GEOMORPHOLOGY AND AGRICULTURAL DEVELOPMENT IN LUNGLEI DISTRICT MIZORAM

ABSTRACT

A THESIS SUBMITTED FOR
THE AWARD OF THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN
GEOGRAPHY

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JULY, 1986

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This is to certify that the thesis entitled ***"Geomorphology and Agricultural Development in Lunglei District, Mizoram"****, submitted by Mr. P. Rinawma to the Department of Geography, School of Environmental Sciences, North Eastern Hill University, Shillong, Meghalaya for the degree of Doctor of Philosophy (Ph. D) is a bonafide study of the author to the best of my knowledge and belief. All the quotations, extracts and ideas of the other studies have been duly referred to. This thesis may be sent to the examiners for necessary evaluation.*

Shillong
The 10.7..1986

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ABSTRACT

In the present study, an attempt has been made to find out the links and the influences of the regional geomorphological factors, viz., Relief, slope, drainage etc. on agricultural development of Lunglei district, Union territory of Mizoram. As Lunglei district is full of rugged hilly topography, its lithological and structural characteristics of rocks, it has ample scope for the investigation of geomorphological processes and its agricultural development. It is quite sure that the agricultural practices of the area has emerged under the influences of the regional processes of landforms and their characteristics manifestations. The present study is a humble attempt in the same direction.

The study area lies between longitude 92°35'E to 93°55'E and latitude 22°35'N to 23°35'N. The region is demarcated by Bangladesh in the west, Aizawl district in the north, Burma in the east and Chhimtuipui district in the south. The total area of the district covers about 4538 sq. kilometres.

METHODS OF STUDY

To study the essential elements of terrain of Lunglei district it has been undertaken measurement and analysis of surface morphological features by employing standard geomorphic techniques. For example, the morphometric techniques which have been used in the present study include the characteristics and nature of average slope, drainage density, stream frequency, superimposed profiles etc. It also includes mathematical calculations to obtain various data from the drainage basins. In this connection the following techniques have been used: stream ordering, law of stream numbers, law of mean stream length, stream frequency, drainage density, sinuasity indices and bifurcation ratio. The above methods have been used to compare the results and for further generalization and correction of accuracy, extensive field studies have been undertaken.

In Chapter I of the study the general introduction and a brief survey on available literature have been attempted. Various studies on regional geomorphology in different part of the world as well as in the Indian context have been done. A general introduction about the study area, its location, salient features, sources of materials, methods of study and a brief working plan of the study have been done.

In Chapter II, the genral account of geology, geological history, structural characteristics of rocks and tectonic history of the region have been discussed. The structural characteristics of rock formations of Lunglei district reveal that the area falls within the part of Tripura-Mizoram mio-geosynclinal basin which evolved after the regional upliftment of Barail group of sediments and thus was related with the plate behaviour in the subduction zone of west Arakan-Yama, after the spreading of Indian Ocean. The rocks of this region are similar with that of Himalayan ranges of other north eastern part of India. This region, in course of Himalayan upliftment has been uplifted to its present height and the geomorphic processes are still in its initial stages.

In Chapter III, evolution of landform, geomorphic processes like different types of weathering and fluvial geomorphic cycle have been discussed. The study of evolution of landform and geomorphic characteristics of Lunglei district reveal that the area is predominates by hilly dissected and immature landform. The study of geomorphic processes reveal that the mechanical weathering predominates mainly in the steep and gentle slopes where Jhum cultivation is practised. The repeated process of heating and cooling of sandstones and shales which are poor conductor of heat give rise to stress and strain in the upper layers of rocks mass in the temperature thus disintegrate the rock surface due to excessive burning for the Jhum land. Chemical weathering predominates, mainly in the steep slope in the form of hydration and solution upon the softer rocks. Rockfalls and landslide is a common feature throughout the region especially along the major road cutting and steep hill slopes. The cycle of erosion is still in its youthful stage.

In Chapter IV of this study, various hill slope elements, analysis of average slope, stream frequency, drainage pattern and identification of erosion surfaces has been discussed. In the study of various hill slope elements, it is interesting to note that the pediment is missing and the debris slope is more prominent. The hillslope .elements of Lunglei district indicates the immature topography. Being a young topography of the region the slopes are still developing stage. The average slope of Lunglei district varies between 2 to 45 degrees and above. The variation in slopes are directly influenced by the topography, Lithological and structural characteristics of the underlying rocks. It is clear that in the initial stage there was a tremendous faulting and folding took place in the area. Gradually due to some agents of erosion the landscape changes gradually to its present forms. The major areas of Lunglei district is covered by 3-6 stream per sq. mile. North western part show higher stream frequency of 6-7 stream per sq. mile. Relief, climate, vegetation are the physical factors which are responsible for the drainage density but the most important being lithology and structural characteristics of rocks. Two main drainage pattern has been identified such as parallel and sub-parallel and rectangular pattern. The drainage pattern of the district reflects the influence of initial slopes, inequalities in the rock hardness, structural controls, folded topography, infiltration capacity and the geomorphic history. Due to presence of break in gradient in the longitudinal profiles of the river suggest the rejuvenation of the old erosion surface. Numerous waterfalls of the region indicates the rejuvenation of the area in recent past. The researcher has identified two erosion surfaces with the help of superimposed profiles, longitudinal profiles, and generalized contours and with the help of field evidences.

In Chapter V, the quantitative analysis of ten sample drainage basins of the region have been discussed. In this chapter the researcher has discussed the morphometric techniques in two separate aspects, viz., the linear and the areal aspects. In the linear aspects stream ordering, law of stream numbers, law of stream lengths, sinuosity indices, and in the areal aspects, drainage density, constant of channel maintenance, stream frequency have been correlated and discussed.

The quantitative analysis of ten selected small basins reveals that there is no direct relationship between area and number of stream segments, while the area is directly correlated with the length of the streams. The hypothesis, that bifurcation ratios within a basin decreases with the increasing order has been confirmed. Empirical data from ten selected basins of the district allows evaluation of relief and the laws of stream number and laws of mean stream lengths on a senile erosion surface. Due to dissected topography and lack of well-developed relief, the valley network is not complete. The standard sinuasity indices indicates that only Saitumlui and Darkhuanglui flow in a straight course, while the rest eight streams flow in a sinuas course. All the basins with a high topographic sinuasity and high hydrolic sinuasity index indicates that these basins are still in their early stages of development. The study of drainage density brings out an interesting relationship with the relief. It has been found that a rise in drainage density occurs with increasing relief in all the ten small drainage basins.

In the Chapter VI attempt has been made to regionalise the area into micro-geomorphic region. On the basis of superimposition of morphometric maps viz. streams frequency, relevant profile, dissection pattern, geological map, relief, slope, drainage system nature of erosion and structural characteristics of rocks Lunglei district is delineated into three micro-geomorphic regions such as:

i) Moderately dissected undulating hill region of the west.

ii) Highly disssected, denudated and sharp crested region and

iii)Central and Eastern Escarpments.

In the Chapter VII of the study the agricultural framework, the factors which control the agriculture, general landuse, cropping pattern, agricultural methods and techniques and shifting cultivation has been discussed. The study of agricultural framework reveal that Lunglei district is agriculturally backward while about 90 per cent of the total workers are directly or indirectly engaged in agriculture as cultivators and agriculture labourers. The district produces only 30 per cent of the total rice requirement of the district. The growth and development of agriculture was not encouraging during the past decades due to several factors such as:

1) Geomorphic characteristics like (a) Nature of Terrain (b) Problem of Irrigation (c) Uncertainty of rainfall (d) Uneven distribution of rainfall (e) Frequency of cyclones (f) soil erosion.

2) Pattern of human behaviour.

3) Location in reference to market.

The regional study of land use in Lunglei district reveals that planned use of land resources has not yet started and the agriculture methods techniques and implements in the district are very backward due to several physico-economic factors. Due to inhospitable nature, environment and difficult terrain about 90 per cent of the total farmers practice Jhum cultivation.

Chapter VIII deals with the study of the impact of morphometric attributes on agriculture landuse from the five selected villages of Lunglei district. The study throws the light that the agricultural landuse pattern in the district indeed is the result of the interaction of the physical and the historico-socio-economic factors. The prominent governing factors of agriculture in the region are various morphometric attribute like rugged and dissected relief, steep gradient of slope, inadequate water supply to irrigate the field and to some extent nature and amount of rainfall.

Chapter IX deals with the influence of landforms on location and distribution of rural settlement and transport and communication. In this chapter effort has been made to explain the relationship between landform characteristics viz., relief, averge slope, drainage and climatic condition with location and distribution of rural settlements. The study confirms that the density of population decreases from east to west. The most important factor is a east-west increase of humidity and temperature which results into a general unsuitability of the climate for human habitation. The study also reveals that due to rugged topography and dissected terrain with numerous narrow deep valleys and escarpments the development of roads and communication lines is very difficult.

Having studied the different aspects of the physical background and the pattern and problems of landuse in Lunglei district it related to the factors of physical geomorphological and to some extent the socio-cultural factors of the area. The geomorphic aspects dominates the pattern of land use in the entire area. Rugged topography and great differences in elevation and relief brings about contrasts in climate, surface drainage and underground water-supply. These factors influences the pattern and development of agriculture in this region.

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ACKNOWLEDGEMENTS

I express my deep sense of gratitude to my teacher and guide Prof. **R.K.Rai** Dean, School of Environmental Sciences, North-Eastern Hill University, for his valuable guidance and keen interest throughout the course of my research work. I wish to express for his intelligent criticism and constant encouragement all along the course of this investigation but for which this study would not have been possible.

I am deeply indebted to Prof. **T.B. Lahiri,** Head of the Department of Geography, North-Eastern Hill University, Shillong for encouraging and providing me with all the necessary facilities in the Department.

I am also grateful to Dr. Gopala Krishnan, Reader, Department of Geography, North-Eastern Hill University, who was always ready to suggest and solve the problems that come during the investigation and analysis. My sincere thanks are due to other members of the teaching staff of the Department of Geography, North-Eastern Hill University and fellow colleagues in the department for their cooperation and help.

I would like to acknowledge the special debt which I owe to my friends Dr. Prakash Panda, Dr. Sahu, B.s. Mipun, Garish Panda and Jahangir Khan, Senior Research Scholar in the Department of Geography, for their valuable suggestions and useful comments.

Grateful thanks are due to Shri L. Sangma, Senior Geologist, geological Survey of India, Eastern Circle, Shillong and Shri S.K.Singh Gaur, Director, Economic Geology Division, Geological Survey of India for their stimulating discussions and suggestions.

I also extend my thanks to the librarians of the North-Eastern Hill University, Shillong and State Central Library, Shillong. Thanks are also due to the staff of State council of Educational Research and Training, Shillong, Meghalaya, Geological Survey of India, North Eastern Circle, Shillong and the officials of various Government Departments of Mizoram for their help and cooperation in making the books, journals and other publications as well as unpublished materials available to me.

I take this opportunity to remember late Dr. S.C. Banwar, former Vice-Chancellor of North-Eastern Hill University, Shillong for his kind permission to do this research work.

I am also grateful to my wife Lalrammawii for her continuous cooperation and valuable help to carry out the work successfully. I must also remember with thanks and love the inspiration and encouragement that I received during my work from my parents. My thanks are also due to all my friends and well-wishers, who have been rendering direct or indirect help to me in the completion of this work.

I must express my gratitude to Shri K.D. Singha for his help in photostats and photographs and to Shri D.K. Das for his help in cartographic works.

SHILLONG
The 10.7.1986

P. RINAWMA

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C H A P T E R - I

INTRODUCTION

Geomorphology is the study of landforms, their description and interpretation. It is an important branch of geography which deals with the evolution of landforms including the sequential developments that might have taken place in shaping them since their initial appearance above the base level.

Geomorphology has been described as 'the earth - shape - Science' (Brown 1970).[1] The science of geomorphology which is concerned primarily with the form of the earth, is little more than one hundred years old. Traditionally the study was essentially concerned with the interpretation of the origin and evolution of landforms. Fennman (1931) and others still agree that "the study and interpretation of the records left by erosion constitute the larger part of the science of geomorphology."[2] The Davisian School of thought at explaining landscapes in terms of the concept of cycle of erosion in relation to "Structure, Process and Stages" (Davis 1924)[4]. On the other hand, geomorphologist like Leopold, Walman and

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[1] *Brown, E.H. (1970), Man Shapes the Earth, Geog. Journ., 136, pp.74-84.*

[2] *Fennman, N.M. (1931), Physiography of Western United States, Mc-Graw Hill, New York.*

[3] *Davis, W.M. (1904), The Explanatory Description of Landforms, Vol. 3, Belgrade (1924), p.24.*

Miller (1964)[4], *while observing that much of geomorphology is 'Stratigraphic geology', have made the study of contemporary processes a conspicuous part of their methodological approach to the subject. Much recent work tends increasingly to emphasise the definition of F. Hijulstrom that 'geomorphology is the Science of landforms and of landforming processes.'*[5]

At the beginning of the nineteenth century, the Science of geology became distinguishable from "Natural Philosophy". Facts and theories about the origin of rocks and mountain ranges accumulated, they were absorbed into regional or descriptive geomorphology as an aid to understanding the origin of landforms. Thus, explanatory description evolved in which a landscape is not simply described by the heights of its hills and the declivities of its slope but by the reconstructed geological history of its evolution. Explanatory description is a higher form of analysis then regional description in that it requires inferences about past events. In a sense, a landscape can not be understood until the entire geological history of the rocks and the slopes is known.

There has been a phenomenal development in the field of geomorphological studies in the twentieth century. The earliest works in this field led to a variety of approaches and this resisted in the development of several schools of thought. According to King (1966)[6] *there are*

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[4]*Leopold, L.B.* **et al** *(1969), Fluvial Processes in Geomorphology.*

[5]*Hijulstrom, F. (1935), Studies of the Morphological Activity of rivers as illustrated by the Pyris, Univ. Upsala, Geol. Inst. Bull 25, pp.221-527.*

[6]*King, C.A.M.(1966), Techniques in Geomorphology, Edward Arnold, London.*

three major groups (i) the first arises out of the work of Walter Penck and may be called the 'Mobilistic view', (ii) the second priority to the effects of climate in studying the characteristics of the landscape; (iii) the third is based essentially on the idea of 'correlation by altitude and therefore, be termed the 'custic view'.

Modern trend in geomorphological study is towards the increasing importance of quantitative methods. Morphometric techniques have been evolved for utilizing various cartographic information about the earth's surface configuration to arrive at numerical indices. Both quantitative and qualitative information provided in published topographical maps aerial photographs and lands at imagery or data directly collected by field investigation are utilized for this purpose. Thus, geomorphology has become more rigorous. Horton (1945)[7] with his description of drainage basins and 'Channel Networks' were transformed from a purely qualitative and descriptive study to a rigorous quantitative science, capable of providing hydrologist with numerical data of practical value. Horton's work was developed by Strabler (1952)[8] and his associates Melton (1957)[9], Morisawn

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[7] *Horton, R.E. (1945), Erosional Development of Streams and their drainage basins; hydrological approach to quantitative Morphology,* Bull. Geol. Soc. Amer. Vol.56, *pp. 275-370.*

[8] *Strabler, A.N. (1952), Dynamic Basis of Geomorphology,* Bull. Geol. Soc. Amer. Vol.63, *pp.923-38.*

[9] *Melton, M.A. (1957), An Analysis of the relations among elements of climate, surface properties and geomorphology,* Columbia Univ. Dept. Geology. Tech. Report 11. *p.102.*

(1957)[10] and Schumn (1956).[11]

The science of Geomorphology is important not only due to its being an academic discipline in geography but also for its practical applications in various fields as engineering geology, economic geology, geohydrology, urban planning, military geology, soil science, agriculture resources. Since the terrain plays a significant role, therefore, the regional geomorphological studies are being used more and more in agricultural science. The increasing use of aerial photographs has given a helping hand to the conduct of these studies. In India, the application of geomorphology in the field of land utilisation especially agriculture, horticulture, forest development, selection of site for dams, transport and communication and human habitations is of great help.

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 and significant role. Geomorphology

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[10] Morisawn, M.E. (1957), Accuracy of determination of stream lengths from topographic maps. Am. Geo-Phys. Union. Trans. 38. p.86.

[11] Schumm, S.A. (1956), Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey, Bull. Soc. Am. 67. pp.597-646.

is so dominant factor in the human environment that it influences the pattern and destiny of agriculture immensely.[12] *This is true on macro-regional as well as micro-regional scales. Thus agriculture in mountains, plateaus and plains differ greatly. Similarly, scarps, pediments, valley flanks, flood plains, ridges and basins are characterised by different types of agriculture. Micro-regional landforms like levees, alluvial cones and fans, drumlins or eskars, monadnocks, sand duns and oases are marked by different agriculture.*

As a matter of fact whether it may be the case of a glacial or periglacial landscape or an arid and semi-arid topography or the landforms of a karst or coastal or volcanic region the geomorphology sets the foundation and background of agriculture which can be adopted or can be feasible in a particular area.

For centuries the landforms were treated very inadequately and superficially. Only during the 18th century the development of surveying allow a correct and full descriptions of landforms and not until the 19th century did not development of geology lay the foundations for a more truely scientific way of thinking about the landforms. The qualitative approach in geomorphology deals primarily with 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

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[12] *Enayat Amad (1981), Geomorphology and Agriculture Perspective in Agriculture Geography - Vol. II, Concept Publishing Company, New Delhi 110 015, p.59.*

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 revelance to the problem before being used. It may also be noted here that a great deal of modern geomorphology is based on the dynamic approach. The regional geomorphology which deals systematically with the broad characteristics of an area and further the micro level details may be filled in.

Since in the last two decades a phase of quantification has emerged during which attempts have been made to replace the study of geomorphology in its correct perspective. This has been fostered by use of systematic approach of model building and design of experiments by the use of more sphisticated techniques and tools of analysis. In modern time man has become one of the most important geomorphological agents. Thus the study of the impact of man directly or indirectly upon both surface forms and processes have become central point of study. So far as the agricultural planning is concerned, regional geomorphological studies have become quite important. In a region like Mizoram where still the agriculture is of very primitive nature the application of geomorphological knowledge in the field of land utilisation particularly for agriculture, horticulture and forest development, transport and communication networks and settlement location may be of great help.

Keeping in mind the above objectives the study of geomorphology and agriculture of Lunglei district has been undertaken.

In India geomorphological studies are yet to be developed and studied on a large scale. Of late, there has been a very little work done in the field of geomorphology. This may be due to lack of detailed geological and topographical maps and aerial photographs. Most of the literatures available are based mainly on geological background. Geographers like S.P. Chatterjee (1962)[13] *and S.P. Chatterjee and B. Basu (1944)*[14] *have worked on physiographical divisions on the basis of structural, topographical differences. Recently many works have been made on geomorphology of different regions of India, such as 'Recognition and Correlation of Erosion Surfaces in the Southern Part of Cuddapah Basin, Andhra Pradesh' Vaidyanadhan, R. (1964)*[15]*, 'Structure, Drainage and Morphology of Chota Nagpur Highlands', Singh, R.P. (1960)*[16]*, 'The Western Ghats of the Indian Peninsula', Radhakrishnan, B.P. (1967)*[17]*, 'Geomorphological Control on the Distribution of Evaporites in West Rajasthan', Ghose, B. and Singh. S. (1969)*[18]*, 'Effects of Rock Types on Stream, Slopes Around Jawai Bandh,*

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[13] *Chatterjee, S.P. (1962), Physiographic Division of India, Progress Summer School of Geography 1962.*

[14] *Chatterjee, S.P. and Basu, B. (1944), Physiographic and Economic bases in Central Provinces and Berar, Geographical Review, Vol.6, No.1, 1944, Calcutta.*

[15] *Vaidyanadhan, R. (1964), Recognition and Correlation of Erosion Surfaces in the southern part of Cuddapah Basin, Jour. Geol. Soc. India. Vol. 5, pp.121-127.*

[16] *Singh, R.P.(1960), Structure, Drainage and Morphology of Chota Nagpur Highlands, Geog. Outlook 2.*

[17] *Radhakrishnan, B.P.(1967), The Western Ghats of Indian Peninsuls, Proc. Semi. Geon. Ltd. Ind. Sagar. pp.4-14.*

[18] *Ghose, B. and Singh, S.(1969), Geomorphological Control on the distribution of evaporates in W. Rajasthan.*

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[19] Sen, D. (1971), Effects of Rock types on Stream Slopes Around Jawai Bandh, S.W. Rajasthan, Jr. Geol. Soc. India. 12(2), pp.189-91.

[20] Dixit, K.R. (1970), Polycyclic landscape and the surface of erosion in the Deccan trap country with special reference to upland Maharastra, Nat. Geog. Journ. India. 14(3&4), pp.236-52.

[21] Sen, D. (1972), Geomorphology of the Aravalli Range, Rajasthan and a reinterpretation of residual surfaces, Geog. Rev.India. 3. 1972.

[22] Gupta, R.B. and Rajaguru, S.W. (1971), Late Pleistocene Geomorphological History of rivers of western Maharastra, Int. Symp. Deccan. Traps and other Flood Eruptions.

[23] West, W.D. and Chaube, V.D. (1964), A Geomorphology of the country around Sagar and Katangi, Jour. Geol. Soc. India. Vol.5, 1964.

[24] Singh, S. (1979), A Geomorphological Study of drainage density of small drainage basins of the Ranchi Plateau, Trans. Inst. India. Geol. Gong. Vol. 2, No.2, pp.49-60.

[25] Pathak, M. (1968), Geomorphology of Checkhari Basin, India. Proc.Symp. Erosion Surface. 21st Inst. Geol. Gong. Nat. Commtt. Geog. Calcutta, pp.149-51.

[26] Mukhapadhyaya, S.C. (1969), Some Aspects of Geomorphology of part of Subarnekha basin around Mahali, Murup, Bihar, Geog. Rev. India. 31(2), pp.33-40.

[27] Sharma, H.S. (1980), Ravine Erosion in India.

Apart from these, Rai, R.K. (1980)[28] *has discussed the Geomorphology of Sonar-Bearma Basin, Madhya Pradesh, Vats, P.C. (1979)*[29] *has represented Influence of Micro-Geomorphological Units on Landuse and Crop Production - A Case Study of Village Dundhi, Savindra Singh (1979)*[30] *wrote on Geomorphological Study of Drainage Density of small Drainage basins of the Ranchi Plateau, Singh, R.L. and Sonar Bahadur Singh (1979)*[31] *studied Morphometric Evaluation of Terrain and Morphogenetic mapping in different Terrain type of areas of India. Other studies are Terrain Analysis of the Swarnamukhi Basin by Reddy, K.R. and Reddy, N.B.K. (1983)*[32] *Drainage-Basin Morphometric Study of a Part of the Alakanda Basin by Rawat, C.P.S., Pande, I.C. and Negi, S.S. (1983)*[33]*, A Coastal Geomorphic Study of Godavari Point Sand Spit by Satya Prakash and Jagmohan Agarwal (1979)*[34]*, The Jabera Basin: Its Geomorphology and Human Settlements*

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[28] *Rai, R.K. (1980), Geomorphology of Sonar-Bearma Basin, Concept Publishing Company, New Delhi.*

[29] *Vats, P.C. (1979), Influence of Micro-Geomorphological Units and Landuse and Crop Production - A Case Study of Village Dundhi, Dec. Geogr. XX.2(1977), pp.317-26.*

[30] *Savindra Singh (1979), Geomorphological Study of Drainage Density of Small Drainage Basins of the Ranchi Plateau, Indian National Geographical Journal of India, Vol.25, Parts 3 & 4, Sept-Dec 1979, pp.213-30.*

[31] *Singh, R.L. and Samar Bahadur Singh (1979), Morphometric Evaluation of Terrain and Morphogenetic mapping in different Terrain type of areas of India, National Geographical Journal of India, Vol.25, Parts 3 & 4, Sept.-Dec. 1979, pp.200-212.*

[32] *Reddy, K.R. and Reddy, N.B.K. (1983), Terrain Analysis of the Swarnamukhi Basin, National Geographical Journal of India, Vol.XXIX, Parts 3 & 4, Sept.-Dec. 1983, pp.176-187.*

[33] *Rawat, C.P.S., Pande, I.C. and Negi, S.S. (1983), Drainage Basin Morphometric Study of a part of the Alakanda Basin District Chamoli, National Geographical Journal of India, Vol.XXIX, Parts 3 & 4, Sept.-Dec. 1983, pp.207-216.*

[34] *Satya Prakash and Jagmohan Aggarwal (1979), A Coastal Geomorphic Study of Godavari Point Sand spit (as evaluated from Hydrographic Surveys and Land set Imagery), National Geographical Journal of India, Vol. XXV, Part 2, June, 1979, pp.84-92.*

by Tamaskar, B.G. (1958)[35]*, and the Drainage Disabilities and Flood Problem in the Tarai Region of Uttar Pradesh by Singh, L.R. (1961)*[36]*.*

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 very little work has been done in the north eastern region of India. Recently in the north-eastern region of India Professor R.K. Rai has contributed quite a lot in the field of geomorphology such as Rai, R.K. (1981)[37]*. Influence of landforms on location and distribution of rural settlements in Khasi and Jaintia Hills, Meghalaya. Rai, R.K. (1982)*[38] *- A Study on average slope of Khasi and Jaintia Hills, Meghalaya. Rai, R.K. (1982)*[39]*, Hill slopes, Landuse and Soil erosion around Shillong (Meghalaya), Rai. R.K. (1982)*[40] *Environmental Framework and Landuse on hill slopes around Shillong.*

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[35]*Tamasker, B.G. (1958), The Jabera Basin : Its Geomorphology and Human Settlements, National Geographer, Vol. II, 1958, p.53.*

[36]*Singh, L.R. (1961), The Drainage Disabilities and Food Problem in the Tarai Region of Utter Pradesh, National Geographer, Vol. IV, 1961, p.49.*

[37]*Rai, R.K. (1981), Influence of Landforms on location and distribution of rural settlements in Khasi and Jaintia Hills, Meghalaya, Nat. Geog.*

[38]*Rai, R.K., (1982), A Study on average slope of Khasi and Jaintia Hills, Meghalaya, Hill. Geog. Vol. 1(1), pp.42-46.*

[39]*Rai, R.K. (1982), Hill Slopes, Landuse and Soil Erosion Around Shillong (Meghalaya), Geog. Rev. India. Vol.41, No.4.*

[40]*Rai, R.K. (1982), Environmental Framework and Landuse on Hill slopes around Shillong. Proc. Symp. Allahabad Univ.*

No geomorphological studies have been done in the Union Territory of Mizoram till the present date. Therefore, the study of geomorphology and its impact on agricultural development may be quite helpful in Mizoram in the field of town and country planning, forest planning, landuse planning, selection of site for dams, transport and communication and especially in the field of agriculture where people need proper planning. It will also certainly reveal some new facts about the geomorphic history of the region.

The present study covers Lunglei district, one of the three districts of the Union Territory of Mizoram, which has not been studied by any geomorphologist. The author belongs to this district and has many advantages and has basic knowledge due to his long association with the region.

Broad Objectives of the Study

Applied geomorphology deals in solving practical planning problems. The application of the detailed geomorphological maps is one of the examples often quoted. From geomorphological maps, other maps can be compiled, providing information about landforms favourable or unfavourable for agriculture landuse, transportation or settlement, etc. of any region. Therefore, the importance of geomorphology in the agricultural landuse can never be ignored.

In the present study, an attempt has been made to find out the links and the influences of the regional geomorphological factors *on agricultural practices of Lunglei district, Mizoram. As Lunglei district of the Union Territory of Mizoram is full of dissected rugged hilly topography, it has ample scope for the investigation of geomorphological processes which are active in the region. It is quite true that the agricultural system and practices of the region have emerged under clear impact of the regional processes of landforms and their characteristic manifestations. The present study is a humble attempt in the same direction.*

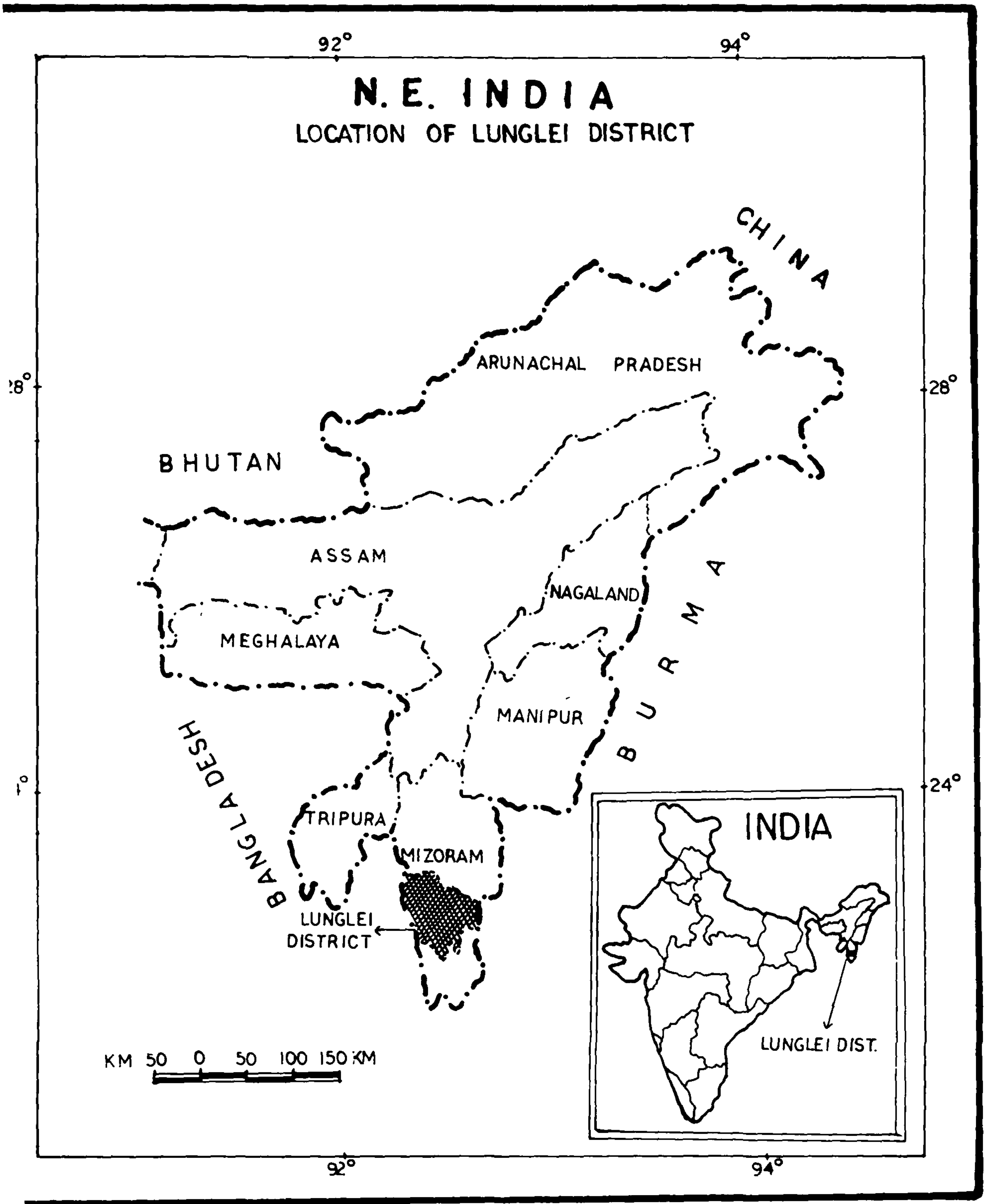
Location of Study Area:

The longitudinal and latitudinal extent (fig. 1) of Lunglei district falls between 92°35' E to 93°55' E and 22°35' N to 23°35' N and the area covers about 4538 sq. kilometres. Its length from north to south is about 78 kilometres and width from east to west is about 60 kilometres. The area is bounded by Burma in the east, Bangladesh in the west, Aizawl district in the north and Chhimtuipui district in the south.

