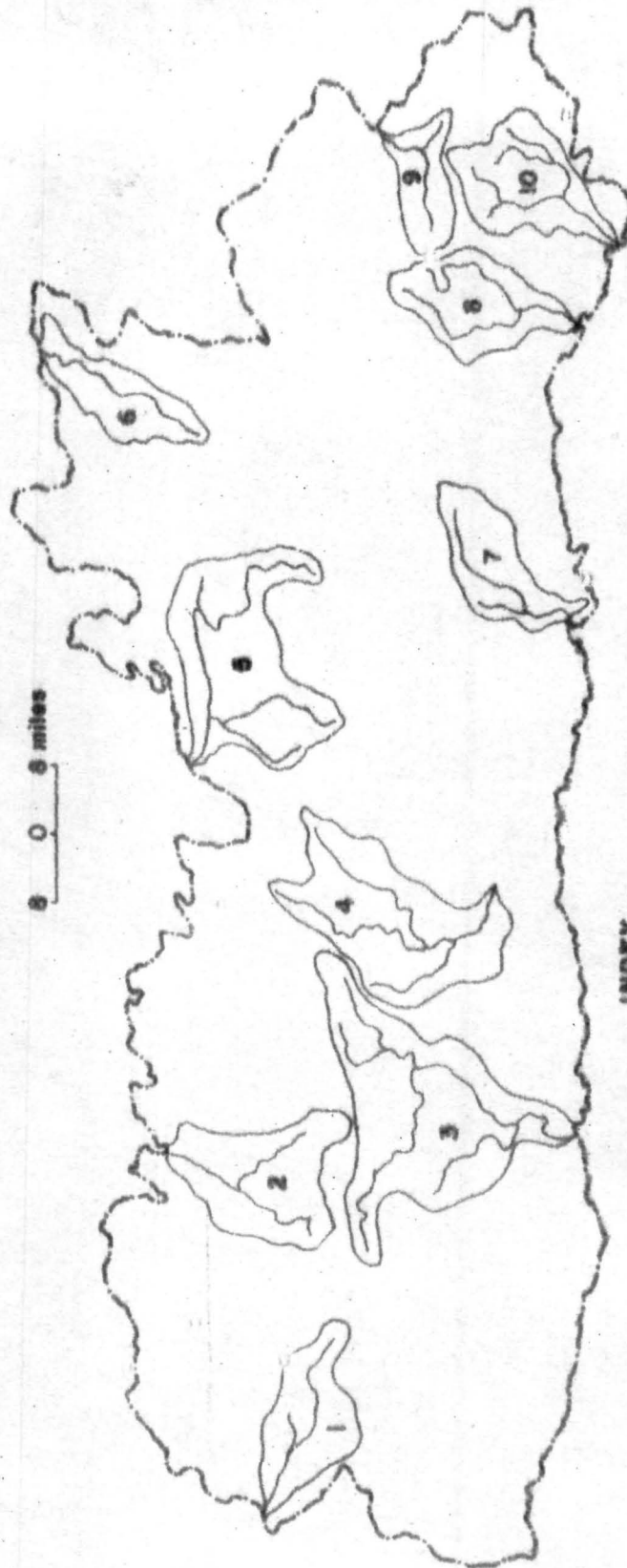
Data Base and Method of Work :

The data which have been used for the present analysis fall into two distinct groups. Some of them are obtained directly by measuring from the map. These include basin area, length of different order streams, number of streams under different orders, etc. Other variables are derived from such direct measurements and include drainage density, stream frequency, bifurcation ratio, etc.

The toposheets which are used for the analysis are quarter inch topographical maps of Meghalaya (Sheet Nos. 78 G, 78 J, 78 K, 78 N, 78 O, 83 B and 83 C) published by the Survey of India. Areas were measured from these maps by graphical method. These values are thus, not ground values but their horizontal equivalents. Lengths and distances were all measured by map measurer. These measurements, too, are the horizontal equivalents of ground lengths. As a result of these measurements the available data for analysis consist of 19 variables as shown in the data matrix (Table - V), either measured or derived from those measured, for the ten fifth order basins - Krishnai, Singwil, Someswari, Khri, Wahlaw, Umiam, Umsiang, Hari, Lubha and Rashu.

MEGHALAYA

5th ORDER BASINS



INDEX

- | | |
|--------------|------------|
| 1. SINGWIL | 6. UMSIANG |
| 2. KRISHNAI | 7. UNIAM |
| 3. SOMESWARI | 8. HARI |
| 4. WAHLAW | 9. RASHU |
| 5. UNKHRI | 10. LUBHA |

FIG-12

TABLE - V
DATA MATRIX

Variables Basins	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Krishnai	372	270	62	32	18	8	1.75	1.68	3.20	4.50	8.00	154	37	10	4	3.59	1.05	0.55
2. Singwil	288	230	40	22	20	4	2.45	1.82	4.40	10.00	4.00	94	21	5	2	4.56	1.10	0.42
3. Somes- wari	852	436	110	40	20	6	1.64	1.29	2.35	10.00	6.00	264	85	17	2	4.60	0.72	0.31
4. Khrī	524	230	60	22	22	6	1.18	1.56	2.44	7.33	6.00	194	39	9	3	3.83	1.07	0.40
5. Wahlaw	432	204	76	44	16	12	1.32	2.05	4.00	5.33	12.00	155	37	11	3	3.55	0.81	0.45
6. Umiam	296	244	92	14	22	4	2.62	3.41	2.80	11.00	4.00	93	27	5	2	4.61	1.27	0.43
7. Umsiang	160	172	60	18	16	3	1.76	2.07	3.00	8.00	3.00	98	29	6	2	3.30	1.68	0.85
8. Hari	308	340	80	42	24	4	1.35	1.57	3.23	8.00	4.00	251	51	13	3	4.04	1.59	1.04
9. Lubha	288	300	116	26	16	8	1.53	2.83	2.26	8.00	8.00	191	41	11	2	4.00	1.62	0.87
10. Rashu	176	170	50	24	12	6	1.53	2.00	3.00	4.00	6.00	111	25	8	3	3.31	1.49	0.84

INDEX TO TABLE - V

<u>Serial No.</u>	<u>Variable</u>	<u>Unit</u>
1.	Area of the basin	Sq.miles
2.	Length of 1st order streams	miles
3.	Length of 2nd order streams	miles
4.	Length of 3rd order streams	miles
5.	Length of 4th order streams	miles
6.	Length of 5th order streams	miles
7.	Mean length of 1st order streams	miles
8.	Mean length of 2nd order streams	miles
9.	Mean length of 3rd order streams	miles
10.	Mean length of 4th order streams	miles
11.	Mean length of 5th order streams	miles
12.	Number of 1st order streams	-
13.	Number of 2nd order streams	-
14.	Number of 3rd order streams	-
15.	Number of 4th order streams	-
16.	Bifurcation ratio	-
17.	Drainage Density	Miles of stream length per sq. miles
18.	Stream frequency	No. of streams per sq.miles.

TABLE - VI
CORRELATION MATRIX

1.00 = Positive 'r' values
1.00 = Negative 'r' values

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1.00	0.73	0.45	0.50	0.36	0.26	<u>0.24</u>	<u>0.48</u>	0.20	0.19	0.13	0.38	0.85	0.72	<u>0.04</u>	0.50	<u>0.78</u>	<u>0.65</u>
2		1.00	0.69	0.53	0.49	<u>0.02</u>	<u>0.10</u>	<u>0.30</u>	<u>0.16</u>	0.43	0.03	0.71	0.90	0.88	<u>0.09</u>	0.59	<u>0.31</u>	<u>0.14</u>
3			1.00	0.28	0.16	0.21	<u>0.10</u>	0.32	<u>0.25</u>	0.40	0.27	0.56	0.62	0.61	<u>0.38</u>	0.42	<u>0.05</u>	0.005
4				1.00	0.09	0.56	<u>0.57</u>	<u>0.55</u>	<u>0.17</u>	<u>0.24</u>	0.57	0.67	0.79	0.89	0.34	<u>0.42</u>	<u>0.42</u>	0.03
5					1.00	<u>0.39</u>	0.18	<u>0.12</u>	<u>0.04</u>	0.62	<u>0.39</u>	0.40	0.30	0.14	<u>0.07</u>	0.66	<u>0.18</u>	<u>0.24</u>
6						1.00	<u>0.47</u>	<u>0.03</u>	0.11	<u>0.57</u>	1.00	0.19	0.12	0.38	0.47	<u>0.30</u>	<u>0.48</u>	<u>0.23</u>
7							1.00	0.52	0.29	0.56	<u>0.47</u>	<u>0.61</u>	<u>0.38</u>	<u>0.60</u>	<u>0.47</u>	0.57	<u>0.004</u>	<u>0.31</u>
8								1.00	<u>0.14</u>	0.28	<u>0.03</u>	<u>0.51</u>	<u>0.47</u>	<u>0.52</u>	<u>0.40</u>	0.16	0.37	0.09
9									1.00	<u>0.12</u>	0.11	<u>0.43</u>	<u>0.47</u>	<u>0.37</u>	<u>0.15</u>	0.34	<u>0.20</u>	<u>0.12</u>
10										1.00	<u>0.56</u>	0.61	0.22	<u>0.09</u>	<u>0.80</u>	0.12	<u>0.04</u>	<u>0.30</u>
11											1.00	0.19	0.12	0.38	0.44	<u>0.53</u>	<u>0.48</u>	<u>0.23</u>
12												1.00	0.81	0.95	0.14	0.22	<u>0.23</u>	0.05
13													1.00	0.95	<u>0.07</u>	0.30	<u>0.41</u>	<u>0.18</u>
14														1.00	0.17	0.16	<u>0.35</u>	<u>0.45</u>
15															1.00	<u>0.51</u>	<u>0.17</u>	0.08
16																1.00	<u>0.34</u>	<u>0.48</u>
17																	1.00	0.89
18																		1.00

The relationships between the above mentioned morphometric properties have been obtained by simple correlation coefficient technique by preparing a correlation matrix (Table-VI). Students 't' test was applied to determine the significant 'r' values at 0.05 level of significance.