Lunglei district is marked by the major watershed between the drainage system of Chhimtuipui (Kaladan) falling in the Arakan sea and the drainage system of Tlawng and Khawthlangtuipui (Karnaphuli) falling in the Bay of Bengal. In the centre, the watershed of Chhimtuipui and Tlawng rivers is clearly demarcated by Lunglei hills.

Salient Features of Lunglei District:

The area comprises predominantly of difficult terrain with narrow valleys in between. Geographically, Lunglei district in the Union Territory


92°
94°
N. E. INDIA
LOCATION OF LUNGLEI DISTRICT
CHINA
ARUNACHAL PRADESH
28°
28°
BHUTAN
ASSAM
NAGALAND
MEGHALAYA
BURMA
MANIPUR
BANGLADESH
24°
TRIPURA
MIZORAM
LUNGLEI DISTRICT
INDIA
LUNGLEI DIST.
KM 50 0 50 100 150 KM
92°
94°

FIG= 1

of Mizoram lies in the eastern most part of India. It is a continuation of Himalayan Patkai Range.

Lunglei district has ranges running from north to south which tend to be higher in the east than in the west. The average height is about 900 metres. The physiographic expression of the area west of Lunglei town imparted mostly by NNW-SSE trending steep longitudinal hills and narrow valleys. The area is characterised by a number of hillocks and mounds spreading over the whole area giving rise to comparatively low undulating terrain. The ridges at the east of Lunglei town are mostly N-S to NNE-SSW trending. The western flank of the ridges are usually steeper compared to the eastern flank.

The hills are higher towards the east, the highest hill is Purun hill 1749 metres located in the north eastern corner of the area. The other high hills are, however, located in the eastern part of the area bordering Burma and the centre part of the area, viz. Darzo 1628 metres, Thingsai 1461 metres, Zopui 1555 metres and Lungleng 1686 metres. The lower hills are located in the west of Lunglei town such as Mualmu 625 metres, Rangte 519 metres and Belkhai 834 metres, etc.

The difference of elevation from the valley floors to the hill tops varies from 232 metres in the western part of the area to 507 metres in the west central part and 720 metres in the central part and 660 metres in the eastern part. The topography in general is immature with structural high producing high relief towards east.

The drainage systems of the area are usually complicated, the river Tlawng having its sources from Zobawk village near Lunglei town flows towards north while parallel to Mat river having its sources from Baktawng village of Aizawl district flows towards south just in opposite direction of Tlawng river. The Tuipuilian, Kau and De rivers have parallel courses for many kilometres but run in opposite direction of Tlawng river. The Tuichawng and the Phairuang rivers flow from the southern most part of Mizoram and flow towards north till they meet De river and which then turns to the west and deliver their combined water into the Khawthlangtuipui which flows from south west. The Chhimtuipui (Kaladan) river, which flows from Burma and enters Mizoram in the south eastern part of Mizoram, flows towards north and turns to the west near Muallianpui village and curves towards south near Hnahthial village of Lunglei district and flows towards south and enters Arakan hill tracts. The rivers or drainages generally flow towards north or south direction. Generally, the eastern part of the area is higher than the western part. The area does not have plain area, small intermount valley plain and river valley flat areas of not considerable size are scattered throughout the area. These have, as a rule, an elevation of about 1000 metres to 1500 metres and are covered with a thin layer of rich alluvium soil. The slope of the hill is very steep and rugged.

The area enjoys a pleasant climate and is neither very hot nor very cold throughout the year. The valleys are unhealthy and during the rains the climate is moist. The area is characterised by warm humid climate with spell of monsoon. There is appreciable temperature difference and *humidity on the hill tops and valley floors. In the higher ridges it is fairly cool and pleasant even in the hotest season of the year. The rainy season starts from April and lasts till the end of September. There is an ample rainfall during summer season.*

Previous Work:

The area selected for the present study has not been studied in detail from geological point of view and no geomorphological study of this region has been attempted by any researcher.

Although the first available report for the geology of Lunglei district appeared in 1891 (La Tauche)[41] *who took short traverse in the area (the then Assam-Arakan Geological Province). Later, Mushi (1964)*[42] *mapped the rocks of the central part of northern Mizoram. In the recent past Nandy, Mukherjee and Majumder (1972)*[43] *recasted stratigraphy and gave the sedimentation behaviour and the tectonic history of the central part of Mizoram by conducting geological traverse.*

The geological mapping of western part of Mizoram and southern Mizoram was also done by Nandy, Sarkar, Saxena and Mukherjee (1973)[44].

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[41] *La Tauche (1891), Note on the Geology of Lushai Hills - Records of the Geological Survey of India, Vol. XXIV Part 2. 1891.*

[42] *Munshi (1964), Geological mapping in parts of Mizo District Assam (Progress Report for 1963-'64) G.S.I.*

[43] *Nandy, Mukherjee and Mazumder (1971), Geological mapping and Mineral Survey in parts of Mizoram (Progress Report for 1971-'72 field season) G.S.I.*

[44] *Nandy, Sarkar, Saxena and Mukherjee (1973), Geological mapping of western part of Mizoram, G.S.I.*

Geological mapping in parts of Lunglei district, Mizoram was also done by Saxena and R.N. Mukherjee (1973).[45]

It may be mentioned here that no full detail geological map is available for the whole Lunglei district and the present geological map given in the thesis on the geological map of Tripura and Mizoram (based on photo interpretation) published by Geological Survey of India 1983.

Sources and Data Base

Since the author could not get sufficient information about geology and geomorphic characteristics as well as agricultural data of this region, it was found necessary to illustrate and supplement the statements and discussions in the thesis by figures and photographs, which give a very clear picture of the natural configuration of the region. To illustrate different aspects and to give a bird's eye view of the whole region, all the maps and diagrams of Lunglei district have been prepared by the author and given in the thesis. In any geomorphological study one can not escape from the field investigation. The author visited the field in different seasons and made field observations.

The necessary materials for the thesis has been collected mainly from the publications of memoirs and records of the Geological Survey of India, topographical sheets on various scales published by the Survey of India, Census Report of the Union Territory of Mizoram, Statistical

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[45]Saxena and Mukherjee (1973), Geological mapping in parts of Lunglei district (Progress report for the field season 1972-73).

Hand Book of Mizoram, Director of Agriculture, Mizoram and other reliable sources. Extensive field work has been taken to collect field data about different types of landforms. With the help of toposheets extensive morphometric analysis and quantitative analysis has been made to draw certain conclusions.

Methods of Study:

In geomorphic research methodology applied depends mainly on the location of the study area, its litho-stratigraphic formations and the processes involved in shaping the landforms. Lunglei district is located in the humid tropical climatic zone with heavy rainfall under the impact of south-west monsoon.

To study the essential elements of terrain of Lunglei district, it has been undertaken through measurement and analysis of surface morphological features by employing standard geomorphic techniques. For example, the morphometric techniques which have been used in the present study includes the characteristics and nature of average slope, drainage density, stream frequency, super imposed profiles, cross-profiles, longitudinal profiles etc. It also include mathematical calculations to obtain various data from the drainage basins. In this connection the following techniques have been used; stream ordering, law of stream numbers, law of mean stream length, stream frequency, drainage density, semiasity indices and bifurcation ratio. The above methods have been used to compare the results and for *further generalization and correction of accuracy, considerable field studies have been undertaken.*

Working Plan:

In order to have a better understanding about the geomorphic features and agricultural development of Lunglei district, the author has divided study into two main parts. The first part deals with the geomorphic aspects of the region which consists of six chapters. The second part deals with the agricultural development of the region which consists of three chapters.

In the introductory chapter, general description of geomorphology, review of previous work, study area and its location, salient feature of the study area, data base and sources, methodology and plan of work has been focussed.

In the second chapter the whole account of geology and structural characteristics of rock formations have been discussed. In the region the important rock formations are the sandstone, siltstone and sandy shale. While discussing the geology, the rock formations and their age and distribution, the geological history has been considered in detail.

Chapter three deals with the evolution of landform, geomorphic processes and fluvial geomorphic cycle. In this chapter the evolution of landform of Lunglei district, its geomorphic features and different weathering processes actively engaged in the region and the factors which influence *weathering has been discussed. It also deals with the drainage system, mass-wasting and especially with landslide in detail.*

Chapter four deals with the various morphometric analysis of average slope, drainage analysis, hillslope elements, cross-section, longitudinal profiles of rivers and superimposed profile. The average slope map of the region, areas of maximum and minimum slope have been demarcated. The second aspect of this chapter, the drainage system analysis provides significant results in relation to the drainage frequency and patterns. The various drainage patterns and their areas of occurences have been discussed in detail. It also discusses the erosional surfaces with the help of morphometric properties.

. In the fifth chapter quantitative analysis of ten selected small river basins (from various community Development Block) have been presented. In this chapter the researcher has taken the various morphometric techniques in two aspects, such as 'linear aspect' and 'the areal aspect'. In the linear aspect; stream ordering, law of stream numbers, law of mean stream lengths, sinuasity indices and in the areal aspect; stream frequency and drainage density have been discussed. The analysis shows that the basins are in youth as well as in later-youth stages of the cycle. The course of stream found to be mainly of straight course, various aspects of affecting stream frequency and drainage density have been discussed separately.

Chapter six deals with the study of micro-geomorphic region. In this chapter, the researcher has divided the region into three micro-

geomorphic regions such as moderately dissected undulating hilly region; highly dissected, denudated hilly region; and central and eastern escarpment region. The researcher has noticed that there is no plane area of a considerable size.

In the study of agricultural development (Chapter seven), an attempt has been made to examine the agricultural framework in the region. It includes the study of various geomorphic factors which influence the agriculture, the general landuse pattern, cropping pattern, agricultural implements and methods of the region. This chapter also discusses the method and practices of shifting cultivation in detail. For landuse study, the study has been undertaken on the basis of Community Development Block.

In the chapter eight, an attempt has been made to examine the impact of various morphometric elements on agricultural land use by selecting five villages to represent the study area.

Chapter nine deals with the study of the influences of landforms on the distribution of population, settlement and transport and communication.

In the last the general conclusion of the study is presented.

C H A P T E R - I I

GEOLOGY

1. Introduction

The aim of geology is to study rocks and since the mantle of the earth is made up of rocks of different mineral compositions which give rise to various types of soils due to certain natural process, the study of geology becomes an essential to understand the relationship between landforms and underlying rocks. Geological structure has a bearing not only on relief and landforms of a region, but also on the distribution of minerals, water table, rocks and drainage, etc. Geology is the base on which various geographical factors operate to create varying landscapes and patterns of activity. To understand and appreciate the geographical peculiarities of the area we must take into account its geological past. Thus geological structure exerts an indirect influence on these processes and on evolution of landforms.

Detailed geological explorations are still awaited in Lunglei district as well as Mizoram as a whole and as such the knowledge of geological formations is very sketchy. A very little work has been done in the geological exploration in the area. In the district of Lunglei the hills consist of sandstone and shales of Tertiary age, thrown into long folds, the axes of which run nearly north and south. The rocks area continuation of southwards of those rocks forming the Patkai *range, and were probably laid down in the delta or estuary of a large river issueing from the Himalayas in the tertiary period. Marine fossils of that age have been found near Lunglei town embedded in nodular dark grey sandstone.*

The present physiographic configuration of the hills had attained through different geological events since miocene to present day as initiated by the polycyclic erosional surfaces at various levels.

2. Geological Formations

The earliest geological reference about the region was made by La Tauche (1891)[1]. According to La Tauche, the area consists of a great flysch facies of rock comprising monotonous sequences of shale and sandstone which are thrown into N-S trending folds. It is believed that the rocks are in fact the southerly continuation of those rocks forming the Cachar Hills and were probably laid down in a delta or estuary of a large river during the late Tertiary period.

Recently, Nandy and and Sarkar (1973)[2] and Saxena and Mukherjee (1973)[3] have worked separately in the western part of central Mizoram and southern Mizoram respectively. Both the parties established the same stratigraphy and gave a different sedimentation history that

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[1] *La Tauche, T.H.D. (1891), Records of the Geological Survey of India, Vol. XXIV, Part 2, 1891.*

[2] *G.S.I. Miscellaneous Publication No.30, Part IV, pp.9-94.*

[3] *Ibid.,*

prevailed in the region. Again, Nandy and Sarkar divided the rock formations into several facies on the basis of lithology and sedimentation structures. They are of the opinion that the sedimentation took place in deep sea flysch environment by the action of turbidity current mechanism. Saxena and Mukherjee (1973)[4] have also done geological mapping in parts of Lunglei district.

The above investigations and systematic geological informations helped very much to list out a general stratigraphic sequence of the information as given in the table below:

TABLE 1

Generalise Geological Succession in Lunglei District

Geological Age	Group name	Formation name	Rock type
1	2	3	4
Miopliocene	Surma	Boka Bil	Grey occasionally light coloured soft friable, loose, medium grained fels-pathic sandstone, sandy shale with interlaminated siltstone and grey shale, occasionally brownish yellow, ferronaceous sandstone.
Miocene	Surma	Upper Bhuban	Sandstone, sand shale and sandsilt shale alternations and inter laminations, sandy shale, siltstone, locally thin conglomerate bands.
			——Contact gradational——
		Middle Bhuban	Shale, sandy shale, shale silt and shale-silt sand, interlaminations and intercalations, siltstone-mudstone, sandstone, shale-sandstone alternations,

~~Table contd..~~

[4]*Saxena, A. and Mukherjee, R.N. (1973), Systematic Geological Mapping in Parts of Lunglei District, Mizoram. Progress Report for the Field Season 1972-'73, G.S.I. 1973.*

Table contd

1	2	3	4
			locally thin conglomerate bands.
			——Contact gradational——
		Lower	Sandstone, sand-shale and sand-silt shale alternations and inter-laminations, locally thin conglomerate bands.
			——Base not seen——
Oligocene	Barail	Barail	Predominantly shale and siltstone with bands of weathered rather soft and micaceous, medium grained, yellowish grey wackes. Locally, a few dark grey compact, medium to fine grained quartz-wacke band.

Surma Group:

Surma group consists of two main sub-groups of rocks which are (a) Bhuban and (b) Boka Bil. Bhuban sub-group is sub-divided into three formations which are as follows:

(i) Upper Bhuban Formation,
(ii) Middle Bhuban Formation, and
(iii) Lower Bhuban Formation.

(i) *Lower Bhuban Formation:*

Lower Bhuban formation comprises mostly of greyish, fine to very fine grained massive sandstone. This rock formation is found in the easternmost part of the district bordering Burma. This rock type is exposed in the anticlinal core of the Darzo hill ranges. Darzo peak 1628 m. (22°53'N 92°58'E) and Lungleng peak 1686 m. (22°53'N 92£59'E) on the Darzo hill where rock exposure is clearly visible. At places there are well bedded, hard compact, fine to very *fine-grained sandstone bands interbedded with comparatively thiner bands of siltstone and shale.*

(ii) *Middle Bhuban Formation:*

This rock formation overlies the upper Bhuban formation conformably the contact being gradational. It is exposed mainly in the synclinal core of Mat and Tuichang rivers in the north east and synclinal core of Mengpui river and Ngengrual stream in the south east of the region.

The rock formation is predominantly argillaceous and comprises mostly of shale, mudstone, siltstone, thin interlaminations of varying amount of shale, silt and sand and massive to well bedded sandstone interbedded with argillaceous sequences of varying thickness.

(iii) *Upper Bhuban Formation:*

The upper Bhuban formation underlies conformably the Boka Bil formation, the contact in most cases is gradational; east of Lungsen village in the western part of Lunglei district, the contact is, however, a faulted one. This formation covers very wide area, it rather covers the whole hill ranges of central and western parts of the area (Fig. 2).

The rock formation is predominantly arenaceous and comprises mostly of massive, brownish, comparatively soft friable,

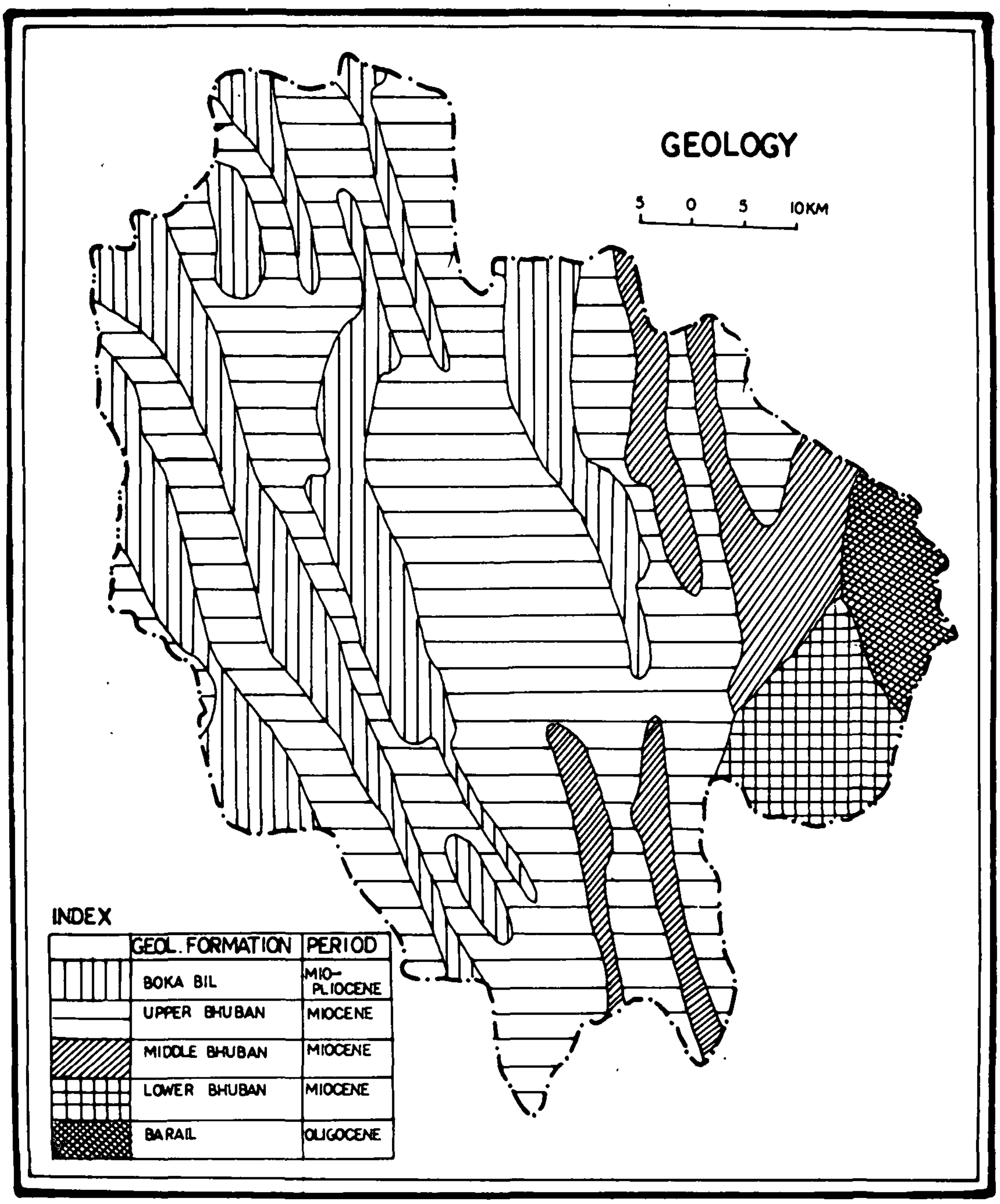
GEOLOGY
5 0 5 10KM
INDEX
GEOL. FORMATION
PERIOD
BOKA BIL
MIO-PLIOCENE
UPPER BHUBAN
MIOCENE
MIDDLE BHUBAN
MIOCENE
LOWER BHUBAN
MIOCENE
BARAIL
OLIGOCENE

FIG. 2

somewhat weathered, medium-grained sandstone usually containing gragments and patches of shale. This rock formation is mainly widely exposed in the anticlinal hill ranges of Lunglei, Sertlangpui and Thorang. It is also exposed in the anticlinal core of Khojoisury and Puankhai hill ranges.

(iv) *Boka Bil Formation:*

The rocks belonging to this formation occurs conformably over the Upper Bhuban and their contact transitional. In Lunglei district it is represented by soft, friable loosely packed medium to fine felspathic sandy grey wacke, sandy shale with interlaminated silt or shale alternation. The rocks of this formation exhibit typical turbidite features with multiple grading and ripple-drift cross laminations. At places through cross-beddings and large current beddings are also present. The shale is generally grey and brownish yellow colour. This type of rock is widely exposed in the western part of the area along the Tuichawng Tuilianpui, Kau and Phairuang rivers synclines. Whereas in the central part of the area it is exposed along the anticlinal core of Haulawng, Mualthuam and Ramlaitui.

(v) *Barail Group:*

Barail group rests conformably on the Surma group. This rock formation is exposed in a small patch in the north eastern corner of Lunglei district, in the anticlinal core of Thingsai hill. The Barail *group is mainly composed of arenaceous rocks. This group of rock is lithologically dissimilar from these of the Bhuban formations lying to the west. The Barails comprise monotonous sequence of weathered shale, interbedded and interlaminated with siltstone, exhibiting weathering pink, violet, greenish grey and white colourations. They enclosed bands of weathered micaceous, felspathic, soft, medium grained sandstone. Unlike Bhuban the Barails contain few sedimentary structures like flute casts. The rocks have low rolling dips and have been folded into a broad anticline with the axis trending approximately E.W.*

3. Geological History

The area falls within the part of Tripura-Mizoram mio-geosynclinal basin (southern extension of Surma Valley - Evans,1964)[5] *which evolved after the regional upliftment of Barail group of sediments and thus was related with the plate behaviour in the subduction zone of west of Arakan-Yama, after the spreading of Indian ocean.*

From the study of proverance, palaescope, dispersal pattern of primary sedimentary structures and regional tectonics, it is apparent that the deposition of the sediments of the area took place, after the upliftment of Barail geosyncline in a great tectonic trough of miogeosynclinal character having "Bell-shape pattern."[6]

Following the great similarities in lithology, mineralogy,

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[5] *Geology and Mineral Resources of the States of India, G.S.I. Miscellaneous Publication, No.30, 1974, p.99.*

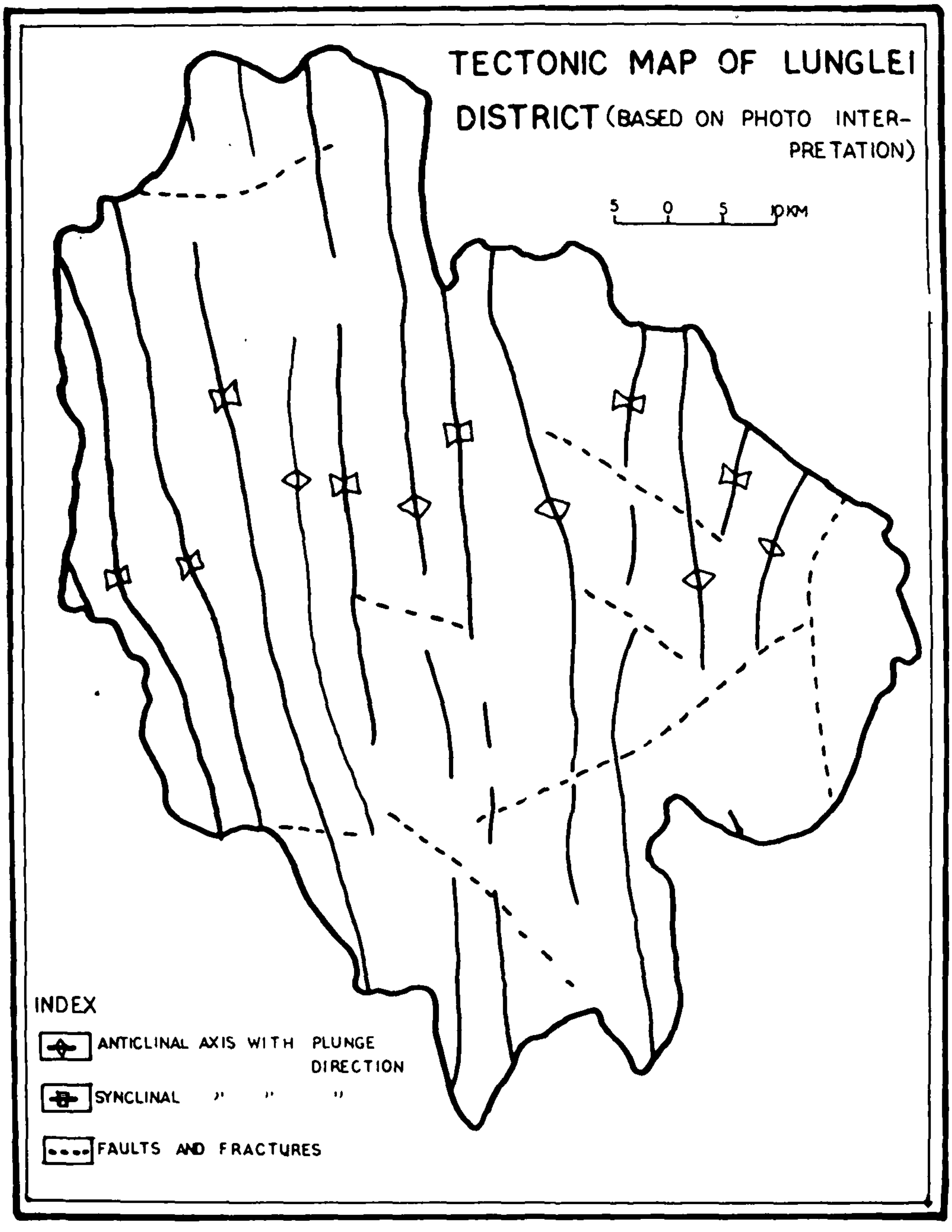
[6] Ibid.,

structures, thickness variation, and spatial distribution of flysch sequence with its recent replica in several areas, it reveals that the sediment transport in the present area might have taken place along the canyans and canyan-extension valleys to the lower slope or continental rise, where the deposition took place from the turbidity current. The thick bedded turbidite grey wackes with typical features were deposited in the interchannel distal areas. Their spatial association is due to the shifting and migration of the fan channel system in the submarine fan and fan valleys. A shallow sea might have prevailed during the late Boka Bil time as is evidenced by the presence of large scale planner cross-bedding, trough cross-bedding and grained sandstone with less clay in the top of the synclinal cores.

4. Tectonic and Structural Characteristics of Rocks

Structural geology is the principal determinant of the first order landform of Lunglei district. The anticlines form the hills and the synclines form the valleys attesting the youthful topography. The present landscape is the result of deep sculpturing by rivers and gullies in a sub-Tropical environment of high rainfall. The entire study region is of irregular shape and can be suitably called hilly rugged terrain land locked strip of land.

Lunglei district is a part of the Neogene Surma basin to the west of the Arakan Yama subduction-collision zone, which


TECTONIC MAP OF LUNGLEI DISTRICT (BASED ON PHOTO INTER-PRETATION)
5 0 5 10KM
INDEX
ANTICLINAL AXIS WITH PLUNGE DIRECTION
SYNCLINAL " " "
FAULTS AND FRACTURES

FIG·3

represents the north west extension of the Sumatra Java Trench - the eastern margin of the Indian plate. The basinal sediments are folded into long arcuate belt in a series of linear narrow anticlines and synclines forming a unique foreland foldbelt in the Indian sub-continent like the Jura mountains and the "valley and ridge province" of the Appalachian.[7]

Tectonic Evolution

Tectonically Lunglei district is a part of entire Indo-Burma oceanic basin configuration of which was guided by the plate motions after the spreading of Indian ocean floor. The present basin was a tectonic trough of mio-geosynclinal character where the sedimentary infillings took place in distinct tectonic environment at different time by complete separate flow mechanism (Sarkar and Nandy, 1977).[8]

According to Nandy (1980)[9]*, the area is a part and related to the eastward subduction of the Indian plate along the Arakan Yoma suture during Eocene time and the subsequent development of the Indo-Burma orogenic belt.*

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[7] *Nandy, D.r., Sujit Das Gupta, Kalyan Sarkar and Anirudha Ganguly (1983), Tectonic Evolution of Tripura-Mizoram Fold Belt, Surma Basin, North East India. Qurt. Journ. Geol. Min. Met. Soc. India, Vol. 55, No.4, p.187.*

[8] *Sarkar, K., and Nandy, D.R. (1977), Structure and Tectonics of Tripura-Mizoram Area, India. Misc. Pub. Geol. Surv. India, pt.1 No.34, p.147.*

[9] *Nandy, D.R. (1980), Tectonic Pattern in N.E. India, Indian Journal. Earth Sc. Vol. 7, No.1, pp.103-107.*

During the Paleozoic and much of the mesozoic eras the sea continued to receive sedimentary deposits in the form of conglomerates, shale, sandstones, erod ed from Archean rocks. The successive period saw repeated orogenetic activities accompanied with extensive igneous intrusions. A final orogenetic phase in early pleistocene age raised the upland to its present position. Both the effect of horizontal compression and vertical movement are noticed in the deformed rocks. The deformation of sediments in the area was first initiated by layer-parallel compressive strain and by buckle shortening in response to compression generated due to lithospheric plate motion and consumption at the leading edges. Then due to an increased byancy effect in basinal materials, as the plate consumption continued, the plate got detached from the subduction zone and pulled the previously folded layers in the basin in response to isostatic adjustment to form the present orography with series of sub-vertical faults which piled the folded layers into the present quasibalancing state.