ANALYSIS :

A glance at the Table - VII(a), which shows the significantly correlated (positive) variables, reveals that there are 37 relationships which are significant at 95 percent level of significance. This indicates that the drainage characteristics of the basins are the results of a series of interactions between the morphometric properties within those basins.

It can be very clearly seen that in the first set of variables there is a significant positive relationship between the area of the basin and other variables such as the length of 1st order streams (0.75), number of 2nd order streams (0.85) and number of 3rd order streams (0.72). The length of the 1st order streams, in turn, shows positive relations with the length of 2nd order streams (0.69), number of 2nd order streams (0.90), number of 3rd order streams (0.88) and the bifurcation ratio (0.59). It is interesting to observe the relationship between the bifurcation ratio and the length of 1st order streams. This is an indirect relationship which is exposed by the fact that when two variables are correlated individually with a third one, it is accepted that both of them are mutually correlated to each other. In this case the two variables - the bifurcation ratio and

TABLE - VII(a)

POSITIVELY SIGNIFICANT RELATIONS

1. Area of the Basin -		
	a) Length of 1st order streams	- 0.73
	b) No. of 2nd order streams	- 0.85
	c) No. of 3rd order streams	- 0.72
2. Length of 1st order streams -		
	a) Length of 2nd order streams	- 0.69
	b) No. of 1st order streams	- 0.71
	c) No. of 2nd order streams	- 0.90
	d) No. of 3rd order streams	- 0.88
	e) Bifurcation Ratio	- 0.59
3. Length of 2nd order streams -		
	a) No. of 1st order streams	- 0.56
	b) No. of 2nd order streams	- 0.62
	c) No. of 3rd order streams	- 0.61
4. Length of 3rd order streams -		
	a) Length of 5th order streams	- 0.56
	b) Mean length of 5th order streams	- 0.57
	c) No. of 1st order streams	- 0.67
	d) No. of 2nd order streams	- 0.79
	e) No. of 3rd order streams	- 0.89
5. Length of 4th order streams -		
	a) Mean length of 4th order streams	- 0.62
	b) Bifurcation Ratio	- 0.66
6. Length of 5th order streams -		
	a) Mean length of 5th order streams	- 1.00
7. Mean length of 1st order streams -		
	a) Mean length of 4th order streams	- 0.56
	b) Bifurcation Ratio	- 0.57
8. Mean length of 4th order streams -		
	a) No. of 1st order streams	- 0.61
9. No. of 1st order streams -		
	a) No. of 2nd order streams	- 0.81
	b) No. of 3rd order streams	- 0.93
10. No. of 2nd order streams -		
	a) No. of 3rd order streams	- 0.95
11. Drainage Density -		
	a) Stream frequency	- 0.89

TABLE - VII(b)NEGATIVELY SIGNIFICANT RELATIONS

1. Area of the Basins -		
a) Drainage Density	-	0.78
b) Stream frequency	-	0.65
2. Length of 3rd order streams -		
a) Mean length of 1st order streams -		0.57
3. Mean length of 1st order streams -		
a) No. of 1st order streams -		0.61
b) No. of 3rd order streams -		0.60
4. Mean length of 4th order streams -		
a) Mean length of 5th order streams -		0.56
b) No. of 4th order streams	-	0.80

the length of streams are both related to the number of streams and hence (as the 'r' value shows) both of them are related with each other. The relationship between the number of 1st order streams and length of 2nd order streams also shows a positively significant 'r' value. This is because formation of new 1st order streams result in the formation of more 2nd order streams thus increasing their length. The length of 2nd order streams is also correlated with the number of 3rd order streams in the same way.

Another interesting significant positive correlation exists between the number of 1st order streams and the number of 2nd and 3rd order streams (0.81 & 0.93 respectively) This can be explained by the established fact that as the order number increases there is a progressive decrease of the streams in subsequent orders¹⁰. The table also reveals that there is a very high significant relationship exists between the drainage density and stream frequency (0.89). It has already been reasoned the relationship between lengths and numbers of streams. The drainage density which is only the length of streams per unit area, tends to change as the stream frequency, which is the number of streams per unit area changes.

A glance at the Table - VII(b) shows that the area of the basin is negatively correlated with the drainage density (-0.78) and stream frequency (-0.65) at 95 percent level of significance. This indicates that as the area increases both these variables tend to decrease in a particular proportion. It is also

interesting to note that there is a significant inverse relationship between the mean length of the 1st order streams and the number of 3rd order streams (-0.60). In general, it can be noted that the drainage density is related inversely to all the variables except the mean length of 2nd order streams, though the 'r' values are insignificant. Similarly the stream frequency has negative relationship with a major number of other variables.

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CHAPTER - V

GENERAL AGRICULTURAL SITUATION AND LAND UTILIZATION

- * Factors Controlling Agriculture
- * Landuse Pattern
- * Intensity of Landuse

Agriculture in Meghalaya does not present a happy picture picture despite concerted efforts by the State Government to improve the situation. Out of a total geographical area of 2.25 million hectares in Meghalaya, only 2.00 lakh hectares are available for cultivation, thus constituting hardly 8.8 percent of the total geographical area. Nearly 80 percent of the population depends primarily on agriculture. Only 26 percent of the cultivated area is under irrigation. Holdings are small in size and techniques of cultivation absolutely backward, resulting in low farm incomes. A vast majority of operational holdings fall between 1.00 and 3.0 hectares. Not a single operational holding was above the size of 20 hectares in Meghalaya in 1970-71. If we assess the performance in the sphere of agriculture, on the basis of selected economic indicators for agricultural development, the following picture emerges.

Between 1972-73 and 1975-76, the gross cropped area in Meghalaya increased by about 10 percent as against a marginal decrease in Assam, nearly 25 percent increase in Manipur, about 20 percent decrease in Mizoram and approximately 6 percent increase in Nagaland. There was an increase in area under high yielding varieties in Meghalaya during 1973-74 to 1975-76, under all the three crops viz. paddy, wheat and maize.

The area under soil conservation also increased, in Meghalaya, between 1973-74 to 1975-76 by about 37 percent. Consumption of fertilizers, however, declined during the same period, as against an increase in other states in the north-east-

tern region.

The food grain production had also increased from base level of 1.25 lakh tonnes to 1.35 lakh tonnes by the end of 1975-76, showing a growth rate of 4.0 percent. All this has happened because of the persistent efforts made by the State Government to undo the harmful effects of the long neglect of this area.

In Meghalaya, as in other parts of the tribal areas of the northeast region the prevailing method of agriculture is shifting cultivation. This is particularly most intensive in the northern sector of the Khasi and Jaintia Hills, the Garo Hills and the central plateau. The main crop is rice, however, mixed cropping of jhum fields is also being practised by the villagers in varying degree. In the central plateau potato is the main cash crop for which an intensive use of fertilizers is made every year, so as to use the same land for more than one crop by rotation with rice, maize and vegetables. In this type of mixed cropping the need to use natural manures and other fertilizers being very high and the fact that their supplies have to be obtained from long distant places lying beyond Gauhati have placed the farmers in a very difficult position, so that even potato cultivation in Khasi Hills is no longer profitable. There are instances where losses have been so considerably large as to make potato cultivation a losing concern and consequently economic distress in a great measure is found in several villages of the Khasi Hills district.

In the southern slope of Khasi and Jaintia Hills, on farms spread out in the foot hill regions upto an elevation of 300 metres, a mixed cropping pattern practised for centuries by the people is the cultivation of several species and varieties of crop mainly citrus, betelnut, bay leaf, bananas, pine-apples jackfruits, black pepper, coconut and other plants according to the suitability of the soil and climate. Ginger, turmeric and other root crops produce high yield in this part of Meghalaya because of the early rains. In these parts of Khasi and Jaintia Hills, the system of monoculture of plantation has not been taken up, and if practised it may not be found satisfactory at all.

Agriculture has not been able to pick up momentum towards accelerated development due to a large extent to the absence of suitable marketing facilities for the products. This is especially so in the case of the border regions of the state. In absence of suitable measures to provide tangible marketing facilities the development of horticulture in these hills would definitely remain moribund and of no consequence.

Such a diversified and still primitive type of agricultural pattern in Meghalaya is controlled by a number of natural factors. Some of the most important factors include -

- (a) Physiographic characteristics
- (b) Climate, and
- (c) Physical and chemical characteristics of the soil

Physiographic characteristics not only influence the distributional pattern of population and other social characters, but they are also responsible, to a large extent for the agricultural pattern in this region. It has already been mentioned in the second chapter that Meghalaya has four main physical regions. The mainland running from the Jaintia Hills to Garo Hills ending perhaps at the Tura peak and determining the courses of rivers of the states the northern belt bordering Assam, the southern belt bordering Bangladesh and the plain portion of the Garo Hills.

The northern slope which borders the Brahmaputra plain is very fertile. Paddy, maize, sweet potato and banana grow well in this region. Vast areas have been made cultivable by terracing the gentle northern slope. The mainland or the central portion of the state is hilly and agricultural lands are very unevenly distributed. The southern belt bordering Bangladesh is a very gentle slope gradually merging southwards into the Bangladesh plain.

The climate of Meghalaya is solubrious. The temperature hardly falls below 35°F and seldom rises above 80°F . The Garo Hills district is comparatively warmer because of its elevation being lower than the other parts of the state. The rains come mostly in summer. The annual rainfall in the whole state is about 4393.5 mm. The southern belt of Meghalaya gets more rain than do the central plateau and the northern slopes. The northern part is comparatively the driest.