Structural Characteristics of Rocks

Structurally the whole region is characterised by a series of continous and discontinous N-S to N 15°E - S 15°W trending anticlines and synclines involving mio-pliocenesediments of the Surma and Barails. Eastern contact of these rocks with the oligocene Barails is faulted by a Koladan fault of N-S trending fault and this have *obligocene Barails is faulted by a Koladan fault of N-S trending fault and this have obliterated the post Barail conformity in this area.*

The structural trend of the area under study coincides with the regional tectonic lineaments.[10] *The general strike of the folded layers is north-south direction, with dip varying from 40° to 50° either towards west or east. Structurally, the rocks of the area lie on highly compressed asymetrical anticlinal ridges and narrow valleys, with parallel to sub-parallel, sub-vertical to vertical axial planes. The axes of the folds show convergence pattern in the direction of plunge, except in few cases where they run parallel. The limbs of the major folds are folded into small anticlines and synclines mostly in Chevron style.*[11] *Mesoscopic folds are observed mainly in the incompetent middle Bhubans which are bounded by the competent lower and upper Bhubans. The overall folded geometry maintains similarity throughout the region. Structural complexity and also the intensity of deformation gradually increase from west to east. To the east the folds are much compressed, overturned and isosclinal. Both the effect of horizontal compression and vertical movement are noticed in the deformed rock. Both megascopic and mesoscopic vertical to sub-vertical strike faults are located along the hinge of the folded layers.*

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[10] *Sarkar, K. and Nandy, D.R., (1977), Op.cit.,*

[11] *Geology and Mineral Resources of the States of India, Pub. No. 30.*

The structural elements observed in the district are both primary and secondary types. The primary sedimentary structures commonly found in the area are cross laminations, ripple-marks parallel laminations, graded bedding, flutecasts, loadcasts and ridge structures. Saxena and Mukherjee (1973)[12] *recognised the primary structures in a wide spread occurence along the Hnahthial-Tlabung road section and found in all formations. They found graded bedding between Hauruang village and Lunglei town, at Gabaswari and west of Mat river towards Zobawk village along the road section. They also recognised flute casts in well developed in a stone quarry east of Rotlang village in the Lungsen hill range. Loadcasts are found by them between Hauruang village (22°52'N 92°43'E) and Pachang village (22°51'N 92°41'E) along the road section of Lunglei-Tlabung road.*

The secondary structures observed in the district are folds and faults. Folds and faults are found in both megascopic structures and mesoscopic scale. The mesoscopic structures are well preserved in the argillaceous sequences and more commonly found in the middle Bhuban formations. The folds are highly compressed and usually accompanied by strike faults which passes either along the axial region of the folds or through the steeper limbs. Saxena and Mukherjee (1973)[13] *recognised that at Pachang, Rotlang, (22°50'N*

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[12] *Anil Saxena and Mukherjee, R.N. (1973), Systematic Geological Mapping in Parts of Lunglei District. Prog. Report for the Field Season 1972-73, G.S.I. unpublished Progress Report.*

[13] *Ibid.,*

92°36'E) and Zobawk (22°52'N 92°49'E) villages and Mat river (22°54'N 92°55'E) there are overturned beds as evidenced from inverted small scale current bedding. This overturning according to them has been caused probably due to tilting along the faults.

The physiographic expression of folding is imparted by a series of steep longitudinal anticlinal hills and narrow synclinal valleys trending N.N.W. - S.S.E. to N.N.E. - S.S.W. There are many major anticlinal structures separated from each other by major synclines. From east to west they are Darzo anticline, Tuipui syncline Hanthial anticline, Mat syncline, Zobawk anticline, Tlawng syncline, Hauruang anticline, Pachang syncline, Lungsen anticline and Tuichawng syncline (Fig. 3). These folds have given rise to local synforms and antiforms. Some of which are plunging mostly towards either N.N.W. or S.S.E. The Mat and Tlawng synclines are plunging toward south and N.N.E. at low angles. The folds to the west of Hauruang village are approximately N.N.W. trending while those to the east are N.S. to N.N.E. trending. They are sub-parallel to each other and indicate that they owe their origin to a single fold movement. The variation in the general trends of the folds axes east and west of Hauruang village may be due to southerly regional plunge of the area.

Another significant structural features of Lunglei district is the arrangement and nature of faults. The area is abounds in minor *and major faults. The faults are mainly sub-vertical and dip slip in nature. Besides, there are a number of small scale strike faults. The major faults are confined mostly along the axial region of the folds or pass along the steeper limbs (fig. 3). Saxena and Mukherjee (1973) observed that the thickness of the upper Bhuban formation in the eastern limbs of the Tuichawng syncline and the upper Bhuban formation in the eastern limbs of Lungsen village and the western limbs of Phairuang syncline respectively have reduced as a result of the major strike faults.*

The prominent faults found in Lunglei`district are Laisawral fault, Ngengrual fault, Kaladan fault and Mat fault (Fig. 3). There is no field evidence as to the nature of the fault in terms of its being a normal or reversed fault. It was considered, however, by Nandy, Das Gupta, Sarkar and Anirudha (1983)[14] that the thrust of Kaladan and Ngengrual faults are NE - SW obligue fault whereas Mat and Laisawral faults are NW - SE transverse fault. The minor fault to the north west of Lunglei town form deep scarp faces, probably due to enormous throw of strata along the fault plane. Nature of the fault plane and altitude of strata indicate high angle reversed fault along the crest of Hauruang anticline.

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[14]Nandy, D.R., Sujit Das Gupta, Kalyan, Sarkar and Anirudha Ganguly (1983), Tectonic Evolution of Tripura-Mizoram Fold Belt, Surma Basin, N.E. India, Quart. Jour. Geol. Min. Met. Soc. India. Vol. 55, No.4, p.194.

C H A P T E R - I I I

EVOLUTION OF LANDFORM, GEOMORPHIC PROCESSES AND FLUVIAL GEOMORPHIC CYCLE

In the foregoing chapter the geomorphology of Lunglei district has been discussed with a particular reference to geological formation, lithological and structural characteristics of rocks. The present chapter analyse the evolution of landform, the geomorphic processes and fluvial geomorphic cycle. The landscape may be moulded by the agencies of running water, weathering, mass-wasting, wind and ice. However, the agencies like wind and ice are not the agents in this region.

As the genesis of landforms is very complex, it is rather difficult to analyse, but there are certain laws under which the geomorphic processes operate. The geomorphic processes are those physical and chemical changes which effect a modification of the earth's surficial form (Thornbury 1954)[1]*. A geomorphic process may be epigenic or exogenetic and hypogenic or endogenitic. However, in the present study analysis will be based on weathering, fluvial erosion, mass-wasting, earthflow and landslides which have been actively engaged in shaping the landscape. Attempt has also been made to assess the stages of fluvial geomorphic cycle in Lunglei district.*

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[1] *Thornbury, W.D. (1971), Principles of Geomorphology, New York, John Wiley & Sons.*

Evolution of Landforms

Emergence of the study region from the sea bed was the primary state of the development of the land. Due to internal forces major folding appears to have been taken place in sub-merged geo-synclines which may be due to the block-movements, general uplift-ment and subsidence. The earlier processes of degradation and deposition operating prior to major tectonic activities may be traced through the rock composition, structural hills and their arrangements. Thus the development of the present land surface implies the successive cumulative effect of processes that had been taking place during the last geological periods. With the lapse of time the changes caused by exogenetic forces became greater and greater. Major landforms might have developed during the oligomiocene period and the successive stages of modifications have taken place into a series within the con-formity of geological periods. There are no evidences of volcanic activity in the region.

The topographical features of Lunglei district are very much influenced by the lithological constituents of rocks of the area and the structural formation of the area. The harder formations of sand-stones form an anticlinal ridges. Their location, shape and direction are determined by the distribution of sandstone, shale and their various interlaminations. Due to continuous erosion by various agents of erosion, it attacks the softer rock formations first, sparing the harder rock *formation to form strike ridges. It is believed that during the miocene period a number of folds and faults were formed and resulted the present landscape.*

Hills

In Lunglei district there are a number of parallel hill ranges running from north to south separated each other by deep narrow valleys occupied by sedimentary rocks of conglomerates, sandstones, shales, etc. and their various intermixtures.

The highest elevation of these hills is 1748 metres above mean sea level at Puruntlang (23°3'N 93°2'E) in the north eastern corner of the area and the average being 909 metres. The forms of the hills seem to be controlled by the structural features. The highest hill range is the extension of Phawngpui (Blue Mountain) from the south east along the Burma border in the east and Chhimtuipui (Kaladan) in the west as far as Puruntlang in the north east. The second high hill range started from Mualthuam village (22°51'N 92°54'E) at the river confluence of Mat and Chhimtuipui and extended towards north upto Bungtlang village (23°71'N 92°54'E) in between Mat and Tuichang rivers. The third and the longest hill range running from Mamte village (22°37'N 92°55'E) in the southern corner and extended towards north till Zote village (23°13'N 92°47'E) in the north in between the rivers Mat and Tlawng. The fourth hill range continued from Vaisam village

(22°45'N 92°41'E) in the south-east and extended upto Khawlek village in the north. The fifth hill range having its initiation from Rualalung village (22°45'N 92°31'E) in the south and extended upto Lungsen village (22°53'N 92°25'E) to the north. The sixth hill range started from Vuakmual village (22°54'N 92°38'E) in the central part of the region at the river confluence of De and Kau and extended towards north upto Darngawn village. The seventh hill range extended from Hruizam village at the river confluence of Kau and Tuilianpui and extended upto Laisawral village in the north. The last hill range extended from Serte village near Tlabung (Demagiri) along the Bangladesh border upto Mauzam in the north.

The forms of hills are very much controlled by the structural features. Although all the hill ranges are made up of monotonous sequence of rather limited varieties of rocks types, viz. sandstone, shale, mudstone, siltstone and they do play an important role for the formation of hills. It is quite true that the structural features are the most important factors for the formation of hills in Lunglei district.

Plains

In Lunglei district there is no single plain area with a considerable size. There are few intermount valley plains, and river valley plains in small pocket lying here and there. The largest intermount valley plain of one square kilometre is located at South Vanlaiphai village (22°48'N 93°E) in the source region of Hnahchang stream at *the elevation of 1200 metres. Mention may also be made that the intermount valley plain is observed at the source area of Ngengrual stream near Thingfal village (22°37'N 92°55'E) in the south. Small river plain is also observed near Lungsen village (22°53'N 92°35'E) in the west at the meeting point of three rivers like Kau, De and Phairuang.*

Geomorphic Features

As the terrain is very immature in response to recent techtonism, to pographical features show prominent relief. The major geomorphic elements observed in the area are both structural and topographic 'highs and depressions', 'flats' and 'slopes' sculptured in a linear fashion. In Lunglei district the topographic "depressions" are in all cases in accordance with the normal structural elements, but the topographic 'highs' are recorded both in the structural highs and depressions. The physiographic expression of the area is imparted by approximately north-south trending steep, mostly anticlinal, longitudinal (linear fashion) parallel hummocks or topographic highs (in an areal fashion). In general, the western limbs of the anticlines are steeper than the eastern limbs. Faulting, in many cases, produced fault scarps especially along the steep diping fault plane. The other geomorphic elements are high dissected ridges with the formation of deep gorges, spurs, keels and cols which developed due to intensive erosion during the isostatic adjustment. The difference of elevation between valley floors and hill tops greatly *varies from west to east, the range being 200 metres to 600 metres. The steep hill ranges are more towards east rather than towards west.*

The major drainage pattern having different bifurcation ratios follows the north-south trending depressions and gorges in the low level topography separated by highland topography in between them. The depressions and gorges in most cases are the physiographic expression of the fault or other structural patterns. The tributaries and streamlets forming 'sub-parallel to parallel' drainage pattern and run both parallel and across the topographic depressions and highs. The slopes of the streams are moderate. In some cases the rivers are restricted within the comparatively soft shale horizons. The main drainage system in the area falls within the piedmont and straight reaches. The water holding capacity is low because of its cleyey nature.

Weathering

The disintegration or decomposition of rocks is generally referred to as weathering. It is collectively or group of processes at or near the surface of the earth. Weathering may be regarded as two distinct kinds, accordingly as the rocks are disintegrated without chemical alternations (mechanical or physical weathering) or rotted or decomposed (chemical weathering).

The various factors which influence weathering are:

(1) Climate,

(2) Petrological and lithological characteristics of rock types,

(3) Structure,

(4) Vegetation.

The processes of weathering in the region are greatly influenced by the type of rocks, the climate and relief. These factors play an important role both individually and collectively, but the extent to which each has had influence on weathering processes is very difficult to generalise. Amongst physical weathering, climate especially rainfall plays most important role in the rate of weathering. It is true that structure and lithology have a great role to play in the intensity and extent of weathering. The steep slopes along the ridges where the rocks are exposed are the weakest part where the effect of physical weathering are noticed first.

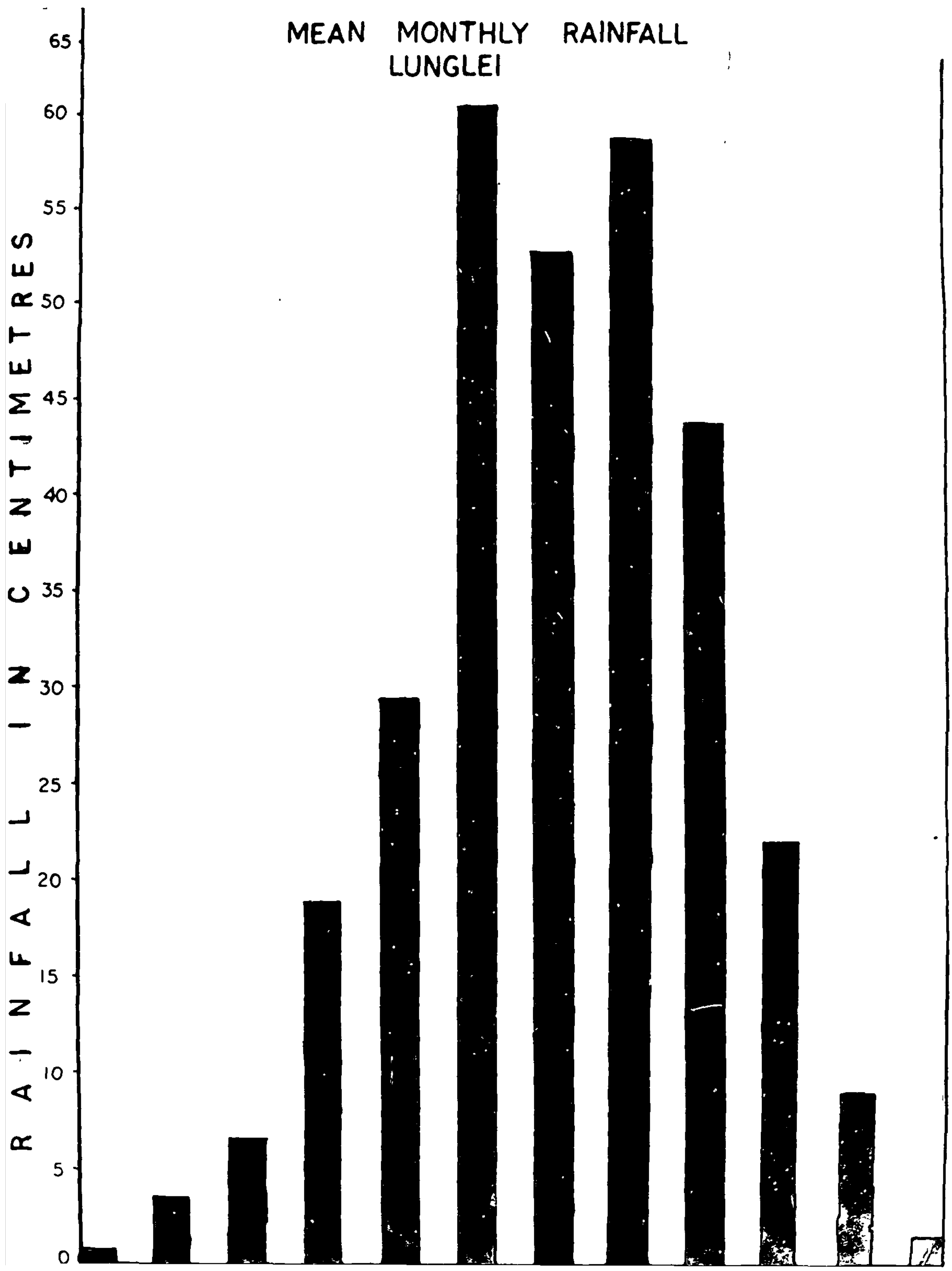
Climate and Weathering

The climatic factors, especially temperature and rainfall in Lunglei district are vital physical factors which decide the nature and extent of weathering and erosional processes and has profound influence on the agricultural conditions. The climate is humid tropical and characterised by long winter, short summer and heavy rainfall.

Temperature

Since there is no any observatory station in the area, it is *really difficult to study the temperature conditions of Lunglei district. Due to its interior location and undeveloped area there was no any rainguage station till 1972. It was only when Mizo hills district became Union Territory, three rainguage stations were established at Lunglei, Tlabung and Hnahthial. Again, due to disturbances in the area caused by Mizo National Front and also due to inefficiency of Agriculture Department, there could not be temperature and rainfall record. The author tried his level best to get the temperature data of this region. The only temperature data available is for the year 1983 of Lunglei town recorded by District Statistical Officer. The author contacted many persons throughout the area to know about the temperature changes of the district and the analysis is done after interviewing many persons in the district.*

One of the chief characteristics of Lunglei district is that the temperature does not fluctuate much throughout the year except on the valley sites. The highest monthly temperature is observed in the months of June and July. Thereafter, the onset of rainy season brings down the temperature. The temperature continues to fall with the break of rains and the lowest monthly temperature is observed in the months of January and December. During the months of June and July normally monthly maximum temperature at Tlabung. Hnahthial and Chawngte are observed to be very high due to its lower altitude but at the same time at Lunglei, Darzo and Thingsai the temperature


MEAN MONTHLY RAINFALL
LUNGLEI
RAINFALL IN CENTIMETRES
0
5
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35
40
45
50
55
60
65

is quite normal due to its high altitude. As far as the annual range of temperature is concerned, it is observed that the places at higher altitude observed lower range of temperature as compared to the places at low altitude experiencing higher range.

Rainfall

The consideration of the nature and amount of rainfall is also greatly significant in the study of weathering. In Lunglei district more than 80 per cent of the rainfall is concentrated during the monsoon period of June to September. In April and May violent storms from the north-west swept over the hills. The area enjoys abundant rainfall. The average rainfall at Lunglei is usually recorded as 327 Cms. The available data shows that the maximum rain falls in the month of June. August is the second rainiest month (Fig. 4a). The data of the monthly rainfall of Lunglei town are as follows (Table 2).

TABLE 2

The data of monthly rainfall of Lunglei town

Month	Mean monthly rainfall (in Centimetres)	Month	Mean monthly rainfall (in (Centimetres)
January	0.76	July	53.14
February	3.53	August	59.06
March	6.45	September	44.12
April	19.10	October	22.07
May	29.72	November	9.30
June	60.83	December	1.47

Source: Records of European Missionaries, Serkawn, Lunglei 1912-1945.

Intensity of Rainfall

The intensity of rainfall is more important than the amount of rainfall. It has a profound influence on soil erosion. The intensity figures of Lunglei district were calculated by dividing the total rainfall by the number of rainy days.

For the present analysis seasonal or monthly intensity of Lunglei have been prepared. The seasonal intensity ranges from 0.33 Cm (0.13") to 22.36 Cms (0.93"). The average annual intensity for thirty years in Lunglei is 1.96 Cm (0.77").

The linegraph of Lunglei (Fig. 4b) illustrates the distribution of the average intensity from month to month. They show maximum average intensity during the wet season from April to September due to much greater fraction of more than 90 per cent of rainfall within six months. The maximum average intensities are recorded in the month of June.

Mechanical Weathering

Mechanical weathering is the breakdown of material entirely mechanical methods brought about by various causes. Some of the forces originate within the rock, while some others are applied externally. The temperature conditions mainly determine the type of mechanical weathering. The effect of average annual temperature and monthly average temperature in weathering processes is quite significant. During

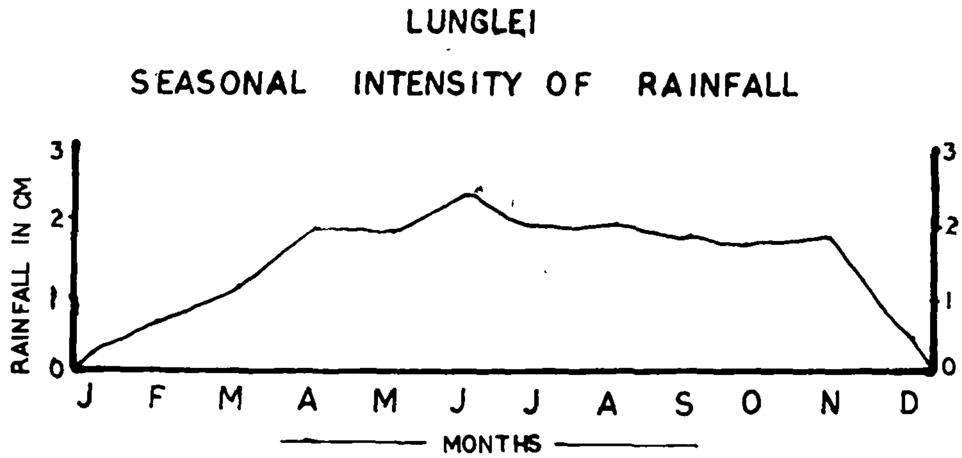
LUNGLEI
SEASONAL INTENSITY OF RAINFALL
RAINFALL IN CM
0
1
2
3
J F M A M J J A S O N D
MONTHS

FIG. 4b

high temperature the mechanical disintegration of rocks are frequent. High degrees of day temperature helps the surface of the earth getting heated and during the night the subsequent fall in temperature cools down the surface, hence, alternating heating and cooling helps the mechanical disintegration of rock easily. The repeated process of heating and cooling of sandstone and shales, which are poor conductors of heat, give rise to stress and strain in the upper layers of rock mass in the temperature thus ultimately disintegrate the rock surface. Various processes have been recognised as mechanical by Ollier (1964)[2], Thornbury (1971)[3] and Sparks (1971)[4]. Amongst these only slaking 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 slaking. On the steep and gentle slope of Lunglei district the tertiary sandstone and shale show this type of mechanical weathering. In the western part of the district especially at Tlabung village and the adjoining areas this type of weathering dominates. The researcher has observed during field work, the disintegration of the fine grained sandstones and mudstones into a small places of unequal sizes (Plate No.1). A great variation in diurnal and monthly rainfall in this region helps in this process of slaking.

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[2]Ollier, C.D. (1969), Weathering, Hongkonh, Logman.

[3]Thornbury, W.D. (1971), Op.cit.,

[4]Sparks, W.W. (1971), Rocks and Relief, London, Logman.

Blackwelder (1969)[5] *has pointed out that a good deal of thermal expansion and contraction of rock is caused by forest fires which caused ununiform heating of rocks. Areas of steep and gentle slope in Lunglei district where extensive jhuming is practiced show spalls of flakes of rock which are produced due to exfoliation caused by unequal heating and cooling. When temperature fluctuates, the mineral grains composing rocks alternately expand and contract. In view of the slow penetration of heat into the depth of rock, the surface layer expands more than those within. The frequent result is the appearance of cracks parallel to the surface of rock blocks and desquamation of the later.*

Thermal weathering is more intense on the steep slopes of high hills, where the air is more transparent, and isolation more stronger than in the adjacent deep valleys. Since jhuming is continuously practiced in the hill slopes, the rock fragments produced by weathering are readily removed from the slopes by gravity due to which the surface of the slopes remain exposed and undergoes further weathering. This results in the accumulation of hillside waste or talus at the foot of the hill slopes (Plate No.2).

During field observation, the researcher came across this type of weathering near villages Tawipui and Zobawk. Thermal weathering is found where jhum cultivation is practiced and left fallows for the next jhum cycle.

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[5] *Blackwelder (1969),*

PLATE NO : 1

Disintegrated Sandstone of unequal size due to Mechanical weathering near Tuichawng village.

PLATE NO

Hillside Waste near Tawipui village

Chemical Weathering

Chemical weathering is the result of interaction of rocks of the superficial layers of the lithosphere with chemically active constituents of the atmosphere, the hydrosphere, and the biosphere. Chemical weathering is chiefly carried on by rain water and the atmospheric gases. 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 (Thornbury 1971).[6]

No Chemical weathering is possible without the presence of water. So, chemical weathering is at its maximum in the rainy season due to the presence of sufficient water and moderate temperature. On the contrary, the intensity of chemical reaction reaches its minimum in the dry season due to lack of water and comparatively high temperature.

When the monsoon sets in, the action of chemical weathering in Lunglei district starts in the form of hydration and solution upon the sedimentary rocks. The water enters through cracks and joints and reaches to a considerable depth. As the water goes through the joints which are more or less in all directions, the edges and corners of the rocks are attacked by chemical action. The process of hydration

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[6] *Thornbury, W.D., (1971),* *Op.cit.,*

and solution takes place with limestone and other mineral constituents of the sedimentary rocks.

It is seen from the geological map (Fig. 2) of Lunglei district that the region is widely occupied by sedimentary rocks. Since the area lacks detailed geological studies it is difficult to give a dividing line between mechanical weathering and chemical weathering. During the course of extensive field study the researcher noticed some caves on the edge of Pukpui village on the Lunglei hill range and at the western part of Darzo village in the east (Plate No.3), which are no doubt caused by chemical weathering in the forms of hydration and dissolution.

Biological Weathering

Mechanical weathering is a process in which the rocks are destroyed by the mechanical action of external agents. Tree roots produce a similar mechanical action. Growing roots exert strong pressure on the walls of cracks and acting as wedges pry them apart into slabs and fragments. The dead roots of plants become swollen with rain-water and also widen the cracks. The mechanical destruction of rocks by plants may be observed practically in all climatic zones.

Biological weathering in the region is not so significant as the other two processes of weathering. However, the effect of roots of trees in penetrating along the joints of the weaker rocks can not *be ignored. This type of weathering is generally noticed in highly-joined rocks, especially along the cliffs and river banks (Plate No.4).*

Mass-Wasting

Large masses of material move downslope as units in mass-wasting an essential process in general wasting a way and levelling of the land. The processes of weathering loosen, decompose, and dissolve rock debris everywhere on the lands, and the processes of mass-wasting then moves this debris to lower altitudes where streams, ice and wind can transport it away. Rock falls, landslides, soil slump, creep, mudflows and slope wash are examples of mass-wasting. In the study of geomorphic processes, mass-wasting is also an important process which is a part of weathering (R.K. Rai 1980)[7]. The weathered material which can not rest on sloping ground comes down under the influence of gravity. The process of mass-wasting starts when due to long continued process of weathering surface rock becomes weak or is converted into a loose mass. Such materials start moving down under the gravitational force. Hence it is more effective on steeper slopes, as well as on slopes which bare or near the bare rock surface. Of course, the vegetation binds the loose material and does not allow it to move down readily. This process is commonly observed in the area under the study.

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[7]Rai, R.K. (1980), Geomorphology of the Sonar-Bearma Basin, Concept Publishing Company, New Delhi.

PLATE NO 3

ave formed by chemical weathering on the scarp face in the
orth west of Darzo village

PLATE NO

Biological weathering in the western part of Thingsai vill

The intensity of mass-wasting depends on such factors like lithology, stratigraphy, structure topography, climate and biotic factors. In Lunglei district all types of mass wasting has been noticed.

In the region of hill side and steep slope, the heavy downpour in the rainy season, the rain water soaked into the surface of the earth softened the rock formation and the weathered rock debris begins to flow down the slope in the form of earthflow and mud-flow. This process becomes more intense in the areas of steep slopes where the bed rocks are steep and exposed near the surface. A large mount of the surface material is washed away in this process.

In the rainy season, it is noticed at many places where the hill slope is quite steep, the rain water disintegrate and decompose rocks into fragments, they fall down from the slopes and scarps in tabular and bedded pieces through various mass wasting agents and accumulate in the valley. It is a common feature throughout the area. Since the region is lithologically and structurally unstable, when the rain water enters the surface of the earth, it dissolves the softer rock formation and subsidence takes place where the underlying rocks are weak. It is noticed in many places of Lunglei district.

Landslides

The downward movement of a large mass of earth or rocks from a mountain or cliff is termed as landslide or landslip. It is often *caused by rainwater soaking into the soil and earthly material on a steep slope; their weight is much increased, and they become more mobile. It may also be caused by an earthquake, or on the sea coast by the undermining action of the sea. Landslides tend to occur on steep slopes underlain by strata or structures (e.g. joints and foliation) that deep parallel to the surface. Water adds weight, reduces the cohesion among the particles in surficial materials, and also reduces internal friction.*

In Lunglei district surface landslide is a common feature throughout the region, especially along the steep slopes and hill sides in the region are lack of support in front and a slip surface. Such conditions are liable to occur on the sides of undercut slopes and cliffs, or of road cuttings, particularly where heavy massive rocks overlie weak sedimentary rock and loose soil. Sliding occurs when bedding or cleavage planes, master joints or fault fractures dip towards a valley or other depression at a dangerous angle.

The researcher during the course of field observations and long associated with the area noticed the seriousness of landslide in the study area. The landslides are more predominate along the road section of Lunglei-Tuipang road and Lunglei-Aizawl road. The Lunglei-Tuipang road passes through a number of steep slopes which are made up of loose sedimentary layer. At first, to some extent the vegetation *cover with their roots binds them against landslide but when they construct the road along the steep slope the upper mantle of the rock with the initiation of heavy rainfall during the months of June-August caused a serious landslides (Plate No.5). It was noticed during the field study that a serious landslide occured in the month of July along the road section of Lunglei-Tuipang which caused the slip off the three houses of Thingfal village (22°37'N 92°33'E) and the traffic was closed for a week. It was also noticed that frequent landslides occured during the rainy season along the road section of Lunglei-Aizawl, Lunglei-Tlabung and Lunglei-Haulawng.*

Besides, the landslides also occur frequently on the steep hillslopes. It appears that due to action of mechanical and chemical weathering, the compactness of the rock mass is lost and boulder along with earth and mud fall down the slope under the effect of gravity. This landslide is mainly caused by heavy rainfall, the rugged topography, the immature topography and clearing away the vegetation cover due to long continuous jhuming in the area.