Basically, soils of the Khasi Hills district are lateritic in nature. This is specially true in the case of the southern region and the central plateau due to heavy rainfall. An assortment of red, brown, black and yellow soils is usually found in the northern part of the central plateau and in the whole northern region due to comparatively less rainfall in these areas. The red and brown soils are usually found in the hill tops and the slopes, while the black and yellow soils are confined to the foot hills and swampy valleys. Testing of soil samples from many areas has recently been taken up at the district research laboratory. The soils of the district may be classified as follows :

- a) The soils of the central plateau and the northern region are loamy as erosion is comparatively less in that region.
- b) The soils of the western region tend to become clayey loam as it approaches the regions of the plains district.
- c) The soils of the southern region tend to become more of sandy loam rather than clayey because of heavy rainfall.
- d) The soils of the slopes are generally gravelly and stoney.
- e) The soils in the middle portion of the southern region are found to be calcareous in character due to the presence of limestones. Immediately above this middle portion, which is the main coal region of the district the soils are again shaly in character.

Good fertile soil in plains and valleys is the most important natural endowment of the district of Garo Hills. The

soil in the hill region is composed of shallow coarse grained pebbles mixed with sandy loam. It is light and less fertile. The soil on the hill slopes has less depth due to soil erosion on account of large scale jhuming practices. Cotton, ginger and some millets are grown in these lands. The soil in the plain areas and in the valleys is alluvial and, therefore, more fertile. The forest areas have red clayey soil with a light covering of humers. The soils in the plain areas sustain a variety of important crops of the district.

LAND UTILIZATION

A glance at the Table VIII(a) showing the land use pattern in the Garo Hills district for the year 1971-72 reveals that there is a wide variation between the blocks in terms of the land under different use. The Rongjang block of the district shows the highest percentage of net area sown of 35.22 in comparison to 5.88 percent in Resu Belpara Block. The Block of Jikjak also has a high percentage of net areas sown which is 33.66 percent to the total geographical area. Songsak block has about 50.71 percent of the total area under current and old fallows. Besides, Rongram has 45.32 percent, Chokpot has 33.94 percent and Dambuk has 32 percent. There are blocks like Resu Belpara (3.58 percent) and Salsella (10.20%) which have comparatively lower percentages of land under current and old fallows. Dadenggiri Block records the highest percentage of land under cultivable waste. Resu Belpara also has quite a large area under cultivable waste. Blocks of Jikjak, Betsang, Sal-

TABLE - VIII(a)

BLOCKWISE LAND UTILIZATION : GARO HILLS - 1971-72

Name of the Blocks	Percentage to total Geographical Area							Total
	Net sown area	Current old fallows	Culti-vable waste	Non-Agri. Use	Barren land	Perma-nent pastu-res & Misc. land	Forest	
1. Resu Belpara	5.88	3.58	21.62	19.00	19.36	17.86	14.71	100.00
2. Dalu	NOT AVAILABLE							
3. Songsak	15.07	50.71	1.48	0.61	3.77	10.52	17.84	100.00
4. Rongram	24.11	45.32	13.29	0.91	1.50	14.33	0.54	100.00
5. Selsella	21.66	10.20	2.37	11.24	20.47	13.82	20.24	100.00
6. Betasing	24.99	14.87	3.06	1.59	1.88	36.53	17.09	100.00
7. Dambuk Aga	9.36	32.00	17.69	1.45	27.34	0.21	12.00	100.00
8. Jikjak	33.66	11.84	0.88	1.92	12.72	14.26	24.72	100.00
9. Rongjeng	35.22	11.54	2.53	4.65	22.91	13.79	2.38	100.00
10. Dadenggiri	10.71	17.46	42.42	2.57	4.14	6.68	7.02	100.00
11. Chokpot	12.93	33.94	9.87	5.92	2.51	24.39	10.44	100.00

TABLE - VIII(b)Blockwise Land Utilization 1971-72Khasi Hills

Name of the Blocks	Net Area sown	Current old fallows	Culti-vable waste	Non-Agri. use	Barren land	Perma-nent pastu-res & Misc. land	Forest	Total
1. Myllicm	13.41	21.87	38.04	10.92	3.20	5.10	7.41	100.00
2. Mawphlang	13.31	4.78	66.12	5.23	4.32	3.82	2.42	100.00
3. Mairang	13.42	5.22	49.75	1.22	2.00	1.57	26.81	100.00
4. Mawsynram	16.27	0.66	30.09	1.63	12.77	17.08	21.50	100.00
5. Mawkyrwat	8.91	4.18	56.10	1.79	16.52	4.78	7.72	100.00
6. Mawryngkn-eng	25.14	7.57	35.12	4.06	5.63	4.31	18.17	100.00
7. Nongstein	2.47	1.56	50.01	0.40	17.14	2.20	18.22	100.00
8. Pynursla	9.21	1.56	56.79	1.48	24.77	4.15	2.06	100.00
9..Shella-Bholaganj	13.37	0.99	45.30	1.58	25.87	5.14	7.25	100.00
10. Bhoi area	5.01	0.76	44.17	1.43	15.33	3.17	29.93	100.00

TABLE - VIII(c)Blockwise land utilization 1971-72Jaintia Hills

Name of the Blocks	Net area sown	Current & old fallows	Culti- vable waste	Non- Agri. use	Barren land	Perma- nent pastu- res & Misc. land	Forest	Total
1. Thadlaskein	13.54	8.96	11.66	6.35	14.84	31.68	12.97	100.00
2. Khliehriat	13.64	16.45	7.02	15.94	5.42	30.32	3.21	100.00
3. Laskein	13.00	0.51	21.96	7.13	27.25	14.96	15.19	100.00

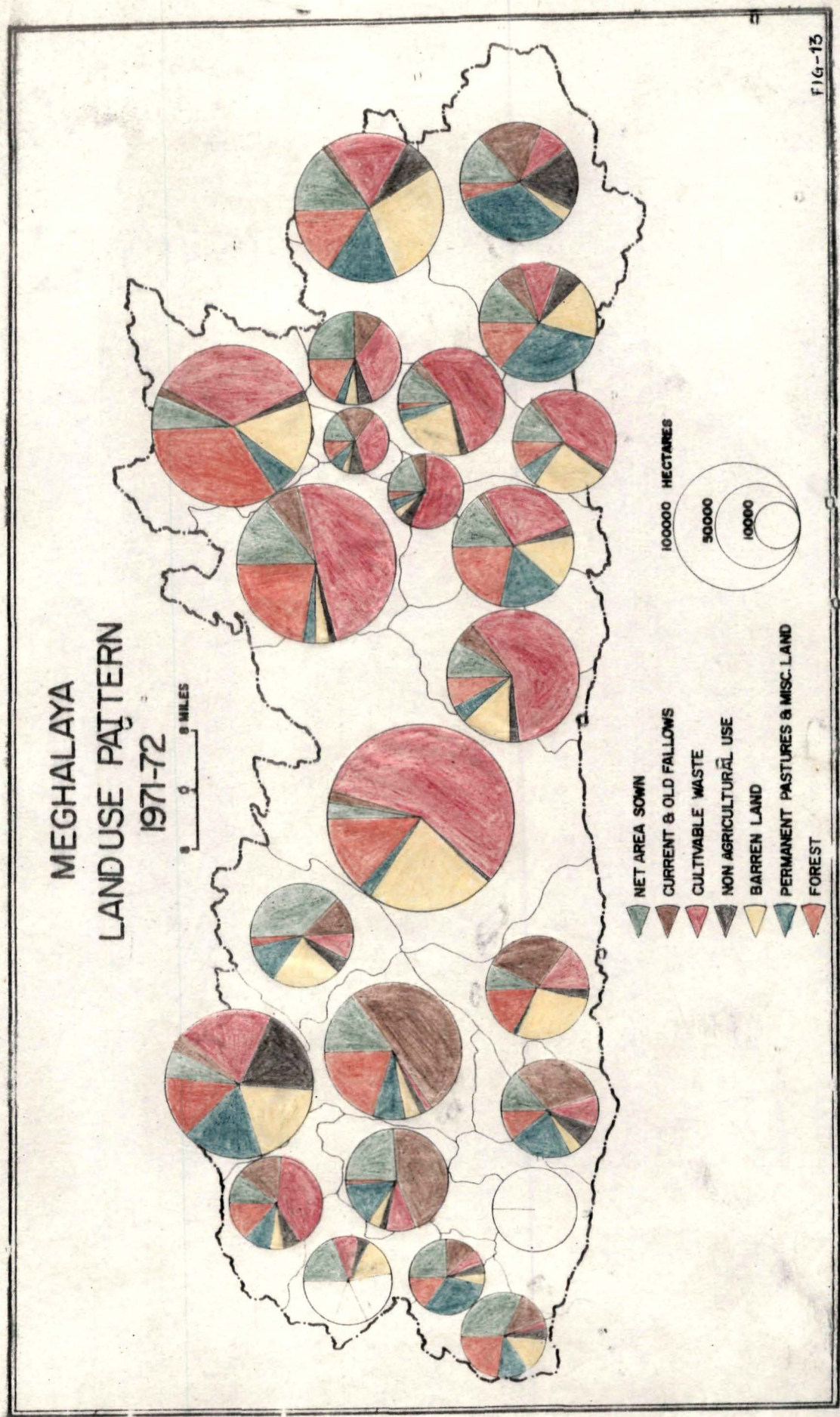


Fig-13

sella and Songsak have respectively 0.88 percent, 3.06 percent, 2.37 percent, 1.48 percent of their total geographical areas under cultivable waste respectively. About 19 percent of the total area in Resu Belpara Block is under non-agricultural use. Next comes Salsella which has 11.24 percent. All other blocks have less than 5 percent of the total area under this category. Forest occupies about 24.72 percent of the total area in Jikjak Block. Only 0.54 percent of the area in Rongram Block is occupied by forest. The land under permanent pastures and miscellaneous use is very high in Betsang Block (36.53%) in comparison to only 0.21 percent in Dambuk Aga block.