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 state."*[8]

Throughout most of the world, run off waters are the dominant geomorphic agency. So in any geomorphological study fluvial cycle of erosion becomes the most important aspect. The study of the fluvial geomorphic cycle in Lunglei district helps in understanding the geomorphic features which have developed due to the fluvial action. The present landform characteristics are the outcome of structure, running water and weathering. The study of erosion surfaces has also helped in tracing the evolution of landforms and drainage. The evolution of landforms and erosion surfaces makes it evident that the existing topographic features of Lunglei district are the outcome of a long and continuous exogenetic process which began after the evolution of Himalayan belt in the Miocene period, after the last phase of the Himalayan orogeny in the pleitocene period.

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[8]Wooldridge, S.W. and Morgan, R.S. (1969), An Outline of Geomorphology, London, Logman.

Stages in the Cycle of Erosion and Fluvial Erosion

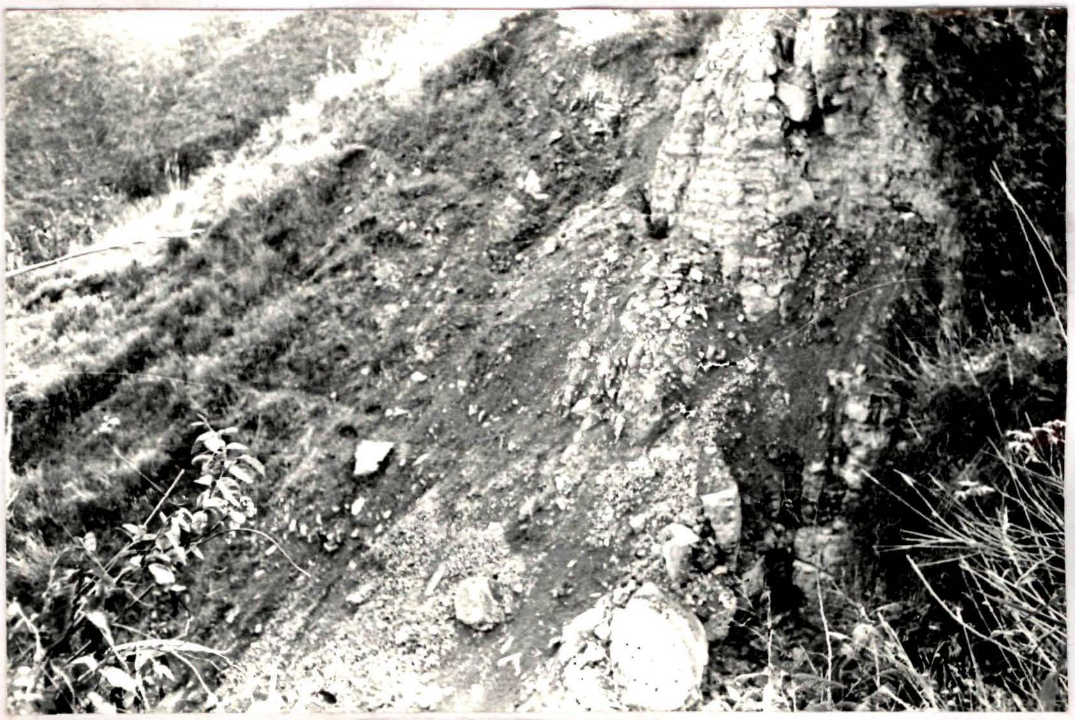
As it has already pointed out that operation of the erosion agents, such as rivers lead to an orderly sequence of landform development. An attempt has been made here to identify the stages in the cycle of erosion in Lunglei district.

Enormous short tributaries and gullies extending themselves by headward erosion in the Lunglei hills show that the cycle of erosion is still in its youthstage. The Tlawng, the Mengpui, the Kau, the De and all the tributaries of the rivers show a 'V' shaped profiles which confirms the youthful stage (Plate No.6). Besides, the prominent waterfalls are the most typical of an early youth stage.

In Lunglei district one finds that 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-streams areas are extensive and drained only by a parallel and sub-parallel streams which are rather irregularly drained.

The above regional picture shows that the general topography of Lunglei district is in a youthful stage. Thus the study of the drainage characteristics and topography indicates that the region has been uplifted in a recent past, so the streams have acquired energy to deepen their valleys. The streams are engaged in headward erosion.

PLATE NO 5



ʃurface Landslide on the steep slopes of loose sedimentary ɾock formation near Thingfal village

PLATE NO 6

ɔuthful valley of Tlawng river near Dawn village

Fluvial Erosion

The intensity of fluvial erosion in the region under study depends on the structure and lithology of rocks, and climate also plays very important role in the fluvial action. Amongst the climatic factors, the intensity and amount of rainfall is the main factor. Since the region falls under Monsoon type of climate and 80 per cent of rainfall is concentrated during the four months from June to September, the fluvial erosion becomes vigorous mainly in these four months period; and during dry season the effect of fluvial action is negligible. The hill ranges, hill slopes and ridges are composed of loose sedimentary rocks and all the zones of intensive erosion.

As Lunglei district is full of hill ranges and very narrow valleys with steep slopes, the intensity of erosion is very severe. When the rain falls a large amount of water percolates below the surface and the rest flows in the form of rills, gullies or in sheet flow over the surface. The rainwater percolates below the surface and softens the surface rocks. The loose weathered material thus produced in the form of coarse soil and rounded boulders is washed away by running water. Thus, the differential weathering and running water are important not only in general lowering of the land surface but also in shaping the landforms of the area. Since the gradient of slope is very high and the volume of running water is very strong and large during rainy season, the weathered materials brought by rivers are transported *to a long distance, and at the same time, the weathered materials act as erosive agents throughout the river coarse in Lunglei district.*

Drainage System

Drainage is the study of the manner in which water flows over an area. Lunglei district covering an area of 4538 sq. kilometres is drained by three broad drainage systems of Tlawng, Khawthlangtuipui and Chhimtuipui by a number of consequent and subsequent streams with a large number of their small and big tributaries.

A glance at the drainage map of Lunglei district (Fig. 5) reveals that the drainage system of this area is to a great extent directed by the surface features or relief of the area. The hill ranges are generally north-south direction with deep valleys in between them. The rivers generally flow towards north or south direction.

(1) The Chhimtuipui:

This drainage system is the biggest system in the region. The Chhimtuipui drains nearly half of the area of the region. It rises from the western part of Burma near Vanum village at the height of 2325 metres, and flows in the south direction. After passing about 70 kilometres it turns towards western direction for about 50 kilometres and enters Chhimtuipui district in Mizoram near Sabawngte village at the height of about 1919 metres. From Sabawngte it flows for about 55 kilometres towards north direction along Burma and India

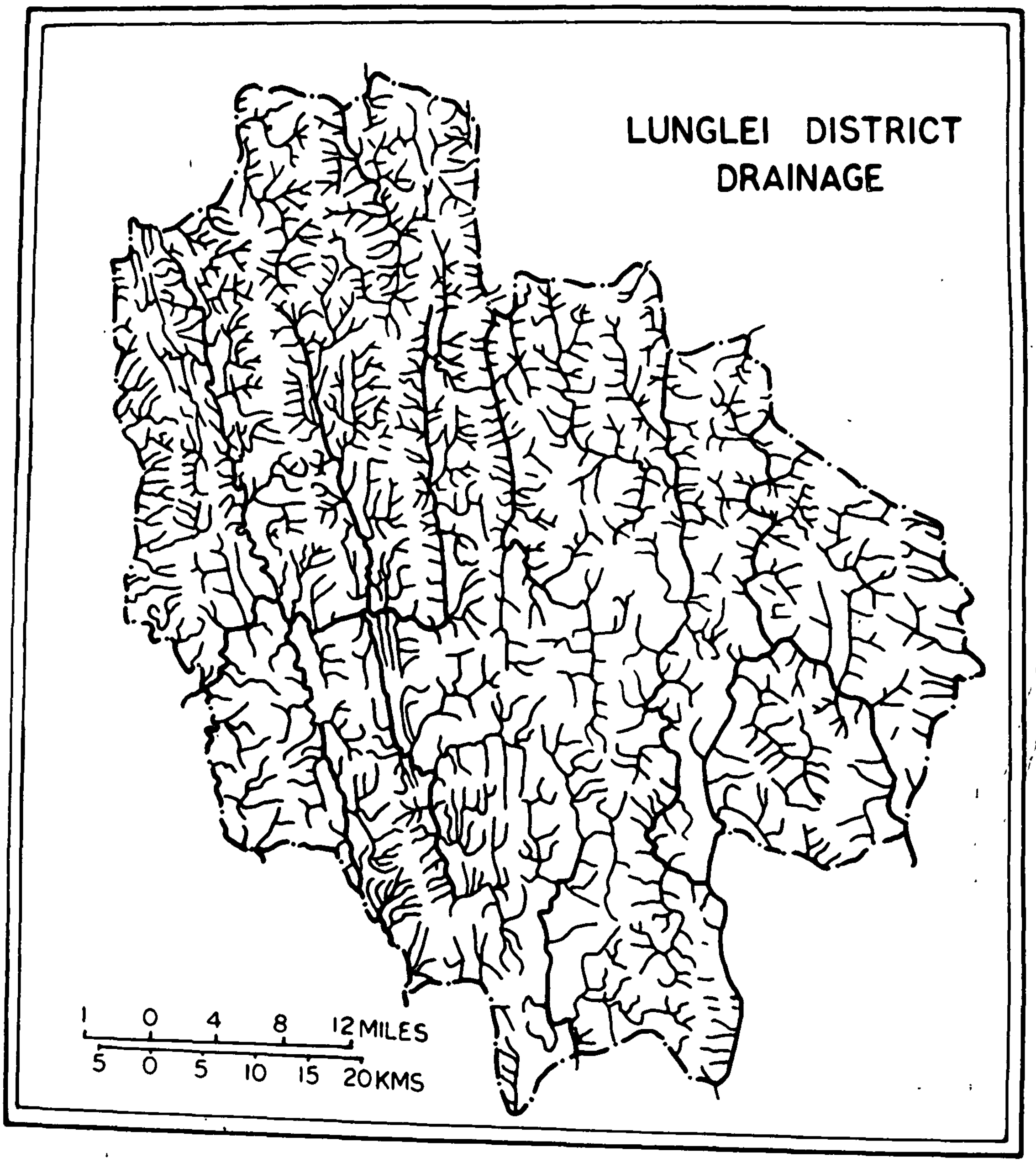


FIG. 5

border and meets Tiau river just in opposite direction. The meeting point of these rivers is quite interesting in the rainy season. The water rises up quite high because too strong current meet just in opposite direction. Then it turns towards north-west and meets Tuchang river near Hnahthial village (22°57'N 92°56'E) and then turns towards south following just on the margin of Chhimtuipui and Lunglei districts boundary. After flowing in the Chhimtuipui district it enters Arakan hill tract. Its tributaries which join this river are Tuichang, Mat and Mengpui. The Tuichang and Mat originate from Aizawl district and flow in parallel for many kilometres. Mengpui, one of the tributaries of Chhimtuipui river, rises from Lunglei town (22°53'N 92°45'E) at the height of about 1080 metres. It flows towards southern direction throughout Lunglei district and enters Chhimtuipui district to the east of Lawngtlai village and after flowing for about 30 kilometres it meets Chhimtuipui river near Bungtlang village.

(2) The Tlawng:

Although Tlawng river is the longest river in the Union Territory of Mizoram it is represented by the upper portion only in Lunglei district. Tlawng river originates from Zopui hill some 8 kilometres to the east of Lunglei town at the height of about 1395 metres. It flows in the northern direction just opposite to De river in the west and Mat river in the east. After flowing for about 50 kilometres it enters Aizawl district near Khawlek village (23°21'N 92°43'E). Its *important tributary is Tut. Originating from Thenhlum village (23°13'N 92°34'E) the Tut flows first in the southern direction for about 8 kilometres and then turns towards northern direction for about 20 kilometres and enters Aizawl district near Vanghro village (23°24'N 92°41'E) Tut continues to flow in the northern direction till it meets Tlawng river in Aizawl district.*

(3) The Khawthlangtuipui:

The Khawthlangtuipui represented here only the upper portion of the basin. Originating from Phuldungsei village in the Aizawl district, the Khawthlangtuipui flows in the southern direction along the border of Bangladesh and Mizoram. After flowing for about 65 kilometres it enters Lunglei district at Marpara village. It continues to flow for about 40 kilometres till Tuichawng village (22°55'N 92°32'E) and flows towards the west by passing through Tlabung, sub-divisional headquarters of Lunglei district. Khawthlangtuipui enters Bangladesh and finally joins Bay of Bengal.

Khawthlangtuipui has numerous important tributaries which drain the western part of Lunglei district. The important tributaries are Tuichawng, Phairuang, Kau and De. Tuichawng, one of the important tributaries, originates from Meilaitlang in the Chhimtuipui district and flows in the northern direction. After flowing for about 80 kilometres it enters Lunglei district at Chawngte village. It then takes *a northern direction for about 35 kilometres and meets Khawthlangtuipui at Tuichawng village. Phairuang river originates near Vaisam village (22°45'N 92°41'E) and flows for about 5 kilometres towards the west and then turns towards northern direction for about 38 kilometres and joins with De river near Lungsen village. Originating from Buarpui village the De river flows towards southern direction for about 40 kilometres in opposite direction to Tlawng river. In the last 8 kilometres it takes westerly course and joins the Phairuang river near Lungsen. The Kau originates from the Thenhlum village. It flows in the southern direction parallel to De river for about 40 kilometres and finally joins De to the north of Lungsen.*

Evolution of Drainage

The area is a constituent part of the Assam-Burma geological region which itself was a part of the Tethy's sea in the Archean period. During the Paleozoic and much of Mesozoic eras the sea continued to receive sedimentary deposits in the form of conglomerates, shales, sandstones erod-ed from the Archean rocks. The successive periods show repeated orogenic activities accompanied with extensive igneaus intrusions. A final orogenic phase in the early pleistocene raised the upland to its present position. A drainage system developed by following the initial slope and the relief and structure of the region. The general pattern of the rivers was from north to south direction. The streams *and rivulets also developed along the slope in the east and west direction.*

After the withdrawal of the Tethy's sea, a new cycle advanced, the river system originated and deepen their valleys through side cutting and vertical erosion. Most of the streams have developed according to their underlying structure. It is believed that the rivers developed after the Himalayan orogeny. It seems that there has not been any major change in the direction of rivers and they continued to follow the same course. The rivers and Streams are mainly controlled by structure and lithological characteristics of the underlying rocks.

During the field study it was observed that the region receives heavy rainfall during the months of June to September and as a result the volume of water increases very much and the current of water is also very strong during these four months. The discharge of rivers is enormous and their transporting capacity is very great. The rivers transport big boulders and logs of wood to a long distance during June to September whereas in the dry season many rivers and streams are dry up in the upper course. It is quite true that rivers are mainly fed by rain water.

Cross Profiles of Valleys

The cross profile of a valley may shed a considerable light upon its geomorphic history, as well as indicate the influence of local *geologic and climatic controls (Thornbury 1971).*[9] *The cross profiles of the rivers of Lunglei district show that their valleys throughout the courses are 'V' shaped, very deep and very narrow. Their sides are very steep sloping and noticed to have steep vertical walls in many places. The river courses are surrounded by very steep slopes on both the sides.*

Valley Deepening and Widening

The valleys in Lunglei district are very deep and narrow. The erosive work of water still deepened downwards by vertical cutting. It has also been noticed that in Lunglei district most of the rivers widened their courses by side cutting during the rainy season. Due to long continued practice of shifting cultivation by local tribals, a large number of gullies are developing and are extending by headward erosion. It is also marked that the rivers are more engaged in vertical erosion. As the courses of rivers are very steep the area is affected by sheet wash, mass-wasting and slide rocks on the valley sides. It is noticed that the valleys become more and more deeper in all the river courses.

Water-Falls

Lunglei district abounds in waterfalls. The streams decending from the hill sides towards the valley sides formed several waterfalls.

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[9] *Thornbury, W.D. (1971), Op.cit.,*

Lunglei district is full of hills with narrow valleys formed during the tertiary time. Due to structural control there are many cliffs, folds and faults.

Since the rivers in this part of the region are nonperennial, the waterfalls can be seen only in the rainy season. During the field study it was noticed that these waterfalls have developed due to differential and headward erosion.

The most important waterfall of the region is the Khawiva fall on the Khawiva stream located to the north east of Zotlang village (22°55'N 92°45'E) in the Lunglei hill range at a distance of three kilometres from Lunglei (Plate No.7). The Khawiva fall at the edge of Zotlang hill formed 60 metres high waterfall which has no doubt receded much by headward erosion and also due to structural control. The highest waterfall of the region is Mamte fall (22°37'N 92°56'E) on the Mamte stream located near Mamte village in the southern most part of the area. The Mamte streams while decending from Mamte hill to Chhimtuipui river formed waterfall of 100 metres. During the field study it was observed that during dry season there is a little more than trickle over this fall but during the rainy season it is said to be imposing sight.

Another important waterfall is found in the north western part of the region. The Miteswari stream, a tributary of De river, *has a fall of 30 metres high at a distance of 8 kilometres from Lunglei-Tlabung road. Other three waterfalls are found in the upper course of Kau river about 6 kilometres to the north east of Bunghmun village (23°11'N 92°33'E) where the Kau river decends from Tleutlang hill formed waterfalls of 55 metres, 45 metres and 40 metres respectively.*

Pot Holes

Although pot holes are observed in almost all the streams of this region, the pot holes in the Mat river near Mat bridge (22°54'N 92°53'E) on Lunglei-Aizawl road and pot holes in the Tlawng river near Zobawk village (22°52'N 92°49'E) deserve mention (Plate No.8). In the sandstone of the river bed depressions or cavities have been formed due to joints. Due to grinding action of the sand grains and the pebbles the depressions are enlarged. Some pot holes occur at the bottom. The river bed at this point exhibits succession of independent and intersecting pot holes. During the rainy season the current of the stream along with erosive tools move with great swirls passing from one pot hole to the next. These pot holes are so big that they might be termed as 'gigantic pot holes'.

PLATE NO 7

hawiva waterfall due to headward erosion east of Zotlang
illage

PLATE NO 8

Pot hole formation in the upper course of Tlawng river

MORPHOMETRIC ANALYSIS

Morphometric analysis of maps aims at the distinct disclosure and precise definition of the form of land as depicted on the map. In the words of Dury,

> *"very many features of the highest significance appear only on those maps drawn by the field geomorphologists, but the techniques of morphometry are of great use in the rapid exploration treatment of large areas in helping the map interpreter to reduce the forms of diversified country to some kind of order and in the treatment of certain class of data which are not well derived from the field study."*[1]

Topographical maps express most of the outstanding features but necessarily subdue significant individual features between contour intervals. Even though many land features are represented in the topographical maps, they may not be distinctive. Such indistinct land features and subdue topographical expressions have to be portrayed on the geomorphological map. The use of the morphometric methods and field techniques would not only lead to an ordered, systematic and scientific portrayed of varying topographical expressions, but also help in understanding of the landforms. In fact, as pointed out by Miller,

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[1]*Proceedings of Summer School, Department of Geography, Banaras Hindu University (Nov. 1-10-1966).*

"The geomorphological evidence, however, does not always stand out obviously on the face of map. Careful examination with measurement of distance or shape is often necessary and the evidence revealed by the measurement can be expressed in figures or in careful drawn sections, and serial projected, superimposed, composite, long cross spur and staggered spur profile."[2]

Morphometric analysis is essential needed for identification of geomorphic characteristics of a region like Lunglei district. The present analysis is based on the results of different morphometric methods which have been applied to bring out clearly the geomorphic characteristics of Lunglei district which are responsible for the development of landform. Lunglei district, though occupying a small area of the earth surface, represents a varied degree slope, numerous streams and rivers, hills and hill ranges, which provide very wide field for investigation, interpretation and analysis of various geomorphic elements to deffuse the geomorphic bondage of this small region as of a type. Morphometric methods and techniques are of great significance from the point of view of geomorphological investigation in this region.

Slope Analysis:

The study of slopes is one of the most important aspects of geomorphology. Slope analysis requires scientific and mathematical analysis to provide both qualitative and quantitative base for the developmental planning such as construction of roads, bridges, dams, as well as agricultural

[2] *Miller, A.(1949), The Dissection and Analysis of Maps, Trans. Inst. Bul. Geographers, Pub. No. 14, p.8.*

landuse planning and any multipurpose project. It is the single largest determinant of landforms that determine activities of man, its socio-economic activities, culture and environment. Thus, the study of slope development and its nature provides fundamental background for multi-developmental planning.

Development of Slopes:

Slopes are the constituent elements of mountains, river banks, coasts. In short, slopes are of all the features that are characteristics of the geography of our globe. Some of these slopes may have been formed by endogenetic process, such as by the thrusting up of mountain range or by the opening up of a rift valley. However, the "Primary" slopes, if one wishes to call them thus, will soon be acted upon by external (Exogenetic) agents such as wind, water, ice and residual stresses, so that their shapes will change. If it can be understood how slopes change under the influence of exogenetic processes, then it is obviously possible to explain physical geography (Scheidegger 1961).[3] There are many important factors which influence the development of slopes:

(i) *The earth's surface has relief and hence slopes because of variety of internal endogenetic forces have raised parts of it to a 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*

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[3] *Scheidegger (1961), Mathematical Model of Slope Development, Bull. Geol. Soc. America. Vol. 72, pp.37-50.*

envisage separate periods of uplift followed by slope and river development.

(ii) Both the weathering and transport of materials on slopes are affected by climate. In considering slopes it is important to assess the nature of rocks, sponteneous mass movement, corrosion, erosion and accumulation.

(iii) The activity of the stream at the base of the slope is important. It removes material conveyed to it from the surrounding slopes. It sometimes moves round the bottom of the valley and undercuts its banks. Thus the slipping of materials on slopes and the removal of sediments from stream banks are but parts of a continuous process in drainage basin dynamics.

(iv) Man has a considerable influence on slope development through agricultural and industrial activities.

Thus, the study of slopes in Lunglei district of the Union Territory of Mizoram will bring the nature and characteristics of development of a slope profiles. The impact of man in this hilly terrain may clearly be noticed in the modification of slope profiles. The domination of the tribal population in this area has its own cultural impact in the practice of agriculture. The long and continued practice of shifting cultivation in the study area has greater influence in the modification of the slope profiles in the region. Thus, the study of slopes in such a region where practice of shifting cultivation continues since historical past needs intensive knowledge of the changing nature of relief of the region.

Average Slope Analysis:

To have a better understanding of the processes of evolution *of landforms an analysis of slopes and their characteristics is very essential. Slope analysis also helps in visualizing the processes of stream development and their work at their sources. At the same time it is also greatly helpful in recognising the erosional surfaces of the area. One can have a better understanding about the relief features of a region through detailed contour map of the region. But one can not wholly depend on slope maps because one can not get a quantitative assessment of slopes. Even though slope map has provided the general visual impression of the geomorphic features and the region may be delineated into different slope categories.*

Method of Study:

There are various methods suggested by many geomorphologists for the study of average slope of the area, such as Finsterwalder, S. (1890)[4], Smith, G.H. (1935)[5], Wentworth, G.K. (1930)[6], Raize, E. and Henry, J. (1937)[7], Miller, A.A. (1949)[8] and Gyel, W.F. (1969)[9]. Some methods are tedious

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[4]Finsterwalder, S. (1890), Annal Association of American Geographers, Vol. 57, No.1, Mar. 1977.

[5]Smith, G.H. (1935), The Relative Relief of Ohio, Geographical Review, 25, pp.272-284.

[6]Wentworth, C.K. (1930), American Journal of Science, Series 5, Vol. 20, pp.184-194.

[7]Raize, E. and Henry, J. (1937), An Average Slope Map of Southern New England, Geographical Review, 27 (1937), pp.467-472.

[8]Miller, A.A. (1949), The Dissection and Analysis of Maps, Trans. Inst. Bul. Geographers, Pub. No.1410, p.8.

[9]Gyel, W.F. (1969), Morphometric Analysis and Worldwide Occurance of Sepped Erosion Surfaces, Jour. Geol. American Soci. Vol. 69, p.388.

and time consuming. So, in the present study the method suggested by Wentworth to determine the average slope of the region has been used. This method is simple and the result obtained is also quite encouraging to get the general picture of the average slope.

The formula proposed by Wentworth is as following:

$$\text{Average slope} = \tan \Theta = \frac{N \times I}{3361}$$

$$\text{Angle} = \Theta = \tan^{-1} \frac{N \times 1}{3361}$$

Where N = Average number of contour crossing per 4 sq. mile.
Where I = Contour interval in feet

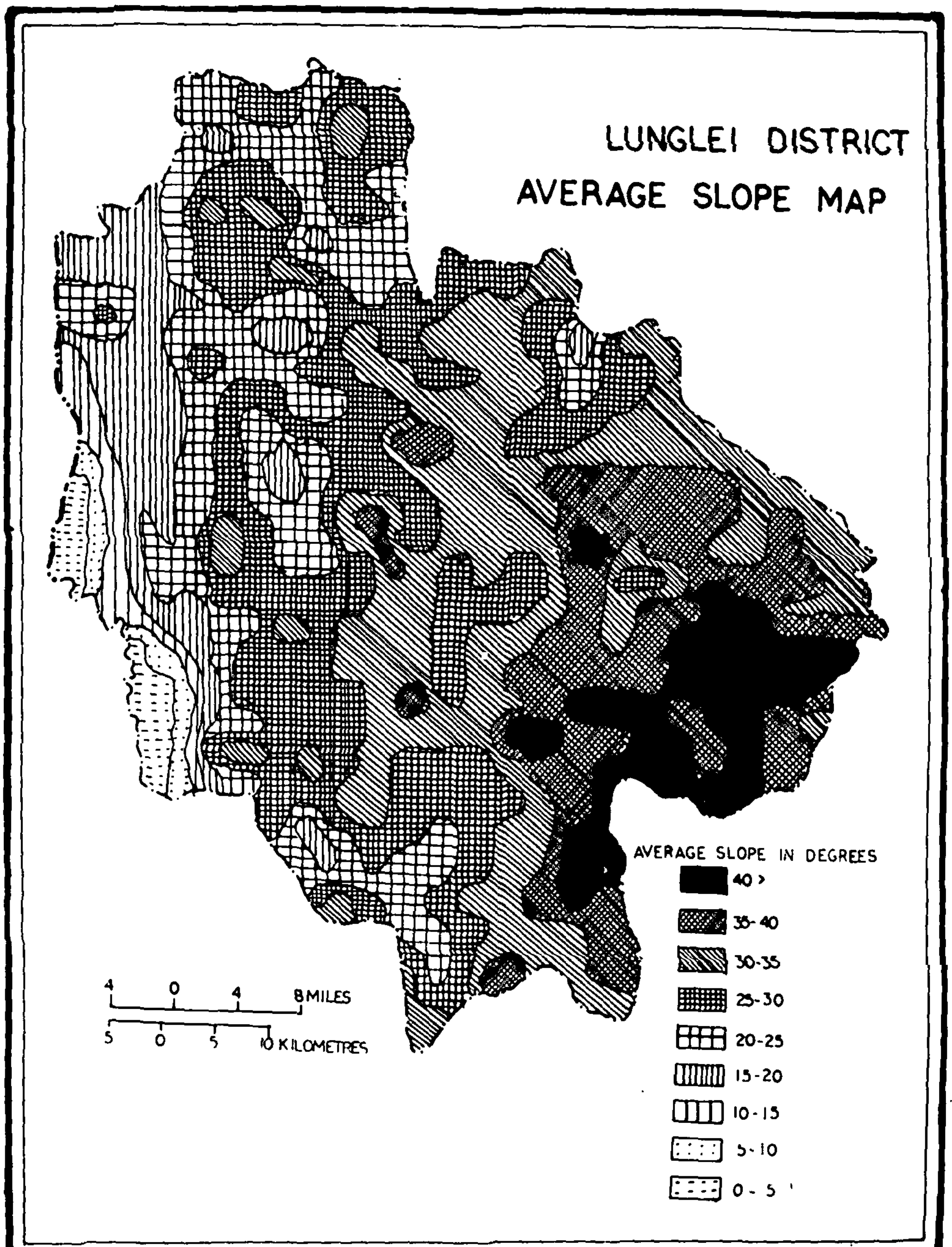
3361 = Constant figure

For the preparation of average slope map, first of all the author has taken the quarter-inch topographical map of Lunglei district. Then grid of straight lines at right angles at half-inch distance have been drawn over contour map. After that, the total number of contour crossings have been counted in each half-inch grid. Then applying the formula :-

$$\text{Average slope} = \tan \Theta = \frac{N \times I}{3361}$$

The researcher obtained the values of Tan O for each grid. After that, using the natural tangent, we obtained the O (degree) value for each grid. After that, a category of slope (degree) has been demarcated, and isolines have been drawn for each category of slope.

From the slope map (fig.6) of Lunglei district, one can recognise that almost all the area is covered by steep slopes. The gentle slope is found in a small pocket along India-Bangladesh border. Very steep slopes



LUNGLEI DISTRICT
AVERAGE SLOPE MAP
4 0 4 8 MILES
5 0 5 10 KILOMETRES
AVERAGE SLOPE IN DEGREES
40 >
35-40
30-35
25-30
20-25
15-20
10-15
5-10
0-5

FIG-6

are found generally in the eastern part of the region. The maximum slope is 40 degrees and above and it covers the eastern parts of the region, starting from Thlengang hill (22°41'N 92°55'E) in the south east towards north following Chhimtuipui river and very steep slope rises upto Dorzo (22°50' 92°55'E), Lungleng (22°53'N 92°59'E), South Vanlaiphai (22°48'E 93°E) and Muallianpui (22°48'N 93°1'E) area.

The slope of 35 to 40 degrees also covers the eastern part of the region, starting from Mamte village (22°3'N 92°55'E) in the south towards north just adjacent to 40 degrees and above, covering Tawipui (22°41'N 92°51'E) Mualthuam hill (92°51'N 92°55'E) and then turns towards north covering Rotlang (22°41'N 92°55'E) and Leite villages (22°54'N 92°55'E). From Leite village it turns towards north-east covering Aithur (22°57'N93°E), Tarpho (23°N 93°E), Thingsai (22°53'N 93°4'E), Ngharchhip (23°N 93°40'E) and Khawhri (23°30'N 23°4'E) villages. It also covers in small pocket in the central part of the region like Lungdai village (22°59'N 92°43'E), Vanhne village (22°56'N 92°43'E) and Haulawng village (23°3'N 92°46'E). It also covers Bunghmun village (23°11'N 92°41'E) in the north west and Chithar village (22°48'N 92°49'E) in the south west.

The slope between 30 to 35 degrees covers very large areas. It rises from Thingfal village (22°37'N 92°53'E) in the extreme south and it extends towards north following Lunglei hill which is the middle part of the region as far as Bungtlang village (23°11'N 92°54'E) in the extreme north of Lunglei district. This category of slope also covers the western margin of Lunglei district and small areas are spreading here and there throughout the region.

The slope between 25 to 30 degrees covers along the Mengpui river in the south, Tuichong river in the south west, De and Kau rivers in the north western part of the region. Lunglei, the headquarters of the district, is also falling under this category. This category of slope also covers Thenhlum village (23°13'N 92°34'E) Thorang hill and Darngawn hill in the north west. It also covers Sekhum (23°11'N 92°45'E), Ramlaitui (23°10'N 92°45'E), Kanghmun (23°21'N 92°44'E) and Buarpui (23°20'N 92°43'E) villages.

The slope between 20 to 25 degrees covers the lower course of Mengpui river in the extreme south of the area, western part of Tuichawng river in the eastern part of Hruizam hill, south and eastern parts of Bunghmun area, Haulansara (23°N 92°30'E), Krishnakanacharia, Mauzam hill and upper course of Tut river in the extreme north western part of the region.

The slope between 15-20 degrees found along Tuipuilian river in the north western part of the region. It also covers Pangzawl village (23°5'N 92°54'E), Maurawp village, Zote village (23°13'N 92°47'E), Vanghro village (23°24'N 92°41'E) and Khawlek village (23°21'N 92°43'E) in the northern part of the region.

The average slope between 0 - 15 degrees is confined along Lunglei district and Bangladesh border starting from Kineshari in the south west towards north Khojoisury hill (22°48'N 92°30'E) and continues upto Hmundo in the north.

If we examine the slope map of Lunglei district (fig.6) it may *become very clear that the whole area is dominated by steep slope. It is very clear that in the initial stage there was a tremendous faulting and folding took place in the area. Gradually due to some agents of erosion the landscape changed gradually to its present form. As the average slope map has been prepared from quarter-inch map, it shows very generalized average slope. It is, in fact, very difficult to locate some small pocket of slope on the slope map.*

The angle of slope is a fact of geomorphology and economic significance. The nature of lithology, process of erosion, nature of tectonic movement, climate of the region and the time factor play an important role in determining slopes into straight, concave or convex surfaces. Debris accumulations are common features at the base of the steep slopes.

The relationship between slopes and the flowing water is significant. A steep gradient allows a greater speed of flow, this in turn helps the stream to scour its course deeply. A meandering course seldom occurs on such steep gradient except when it is produced by excessive power of over loading or due to the physical obstructions in the stream. The steep slopes provide the velocity required for the transportation of all the load supplied to the streams from above. The areas without vegetation suffer from severe erosion. However, on the slope zones the erosional changes are continuous.

The slope units selected to express geographical significance are not rigidly true to the angular scale, it is a generalised picture. As for example, a slope, instead of being uniform, may be concave or convex *or it may be marked by knicks associated with rock junctions, falls and rapids, etc. Such irregularities have been overlooked in drawing the map of the average slope (fig. 6).*

The slopes have great influence on landuse. The different slope categories may further scrutinized and very useful information may be gathered on the basis of slope sub-units for micro-regional studies.

A knowledge of slope gradients is very essential for the construction of dams, roads, railtracks and agricultural landuse. In fact, slopes play an important role in determining how far and how fast development can proceed. The intimate acquaintance with slopes and awareness of their importance can, however, only be acquired through persistent field observation.

Analysis of Hillside Slopes:

Studies on the nature of formation of hill slope elements, surfacial deposits and landuse in different parts of the country had been very few and even though a few studies had been carried out by a few geographers in the field of geomorphology. The Union Territory of Mizoram which is totally a hilly terrain, lacks totally in such studies. Such type of detailed studies could be formed as a basis for the further planning of house sites, settlement especially agricultural landuse as well as development of horticulture and development of forest resources.

The configuration of the earth is not flat. It is made up of several *slope form, process, pattern, evolution and classification provide an important theme for current discussion in geomorphology.*

The study of hill slope profiles and recognition of four elements was started first by Alan Wood (1942)[10], who distinguished four elements in a fully developed slope. King and Fair (1947)[11], while discussing slope development in Natal South Africa, designated as these four elements as from the top:

(a) Waxing slope (Crest),
(b) Free Face (Scarp),
(c) Constant slope (debris slope), and
(d) Waning slope (Pediment).

Each element undergoes a semi-independent evolution though, of course, on a given slope the element to a greater or lesser extent react upon each other. Any element may be absent from a given slope profile, which is then not fully developed.

Wood (1942)[12] contribution is quite significant because this analysis applies to hill slopes all over the world in all stages of development in geological ages.

In the present study, an attempt has been made to throw some light on the hill slopes. The region exhibits the multicyclic landscape of isolated pointed hills varying in height and narrow and deep 'V' shaped valley. The rock formations are covered along hill slopes by thick leamy soil. The

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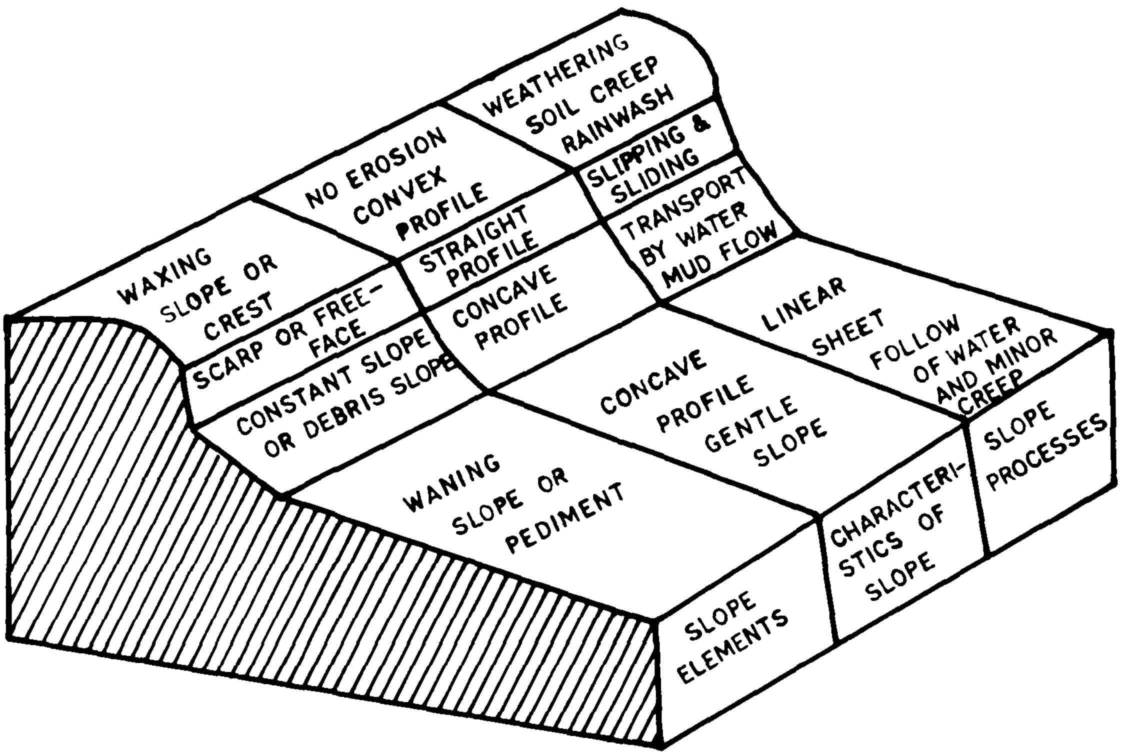
[10] Wood, A. (1942), The Development of Hill-Side Slopes, Proc. Geol. Assoc., Vol.53, pp.128-140.

[11] King and Fair, J.J.D. (1947), Slope Form and Development in the Interior of Natal, South Africa, Trans. Proc. Geol. Soc., South Africa, Vol.50, pp.105-119.

[12] Wood, A.(1942), Op.cit.,



ELEMENTS OF SLOPE
(AFTER L.C.KING AND T.J.D FAIR 1944)

FIG.7

big rock boulders are exposed at some places on the surface. Due to long geological history of the region, the topographical, structural characteristics and weathering and some agents of erosion the region presents different slope elements.

Hill slope elements as discussed earlier, are broadly classified into four divisions (fig. 7) by Wood (1942), King and Fair (1947) and others. These are crest or convex slope, scarp or free face, debris slope and pediment. During the field study of hill slopes of Lungldi district, it was marked that in most of the cases, the hills do not have pediment except few pocket which are very negligible. It is recognised that debris slope occupies maximum areas throughout the region.

(a) <u>The Waxing Slope or the Crest:-</u>

This part of slope is the summit area of a hill. This is a zone of weathering and soil creep and the hill slope is the convex crest of a hill scarp, usually longest in the areas of greatest surficial detritus.

In the region under study, the hills are characterised by a pointed surface. Generally, the hill tops of the western part are comparatively more flat than the hill tops of the centre and the eastern parts. According to King (1962)[13], on the crest, there is a critical distance over which no erosion takes place. But the author, during the field study, especially in the rainy season on the hill tops, has observed that during heavy shower, the whole surface of the hill crest is completely submerged under water and the weathered materials in the form of coarse to fine grained soil, is washed in the form

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[13]King, L.C. (1962), Morphology of the Earth, Oliver and Boyd,p.136.

of sheet erosion. Although the hills are covered with thick tropical and sub-tropical forests which minimise the soil erosion, but due to the practice of jhum cultivation, the tribals cut down the trees and clear the land for cultivation which gradually accelerates the process of soil erosion. Heavy rainfall cause intensive gullying and transportation of large volumes of debris in the form of top soil. Due to their long traditional way of cultivation many rock boulders are exposed on the surface and the hill tops become more and more pointed.

(b) Scarp (Free face):-

The scarp or free face is the zone immediately below the crest. Outcrops of bedrocks are usually exposed along the scarp. The steepness of the slope deter against any accumulation of sediments and soil formation. The disintegration of this scarp zones leads to tumbling down of fragments under the influence of gravity.

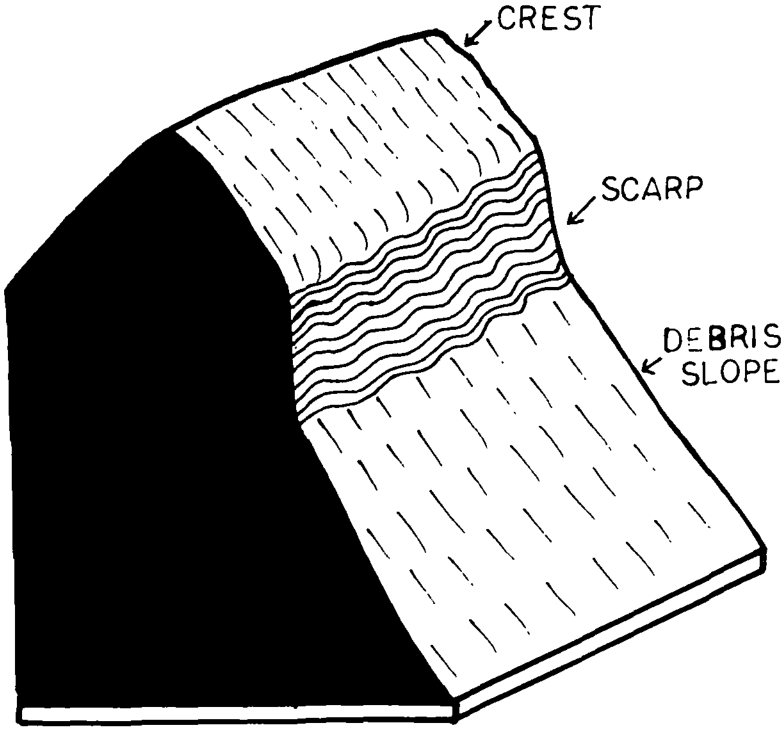
This element of hill slope is clearly seen in many places of the region under study. This element is clearly noticed in the chain of hills running to the central part starting from Vanhne village (22°56'N 92°43'E) along Sertlangpui hill range on both east and west till it reaches Aizawl district in the north. It is also noticed in the Lunglei hill range right from Thingfal village (22°37'N 92°53'E) in the south and continued till it meets Aizawl district in the north. The scarp face also clearly seen in the eastern part of the region like Darzo hill (22°50'N 92°58'E), Lungleng hill (22°53'N 92°59'E) and Thingsai hill (22°53'N 93°4'E). During the field study it was observed that the free face is well developed in the western flank of the slope than the eastern flank of the slope and it was noticed that the numerous rills and gullies have developed in a parallel fashion along the scarp face and *this zone of hill slope lacks the cover of soil or where bedrock was not exposed, the soil was thinnest and was being moved most rapidly.*

Field observations have also revealed that most of the scarps are very steep and it formed cliff at many places the bedrock exposed on the surface. It is also marked that upon a hill slope, the scarp element due to weathering and erosion, characteristically retreats, reducing the area of hill crest. Due to steepness of the slope, when the agents of weathering attacks the rock formations and the disintegrated fragments are falling down towards debris slope in the form of rockfall and landslide. At first the falling of rock and landslide was prevented by the roots of the trees who bind against from falling down. But due to careless use of cutting the forest by the tribal population, the area suffers great landslide and rockfall.

(c) *Constant Slope or Debris:*

This element originates below the scarp or free face. The debris slope consists of detritus slipped or fallen from the scarp and resting at its angle of repose against the lower part of the scarp face. As the debris is weathered to finer detrital grades, it is removed under erosion and so the debris slope retreats in essentially conformity with the free face above. This element of hill slope consists of the thickest cover of weathered and eroded material which had come from the crest and the scarp face.

During the field study it was observed that the debris slope occupies the maximum areas in the region under study. Generally its gradient varies from 25 to 36 degrees. It is noticed that the loose materials produced by



ELEMENTS OF SLOPE IN LUNGLEI HILL

FIG : 8

weathering and erosion in the young hills formation, especially the hills composed of softer rocks of the upper sandstones and shales, move downward. The finer materials are transported to the valley side by running water and the coarser material is left on the debris slope. During the field study it was noticed that many boulders are remaining on the upper part of the debris slope which are covered by vegetation.

(d) Waning Slope or the Pediment:-

The pediment is a broad concave lower most slope extending from the base of debris slope to the bank of the stream or the alluvial plain. It is fashioned under the influence of running water.

During the field study the author did not notice this slope element in most of the hill slopes of the region (Fig. 8). It is noticed only areas in the south west of Tlabung which is the border area of Lunglei district and Bangladesh. It appears that the gullies and rills decending down the hills are not checked on this steep rugged topography with deep narrow valley. Being a young topography of the region the slopes are still in developing stage. The slopes are more steep and crest is narrow and sloping down.

Drainage Analysis

Morphometric analysis of the drainage of Lunglei district will help in understanding the geomorphic characteristics. The study of drainage frequency of streams is an expression of the spacing of the smallest drainage units both intermittent and perennial. The study of drainage frequency in *the Lunglei district has been undertaken to identify the regions of varying drainage frequency into different categories of "very high", "high", "medium" and "low". This type of classification may normally work out on the basis of large scale topographic maps e.g. one inch to a mile. In the present study, due to unavailability of large scale topographical maps, the author has used quarter-inch topographical maps. The analysis by this method has been done to get satisfactory results. The author really feels that this analysis has helped in understanding the nature of geomorphic features of the region and also the nature of fluvial processes.*

Drainage Frequency

According to Horton (1945)[14] what are commonly referred to as drainage texture includes both drainage density and stream frequency. He defined drainage density as the total length of the streams in a given drainage basin. On the other hand, the stream frequency is calculated by the total number of streams in a drainage basin or the stream frequency is calculated by the total number of streams in a unit area in a given drainage basin.

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

FS represents stream frequency

N represents total number of streams in a unit area.

A represents the Unit area.

In the present study of stream frequency, the latter method has been applied.

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[14] *Horton, R.E. (1945), Erosional Development of Streams and their Drainage Basins, Hydro Physical Approach to Quantitative Morphology, Bull. Geol. Soc. Amer., Vol. 36, pp.275-370.*

Method of Study

First of all the drainage map of Lunglei district is prepared from the quarter-inch-topographical sheets (sheet nos. 84 B, 84 A, 84 E and 84F). This map is then divided into a number of half-inch squares representing four square miles on the surface. The total number of streams crossings in each square are counted and plotted in the centre of the squares. These represent the number of streams per four square miles. Isopleths at the three-streams interval are drawn, the resulting map of drainage frequency brings out the regional variation very clearly (fig. 9). The study of this map reveals that the frequency of streams in Lunglei district, depends upon a number of variable factors. These variable factors may broadly be divided into two categories:

1. *Physical Factors*
2. *Map factors.*

The most important physical factors which have affected the drainage frequency of Lunglei district are as follows and their importance are not the same from place to place.

(1) Climate
(2) Lithological and Structural Characteristic of rocks.
(3) Relief.
(4) Infiltration Capacity.
(5) Vegetation.

A glance at the drainage frequency map of Lunglei district (fig.9) it is noticeable that most of the area in the district is covered by the category of medium stream frequency, i.e. 3 to 6 streams per 4 square miles. A major area of Lunglei district is occupied under this category. In general one can

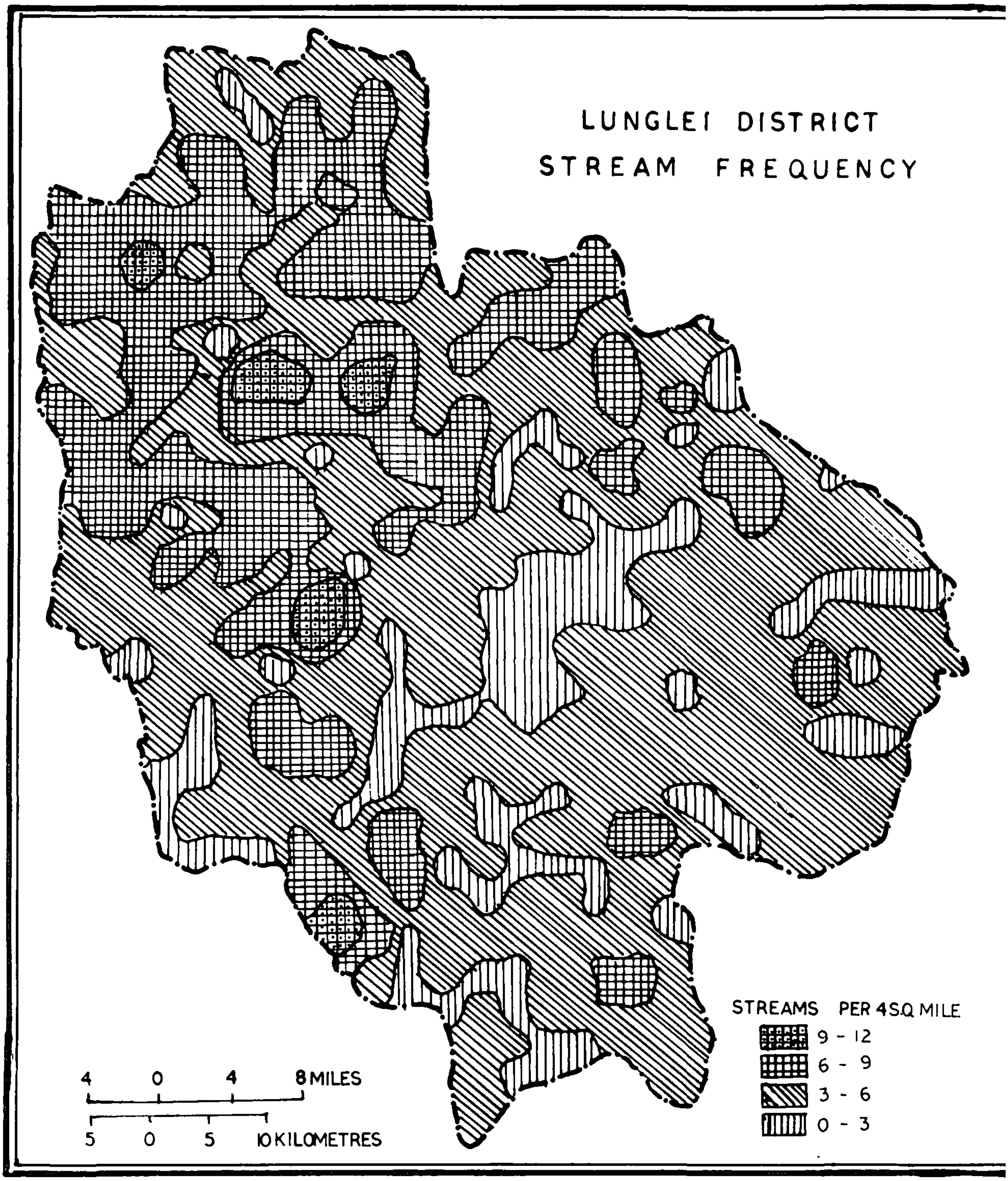
LUNGLEI DISTRICT
STREAM FREQUENCY
STREAMS PER 4 SQ. MILE
9 - 12
6 - 9
3 - 6
0 - 3
4 0 4 8 MILES
5 0 5 10 KILOMETRES

FIG. 9

see that whole eastern part of the area is mainly occupied under this category. It is noticeable that the western part of the area shows the maximum variation in stream frequency. The eastern part shows moderate variation. The finer frequencies are found in the western side of the area, while the lower values are found to be on the eastern part. This explains that the drainage network in the western part is more complicated than the eastern part which shows a simpler drainage network.

It will be seen from the map that the north western parts show higher stream frequency between 6 to 9 streams per 4 square miles which is termed as having medium texture as far as stream frequency is concerned. This area is drained by the Khawthlangtuipui and its tributaries which is one of the largest basins in the region as a whole. The Kau river which originated from Thenhlum village (23°13'N 92°34'E) displays fine texture. The reason for this higher frequency of the streams in this area may be attributed to the fact that this part has more vegetation cover than the other areas of the district. In this area the population density is much less than the other parts of the region and there is more vegetation cover than the other areas. Relief and physiography are the important factors controlling the drainage network but the most important factors are mainly the infiltration capacity of this area.

There is a marked difference in the stream frequency in the western part of the area. It will be seen from the drainage map that the north western part shows maximum variation in stream frequency from 0 to 12 streams per 4 square miles. This variation may, again, be mainly because of relief structure and lithological characteristics. The area is undulating hilly terrain *with numerous small streams resulted the variation in the drainage frequency.*

The lithological and structural characteristics including infiltration capacity play very significant role in the stream frequency in this region. Drainage lines develop in large number upon an irregular surface than upon one which lacks conspicuous relief. It will be seen from the relief map that the relief plays important role in the stream frequency in this region and it appears that lithological and structural characteristics including rainfall and infiltration capacity has more important role in the development of drainage lines. From the slope map (fig. 6) it is found that the eastern part has maximum slopes than the western part of the area but the western part has more higher drainage density which indicates that although relief, climate, and vegetation are the physical factors which are responsible for the drainage density but the most important factors being lithological and structural characteristics in this region.

Map Factor

In the study of drainage, the effect of the map factor is also greatly significant. In the map, the most important factor in determining the frequency of drainage is the scale of the map and the accuracy of the mapping. Large scale maps are the best scale to get better and accurate picture for the analysis of drainage frequency than from small scale maps. Since the study area is restricted part of India, it is difficult to get the large scale maps to cover the whole area and as a result the author could not get the required topographical sheets. In spite of all these problems, the drainage analysis of Lunglei district has been done on quarter-inch maps.

Drainage Pattern

"Drainage patterns refers to the particular plan or design which the individual stream actively form."[15] A study of drainage patterns often reveals a very delicate and intricate adjustment with structure and lithology. The study of drainage patterns of the region, may give knowledge of the structure of underlying rocks, slopes, inequalities in rock hardness or softness, structural controls, recent diostrophism and the recent geological and geomorphic history of the drainage basin. Drainage pattern is very helpful in interpreting the geomorphic features and tracing the evolution of landforms.

The drainage map of Lunglei district (fig.5) reveals that there are two types of drainage patterns, as mentioned below:

(i) Parallel and sub-parallel pattern.
(ii) Rectangular pattern.

(i) Parallel Pattern

Regional slope plays a significant role and to some extent joints and cracks also help in the development of parallel drainage pattern (fig.10). The ridges run in the north-south direction with alternate deep valley gorges. The average slope map of Lunglei district (fig.6) show that in Lunglei district the variation in regional slope increases from west to east. Average slope map indicates that ridges consist of steep and very steep slopes. Most of the streams follow NS-EW lineaments and as such parallel pattern have developed within the limit of a particular lithological unit. Again prominent perennial and non-perennial streams of almost all the rivers are originating

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[15]Satpathi, D.D. (1981), An Outline of Indian Geomorphology, pp.121-122.

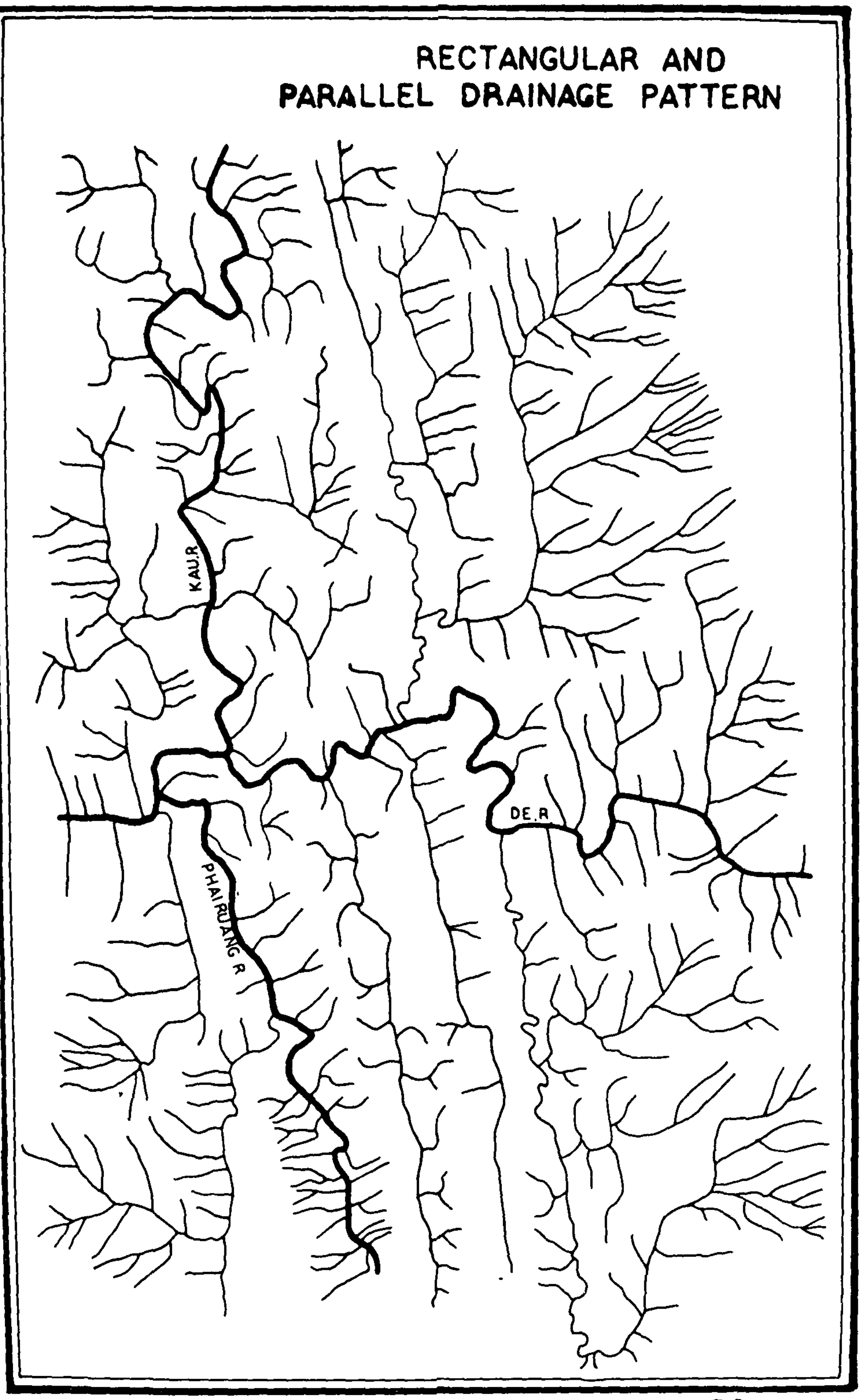
RECTANGULAR AND
PARALLEL DRAINAGE PATTERN
KAU.R
DE.R
PHAIRUANG R

FIG-10

from the hill ranges, runs parallely and joins the main channel almost at right angle.

(ii) Rectangular pattern:

A system of well-developed joints, fractures zones or small faults may give rise to a rectangular drainage pattern with many straight stream segments and sharp-angular changes in stream direction (fig.10). If we examine the drainage map of Lunglei district (fig.5) all the streams are dominated by well-developed rectangular drainage pattern. The structure of rocks and landforms plays the most vital roles in the development of rectangular drainage pattern. It is seen that wherever the rivers are obstructed by a ridge or resistant rock structure, the rivers take a sharp change in its course at the end of the ridge or at a place of less resistant rock.

The general patterns throughout the area are rectangular and parallel to sub-parallel pattern. In some cases streams owe their origin from springs and most of which are non-perennial and emerged in the form of gulluies near the ridges. The physiographic slope and dip of the beds being sub-parallel precipitation on the hillslopes is easily drained off to the synclinal valley both in surface run off and along the bedding planes. The water holding capacity of the soil is very poor in the area. The above factors have resulted in acute water scarcity on hilltops and hillslopes.

The Erosion Surface

"Strictly speaking, any surface which is not an original structural or constructional surface is an erosional surface." Practically the term is applied to "surface of faint relief, the end products of complete or incomplete

cycles of erosion" (Satpathi 1981).[16] The term erosion surface denotes in general those areas of relatively flat land formed by the process of normal erosion during a period of base-level stability, and now above present base-level and in process of destruction by retrogressive erosion. This surface represents the penultimate stage of the cycle of erosion and according to W.M. Davis, this should be called a 'peneplain'. Other terms as 'penplain', 'pediplain', etc. represent the same stage of the cycle of erosion but formed by different processes and under different climatic conditions.