In 1975-76 (Table IX(a)) there is a rapid decline in the percentage figures of the net sown area in most of the blocks. In Songsek the percentage has come down by roughly 2.5 percent. In Rongram block only 10.9 percent of the land in 1975-76 is reported to be under net area sown in comparison to 24.11 percent in 1971-72. The decline is maximum in the block of Jikjak where in 1975-76 only 13.3 percent of the land was under the category of net area sown in comparison to 33.66 percent in 1971-72. Land under current and old fallows is very high in Songsek Block in 1975-76. There has been an increase from 50.71 percent in 1971-72 to 77.33 percent during 1975-76 in this block. Rongjeng Block shows the lowest percentage of area, 2.3 percent under current and old fallows during 1975-76. About 55.25 percent of the total geographical area in Selsella is under cultivable waste. Chokpot block has 18.82 percent of its area under this category. Other blocks have comparatively lower percentage

of land under cultivable waste. Except Dadenggiri which has 16.75 percent of the land under non-agricultural use, all other blocks have very low percentages under this category. About 57.79 percent of the total area in Resu Delpara is under permanent pastures and land under miscellaneous use. Salsella Block records only 0.79 percent of its land under this category. Forest occupies about 39.2 percent of the land in Jikjak and only 0.26 percent in Chokpot.

In Khasi Hills district 14.32 percent of the area is under net area sown compared to 24.81 percent of the Garo Hills district. This district has a vast expanse of forest which accounts for 19.22 percent of the total geographical area. A glance at Table - VIII(b) reveals that about 25.11 percent of the total geographical area in Mawryngkneng Block is occupied by crops. Out of the rest, 35 percent is under cultivable waste. Most of the blocks in the district record their highest percentages of land under cultivable waste. This may be due to the fact that people are more engaged in tertiary activities least bothering about agriculture from which they would not get sufficient output for living. As much as 66.12 percent in Mawphlang block is under cultivable waste. This block borders the urban area of Shillong city. Besides Nongstoin block has 58.01 percent of the total geographical area under cultivable waste. In this block lies one of the largest sillimanite mines in India. As much as about 11 percent of the area in Myllem Block is under non-agricultural use. One can include under this category the land utilized for urban purposes. In Mawsynram Block 17.08 percent of the land is under permanent pastures where as 16.27 percent is under

TABLE - IX(a)BLOCKWISE LAND UTILIZATION - 1975-76GARO HILLS

Name of the Blocks	Net sown area	Current old fallows	Culti-vable waste	Non-Agri. use	Barren land	Perma-nent pastu-res & Misc. land	Forest	Total
1. Resu Belpara	18.19	3.54	1.41	3.57	1.31	57.79	14.24	100.00
2. Dalu	37.61	25.75	8.39	1.07	4.18	12.48	10.52	100.00
3. Songsek	13.51	77.33	0.07	2.41	0.83	1.38	4.47	100.00
4. Rongram	10.90	42.86	0.84	2.30	1.66	2.15	33.29	100.00
5. Selsella	26.96	14.07	55.25	2.21	1.22	0.79	-	100.00
6. Betasing	NOT AVAILABLE							
7. Dambuk Aga	9.35	34.15	18.93	9.30	12.18	9.94	6.15	100.00
8. Jikjak	13.30	8.56	13.12	0.92	15.11	9.79	89.20	100.00
9. Rongjeng	35.86	2.30	15.58	8.87	14.51	5.92	16.96	100.00
10. Dadenggiri	35.21	29.06	9.45	16.75	0.34	4.63	4.57	100.00
11. Chekpot	10.98	29.47	18.82	6.93	20.35	13.19	0.26	100.00

TABLE - IX(b)Blockwise Land Utilization 1975-76Khasi Hills

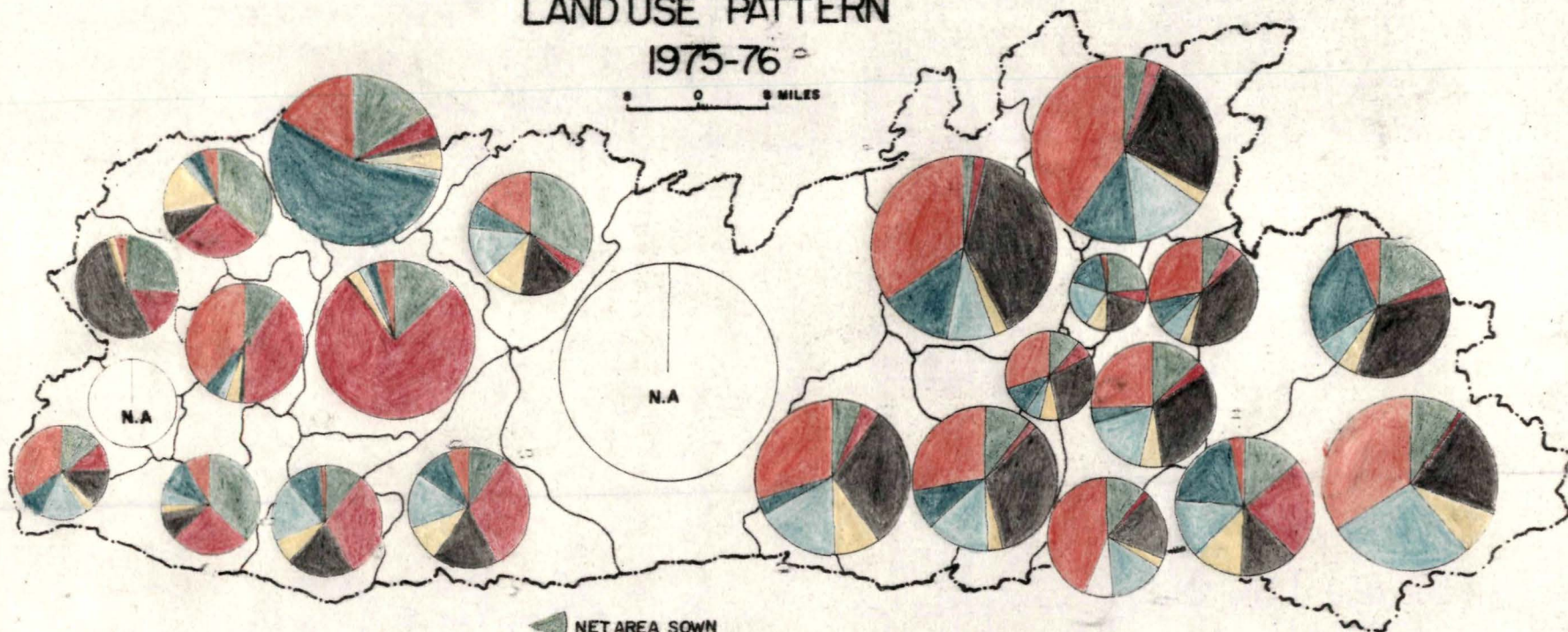
Name of the Blocks	Net area sown	Current old fallows	Culti-vable waste	Non-Agri. use	Barren land	Perma-pas- tures Misc. land	Forest	Total
1. Myllem	24.23	4.75	14.34	5.79	21.95	21.49	7.45	100.00
2. Mawphlang	10.83	4.65	31.21	5.23	4.32	9.70	34.07	100.00
3..Mairang	0.97	1.03	41.31	1.22	4.91	9.75	40.86	100.00
4. Mawsynram	7.27	0.58	33.54	1.63	10.23	8.61	38.14	100.00
5. Mawkyrwat	5.25	4.02	29.62	7.64	16.52	2.99	33.96	100.00
6. Mawryngkneng	5.67	5.30	39.91	4.14	5.63	10.76	28.60	100.00
7. Nongstoin	NOT AVAILABLE							
8.Pynursla	8.99	1.51	32.39	4.93	15.56	7.75	22.87	100.00
9. Shella-Bhollaganj	9.86	0.92	20.69	1.60	14.51	6.93	45.49	100.00
10.Bhoi Area	2.21	1.12	26.48	1.43	13.05	13.93	41.78	100.00

TABLE - IX(c)Blockwise Land Utilization 1975-76Jaintia Hills

Name of the Blocks	Net area sown	Current & old fallows	Culti- vable waste	Non- Agri. use	Barren land	Perma- nent pastu- res & Misc. land	Forest	Total
1. Thadlas- kein	13.75	26.93	9.05	10.10	11.57	27.07	7.53	100.00
2. Khliehriat	16.65	2.34	33.79	3.24	4.30	32.93	6.76	100.00
3. Laskein	6.78	0.31	23.41	6.30	26.30	-	36.66	100.00

MEGHALAYA LAND USE PATTERN 1975-76

0 5 MILES



- NET AREA SOWN
- CURRENT & OLD FALLOWS
- CULTIVABLE WASTE
- NON AGRICULTURAL USE
- BARREN LAND
- PERMANENT PASTURES & MISC. LAND
- FOREST

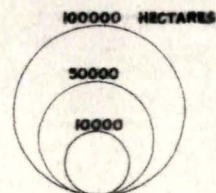


FIG-14

net area sown. It becomes clear that the population in this block extract their living more from the livestock than from direct cultivation.

In the year 1975-76 there has been a remarkable change in the land utilization in the Khasi Hills district. The figures under most of the categories have sharply come down (Table - IX(b)). All the blocks except Myllem record a decline in the percentage figures under this category of net area sown. Only Myllem, which had 13.44 percent of the land under net sown area has 24.23 percent in 1975-76 under this category. As low as 0.92 percent of the total geographical area in Mairang Block is recorded under net area sown during the same period of 1975-76.

Table VIII(c) shows that in Jaintia Hills district, Khliehriat Block records the highest percentage of area under net area sown which has 13.64 percent under this category. Thadlaskein block has 13.54 percent of the total area under the same category. The Laskein Block also has approximately equal percentage of land under net area sown. Only 0.51 percent of the area in Laskein is occupied by current and old fallows against 16.45 percent in Khliehriat and 8.96 percent in Thadlaskein are under the same category of land use. About 38.32 percent of the total area in Khliehriat is under permanent pastures and land under miscellaneous use. Thadlaskein has 31.68 percent and Laskein has 14.96 percent under the same category.