Geological sequences and geomorphic history of a region is marked by a series of sequential events heading to an ultimate phase of peneplains. Landscapes are thus envisaged as products of an orderly evolutionary scheme of essential sculpturing of landscapes. Lunglei district represents youthful topography. Geological structure controls the first order hills and valleys. The area experienced vigorous erosion which caused the sculpturing of anticlinal ridges and formation of narrow and deep synclinal valleys. Among the geomorphic processes fluvial process is most active in this region. Erosion begins with the first appearance of land above the sea level and continues throughout the time of 'growing up' the time of intermittent uplifts culminating in the upland surface.

In the study of geomorphological features of Lunglei district, the study of erosion surfaces has great significance because the region is still in the process of active erosion. The study and correlation of erosion surfaces will help in tracing the geomorphological history of the region.

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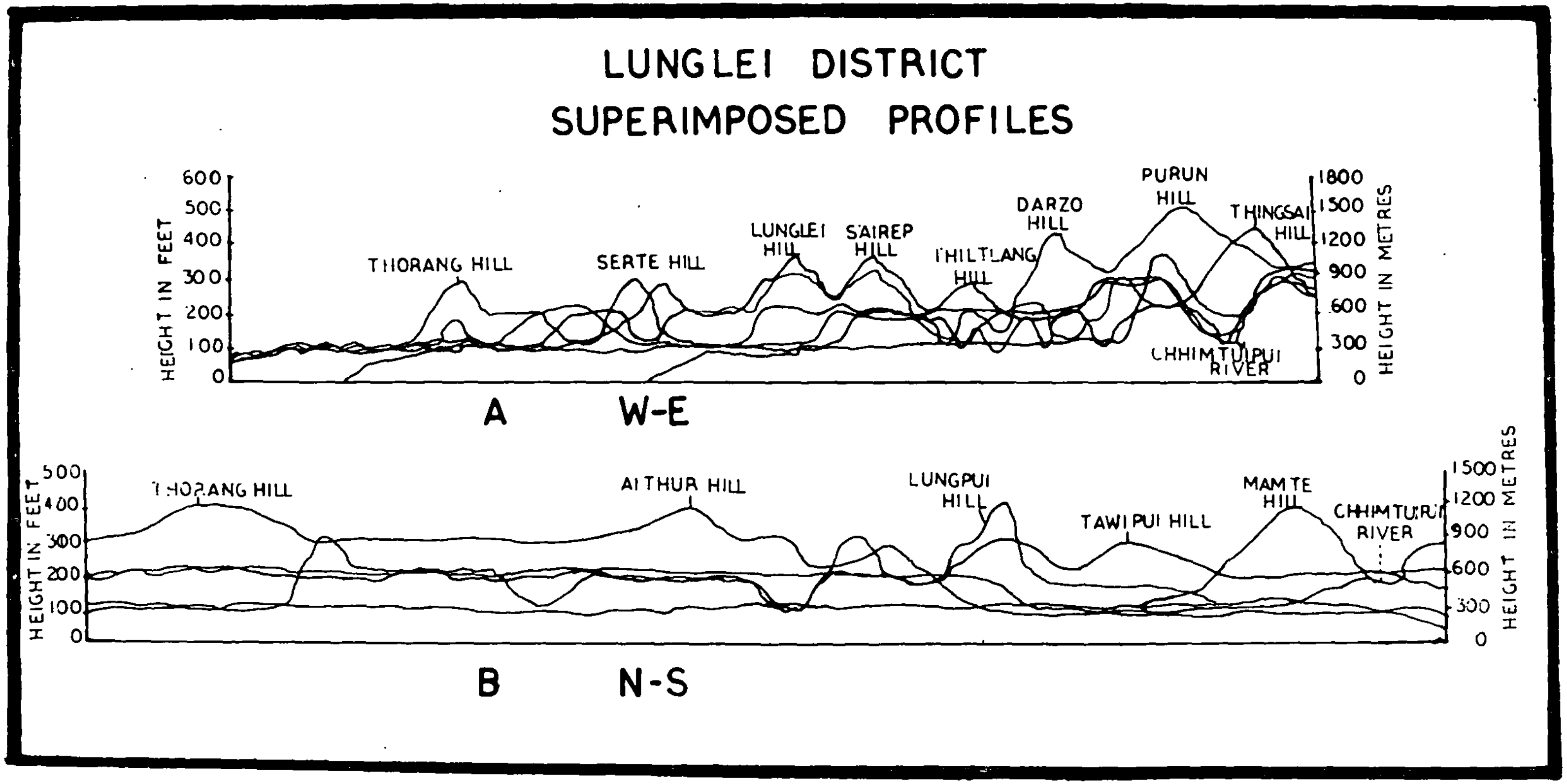
[16]*Ibid., p.248.*


LUNGLEI DISTRICT
SUPERIMPOSED PROFILES
HEIGHT IN FEET
HEIGHT IN METRES
THORANG HILL
SERTE HILL
LUNGLEI HILL
SAIREP HILL
THILTLANG HILL
DARZO HILL
PURUN HILL
THINGSAI HILL
CHHIMTUIPUI RIVER
A W-E
AITHUR HILL
LUNGPUI HILL
TAWIPUI HILL
MAMTE HILL
B N-S

FIG·11

Method of Study

To recognise the erosion surfaces in the region, different morphometric techniques have been applied and to collect field evidences an extensive field work has been undertaken throughout the study area. During the course of study, the researcher faced many problems due to lack of relevant literature on the geology of the region. Inspite of all the difficulties the researcher consulted any available literature on geology to understand the geological history of the region.

Superimposed Profiles

From the quarter-inch toposheets, a series of profiles have been drawn at two inches interval with a vertical scale of half-inch to one thousand (1000) feet. A number of simple profiles are drawn both in the west-east and north-south directions and all the serial profiles have been superimposed (fig. 11). Superimposed profiles of the region represent the nature of differential erosion. The profiles indicate that the low undulating hilly terrain in the western margin bordering Bangladesh and rugged topography in the central and eastern parts of Lunglei district. Two levels of erosional surfaces can be distinctly identified from the superimposition of the profiles at a certain height. The younger surface may be seen in the western part of Lunglei district along the Khawthlangtuipui river basin which is in many places below 50 m. The remnants of high dissected hill tops may be seen in between the rivers valleys in the central and eastern parts of Lunglei district.

The north-south superimposed profiles indicate that the hill ranges are running from north to south with deep narrow valley in between them.

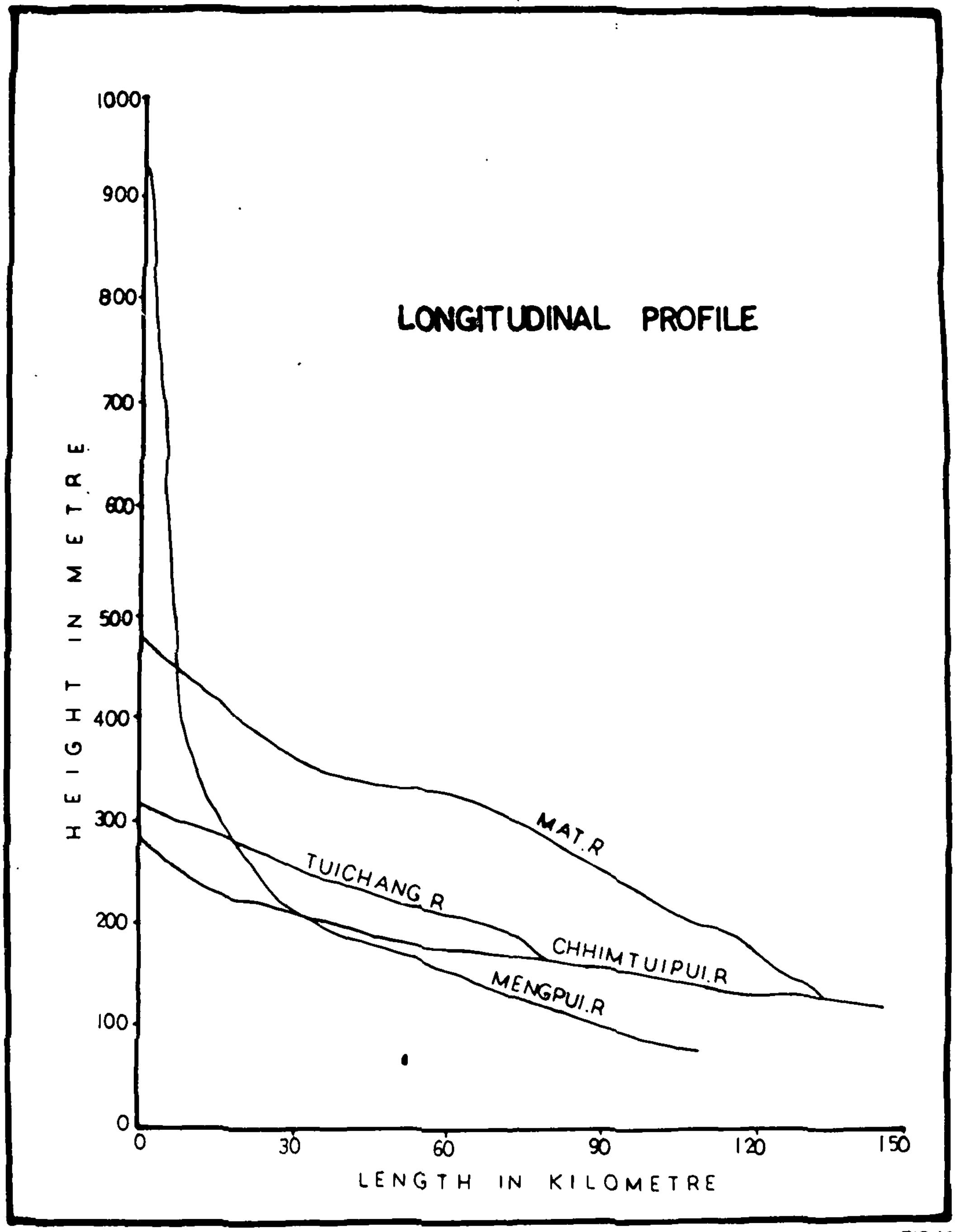

LONGITUDINAL PROFILE
HEIGHT IN METRE
1000
900
800
700
600
500
400
300
200
100
0
30
60
90
120
150
LENGTH IN KILOMETRE
MAT.R
TUICHANG.R
CHHIMTUIPUI.R
MENGPUI.R

FIG-12a

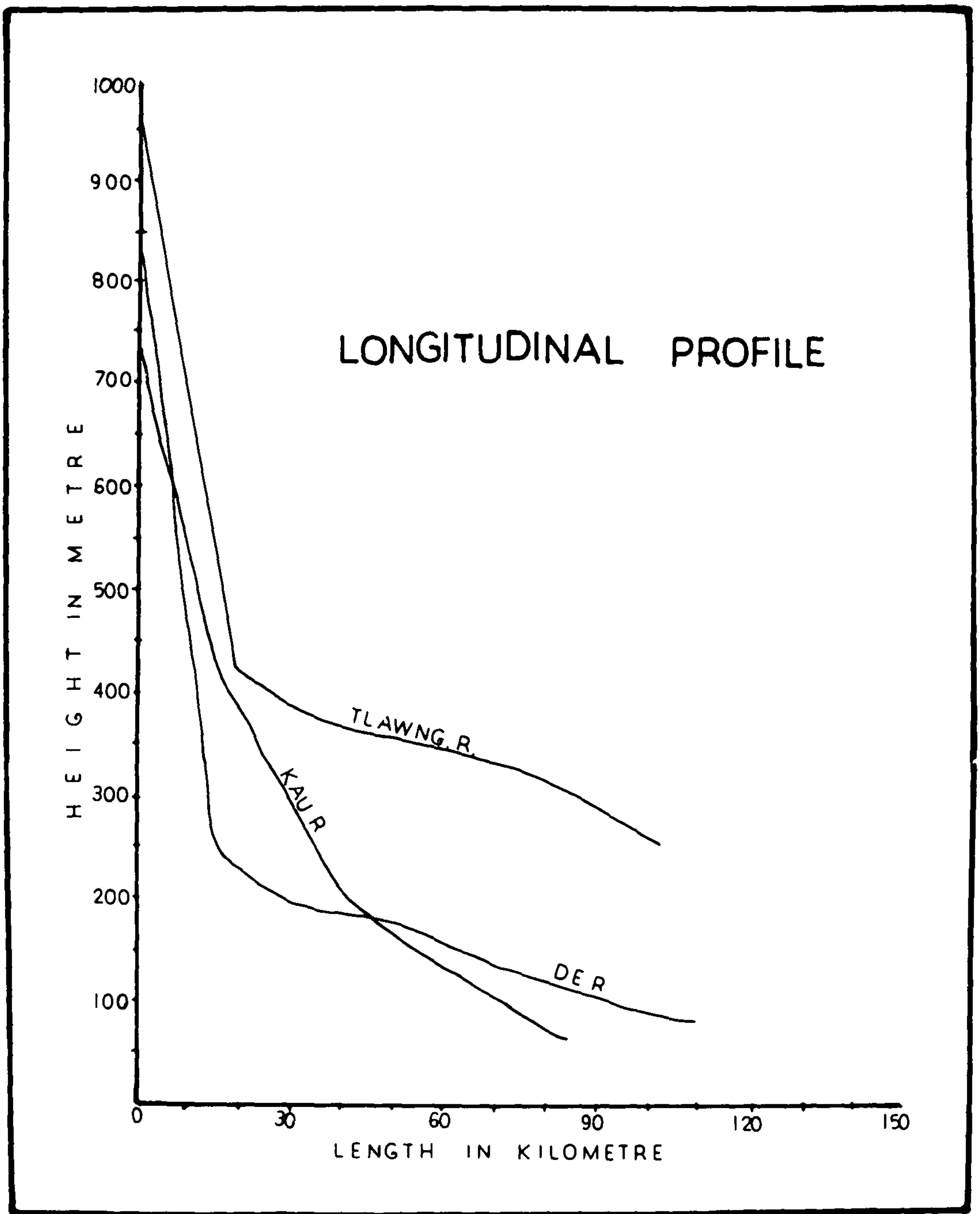

LONGITUDINAL PROFILE
HEIGHT IN METRE
1000
900
800
700
600
500
400
300
200
100
0
30
60
90
120
150
LENGTH IN KILOMETRE
TLAWNG R.
KAU R
DE R

FIG. 12 b

This shows that thin alluvium deposit of younger sediments are scattered in the valley sides.

Longitudinal Profiles

From the 1:50000 topographical maps, the length of important rivers has been measured and with a vertical scale of 2 Centimetres to 100 metres and horizontal scale of 3 Centimetres to 30 kilometres, the longitudinal profiles of the Chhimtuipui, Mat, Tuichawng, Tlawng, Kau, De and Mengpui have been drawn (fig. 12a & 12b). The rivers for which profiles have been prepared are flowing in north to south, south to north directions. From the profiles, it appears that there is no major nick point in any rivers. There are some breaks in the gradient which give an idea that the region had uplifted in the different geological periods. The breaks of the profiles are mostly in between 200m to 400m in altitude. None of the rivers has attained the graded profiles. Sudden changes in the profiles of Tlawng, Kau, De and Mengpui rivers give an idea of tectonic activities. Most of the rivers originate in the high hill ranges and flow towards Bangladesh plains, Arakan sea and Bay of Bengal and as such the upper courses of all the rivers are steep.

The only south-north flowing river of the region Tlawng has a sharp break in the gradient in the eastern part of Lunglei hill range where the Nghasih waterfall is located. On the other hand, Mengpui river which rises from Lunglei hill and flows in the southern direction also has a sharp break in the gradient in the upper part due to the presence of a number of minor waterfalls.

Generalised Contours

Generalised contours attempt to reconstruct the whole landscape before dissection took place. In this study an attempt has been made to identify large surface before dissection took place by the technique of drawing generalised contours. The generalised contour map gives some interesting results (fig. 13). By this method, the oldest erosion surface may be revealed which has been considerably dissected. Lunglei district is covered with sedimentary deposits in the form of conglomerates, shales and sandstones eroded from the Archean rocks from this map (fig. 13). Pleistocene erosion surfaces are seen generally along the ridge of high altitude. The valley sides are recent formation.

Identification of Erosion Surfaces

The analysis of the superimposed profiles (fig. 11). Longitudinal profiles (fig. 12a & 12b) and generalised contours (fig. 13) field evidences suggest atleast two erosion surfaces at different heights. These are as follows:

(i) Pleistocene Surface
(ii) Recent Surface

The large scale differential erosion of the region and the presence of highly dissected hills and deep narrow valleys at different heights may be due to the effect of upliftment and rejuvenation of this region in different geological periods leads to the development of different erosion surfaces on various geological formations.

The presence of break in gradient in the longitudinal profiles of river suggest the rejuvanation of the old erosion surface (fig. 12a & 12b).

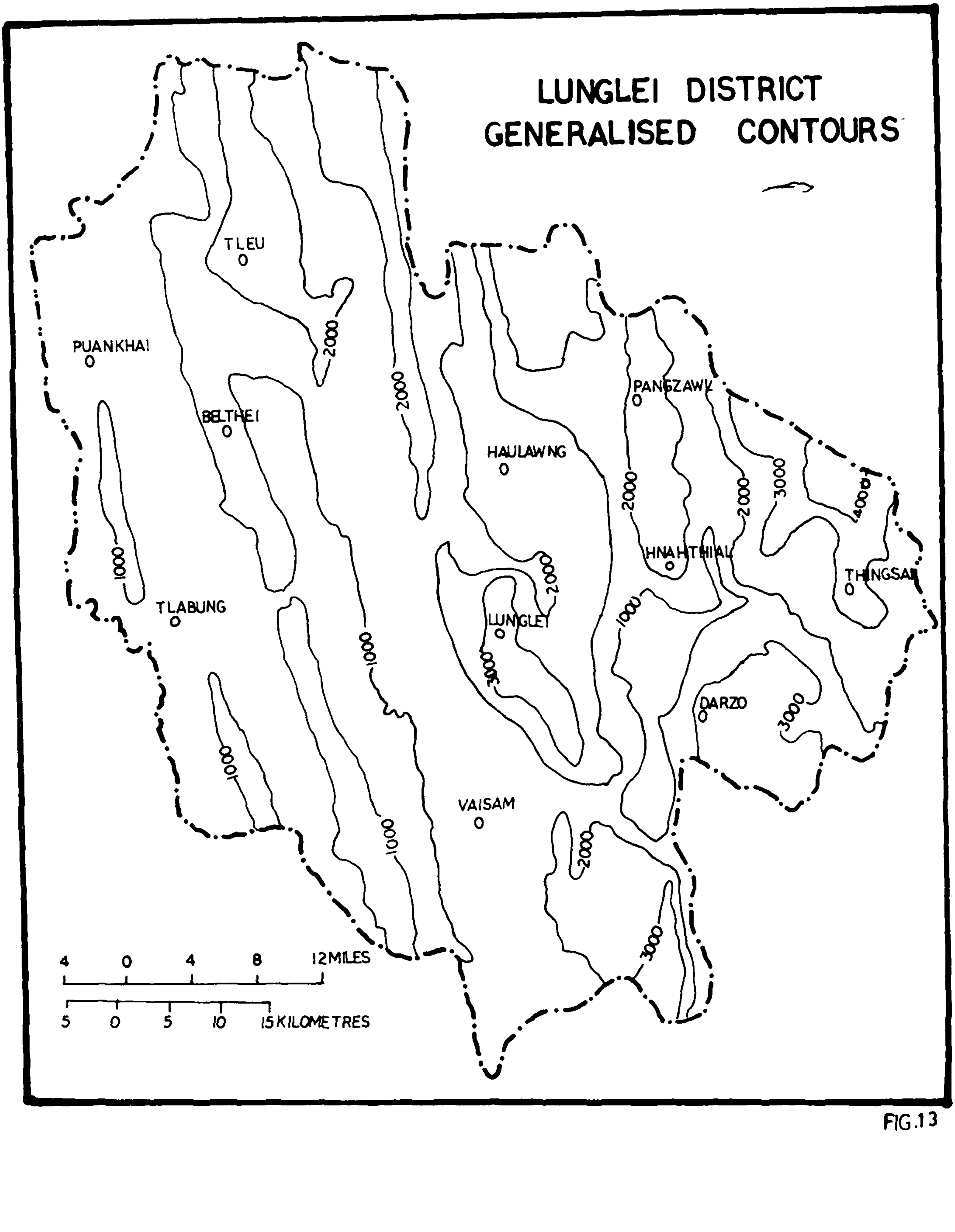

LUNGLEI DISTRICT
GENERALISED CONTOURS
TLEU
PUANKHAI
BELTHEI
TLABUNG
HAULAWNG
PANGZAWL
HNAHTHIAL
THINGSAI
LUNGLEI
DARZO
VAISAM
1000
2000
3000
4000
4 0 4 8 12 MILES
5 0 5 10 15 KILOMETRES

FIG. 13

A numerous waterfalls and rapids in the region which indicate the rejuvenation of the area in recent past. It is believed that the highest parts of the hill ranges would be the last to lose remnants of the former erosion surface as the dissection spreads through the month of the river valleys. Narrow pointed hill ranges of hard sedimentary rocks are the remnants of old erosion surfaces where few rock exposures are noticed. There is a transverse cross-folding extending from north to south belongs to the pleistocene surface.

From the study of superimposed profiles (fig. 11) it is clear that especially along the valleys of major rivers, recent surface is in developing stage. The rivers are still deepening their valleys. From the study of superimposed profiles and field observations it is clear that this surface is developing at the expense of the pleistocene surface. The old surface has been gradually destroyed along the river valleys.

QUANTITATIVE ANALYSIS OF 10 SELECTED SMALL DRAINAGE BASINS OF LUNGLEI DISTRICT, MIZORAM

Introduction

Quantitative evaluation of geomorphic characteristics of the drainage basins and their correlation to basin hydrology have now-a-days become the principal objective of research in fluvial geomorphology. A great impetus was given to fluvial morphometry by Horton's researches (1945).[1] *He has suggested the method of quantitative analysis of morphometric characteristics of drainage basins. Several works have been done by Strahler (1952)*[2]*, Schumm (1956)*[3]*, Chorley (1959)*[4]*, Morisawa (1962)*[5]*, and in India by Singh (1969)*[6] *Pal (1973)*[7]*, Dixit (1976)*[8] *and others. The results of these studies indicate*

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[1] *Horton, R.E. (1945), Erosional Development of Streams and their Drainage Basins "Hydro-Physical Approach to Quantitative Morphology", Bull. Geol. Soc. America 56 (1945).*

[2] *Strahler, A.N. (1952), Quantitative Geomorphology of Erosional Landscapes, 19th International Geological Congress, Algiers, Sec. 13, pp.341-359.*

[3] *Schumm, S.A. (1956), Evaluation of Drainage Systems and Slopes in Badland at Perth Ambay, New Jersy, Bull. Geol. Soc. America 67, pp.597-646.*

[4] *Chorley, R.J. (1959), Drainage Basin as the Fundamental Geomorphic Unit in Water, Earth and Man, ed. by Chorley, R.J., pp.85-89.*

[5] *Morisawa, M.E.(1962), Quantitative Geomorphology of Some Watersheds in the Appalatian Plateau, Bull. Geol. Soc. Ame. Vol.73, pp.1025-1046.*

[6] *Singh, S. (1969), Quantitative Geomorphology of Drainage Basins in Semi-Arid Environment, Ann. Arid Zone, Vol.8, pp.37-44.*

[7] *Pal, S.K. (1973), Quantitative Geomorphology of Drainage Basins in the Himalayan Geographical Review of India, Vol.35, pp.81-101.*

[8] *Dixit, K.R. (1976), Drainage Basins of Konkan, Forms and Characteristics, National Geographical Journal of India, Vol.22, 1976, pp.79-105.*

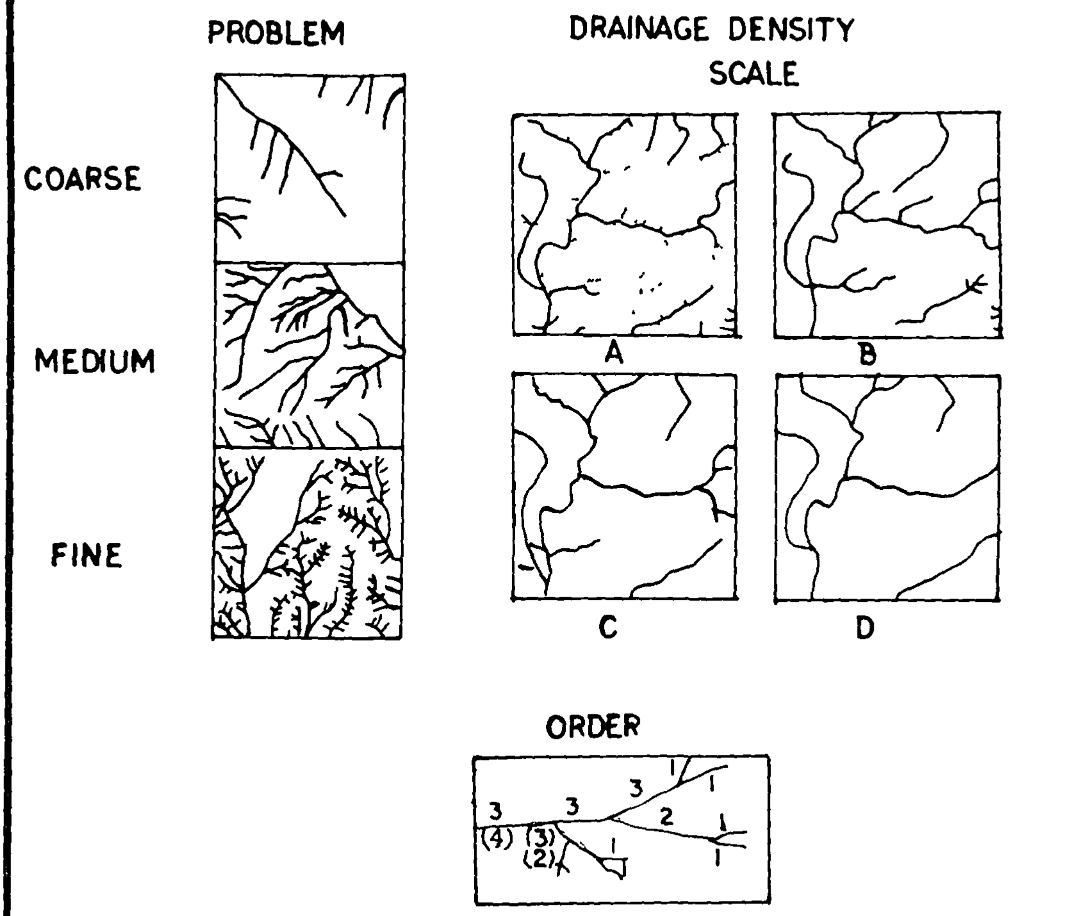
that morphometric attributes like bifurcation ratio, stream length, drainage density, sinuasity indices and stream frequency will substantially contribute to the hydrological characteristics of the basin.

Keeping the above view in mind, an attempt has been made in the present chapter to analyse the morphometric attributes and their correlation with the landforms of Lunglei district and 10 small drainage basins have been selected from all the four blocks. This area is characterised by rugged terrain, poor soil, and the practice of agriculture is primitive and experiencing tropical monsoon climate.

A systematic description of the geometry of a drainage basin and its stream channel system required measurements of linear aspects of the drainage network, aerial aspects of the drainage basins and relief aspect of channel network and contributing ground slopes. Whereas the first two categories of measurement are plainimetric (i.e. these properties projected upon a horizontal datum plane) and the third category treats the vertical inequalities of the drainage basin forms. In this chapter, the above first two aspects have been discussed in detail by selecting 10 small drainage basins from every corner of the area.

Linear Aspects of the Basins

Linear aspect of the drainage basins includes the study of the channel patterns of the drainage network in terms of open links wherein the topological properties of the stream segments are analysed. The drainage network, which includes all the segments of a particular basin is studied in graphic terms where stream junctions are considered as points and streams are regarded



SOURCE:- GREGORY & WALLING (1973) DRAINAGE FORM AND PROCESS (A GEOMORPHOLOGICAL APPROACH)

FIG. 14

as the lines which connect them. For this the numbers (Nu) of all the streams are counted, their hierarchical orders are determined, the length of the stream segments are measured and various inter-relationships are analysed. The sinuasity of the stream is also included in the linear aspects of the drainage basins. Thus, the study of linear aspects of the drainage basins includes the analysis and interpretation of stream order (u), stream number (Nu), bifurcation ratios (Rb), stream lengths (Lu) and sinuasity indices.

The drainage basin is bounded by its perimeter which is determined by its watershed. The length of overland flow (Lg) is the mean distance from the watershed to the stream of the first order having direct channel. This length of overland flow is very significant in the study of drainage basins because it denotes the spacing of streams. The length of the master stream (L) from the mouth to the source is called 'Mesh length'. The distance from the mouth of the trunk stream to the 'centre of the gravity' of the drainage basin is "usually measured up the main stream to a point where one-half of the drainage basin area lies headward of it, but for most basins Lca (distance from the mouth to the centre of the gravity = 0.51) is a good approximation". The straight line horizontal distance point on the perimeter (Lc) is significant in determining the shape of the basins. In the present study, the data of various attributes of linear aspects of the basins have been derived and calculated from the topographical sheet of 1:50,000 and results drawn so far have been verified by intensive field work.