During the period of 1976-76 the district records an increase in land under various categories such as net area sown, current and old fallows (Table - IX(c)). There has been an increase of 0.21 percent in the land under net area sown in Thadlaskein block and 3.01 percent in Khliehriat block. But Laskein block has a decline of about 7.78 percent in the area under net area sown. Land under forest has come down to 7.53 percent in Thadlaskein because of extensive jhuming practices, but has increased to 6.76 percent and 36.66 percent in Khliehriat and Laskein blocks respectively.

INTENSITY OF LANDUSE

Landuse is the basic concept of rural society. It is the key to an understanding of a geographic adjustment of the agricultural resources. Expansion of cultivated land is a major means to increase the agricultural status of an under-developed economy. In order to assess the landuse pattern for agricultural planning, one needs to identify the variations in the intensity of landuse in a particular geographical region. It gives the possibilities and scope for future agricultural development.

The data which have been used for the present study include the total cropped area and the area sown more than once for the blocks of Meghalaya during the period 1974-75. The Chokpot block of the Garo Hills district has not been taken into consideration because of unavailability of data for the same block.

The method of finding out the intensity of landuse(I) in Meghalaya includes simple calculation of percentage of area sown more than once(D) to the total cropped area (T) by the following formula :

$$I = \frac{D}{T} \times 100$$

These percentage figures have been grouped into five classes in order to simplify the variation between the blocks- less than 5 (very low); 5 to 15(low); 15 to 25 (medium); 25 to 35(high); and above 35 (very high).

A glance at the map (fig - 15) would reveal that a major portion of the state is occupied by a very low group of landuse intensity varying between 0.19 to 4.57 percent. In total, nine blocks fall under this category out of all the 23 blocks. Mawsynram (2.32) and Shella-Bhollaganj(0.19) of Khasi Hills district; Selsella (2.12); Rongram (3.92); Songsek (3.61) and Dam-buk Aga (4.57) of the Garo Hills district and all the three blocks of the Jaintia Hills district - Thadlaskein (1.90), Laskein (0.25) and Khliehriat (2.55) show very low intensity of landuse. It can be seen from the Table - X that these blocks show very little area under double or multiple cropping. For example in Shella-Bholaganj with a intensity of 0.19 percent, only 15 hectares out of 7720 hectares of total cropped land area under the area sown more than once. A comparison with the slope map of the region (Fig - 8) would reveal that these blocks fall under steep slope categories where the general practice of agriculture is

MEGHALAYA INTENSITY OF LANDUSE

8 0 8 miles

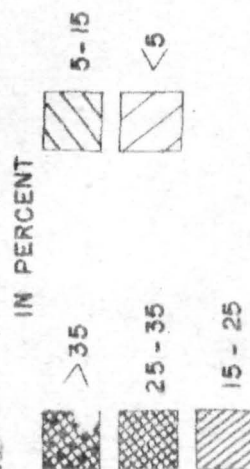


FIG-15

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INTENSITY OF LANDUSE - 1974-75

Blocks	Total Cropped Area (in Hectares)	Area sown more than once	Intensity

1. Myllem	4794	1284	26.78
2. Mawphlang	5373	1243	23.13
3. Mairang	13019	1469	11.28
4. Mawsynram	7120	165	2.32
5. Mawkyrwat	6064	575	9.48
6. Mawryngkneng	4175	1015	24.31
7. Nongstoin	5214	434	8.32
8. Pynursla	8698	883	10.15
9. Shella-Bholaganj	7735	15	0.19
10. Bhoi Area	14482	4379	30.24
11. Jikjak	21770	2348	10.79
12. Betasing	13026	2108	16.18
13. Selsella	16972	360	2.12
14. Rongram	13380	524	3.92
15. Dadenggiri	19568	7513	38.39
16. Chokpot	-	-	-
17. Resu-belpara	23664	2083	8.80
18. Songsek	16114	582	3.61
19. Rongjeng	38240	2002	5.24
20. Dambuk Aga	6810	311	4.57
21. Dalu	11981	978	8.16
22. Thadlaskein	12134	230	1.90
23. Laskein	15039	38	0.25
24. Khliehriat	10023	256	2.55

either jhuming or monoculture.

Under the next category come eight blocks which have been referred here as having low intensity of landuse. The blocks of Mairang (11.28), Mawkyrwat (9.48), Nongstoin (8.32) and Pynursla (10.15) of the Khasi Hills and Jikjak (10.79), Resubelpara (8.80), Rongjeng (5.24) and Dalu(8.16) of the Garo Hills fall under this category. It will be interesting to note that Dalu which is a ten-crop combination region(Fig - 17) shows such a low landuse intensity. This may be attributed to the fact that this block with comparatively lower share of area sown more than once, experiences more frequency of rotation of crops.

The blocks of Mawphlang and Mawryngkneng of Khasi Hills and Belasing of Garo Hills district fall under the next category of medium landuse intensity. About 24.31 percent of the cropped area in Mawryngkneng, 23.13 percent in Mawphlang and 16.18 percent in Betasing are sown more than once.

There are only two blocks in Meghalaya - Myllem(26.78) and Bhoi Area (30.24) of Khasi Hills district which show high landuse intensity. In Myllem 1284 hectares out of 4794 of total cropped area is under double cropping (Table - X). Bhoi Area which is a four crop combination region shows 4379 hectares of area sown more than once out 14432 hectares of total cropped land. The highest intensity of landuse is found in the block of Dadenggiri where 38.39 percent of the total cropped land is sown more than once. A glance at the Table - XIV would reveal that

the main crops of this block are rice and cotton. Rice, which occupies about 53 percent of the total cultivated land allows a few pulses to be rotated on the same fields; while cotton, which covers 8.08 percent of the total cropped areas in this block is rotated with jute and mesta which occupy over equally high percentage of the cultivated area.

CHAPTER - VI

CROPPING PATTERN AND CROP COMBINATION REGIONS

- * Cropping Pattern
- * Principal Crops
- * Crop Combination Regions
- * Shifting Cultivation
- * Mechanization of Agriculture

CROPPING PATTERN :

In order to have a proper understanding of the agricultural characteristics in any region one has to know the cropping pattern of that region. Geomorphology plays a very important role in the cropping pattern of an area particularly in a hilly terrain like Meghalaya. In this region most of the crops are spatially very unevenly distributed. This is so because in this region the physiographic characteristics mostly control the cropping pattern.

CROPPING PATTERN IN JHUM LAND :

Jhum lands are normally mono-cropped but almost always under mixed cultivation. Local paddy varieties commonly covered under the term "hill paddy" is the main crop though varieties may differ in different altitudes and localities. Mixed with paddy are grown different crops like sesamum, pumpkins, arums and others which are consumed mostly to meet the farmer's own need. Crops like ginger, cotton, millets, maize, soyabean, tapioca, etc. are also grown in jhum land mixed in different combinations. The crops are mostly sown alongwith pre-monsoon rains by March-April and harvested at different time extending to November - December depending on duration of the crops involved. Improvement in agriculture and better utilization of land in such areas would involve the following :

1. Conversion of mild slopes into terraces for growing field crops.

2. Growing of fruits in moderate hill slopes without going for regular terraces but preferably with half-moon terraces.
3. Utilization of steep slopes for reserve forest only.

CROPPING PATTERN IN THE CENTRAL PLATEAU

Potato is the main food crop in the central plateau. Cole - crops are also widely grown in this region but mostly confined within 25/30 Km. radius of Shillong. Improved varieties of potatoes have already been introduced and are getting popular. Paddy, maize and soyabeans are other crops grown in this region, most often in a mixed cropping.

Wet paddy cultivation is also practiced in narrow valleys between the hills. The recognized high yielding paddy varieties of all - India standard area, however, not suitable for this region though a few local improved varieties have been developed suitable for the area and is getting popular.

Double cropping has been slowly introduced specially in flat land involving an early potato crop (February to May) to be followed by paddy (June - November). Introduction of wheat is also under experimentation in this region as a second crop after potato. Findings so far indicate that it may be a successful second crop and the growers are only to be motivated for growing and using it. Barley can also prove a successful crop which would be a better substitute for rice for brewing.

MEGHALAYA

AGRICULTURAL LANDS

0 0 5 miles

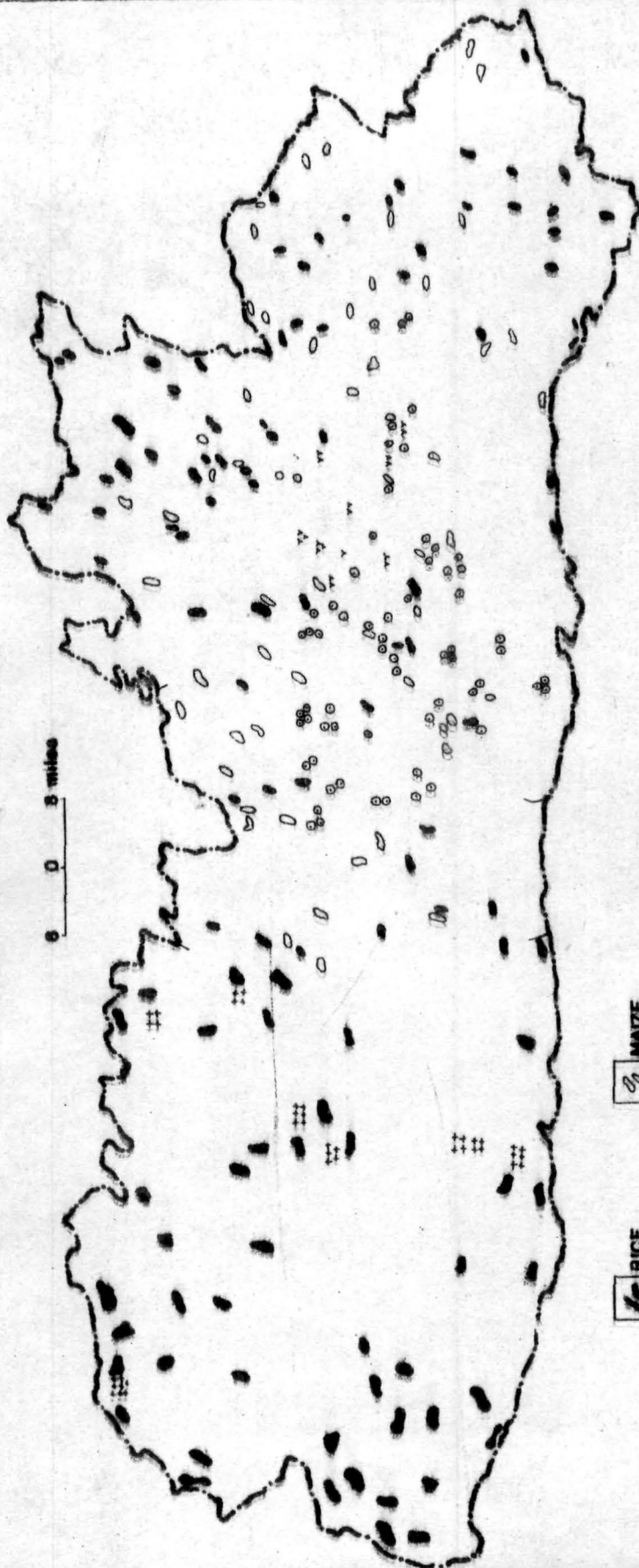


FIG - 16

BORDER AREAS AND THE SOUTHERN SLOPES :