Concept of the Hierarchical Orders of the Basins

Different stream segments of a drainage basin have their definite *positions in the domain of a drainage basin. They have their distinct morphometric characteristics which necessitate the determination of their relative positions on the hierarchical scale of stream segments. "This has required the assignment of a level of relative order of magnitude to each segment in a stream segment hierarchy, determined by sequential arrangement of tributaries with respect to the main trunk" (Haggett and Chorley 1969).*[9] *Thus stream order is defined as a measure of the position of a stream in the hierarchy of tributaries (Leopold, Wolman and Miller 1964).*[10]

Playfair was the first geomorphologist who recognised the unitary features of the geometry and process presented by the erosional drainage basin (Chorley, 1969).[11] *Later on, Davis (1899)*[12] *described the drainage basin as a leaf and the streams as the veins of that leaf. It was Gravelieus (1914)*[13] *who made the first systematic attempt to decide the hierarchical orders of the streams of a drainage basin by tracing the streams from the mouth to the source. He tried to recognise the trunk streams through greatest width, discharge, headward branching and junction angle which he allotted the position of first order. He assigned the second order to those rivers which join the main river of first order and so on. Gravelius' scheme was based on subjective*

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[9] *Haggett and Chorley, R.J. (1969), Fluvial Processes in Geography, p.59.*

[10] *Leopold, L.B., Wolma, M.G., and Miller, J.P. (1964), Fluvial Processes in Geomorphology, Freeman, New York.*

[11] *Chorley, R.J. (1969), Op.cit.,*

[12] *Davis (1899),*

[13] *Gregory, K.J. and Walling, D.E. (1973), Drainage Basin Form and Processes - A Geomorphological Approach, Edward Arnold Ltd., pp.3-4 and p.46.*

decision of the worker at each bifurcation and hierarchical order, this determination was not symmetrically related to the magnitude of a given segment or link (Haggett and Chorley, 1969)[14] *(fig. 15) shows the ordering scheme of Gravelius.*

Horton presented his scheme of stream ordering just opposite to Gravelius' scheme. As defined by Horton (1945),[15] *"the stream order is a measure of the position of a stream in the hierarchy of tributaries". According to Horton (fig. 15), in a given map of certain scale, the first order streams are those which have no tributaries, the second order streams are those which have as tributaries only first order streams receive as tributaries only first order and second order streams and so on. Horton's original system is somewhat more complex than this, in that the streams of maximum order in the drainage basin is determined as in the extended back to its furthest source. In other words, the largest stream of the basin will be given the number of highest order. When both the streams of the first order have the same length, the extension is arbitrarily decided by the choice of the worker. In this process of renumbering only, the fingertip streams of the first order are unaffected by their positions.*

Horton's scheme of ordering of rivers is difficult tedious and time consuming because it involves double phases of classification and relcassification at several times. During the second phase of renumbering some finger-tip tributaries are upgraded and other are left.

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[14] *Haggett and Chorley, R.J. (1969), Op.cit.,*

[15] *Horton, R.E. (1945), Op.cit.,.*

Strahler (1952, '53, '57)[16] *modified the limitations of Horton's (1945) ordering scheme. Strahler proposed a simple scheme out of Horton's method. In his method, Strahler retained the original definition of first order. Second order, etc. streams as suggested by Horton (1945). Strahler simplified the computation but it reduces the length of the main trunk, because the method of giving order number is restricted to stream segments only. While originally intended to order streams, the Strahler's method actually order basins. This seemingly arbitrary way of ordering streams actually is an accurate and easy way to order basins.*

According to Strahler, "each finger-tip channel is designated as a segment of the first order. At the junction of any two first order segments, a channel of second order is produced and extends down to the point where it joins another second order segment whereupon a segment of third order results and so forth."

The limitation of Strahler's segment ordering system is that the lower order segments do not increase the order of streams of the higher order in lower reaches whereas in the upper reaches of the basin a single finger-tip first order segment can upgrade the trunk stream (fig.15).

Shreve (1966)[17] *presented his scheme of stream link-magnitude based on the 'interval scale' of stream ordering whereas each exterior link or its first order segment is given a magnitude (m) of 1 and "each successive*

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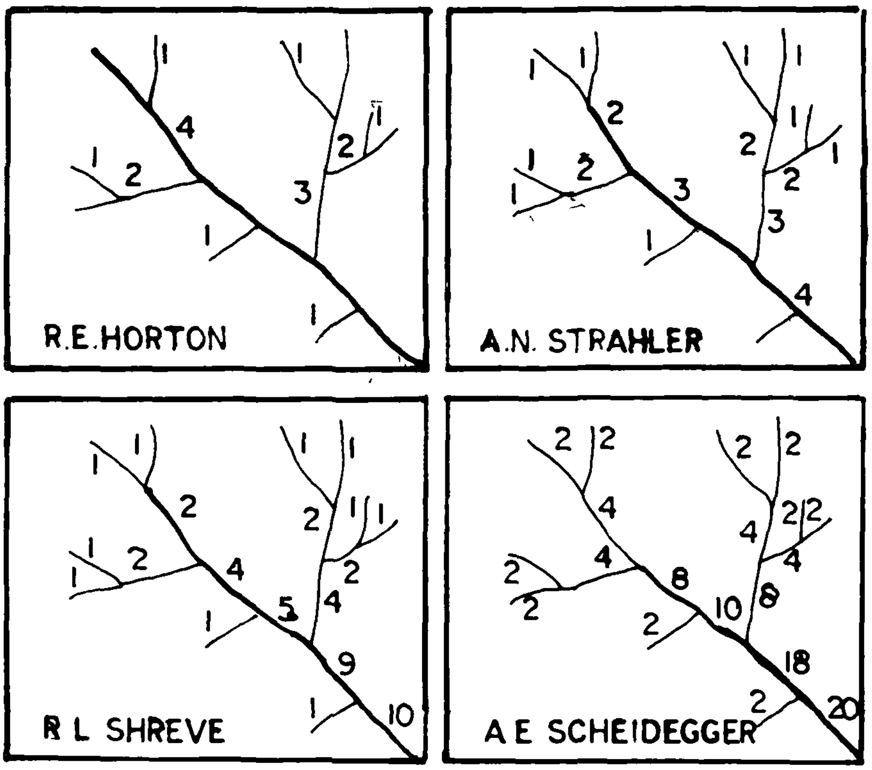
[16]*Strahler (1964), Quantitative Geomorphology of Drainage Basins and Channel Networks, in the Handbook of Applied Hydrology edited by U. T. Chow, New York, McGraw Hill, Section 4-11.*

[17]*Shreve, R.L. (1966), Statistical Law of Stream Numbers, Journ. of Geol. Vol. 74, pp.17-37.*



METHODS OF STREAM AND SEGMENT ORDERING

FIG. 15

link a magnitude equal to the sum of all the first order segments, which ultimately feed it" (Hagged and Chorley, 1969). Thus combination (*) of link M_1 and M_2 gives a down stream link magnitude of $M_1 + M_2$.

$$M^*{}_1 M_2 = M_1 + M_2$$

Thus in Shreve's scheme of stream ordering, each segment contributes in increasing the magnitude (order) of the segment which it joins (fig. 15).

Lewin (1970)[18] has drawn attention to the fact that the Shreve system is based only upon the outer segment and neglects the fact that the inner links gather water as well. Thus a modification of Shreve's method would be proposed and alternative ordering methods can be based either upon junctions (nodes) or paths.

Scheidegger (1965)[19] proposed his scheme of 'constant law of stream ordering' based on 'ratio-scale measures' and presented for postulates defining an algebra of combination of stream segments, which is cumulative as well as associative (fig. 15).

Woldenberg (1967) used Scheidegger's index to desire a new order magnitude (W) which, unlike Scheidegger's (G) gives an increase in geometrical progression down stream in:

$$W = \frac{\log m}{\log Rb} + 1$$

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[18] *Lewin, J. (1970), A Note on Stream Ordering Area 2, pp.32-35.*

[19] *Scheidegger, A.E. (1965), The Algebra of Stream Order Numbers, United States, Geol. Surv. Professional Paper, 525-B, pp.187-89.*

Where N 1/2 and the order magnitude (W) conforms the geometric progression $Qu = Qi\ (Rb)^{u-1}$

Thus it becomes clear from the critical analysis of different stream ordering that Strahler's scheme of modification of Horton's method has been used most extensively, particularly in conjunction with the 'laws of drainage composition'. Geomorphologists have frequently used Strahler's scheme for the morphometric analysis of drainage basin because it is the modified form of Horton's scheme and is best suited for the explanation of different laws of stream network which were postulated by Horton and verified by Strahler himself. The researcher has applied this method in the present study, but Horton's laws are also used for the analysis of networks of the small basins.

(i) <u>Ordering of the Basins:</u>

In ordering the drainage basin network, scale of the maps play a vital role in deciding the accuracy of the orders of stream segments. Large scale map like 1: 50,000 may produce more accurate results than the small scale maps because finger-tip tributaries and rills are correctly depicted on such maps but in the region of very high drainage density and in the areas of closely spaced rivers, it becomes very difficult to differentiate finger-tip channels, rills and rivulets. Some geomorphologists have suggested to use contour maps for the determination of streams. In such cases, contour crenulations are used to determine the streams but at certain occasions contour crenulations becomes helpless because they do not depict stream lines, but merely topographical irregularies. In the present study the author has used two Cm to one Km maps (1:50,000) in his scheme of stream ordering.

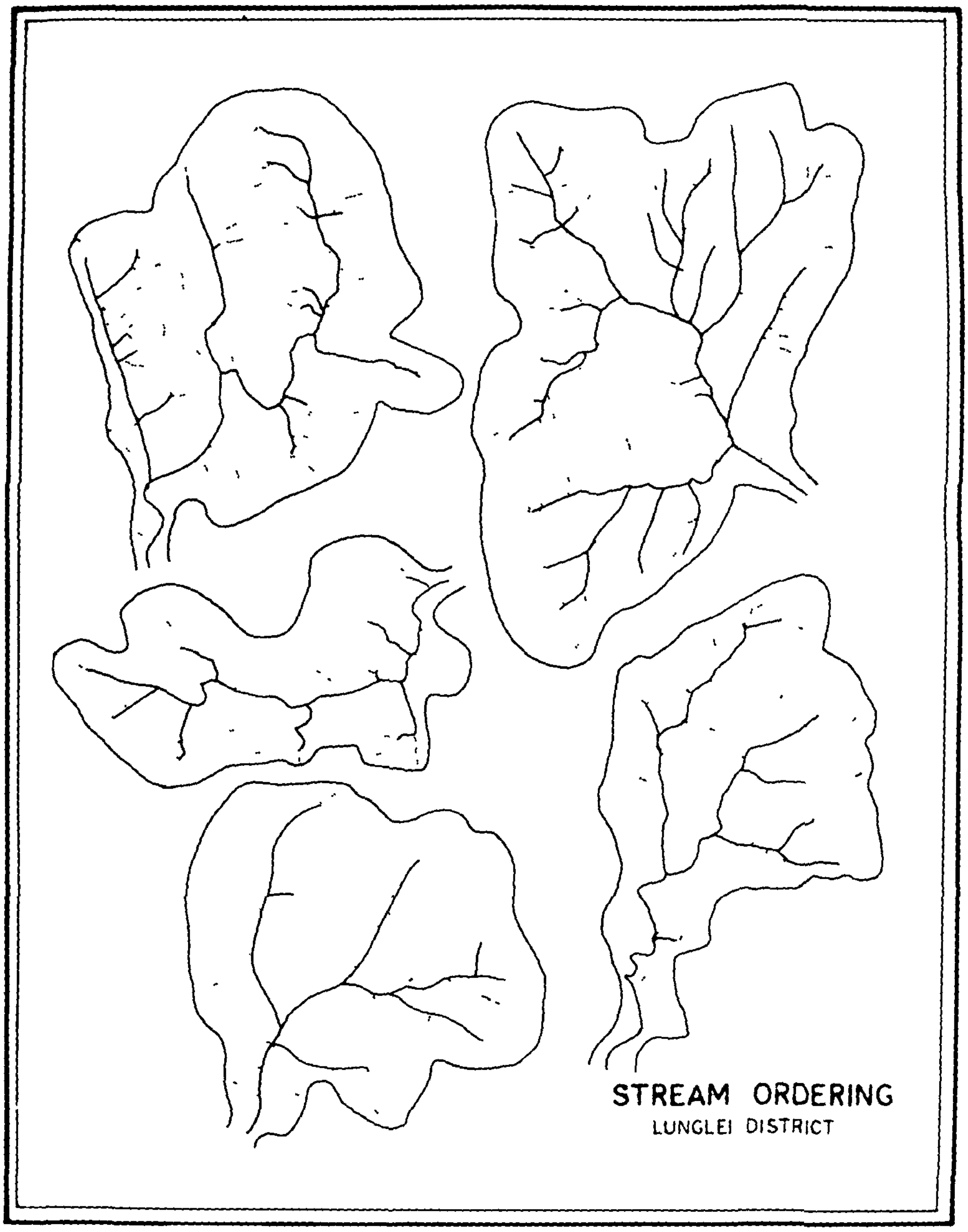

FIG 16 a

All the ten selected small drainage basins have been traced from two Cm to one Km (1:50,000) topographical sheets of the Survey of India. The selected ten small drainage basins have been ordered according to Strahler's scheme of ordinal scale of stream ordering and stream segments of different orders are represented in (fig. 16a and 16b). Out of the ten selected small drainage basins, Sawnngailui (3), Khawivalui (9) Vankailui (7) from Lunglei Community Development Block, Rangtelui (1), Saitumlui (5) and Sazuklui (8) are from Lungsen Block. Darkhuanglui (6), Nghachhinglui (10) and Saikallui (4) are from Hnahthial Block and Sakuhlui (2) is from Bunghmun Community Development Block.

After the completion of the ordering of the basins the numbers of all the segments of each order have been counted which are represented in Table 3. It is clear from the table that Sakuhlui (Bunghmun Block) tops the list by having the largest number of stream segments (133), whereas the bottom position is occupied by Sawng-ailui (Lunglei Block) with stream segments of (41).

It is clearly understood from the Table 3 that there is no direct relationship between the area of the basin and the number of stream segments. The Sakuhlui of Bunghmun Community Development Block occupies the largest number of stream segments. Vankailui of Lunglei Community Development block has the second position in stream segments (97), but the other basins which are almost of equal area has less stream segments like Rangtelui basin (85) and Darkhuanglui basin (81).

TABLE 3

Number of Stream Segments (Nu)

Sl No	Basins	ORDER (U)					Total No. of stream segments
		Nu_1	Nu_2	Nu_3	Nu_4	Nu_5	
1.	Rangtelui	64	16	2	1	-	83
2.	Sakuhlui	101	22	5	4	1	133
3.	Sawnngailui	31	9	1	-	-	41
4.	Saikallui	48	7	2	1	-	58
5.	Saitumlui	41	9	3	2	1	56
6.	Darkhuanglui	64	12	4	1	-	81
7.	Vankailui	73	15	6	2	1	97
8.	Sazuklui	48	11	3	1	-	63
9	Khawivalui	64	14	4	2	1	85
10.	Nghachhinglui	51	12	2	2	1	68

It is quite clear from the table 3 that the number of stream segments of any given order will be fewer than for the next lower order but more numerous than for the next higher order.

(ii) Bifurcation Ratio (Rb):

Bifurcation Ratio (Rb) is related to the branching pattern of the drainage network. It is defined as the ratio of number of segments of a given order Nu to the numbere of segments of the higher order Nu+ 1 is termed the bifurcation ratio Rb, and is expressed in terms of the following equation:

$$Rb = \frac{Nu}{Nu + 1}$$

Where Nu = Number of streams of a given order,

Nu + 1 = Number of streams of the next higher order.

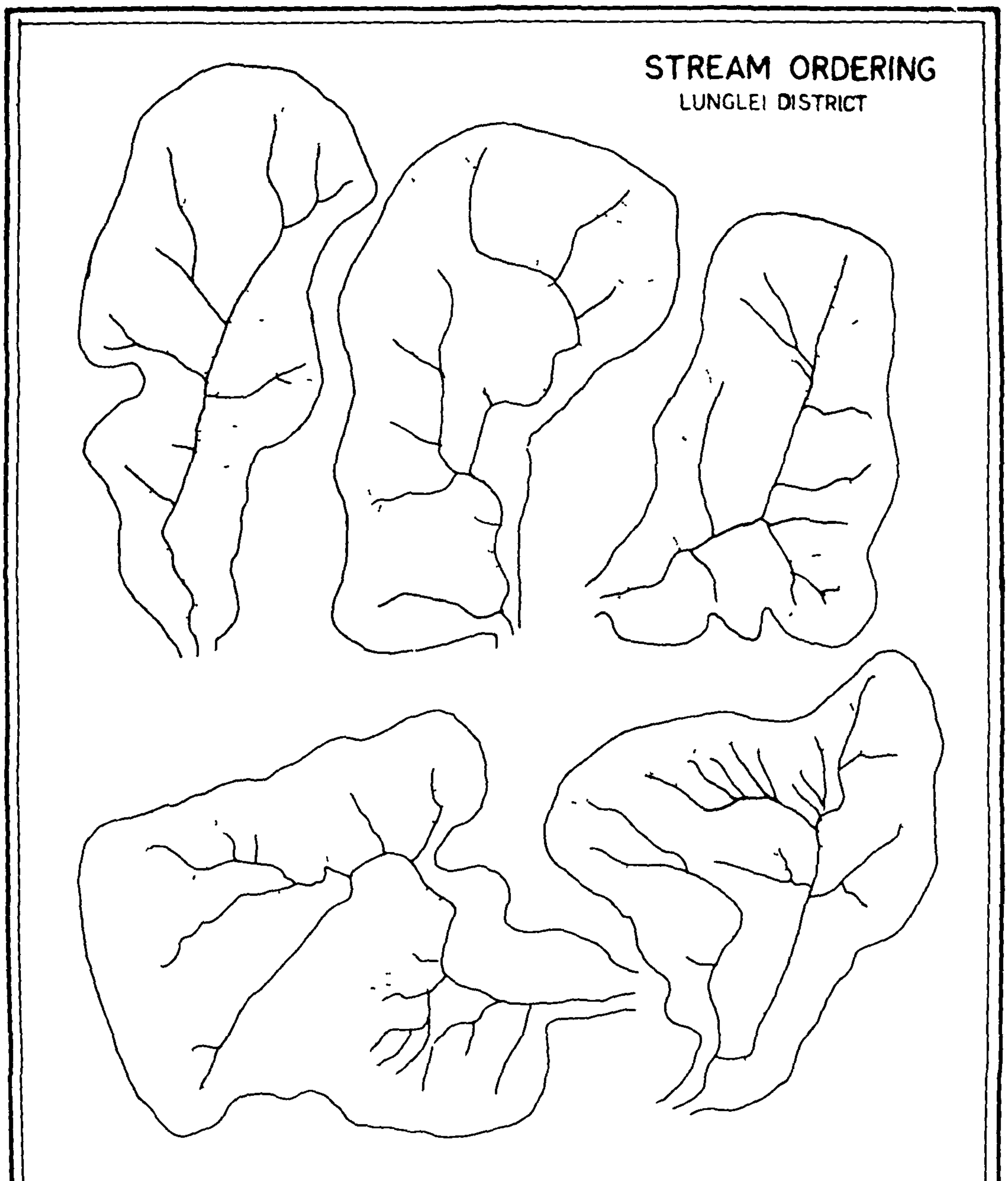

FIG 16 b

Horton (1945)[20] *recognised bifurcation ratio as one of the most important characteristics of drainage basin. The bifurcation ratio will not be precisely the same from one order to the next because of chance variations in watershed geometry, but will tend to be a constant throughout the series. This observation is the basis of Horton's (1945) 'Law of stream numbers' which states that the numbers of streams of each order form an inverse geometric sequence with order number or*

$$NU = Rb^{K-U}$$

Where K is the order of the trunk segment and the other terms are as previously defined.

Bifurcation ratio has been studied by a number of eminent geomorphologists (Maxwell, 1955; Schumm, 1956; Chorley, 1957; Strahler, 1957; Strahler in Chow, 1964; Coates, 1958 and Milton, 1966) in different regions having varied geological formations and relief characteristics. These studies clearly indicated marked regional variations in bifurcation ratios due to differences in climatic conditions, geololgical and structural characteristics, lithology, relief features and stage of basin development. Horton (1945) has postulated that bifurcation ratio varies from 2.00 in the flat or rolling basins to 3.00 to 4.00 in the mountainous highly dissected basins. Strahler (1964, in Chow, pp.40-45) has observed that "because of the bifurcation ratio is a dimensionless property and because drainage systems in homogeneous materials tend to display geometrical similarity, it is not surprising that the ratio shows only

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[20] *Horton, R.E. (1945), Op.cit., pp.275-370.*

a small variation from region to region". Coates (1958, pp.32-33)[21] *has observed, "that maximum possible ratio of 2.00 is seldom approached in nature, lying between about 3.00 and 5.00 in basin without differential geological controls favour the development of elongated narrow basins."*

The bifurcation ratios of all the ten selected basins have been calculated and the same have been represented in table 4. The average bifurcation ratios (Rb) of 8 basins confirm the observation of the above geomorphologists because the ratios range between 3.01 and 4.66. The only exception is the basin Sawnngai of Lunglei Block which is a tributary of Mat river has the mean bifurcation ratio of 6.22. This is the result of highly dissected and relief features. The river Saitumlui of Lungsen Block which is a tributary of De river has the mean bifurcation ratio of 2.76. This low mean bifurcation ratio is due to flat foot hill of the area.

TABLE 4

Bifurcation Ratio (Rb)

Sl.No	Basins	N_1/N_2	N_2/N_3	N_3/N_4	N_4/N_5	Rb
1.	Rangtelui	4.0	8.0	2.0	-	4.66
2.	Sakuhlui	4.59	4.4	1.25	4.00	3.56
3.	Sawnngailui	3.44	9.00	-	-	6.22
4.	Saikallui	6.85	3.5	2	-	4.11
5.	Saitumlui	4.55	3.0	1.5	2	2.76
6.	Darkhuanglui	5.33	3.0	4.00	-	4.11
7.	Vankailui	4.86	2.5	3.0	2.00	3.09
8.	Sazuklui	4.36	3.66	3.00	-	3.67
9.	Khawivalui	4.57	3.5	2.00	2.00	3.01
10.	Nghachhinglui	3.41	6.0	1.0	2.0	3.10

[21]*Coates, D.R. (1958), Quantitative Geomorphology of Small Drainage Basins in the Southern India.*

Guisti and Scheidegger (1965)[22] *have advocated that bifurcation ratios within a region decreases with the increasing order -*

$$R_{b_1} > R_{b_K}$$

K stands for successive increasing orders.

The general trend of the bifurcation ratios conforms with the above hypothesis because there is a general trend of decrease in the bifurcation ratio of 5 basins viz. Saikallui, Saitumlui, Vankailui, Sazuklui and Khawivalui basins show decreasing bifurcation ratios with increase in orders. The rest 5 basins show mixed conditions.

Guisti and Scheidegger (1965) have further propounded "basins of equal order but variable areas tend to have the smallest bifurcation ratios in the smallest areas; the ratio increases with increasing areas upto a certain size beyond which the bifurcation ratios tend to become constant". This hypothesis can be applied to these 10 small basins. The 5 5th order basins show that basin Saitumlui has smallest area and has the lowest bifurcation ratio (2.76), while basin Sakuhlui has largest bifurcation ratio (3.56). In the rest 5 3th and 4th order basins also show that same tendency, the basin Sazuklui has the smallest area as well as the low bifurcation ratio (3.67), while the basin Rangtelui has the largest area as well as the highest bifurcation ratio (4.66).

The only exception is in 3rd order basin, the Sawnngailui has the smallest area but the bifurcation ratio is the highest (6.22). This may be due to the

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[22]*Guisti, E.V. and Scheidegger, W.J. (1965), The Distribution of Branches in River Networks, U.S.,Geol. Survey, Prof. (1965), paper 422G.*

other factors like structural characteristics of rocks, lithology, slopes, relief feature, stages of basin development, etc. play dominant role in deciding the branching of streams.

(iii) Law of Stream Numbers:

Some definite relationship exists between the orders of the basins and numbers of stream segments. Horton and Strahler have propounded an inverse geometric series of the number of stream segments and orders and have stated "that the number of stream segments of successively lower orders in a given basin tends to form a geometric series beginning with a single segment of the highest order and increasing according to constant bifurcation ratio". They have recommended the following equation of stream number:

$$N_u = R_b^{(K - U)}$$

where, N_u = *Number of stream segments of a given order*

R_b = *Constant bifurcation ratio*

K = *Highest order of the basin.*

Horton further worked out the following formula (using constant Rb) to find out the total numbers of stream segments of the whole drainage basin.

$$\sum_{U=1}^{K} N_u = \frac{R_b^K - 1}{R_b - 1}$$

Where, K = *highest order of the basin.*

Horton has used constant bifurcation ratio in his equation which is not possible in reality, therefore, the practical application of this rule becomes doubtful. When the numbers of stream segments of different orders are plotted on a graph paper, a straight line of regression representing negative exponential function model is obtained. Though Strahler's scheme of ordinal scale of stream ordering differs significantly from the Horton's scheme of ordering, yet Strahler's system also produces the same inverse geometric series of number of stream segments.

In the present study, the streams (Nu) have been plotted against orders on a graph paper using the following equation of negative exponential function model as suggested by Strahler. The regression co-efficient (b) for each plot have been calculated and the same have been represented on the graphs (fig.18).

$$Y = A_e^{-bx}$$

$$\text{Log } e^{y} = \text{Log } e^{a - bx + 1 \text{ (Epsition)}}$$

Where, Y = Number of stream segments

X = Stream order (u)

a = Constant, and

b = regression co-efficient.

Explanation

The (fig. 17) reveals that, when the number of stream segments are plotted against successive orders of the streams, the graphs for the 5th order basins, 4th order basins and 3rd order basins show deviation of all the stream numbers and the points are not coming on a straight line. In other words,

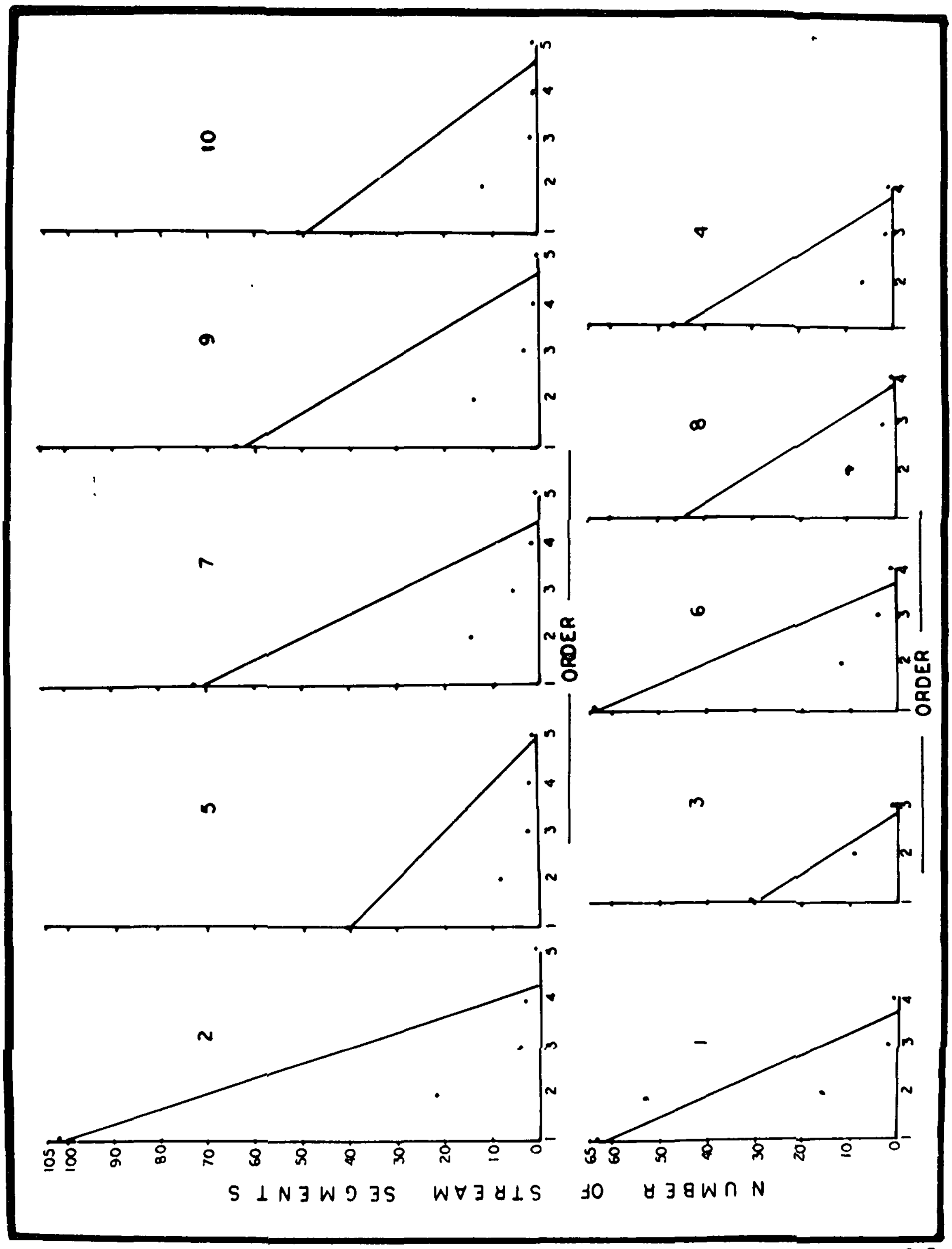

FIG.17

the number of stream segments of the various orders are not proportional to the next orders in all the basins.

The deviation of the stream numbers from the straight line indicates that the effect of various factors which cause this deviation. This is mainly due to the structural, underlying rock and unfavouravle conditions for the development of the stream network. All the streams are descending from the hill top and followed the general landform pattern. Hence, the number of streams are not found in a proportion to the orders.

(iv) Stream Lengths:

The stream length is a significant morphometric parameter of the drainage basin as it helps in the calculation of drainage density. The stream lengths of different orders of all the selected 10 basins have been measured in kilometres and represented in table 5. The total lengths of various orders have no significance because they may not be compared. Therefore, mean lengths (Lu) of each order have been calculated which have been arranged in table 6. Generally, the 1st order stream segments have the shortest mean length but the mean length increases with the increase in order. All the streams follow this postulation except some departures in certain orders of a few streams only.

Saitumlui, Saikallui and Vankailui basins exhibit departure in certain orders. Saitumlui basin shows the mean length of 3th order, higher than 4th order and Saikallui shows the mean length of 3th order more than 4th order. Again, Vankailui shows that the mean length of 4th order is less than 3th order segments.