The southern slopes from the end of central plateau down to the valley adjoining Bangladesh is generally very steep. Rainfall is also very heavy there. The crops commonly grown in the areas are horticultural and plantation crops such as oranges, bananas, pineapple, jackfruit, arecanut, betel leaf, blackpepper and peepul and bay leaf. In the pre-partition days the main market for these commodities was the then East Bengal now Bangladesh. With the creation of a separate country, the normal trade channels were choked and the people have been economically hard hit. To bring their produce up to the plateau and then down the northern slope to Assam plains and outside has proved to be too costly to stand any competitive marketing. Cultivation of grain crops in these slopes are also not considered economic. It is considered that subsidiary food crops like tapioca, yams, etc. can be suitably grown in many areas of the region.

SUB-MONTANE REGION ALONG NORTHERN SLOPE :

Paddy is the predominant crop of the region grown both as jhum crop in hill slopes and as wet paddy in the valleys. In either case, it is mainly a rainfed kharif crop. Maize and millets are the other two cereals grown extensively in this region.

Other than cereals, crops are grown in this region are cotton, jute and mesta, all confined to the Garo Hills district; Oilseeds like mustard and sesamum also confined to the Garo

Plate No.8



Plate No.9



Hills; ginger, turmeric, mostly confined to the district of Jaintia Hills. Experimental plantings have indicated that sunflower can also be a suitable oilseed crop in the upwards of the region. The fruit crops suitable for the region are also pineapple, bananas, citrus fruits, guava, etc. Some of the moderate slopes can be converted into beautiful orchards.

THE PRINCIPAL CROPS

Although the land under cultivation is quite low compared to the other states, there are a variety of crops grown in Meghalaya. Crops include both food crops such as rice, maize, potato, fruits, etc. and non food crops such as jute, cotton, oilseeds, etc.

Three varieties of rice are grown in this region viz. autumn rice, winter rice and spring rice. The sowing time for autumn rice is March to May and the harvesting time is July to August. The sowing time for winter rice is June to August. The crop is harvested in November and December. Spring rice is sown during the months of October and November and is harvested in February and March. Among these varieties it will be seen from the table that winter rice covers the maximum area. But from the point of view of productivity, spring rice is more important. The average yield per hectare of spring rice is 3,501 Kg., whereas the yield of winter rice is 1203 Kg. The area under different varieties of rice and the output under each variety is given below¹ :

TABLE - XI

<u>Variety of rice</u>	<u>Area in hectares</u>	<u>Production in tons</u>
Autumn rice	31,200	24,305
Winter rice	67,440	79,444
Spring rice	1,500	3,000

Rice is grown throughout the state. The best variety of rice is produced in the Sung area near Jowai.

Maize is next in importance as a food crop. In 1973-74 the area under maize cultivation was 15,600 hectares. The area increased to 18,000 hectares in 1974-75.

The cultivation of wheat was almost negligible a few years back. In 1973-75, the area under wheat was only 615 hectares. But it increased to 1500 hectares in 1974-75. This indicates that wheat cultivation is finding favour with the people. Different high yielding varieties of wheat have been introduced since 1974. In 1976, the Govt. of Meghalaya introduced two high yielding varieties of wheat, namely, the Sonalika and the Girija, bringing the total varieties to fifteen. In 1976-77 Government encouraged an extension in wheat cultivation to cover an area of 15,000 hectares. The Government plans to introduce wheat as a second crop in all irrigated areas and valleys with residual moisture.

Among the different varieties of oil seeds, rape and mustard are the most important. Seesamum and castor are grown

on a smaller scale. In 1974-75, the area under mustard and rape was 6105 hectares, but in the case of sesamum and castor, the area was 475 hectares and 33 hectares respectively.

Cotton, jute and mesta are also grown in the state. Cotton is grown mainly in the Garo Hills. The production of cotton for the years 1969-70, 1970-71 and 1971-72 was 3.6, 4.1 and 4.1 thousand bales respectively. Jute and mesta are grown in the Garo Hills. The production of these two fibre crops in 1974-75 was 58.14 thousand bales.

Among the different types of commercial crops in the state, the most important is potato. The temperature, the seasons in which it is grown, and soil conditions have given an impetus to the production of seed potato in the state. In Meghalaya, the potato crop can be raised upto 3 and 4 times in a year. This cycle is unmatched anywhere else in India. Potato is grown mainly on the slopes of the hills throughout the state. The most extensively grown varieties in the state are the Arran - Consul, the Great Scott and the Royal Kidney. The average annual production of potato is about 74,000 tonnes. The area under potato cultivation is 18,000 hectares.

Tapioca is one of the staple food of the people of Meghalaya. The crop grows in abundance in the western part of the Khasi Hills, particularly in the Ri War border areas.

Fruit growing has a profitable future in Meghalaya. A varieties of fruits are grown extensively over most of the parts

TABLE - XII**Area and Production of Principal Crops****1975-76**Area in Hectares
Production in Tonnes

Name of crops	Khasi Hills		Jaintia Hills		Garo Hills		Meghalaya	
	Area	Production	Area	Production	Area	Production	Area	Production
1. Rice	27,050	35,240	19,952	22,429	57342	61,633	1,04,344	119302
2. Wheat	29	40	-	-	1471	1760	1500	1800
3. Maize	6260	4326	4970	2748	4954	4250	16184	11324
4. Pulses	46	26	30	19	1413	933	1489	976
5. Oilseeds	62	26	37	19	7040	3551	7139	3596
6. Jute (in bales)	-	-	-	-	5000	35000	5000	35000
7. Mesta (in bales)	-	-	-	-	7000	25200	7000	25200
8. Cotton (in bales)	-	-	-	-	7542	3353	7542	3353
9. Sugarcane	22	80	3	12	180	720	205	812
10. Arecanut	4690	3474	1020	488	355	181	6065	4143
11. Potato	15320	64955	2000	5571	660	3354	17980	73880
12. Tapioca	1070	6300	-	-	905	3972	1955	10272

in this state. The fruits which are in great demand are pineapples, oranges, bananas, plums, pears, peaches and apricots.

The pineapples grown in Meghalaya and other north-eastern region are considered to be one of the best varieties in India. It is a tropical crop and it grows well in warm humid areas. The crop grows well in areas with a high rainfall. In the Khasi Hills district, the bulk of pineapple production comes from the southern part in the Dawki area. Cultivation has now been extended to the north and along the Shillong - Gauhati road.

Good quality oranges are produced in this state; the most important variety grown in Meghalaya is the Khasi Mandarin which has great commercial value. Oranges are grown extensively in the War border areas. The best type are grown in the Shella area of the Khasi Hills. The scope for extensive cultivation of different varieties of citrus fruits to sustain and develop this industry exists in the state.

CROP COMBINATION REGIONS :

The study of cropping pattern, crop combinations and diversifications are some of the imperative and useful techniques, as far as agricultural planning of developing economies are concerned. They enable the farmers in returning an optimum profit by identifying the suitable combination of the crops. For the present study Weaver's minimum deviation method

has been adopted to analyse and identify the crop associations in Meghalaya.

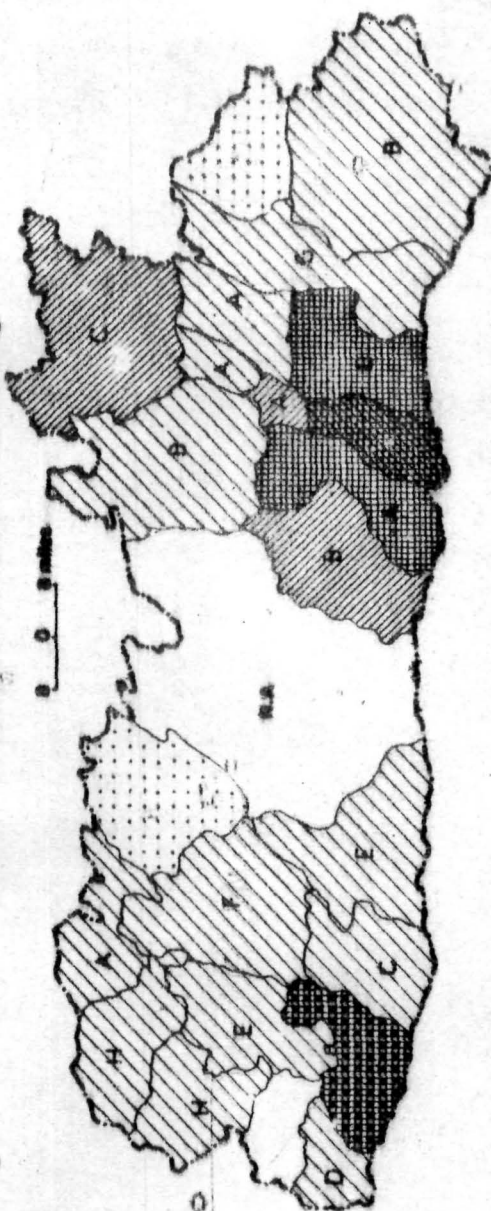
METHOD OF WORK : J.C. Weaver² has suggested a simple and convenient method of finding out the various combinations of crop, having significant share in the total cropped area. He defined a theoretical curve based on the area of crop land being equally divided between the individual crops in the combination ranging from 100 percent in a region of monoculture to 10 percent in ten-crop combination region. He then measured the actual crop percentage in the combination against his theoretical curve. He used the standard deviation formula without extracting the square root because he was interested in relative rank of deviation from the expected, and not the actual magnitude of deviation. The formula is expressed as follows :

$$S^2 = \frac{\sum d^2}{n}$$

Where d is the difference between the actual and expected values of crop percentage and n is the number of crops in a given combination. The minimum of S gives the best fit for each unit. Thus, by applying the above formula for Meghalaya, seven combinations have emerged. The blocks falling into different combinations are given in table XIII and are plotted in Fig - 17.

MEGHALAYA

CROP COMBINATION REGIONS



N.A. DATA NOT AVAILABLE

R RICE
M MAIZE
P POTATO
C CEREALS
O OTHER CEREALS
V OTHER VEGETABLES
F OTHER FRUITS
P PINEAPPLE
T TAPIOCA
T TOBACCO
J JUTE
C COTTON
R RAPESEED
S SESAMEUM
P PULSES
P PAILLEAF
B BAYLEAF
A ARECA NUT

R R
A M
B P
C J
D R
E R
F R
G R
H R
I R
J R
K R
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ZB R
ZC R
ZD R
ZE R
ZF R
ZG R
ZH R
ZI R
ZJ R
ZK R
ZL R
ZM R
ZN R
ZO R
ZP R
ZQ R
ZR R
ZS R
ZT R
ZU R
ZV R
ZW R
ZX R
ZY R
ZZ R

FIG-17

TABLE - XIII

<u>No. of crops</u>	<u>No. of Blocks</u>	<u>Name of Blocks</u>
1	2	Khliehriat, Rongjeng
2	13	Myllem, Rasubelpara, Maw- ryngkneng, Mairang, Chokpot, Laskin, Jikjak, Rongram, Dambuk Aga, Songsek, Thad- laskein, Selsella, Daddeng- giri.
4	3	Mawphlang, Bhoi Area, Mawkyrwat.
6	2	Mawsynram, Pynursla
7.	1	Shella-Bhollaganj
10	1	Dahu

MONOCULTURE : There are two blocks in the state - Khliehriat of Khasi Hills district and Rongjeng of Garo Hills district show monoculture of rice. Khliehriat, with a flat surface and gentle slope, covers 69.31 percent of the cropped area under rice cultivation. Since there is a remarkable variation in the relief in the Rongjeng block in relief, rice is grown on terraces and the crop occupies 87.29 percent of the total cropped area.

TWO - CROP COMBINATIONS : In Meghalaya, 13 blocks show two crop combinations. Out of this the Garo Hills district contains 8 and Khasi Hills district 5 blocks. Although a large number of blocks are under this category, there is a remarkable variation in the combinations of the crops. It will be seen from the table - XIV that the most important of these combinations is

rice - maize which cover the three blocks of Myllem and Mawryngkneng of Khasi Hills and Resubelpara of Garo Hills district. Other important combinations include Rice - potato, Rice - fruits and Rice - cotton covering two blocks each. Rest of the combinations are found to be scattered all over the area. It is interesting to notice that out of the above mentioned 8 combinations, rice constitutes the major crop in seven.

FOUR - CROP COMBINATIONS : The blocks of Mawphlang, Mawkyrwat and Bhoi area of the Khasi Hills district show four crop combinations. It will be seen from the relief map (fig-4) that all these blocks are parts of the central plateau with a little variation in the relief. In all these regions rice is the only common crop which occupies the most share in Mawkyrwat block. Other important crops within this combination are Tapioca and other fruits in the Bhoi area.

SIX - CROP COMBINATIONS : There are two combinations observed in the state with six crops each. In Mawsynram area nuts is the first crop with rice, potato, pan-leaves, pineapples, and bayleaf to follow; whereas in Pynursla, bayleaf occupies the major portion of the cultivated area with areca, panleaf, pineapple, other vegetables and potato as the succeeding crops.

SEVEN - CROP COMBINATIONS : Shella - Bhollaganj of the Khasi Hills district shows seven - crop combinations with rice as the major crop and rape seed and mustard constituting as the 7th crop. Other crops are potato, other vegetables, other

TABLE - XIV

<u>No. of crops</u>	<u>Crops in order</u>	<u>Blocks</u>
1.	Rice	Khliehriat, Rongjeng
2.	a. Rice - maize	Mylliem, Resubelpara, Mawryngkneng.
	b. Rice - potato	Mairang, Laskin
	c. Rice - other fruits	Rongram, Dambukaaga
	d. Rice - cotton	Selsella, Dadengiri
	e. Rice - jute	Chokpot
	f. Rice - other cereals	Jikjak
	g. Rice - bayleaf	Songsek
	h. Other vegetables - other cereals	Thadlaskein
4.	a. Potato - maize - other vegetables - rice	Mawphlang
	b. Rice-maize-other fruits - other cereals	Mawkyrwat
	c. Other fruits-rice-tapioca-potato	Bhoi area
6.	a. Areca-rice-potato-panleaf-pineapple-bayleaf	Mawsynram
	b. Bayleaf-areca-panleaf-pineapple-other vegetables-potato	Pynursla
7.	Rice-potato-other vegetables-other fruits-maize-other cereals-rapeseed	Shella - Bhollaganj
10.	R-J-F-R _p -V-C-M-S-P-T	Dalu

fruits, maize and other cereals.

TEN - CROP COMBINATIONS : This is the maximum number of crops grown proportionately in one of the blocks of the state. The block of Dalu in the Garo Hills shows this combination of ten crops with rice as the main crop. This region is one of the important jute producing areas of the Garo Hills which occupies 12.36 percent of the total cultivated area while rice occupies 41.83 percent. This is the only block in the state where tobacco is cultivated over a considerable area ranking as the tenth crop of this region. Cotton occupies 3.01 percent which is the 6th crop of the combination.

The state falls broadly into three agro-climatic regions : (a) areas bordering Bangladesh, (b) the central plateau and (c) the sub-tropical regions bordering Assam. The border area stretches downwards from where the central plateau ends towards the plains of Bangladesh in the south. It is the main region where tropical and sub-tropical fruits are grown. The central plateau is the highest region in the state where high altitude paddy, maize, millets, potatoes, etc. are grown. The sub-tropical regions bordering Assam is dominated by paddy and maize as principal crops.

SHIFTING CULTIVATION : The characteristic features of shifting cultivation are the rotation of fields rather than of crops, the clearing of fields by means of fire, and the use of human labour without the aid of animals. Shifting cultivation does not take recourse to artificial irrigation or manure, and

places reliance on the use of a dibble stick or hoe. The initial investment in shifting cultivation is small. A jhum field is occupied for a short period, then it is left fallow for a long period to regain its fertility by natural means. The period of fallowing depends upon the pressure of population and the availability of land.

The different stages involved in shifting cultivation are selection of site, clearing the site by cutting down the jungle, burning the debris to ashes, offering worship and sacrifice, dibbling and sowing seeds, weeding, watching and protecting the crops, harvesting, thrashing and storing, celebrating the harvest and leaving the field to fallow.

Shifting cultivation is generally done on the slopes in this region. A variety of crops are grown on the jhum fields. The crops depend on the agroclimatic conditions of the area and the needs and food habits of the people. The crops include highland paddy, maize, millet, potato, tapioca, cotton and vegetable.

A jhum field is used for cultivation for one to three years. Then the field is abandoned for natural recuperation. The jhum cycle is estimated by the North-Eastern Council³ as 5.47 years for Meghalaya which compares unfavourably with that of Mizoram and Arunachal Pradesh.

Table - XV shows the rotation of crops adopted by the Jhumias in Meghalaya. It will be seen that in Garo Hills the jhum fields are given to millets, maize, cotton, sweet potatoes

TABLE - XVROTATION OF CROPSGARO HILLS

<u>First year</u>		<u>Second year</u>	
Kharif	Rabi	Kharif	Rabi
(i) Millets, maize, cotton, sweet potatoes, vegetables, pignon peas	-	(i) Short duration paddy, tobachu, tapioca, lac.	-
(ii) Paddy, maize, millets, sesamum, yam, hilly cucumber, brinjal, peas	-	(ii) Small millets, pignon pea, vegetables	-

KHASI AND JAINTHIA HILLS

<u>First year</u>		<u>Second year</u>	
Kharif	Rabi	Kharif	Rabi
(i) Maize, rice, millets, kri, sweet potatoes, pumpkins, ginger, cucumber, tapioca, beans	-	(i) Short duration paddy or millets or both mixed	-
(ii) Maize, beans	Potato	(ii) Maize, mixed paddy, Potato vegetables	
(iii) Potato	Cabbage	(iii) Potato	Potato

Source : Majid Husain (1979); Agricultural Geography; Delhi, Inter-India Publication; P.67

vegetables, peas, etc., in the Kharif season of the first year. The same field in the next year is occupied by paddy, tobacchu, tapioca, etc. during the same period. It is interesting to note that the jhum fields are left fallow during the Rabi season in Garo Hills. But in case of Khasi and Jaintia Hills districts, potatoes and cabbage occupy the fields during Rabi season and in this district mixed cropping is usually practised during the Kharif season of the subsequent year. This type of mixed cropping generally involves cereals of inferior quality and vegetables.

TABLE XVI

	Total Reported Area	Net Area Sown	Area Available for jhum	Area under jhumming at one point of time
IN LAKH HECTARES				
Meghalaya	27.79	1.68	4.16	0.76
N.E. Region	227.35	29.42	26.95	4.53

Source : Majid Husain (1979); Agricultural Geography, Delhi, Inter-India Publication; P. 71.

Out of the total reported area of 27.79 lakh hectares, 4.16 lakh hectares are available for jhumming in the Meghalaya plateau. The area brought under shifting cultivation in Meghalaya is approximately 76 thousand hectares or 18.46 percent of the total geographical area annually.

IRRIGATION :

Irrigation projects were started earlier by the Government of Assam, but all those were minor schemes. Cultivators were given incentive in the form of subsidy. It was later found that such practice of giving incentive was not very helpful since the schemes did not benefit a large number of cultivators.

Though having the two rainiest places in the world namely Cherrapunjee and Mawsynram in Khasi Hills, water is not available for cultivation in flat lands because it flows quickly down to the streams and rivers. Thus to bring more plots under permanent paddy cultivation, irrigation has been assigned high priority since the state was created.

Till 1976, the total area under cultivation was estimated at 2,60,000 hectares of which about 100,000 hectares were under paddy cultivation. During 1970-72 about 7110 hectares were irrigated and by March 1974 about 10,500 hectares were covered by the minor irrigation schemes⁴.

Being a state with hilly difficult terrains, there is certainly difficulty in implementing the irrigation schemes. There is flat land with an area of about 3000 hectares which could be irrigated for agricultural purposes.

MECHANIZATION OF AGRICULTURE :

Any development in a dynamic sphere like agriculture must be backed by what is known as modernization or mechanization of agriculture. Technical knowledge which is used synonym to mechanization is accumulated by means of two processes : inventions and innovations⁵. Invention is the introduction of new production processes and techniques to the existing stock of knowledge. Innovation is the adoption of those processes and their translation into actual production processes⁶.

Development of agriculture is most vital for the integrated development of an agrarian state like Meghalaya where nearly 85 percent of the population live in rural areas depending mainly on agriculture for their livelihood. In recent years there has been some changes in the agricultural practices as far as mechanization is concerned.

TABLE - XVIICONSUMPTION OF FERTILIZERS AND PESTICIDES IN STATE

	Total Consump- tion of fertili- zers in tonnes	Per hec- tare con- sumption in Kgs.		Total Consump- tion of pesticides in tonnes	Per hec- tare con- sumption in Kgs.
1972-73	2750	15.10		12	0.06
1975-76	4182	26.32		18	0.09

In the year 1974-75 there were 55 tractors, 67 power tillers, 2192 sprayers and dusters in use in Meghalaya. The total consumption of fertilizers has increased from 2750 tonnes in 1972-73 to 4182 tonnes in 1975-76. The table - XVII shows that there has been a very slow growth in the per hectare consumption of pesticides. In the year 1975-76 the per hectare consumption is 0.09 Kg. against 0.06 Kg. in 1972-73.

TABLE - XVIII

AREA UNDER HYV (1976-77)

Crop	Total area under cultivation in hectares	Area under HYV in hectares	Percentage of area under HYV
Rice	1,06,133	10,500	9.89
Maize	15,676	4,750	30.30

As far as high yielding varieties of rice and maize are concerned it has been found out that there are no suitable high yielding varieties for the higher altitude ranges. However, there has been some success in increasing the production by using high yielding varieties. The table - XVIII shows that in 1976-77 only 9.89 percent of the total area under rice is occupied by high yielding varieties, whereas 30.90 percent of the area is occupied by high yielding maize varieties.

Although the state of Meghalaya is passing through a phase of transformation in agriculture, the rate has so far not been spectacular. There is a need to develop suitable varieties of rice and maize and to increase the number of agricultural implements so as to increase the productivity level.

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CHAPTER - VII

CONCLUSION

Made up largely of the Pre-cambrian rocks, the Shillong plateau is stated to be an extended but disconnected part of the Peninsula. The prevailing rocks of the plateau have more in common with the gneissic and Dharwar rocks of Bengal and Bihar than those of more neighbouring Himalayan sequence. The region contains marks of peneplanation on its bare face which ranges from Pre-cambrian to recent and sub-recent periods. The present height of the plateau owes its origin to the upliftment of the block during the Jurassic times. The highly dissected and irregular terrain in the western and northern faces makes the physiographic features, characteristic in this plateau. In contrast, the southern face is characterized by the regular and steep fall down to the Surma plain.

The study of the geomorphic processes of the region reveals that the process of slaking of weathering activity is most common. The Shillong group of rocks are generally composed of quartzite - schists which show an interaction of mechanical and chemical weathering. The region of most intensive chemical weathering is the southern margin of the plateau where the Sylhet Traps are exposed in a narrow east-west strip. In general, it is evident that the complex processes of weathering in Meghalaya is influenced by a number of factors, the most important of which are lithological and structural characteristics of rocks and climatic characteristics of the region. Thinking in terms of the fluvial cycle of erosion, one can say that most of Meghalaya is in a youth stage of the

cycle. The 'V' shaped valley profiles, numerous short tributaries and gullies and a number of waterfalls suffice the above statement. In general, the plateau represents a multi-cycle landscape.

The analysis of the average slope in Meghalaya leads to conclude that the most important factor which is responsible for the varying slope characteristics in the plateau is mass movement. In the plateau which experiences heavy rainfall throughout most of the year, movement on the surface is caused directly by the action of the falling rain and surface runoff. The excess material tend to be carried downslope by the force of gravity thus gradually steepening the slope. This is the case in the southern part of the plateau where the average slope is comparatively higher. Variations in the lithological composition of rocks also effects the average slope in the Meghalaya plateau. Areas of less resistant rocks show steeper slopes as in the case of southern Khasi Hills and eastern Garo Hills. The higher angles of slope in the southern part of the Jaintia Hills may be due to the fault lines. As far as stream frequency distribution is concerned, it seems clear that the relief primarily controls the stream frequency in Meghalaya. When superimposed on the relief map it will be seen that on lower elevations streams are less in number and vice versa. Comparatively higher number of streams in the southern margin may be due to steep escarpments present in that region. As observed from the multivariate analysis of the morphometric properties of the drainage basins, it seems clear that there are a number of morphometric characteristics which

are significantly intercorrelated with one another, both positively and negatively. Thus, one can say that the drainage characteristics of a basin are dependent upon one another in the evolution of a fluvial landform.

A glance at the agricultural pattern in Meghalaya shows that there is a wide variation in the spatial distribution of crops. A close examination would further reveal that this distribution is primarily influenced by the relief and slope and soil conditions. In the central plateau potato is the chief cash crop grown mixed with other vegetables, rice and maize. In the southern slope of Khasi and Jaintia Hills a mixed cropping pattern is practised for centuries by the people. They produce several spices and varieties of crops mainly citrus, betelnut, bayleaf, bananas, pineapples, jackfruits, black pepper, coconut and other fruits. The fields are spread out on farms in the foot hill regions upto an elevation of 300 meters. The northern slope which borders the great Brahmaputra valley with a gentle slope is very fertile. Terracing is widely practised here. Coming southwards to the mainland of the central plateau, the state displays an uneven, rugged terrain. Agricultural lands here are found to be irregularly distributed. In general it can be observed that there are four distinct agricultural regions in Meghalaya as far as the soil and topographic conditions are concerned.

I. The Western Lowland : The northern and the western peripheral area of the Garo Hills come under this agricultural region. In this zone low lying crops such as rice and jute are

predominantly grown. The region lies below the 150 meters contour and covers a major portion of the Old Alluvium soil belt of Garo Hills. It produces cotton along the margin touching the forest region. Most of the blocks in this region show association of two crops.

II. The Northern Slope : Bordering the great Brahmaputra valley of Assam, the northern slope of Khasi Hills extend as far as to the north of Khri and Umlra rivers. The general elevation averages to about 150 meters. It covers the old alluvial soil belt of Khasi Hills. Upland wet crops such as rice and maize are predominant. Rice is cultivated mainly in the intermontane valleys and foot hills.

III. The Southern Region : Rainfall plays a very important role in the agricultural pattern in this region. The region forms a narrow strip of Khasi and Jaintia Hills running along the Indo-Bangladesh border. It also follows the 150 meters contour. Adequate rainfall in summer, warm conditions and fertile hill slopes are the main physical conditions. Fruits dominate the total output of this region. Orange, jack-fruit, betel-nut of Khasi and Jaintia Hills come mainly from this region. The crop association in this region varies from six to ten crops with fruits common in most of the combinations.

IV. The Central Plateau : The central part of the eastern Khasi Hills including the Shillong area in the south and Nongpoh area in the north, come under this agricultural

region. This is a triangular belt with less vegetation cover, moderate climatic conditions and somewhat rocky soil. These conditions limit the cultivation of crops. However, on gentle slopes potatoes and fruits like pear, plum, etc. are grown by terracing.

The practice of jhuming in Meghalaya since historical past indicates that it has been very much influenced by the geomorphic characteristics of the region. In the ancient time due to the lack of plain surfaces available for cultivation, the early settlers of such a dissected topographic region might have preferred jhuming as their means of living. Thus, the practice of jhuming appears to be very much associated with the topography of the region.

The foregoing analysis explains the fact that there exists a close relationship between geomorphology and agriculture in Meghalaya. With the findings in mind a few suggestions can be made for further improvement of agriculture and better utilization of land resources in this region.

1. In the central plateau, the soil and topographic conditions favour for the production of wheat. So, it can be successful second crop in this region.
2. Some of the moderate slopes of the submontane region can be converted into extensive fruit growing areas.

3. In order to check the surface erosion and runoff resulting from jhuming practices there should be

- (a) a conversion of mild slopes into terraces for growing field crops.
- (b) fruits should be grown in the moderate hill slopes without going for regular terraces but preferably half moon terraces; and
- (c) the steep slopes are to be utilized for reserve forests only.

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