TABLE 5

Stream length (in Km) (Lu)

Sl No	Basins	Stream length (in Km)				
		L_1	L_2	L_3	L_4	L_5
1.	Rangtelui	49	14	10	8	-
2.	Sakuhlui	63	26	5	6	4
3.	Sawnngailui	24	9	5	-	-
4.	Saikallui	42	11	7	2	-
5.	Saitumlui	40	10	9	1	4
6.	Darkhuanglui	46	12.5	4.5	7.5	-
7.	Vankailui	54.5	19.5	8	2	4
8.	Sazuklui	41	16	7	2.5	-
9.	Khawivalui	66	19.5	6	2.5	6
10.	Nghachhinglui	37	15	1	2	3.5

TABLE 6

Mean Stream Length (Lu) of Stream Segments (Kms)

Sl No	Basins	L_1	L_2	L_3	L_4	L_5
1.	Rangtelui	0.76	0.87	5.00	8.00	-
2.	Sakuhlui	0.62	1.18	1.00	1.50	4.00
3.	Sawnngailui	0.77	1.00	5.00	-	-
4.	Saikallui	0.87	1.57	3.50	2.00	-
5.	Saitumlui	0.97	1.11	3.00	0.50	4.00
6.	Darkhuanglui	0.71	1.04	1.12	7.50	-
7.	Vankailui	0.74	1.30	1.33	1.00	4.00
8.	Sazuklui	0.85	1.45	2.33	2.50	-
9.	Khawivalui	1.03	1.39	1.50	1.25	6.00
10.	Nghachhinglui	0.72	1.25	0.50	1.00	3.50

(v) Law of Stream Length:

Horton (1945)[23] has postulated a law of positive geometric progression between cummulative mean length and stream segments increase geometrically with successive increase in stream orders with constant length ratio. The model of law of stream length is called positive exponential function model and is expressed through the following equation:

$$Lu = L_1 \, R_L^{(u - 1)}$$

Where, L_1 *= The mean length of 1st order*

$$RL = \frac{L_u}{L_u - 1} \quad = \text{Constant length ratio.}$$

This theoretical model may not be applicable to the natural stream system in its totality because constant length ratio seldom exist, as is evident from table 5 wherein significant variations in length ratios may be noted in all the ten small drainage basins.

Where cummulative mean lengths of stream segments table 7 are plotted on the ordinate against the orders on the abscissa on a graph paper a straight line (fig. 18) of positive exponential function model is derived. The regression lines for all the ten basins have been drawn (fig. 18) on the basis of the following regression equation.

$$Y = a_e^{bx}$$

$$Log_e Y = log_e a + bx + u$$

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[23] *Herton, R.E. (1945), Op.cit.,*

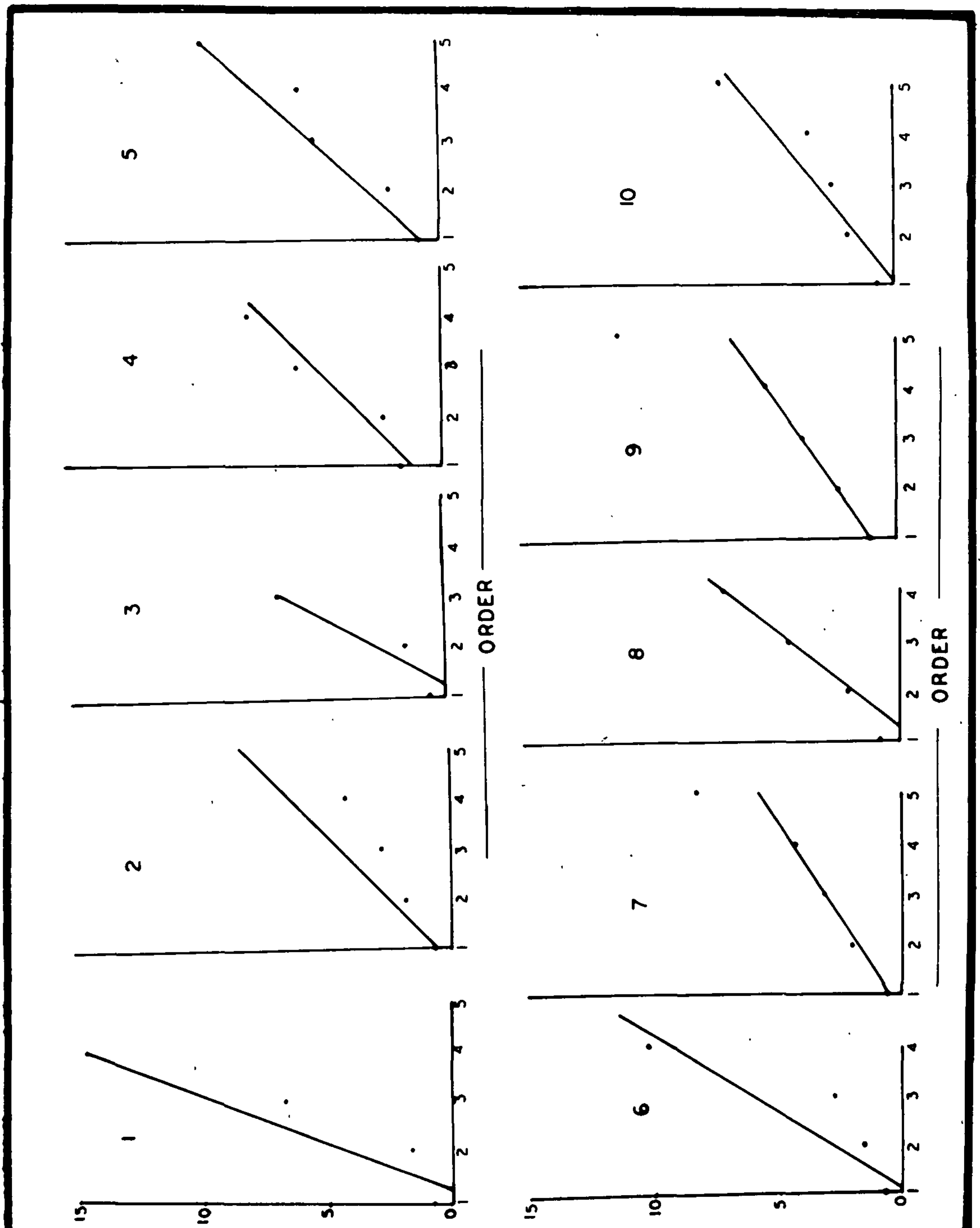

FIG.18

Where 'Y' stands for Cummulative mean length and

'X' denotes order (u)

'b' is the coefficient of regression, and

'a' is the constant.

TABLE 7

Cummulative mean lengths (Kms)

Sl No	Basins	Order (u)				
		1	2	3	4	5
1.	Rangtelui	0.76	1.63	6.63	14.63	-
2.	Sakuhlui	0.62	1.80	2.80	4.30	8.30
3.	Sawnngailui	0.77	1.77	6.77	-	-
4.	Saikallui	0.87	2.44	5.94	7.94	-
5.	Saitumlui	0.97	2.08	5.08	5.58	9.58
6.	Darkhuanglui	0.71	1.75	2.87	10.37	-
7.	Vankailui	0.74	2.04	3.37	4.37	8.37
8.	Sazuklui	0.85	2.30	4.63	7.13	-
9.	Khawivalui	1.03	2.42	3.92	5.17	11.17
10.	Nghgachhinglui	0.72	1.97	2.47	3.47	6.97

Explanation

The fig.18 reveals that, when the cummulative mean stream lengths are plotted against successive orders of the streams, the graphs for the 5th, 4th and 3rd orders show that all the points are much deviated from the straight line. The Samuklui basin indicates almost a straight line except the deviation of 1st order. The Khawivalui and Vankailui basins also indicate almost a straight line except the deviation of the 5th order.

The deviation of the cummulative stream lengths from the straight line indicates the effect of various factors. The deviation from the straight line shows that the law of drainage composition, geometric regularity is not maintained and the valley is not fully developed. This may be due to the structural control, difference in geological structure and immature landform of the area.

(vi) Sinuosity Indices:

The shape of the open link in terms of geometric structure of drainage lines involves the calculation of departure of observed path (O_L) from the expected path (E_L) of a river from its source to its mouth. It is supposed that the expected path of the river will be in a straight line. The calculation of such deviations presents a great problem because "it is not always clear where the terminating points for the observation should be located" (Hagget and Chorley, 1969).[24] Practically, the straight line path of the river is never possible because it is affected by a number of causative factors which force the drainage line to deviate from it straight line expected path. These factors include geological and hydrological controls, dip angles, slopes, absolute relief, relative reliefs, degree of dissection, stage of valley development, etc. Sinousity indices of the drainage line helps in studying the effect of terrain over xx river course and vice-versa. The present study includes the calsulation of sinousity index of the ten selected small drainage basins of Lunglei district.

Smart and Surken (1967)[25] measured the unsystematic deviations from a straight line path and curves of considerable symetry, whose dimensions were proportional to the size of the channel and they recognised two types of shapes of a drainage line, viz. (i) Wandering (ii) Meandering. The wandering

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[24] Haggett and Chorley, R.J. (1969), Op.cit.,

[25] Gregory, K.J. and Walling, D.E. (1973), Op.cit., pp.2-15 and 45-55.

path may be calculated by relating to the length of the observed path (O_L) to the length of the expected path (E_L) Schumm (1956) expanded the above ideas and after measuring the deviations from a straight line path presented five categories of channel sinousity, viz. (i) straight ($0_L/E_E = 1.00$), (ii) transitional, (iii) regular, (iv) irregular, (v) tortous ($O_L/E_L =$ 2.00) (fig. 19).

Muller (1968)[26] *modified the difficulties found in Schumm's method and presented his model of sinousity index. This model explains the effects of hydrolic and topographic controls on the courses of the streams. He measured the length of channel (CL), the length of the valley between the base of the valley walls (VL) and the shortest distance between the source and mouth of the river (Air L) and presented his model in the form of the following equations:*

(i) $CI = \frac{CL}{Air\ L}$

Where CI = Channel index.

(ii) $VI = \frac{VL}{Air\ L}$

Where VI = Valley Index

(iii) HSI = % equivalent of $\frac{CI - VI}{CI - I}$

Where HSI = Hydraulic sinousity index

(iv) TSI = % equivalent of $\frac{VI - I}{CI - I}$

Where TSI = Topographic sinousity index.

(v) $SSI = \frac{CL}{VL}$

Where SSI = Standard Sinousity Index.

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[26] *Muller, J.E. (1968), An Introduction to the Hydraulic and Topographic Sinuasity Index, A.A.A.G., Vol. 58, No.2 (1968).*

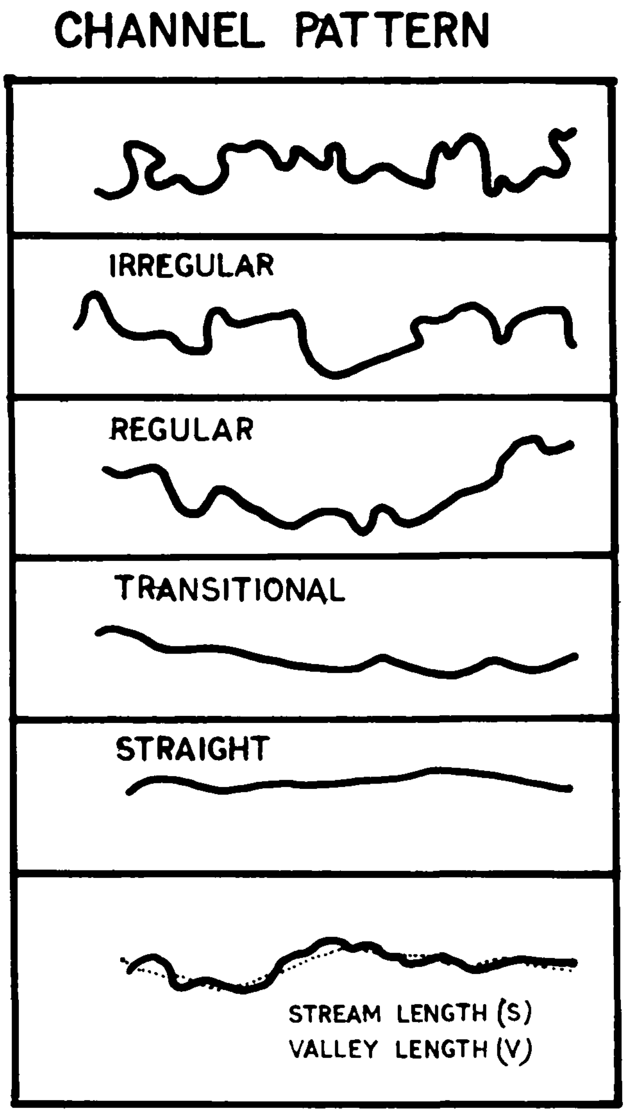
CHANNEL PATTERN
IRREGULAR
REGULAR
TRANSITIONAL
STRAIGHT
STREAM LENGTH (S)
VALLEY LENGTH (V)

FIG.19

The present study aims at the application of Muller's model of sinousity indices for the ten small drainage basins of Lunglei district of the Union Territory of Mizoram. The river courses are classified into three categories on the basis of the standard sinousity index, viz. (i) straight river course (SSI = 1.00) and (ii) sinous course (SSI = 1.00-1.50) and (iii) Meandering course (SSI = > 1.50).

TABLE 8

Sinousity Indices

Sl No	Basins	CI	VI	HSI	TSI	SSI
1.	Rangtelui	1.62	1.33	0.47	0.53	1.18
2.	Sakuhlui	1.11	1.06	0.41	0.54	1.11
3.	Sawnngailui	1.28	1.12	0.57	0.43	1.12
4.	Saikallui	1.50	1.25	0.50	0.50	1.12
5.	Saitumlui	1.10	1.04	0.60	0.40	1.00
6.	Darkhuanglui	1.10	1.03	1.70	1.30	1.00
7.	Vankailui	1.11	1.10	0.09	0.90	1.12
8.	Sazuklui	1.37	1.26	0.29	0.70	1.31
9.	Khawivalui	1.44	1.23	0.48	0.52	1.44
10.	Nghachhinglui	1.12	1.05	0.58	0.42	1.12

It is clearly seen from the table 8 that channel index (CI) and the valley index (VI) are having almost the same figure for all the ten basins. This shows that there is no so much difference between the channel index and valley index. It is clear from the figures of standard sinousity index that the basins Darkhuanglui and Saitumlui have both the value of 1.00 which indicates the straight river course.

The other eight basins have standard sinousity indices ranging from 1.11 to 1.44. These can be put in the second category of standard sinousity index which ranges from 1.00 to 1.50 indicating sinous course of the streams.

The hydraulic and topographic sinousity indices (HSI and TSI) are the valuable morphometric tools which help in determining the stages of the basin development as well as determining the controlling factors of sinousity. The following basins show high topographic sinousity index (TSI) : Khawivalui (0.53%, Sazuklui (0.70%), Vankailui (0.90%), Saikallui (0.50%), Sakuhlui (0.54%) and Rangtelui (0.53%). This indicates that these basins are in their early stages of basin development. Whereas the basins Sawnngailui (0.57%), Saitumlui (0.60%), Darkhuanglui (0.70%) and Nghachhinglui (0.58%) show high percentage of hydraulic sinousiy index (HSI). This indicates that these basins are in their early mature stages of basin development.

II. Aerial Aspects of the Basins:

Basin area is one of the most important morphometric parameters affecting the spatial distribution of a number of morphometric attributes such as drainage density, texture, stream frequency, slopes, dissection index, etc. Keeping this view in mind, Anderson (1957) termed it as a "devil's own variable because almost every watershed characteristic is correlated with area". The areas of the drainage basins are delineated by watersheds which termed as basin perimeters.

<u>Basin Perimeters:</u> A number of prominent geomorphologists have postulated that basin perimeter in highly correlated with basin area, i.e.

increase in perimeter is followed by increase in basin area. In the present study this hypothesis is tested and has been confirmed. It has been found that basin perimeter and area have inter-dependent among each other.

Basin perimeter is positively correlated with channel length. The perimeter increases with increase in channel length and the former decreases with the decreases in the latter. In the present study, the coefficient of correlation is calculated for ten basins and found to be very high positive correlation; it is significant at 1 per cent level of confidence indicating a strong relationship between permieters and channel length.

(i) Drainage Density:

Density of the stream network has long been recognised as a topographic characteristic of fundamental significance. This arises from the fact that network density is a sensitive perimeter which in many ways provides the link between the form attribute of the basin and the process operating along the stream course. If drainage basins were uniformed in every aspect, stream flow would be proportional to the length of the water course in a basin, because channel flow is much more rapid than the alternative flow on, or beneath slopes. As the extent and density of the network reflect topographic, lithological, pedological and vegetational control, and because they also incorporate the influence of man, network density promises to be a valuable index.

Use of maps of varying scales and degree of detail, or aerial photographs taken at different seasons, produced widely divergent results, especially *in areas where seasonal stream flow is marked characteristic and the definition of drainage lines not always without ambiguity. Thus, figures such as those given by Selbey (1967) show that measures of drainage density may vary by a factor of 10, and are very difficult to compare. They also indicate that lithology and relief development as well as climate and vegetation cover, are major controls. Thus, in semi-arid areas drainage density over poorly consolidated shales may rise into hundreds of kilometres of terrain, while in humid temperate areas with a forest or wood-land vegetation cover, figures tend to vary from 1.8 to 5.6 Km/Km^2 (Salbey 1967).[27]*

Infiltration capacity is also a major factor which is directly affected by lithology and, all are closely related to climate. Charley (1957)[28] and Chorley and Morgan (1962) compared three lithologically similar areas from Britain and confirmed a close relationship between drainage density and rainfall.

It is perhaps significant that figures from areas of low relief in the humid tropics generally exhibit a range below those just quoted. Doornkamp (Doornkamp and King, 1971)[29] has analysed more than one hundred third order basins from Uganda and found drainage densities ranged from 0.62 to 6.25 Km/Km^2,

For the present study, the drainage density for all the ten selected

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[27]Selbey, M.J. (1968), Morphometry of Drainage Basins in Areas of Pumice Lithology (1968), pp.169-74.

[28]Chorley, R.J. (1957), Illustrating the Laws of Morphometry, Geol. Mag. Vol. 94, pp.140-150.

[29]Doorkamp, J.C. and King, C.A.M. (1971), Numerical Analysis in Geomorphomology - An Introduction, London, Edward Arnold.

small basins have been calculated by using the following formula as suggested by Horton (1945, p.283).

$$Dd = \frac{\sum_{I=I}^{K} \sum_{J=I}^{N} L_u}{A_u}$$

Where L_u = Length of the stream

A_u = Total area of the basin

Thus, Dd is simply the ratio of total channel segment lengths cummulated for all orders within a basin calculating the drainage density for all the ten small basins, the values have been represented in Table 10. The low drainage densities of Sawnngailui basin (2.19), Saikallui (2.78), Saitumlui (2.42), Darkhuanglui (2.88), Sazuklui (2.50) and Nghachhinglui basin (2.77) are due to the fact that these basins are located in a region of highly permeable sub-soil material, under dense vegetation cover and where the relief is low. While the high drainage densities shown by Rangtelui (3.11), Sakuhlui (3.64), Vankailui (3.68) and Khawivalui basin (3.33) are due to the fact that these basins are located in regions of highly impermeable sub-surface material, sparse vegetation and highly dissected relief.

Generally, drainage density rises with increasing relief. In the present study also the impact of above elements are noticed. The contour map (fig. 13) of Lunglei district reveals that the relief increases from west towards central and increases more towards east. Out of ten selected small drainage basins, two of them, i.e. Khawivalui and Vankailui are situated on the central hill zones of Lunglei district. This is the fact that these basins represent high drainage density in respect to other. But the basin such as

Saitumlui and Sazuklui are located in the low relief. On the other hand, Sawn-ngailui, Rangtelui, Saikalllui, Darkhuanglui and Nghachhinglui are located on the fringe of the high and low relief zone, hence representing medium drainage density.

With relation to texture ratio, Smith (1950) and Strahler (1957) described drainage density values less than 5.00 as coarse, between 5.00 and 13.7 as medium, between 13.7 and 155.3 as fine, and greater than 155.3 as ultra-fine (fig. 16). As texture may also be represented by the relative close-ness of the drainage network, i.e. drainage density (Dd). Thus, a high drainage density results in fine texture and a low density in coarse texture.

The following table 9 reveals that all the ten drainage basins show less than 5.00 drainage density representing coarse texture in Lunglei district.

TABLE 9

Drainage density (Dd) (Km/Km^2)

Sl No	Basins	Drainage density (Dd)
1.	Rangtelui	3.11
2.	Sakuhlui	3.64
3.	Sawnngailui	2.19
4.	Saikallui	2.78
5.	Saitumlui	2.42
6.	Darkhuanglui	2.88
7.	Vankailui	3.68
8.	Sazuklui	2.50
9.	Khawivalui	3.33
10.	Nghachhinglui	2.77

The above table 9 shows clearly that the drainage densities of ten selected small drainage basins ranges from 2.19 to 3.68 Km/Km^2. The lowest drainage density value is shown by Sawnngailui basin of Lunglei block, *while, the highest drainage density value is shown by Vankailui basin of Lunglei block.*

(ii) Constant of Channel Maintenance (CCM):

Schumm (1956)[30] *used the inverse of drainage density as a property termed constant of channel maintenance (CCM). Thus:-*

$$CCM = \frac{I}{D} = \frac{A_u}{\sum_{i=I}^{K} \sum_{i=I}^{N} L_u}$$

Specifically, the constant CCM tells the number of Sq. miles or Kms. of watershed surface required to sustain I linear miles or Kms. of channel.

For the present study, the constant of channel maintenance for all the ten selected drainage basins have been calculated and represented in Table 11.

TABLE 10

Sl No	Basins	CCM (Sq. km/Km)
1.	Rangtelui	0.32
2.	Sakuhlui	0.27
3.	Sawnngailui	0.46
4.	Saikallui	0.36
5.	Saitumlui	0.41
6.	Darkhuanglui	0.35
7.	Vankailui	0.25
8.	Sazuklui	0.40
9.	Khawivalui	0.30
10.	Nghachhinglui	0.36

[30] Schumm, S.A. (1956), Op.cit.,

It is clearly understood from the above table 10 that Sawnngailui basin requires 0.46 sq. kms to maintain 1 Km length of stream, is the highest and the Vankailui basin requires the lowest amount of area i.e. 0.25 sq. km to maintain 1 Km. length of stream. It is interesting to note that there exist an inverse relationship between drainage density (Dd) and constant channel maintenance (CCM). The basin which represents the second highest drainage density figures are seen showing lowest CCM figures. This can be stated in a different way like, while it is the relief which controls drainage density, i.e. higher the relief, the drainage is high. In this case, higher the relief, lower the CCM value and vice-versa. Therefore, it is confirmed that Schumm's formula for CCM = $\frac{I}{Dd}$ *is applicable for the study.*

(iii) Stream Frequency (FS):

Horton (1945)[31] *introduced stream frequency (or channel frequency) FS, as the number of stream segments per unit area. Melton (1958)*[32] *analysed in detail the relationships between the drainage density and stream frequency, both of which measure the texture of the drainage net, but each of which treats a distinct aspect. He derived the dimensionally correct question.*

$$F = 0.694 \quad D^2$$

Add from this the dimensionless number F/D^2*, which tends to approach a constant value 0.694 despite as variations in linear scale.*

It is now clear that the stream frequency is calculated by the

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[31] *Horton, R.E. (1945), Op.cit., pp.597-646.*

[32] *Melton, M.A. (1958), Geometric Properties of Mature Drainage System and their representation, pp.35-54.*

total number of streams in a drainage basin divided by the area of the basin, or the stream frequency is calculated by the total number of stream in a unit area in a given basin (Horton, 1945).

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

Where, F is the stream frequency,
N is total number of streams in a unit area and
A is the unit area.

In the present study of stream frequency, the latter method has been applied.

Method of Study

The drainage maps of all the ten selected small drainage basins on the scale 2 Cm to 1 Km, were first divided into two Cm grids, thereby making each grid to represent 1 sq. km. The total number of streams crossing to each grid was calculated and then put in the centre of the grids. By counting the maximum and minimum number of streams in each grid the isopleth of three stream interval have been drawn on all the ten selected small drainage basins. The resulting maps of stream frequency brings out the regional or spatial variation very clearly.

The drainage frequency of all the ten basins have been put in certain category of three stream interval. Then the different categories have been termed as coarse, moderate, moderately high, high and very high. The areas for all these five categories have been measured for all the ten basins and their percentage to the total area have been calculated and represented in the table 12.

TABLE 11

Stream Frequency (Area in Sq. km.)

Sl No	Basins	Total area (Sq.Km)	0 - 3 (Coarse)	3 - 6 (moderate)	6 - 9 (moderately high)	9 - 12 (High)	12 and above (very high)
1.	Rangtelui	12	1.00 (8.33%)	0.90 (7.50%)	7.00 (58.33%)	2.10 (17.6%)	1.00 (8.33%)
2.	Sakuhlui	17	0.80 (4.70%)	1.30 (7.65%)	7.90 (46.48%)	5.25 (30.88%)	1.75 (10.29%)
3.	Sawnngailui	7	0.75 (10.71%)	1.75 (25.00%)	3.50 (50.00%)	1.00 (14.29%)	- -
4.	Saikallui	10.75	-	5.85 (54.18%)	4.10 (38.38%)	0.80 (7.44%)	-
5.	Saitumlui	9.25	1.25 (13.51%)	3.15 (34.06%)	4.60 (49.73%)	0.25 (2.70%)	-
6.	Darkhuanglui	9.75	0.45 (4.62%)	1.75 (17.95%)	5.55 (56.92%)	1.20 (15.38%)	0.50 (5.13%)
7.	Vankailui	10.20	0.30 (2.94%)	3.50 (34.32%)	0.75 (7.35%)	4.85 (47.55%)	0.80 (7.84%)
8.	Sazuklui	9.45	0.40 (4.21%)	4.35 (45.79%)	2.75 (28.95%)	1.40 (14.74%)	0.60 (16.31%)
9.	Khawivalui	13.55	1.65 (12.18%)	3.15 (23.25%)	5.20 (38.38%)	3.20 (23.61%)	0.35 (2.58%)
10.	Nghachhinglui	7.50	0.30 (4.00%)	3.20 (42.67%)	2.20 (29.33%)	1.80 (24.00%)	- -

*(Figures in the parenthesis indicates percentage to the total area).

ANALYSIS

Spatial Distribution of Stream Frequency

The stream frequency map (fig. 2 (a) & 2. (b)) for ten small drainage basins selected from different blocks of Lunglei district shows clearly the regional variation on space.

(i) Coarse Frequency (less than 3):

This category of frequency can be noticed in all the basins excepting Saikallui basin. The stream frequency map reveal that in all the nine basins this category of stream frequency is found only near the watershed area of the basins. In Khawivalui basin three patches of coarse stream frequency found in the northern corner, south west corner and south east corner. In Sakuhlui basin, there are two small patches of coarse stream frequency found in north eastern corner and south western corner. Sawnngailui basin have three places of coarse stream frequency in the north west, south and east. Sazuklui shows two small patches of coarse stream frequency in the western part. In the Rangtelui basin also, this category of stream frequency is found in small patches in the north east and west. The four drainage basins Vankailui, Darkhuanglui, Saitumlui and Nghachhinglui, this category of stream frequency is found in small patches in the north west, south west, west and south east respectively.

(ii) Moderate Frequency (3-6):

The stream frequency map (fig. 2 a & 2 b) reveals that the moderate stream frequency are found extensively in Sazuklui and Saikallui basins. In

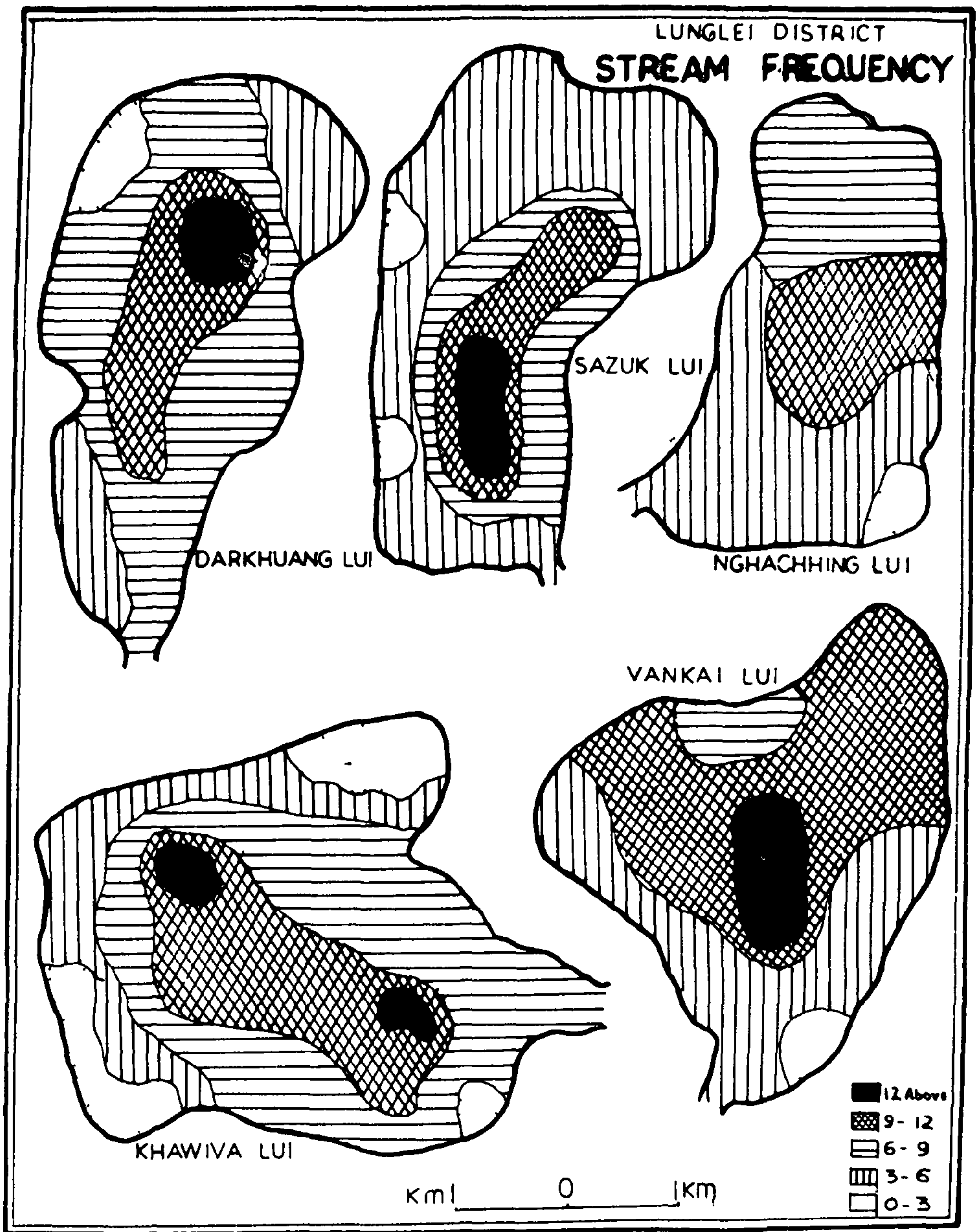
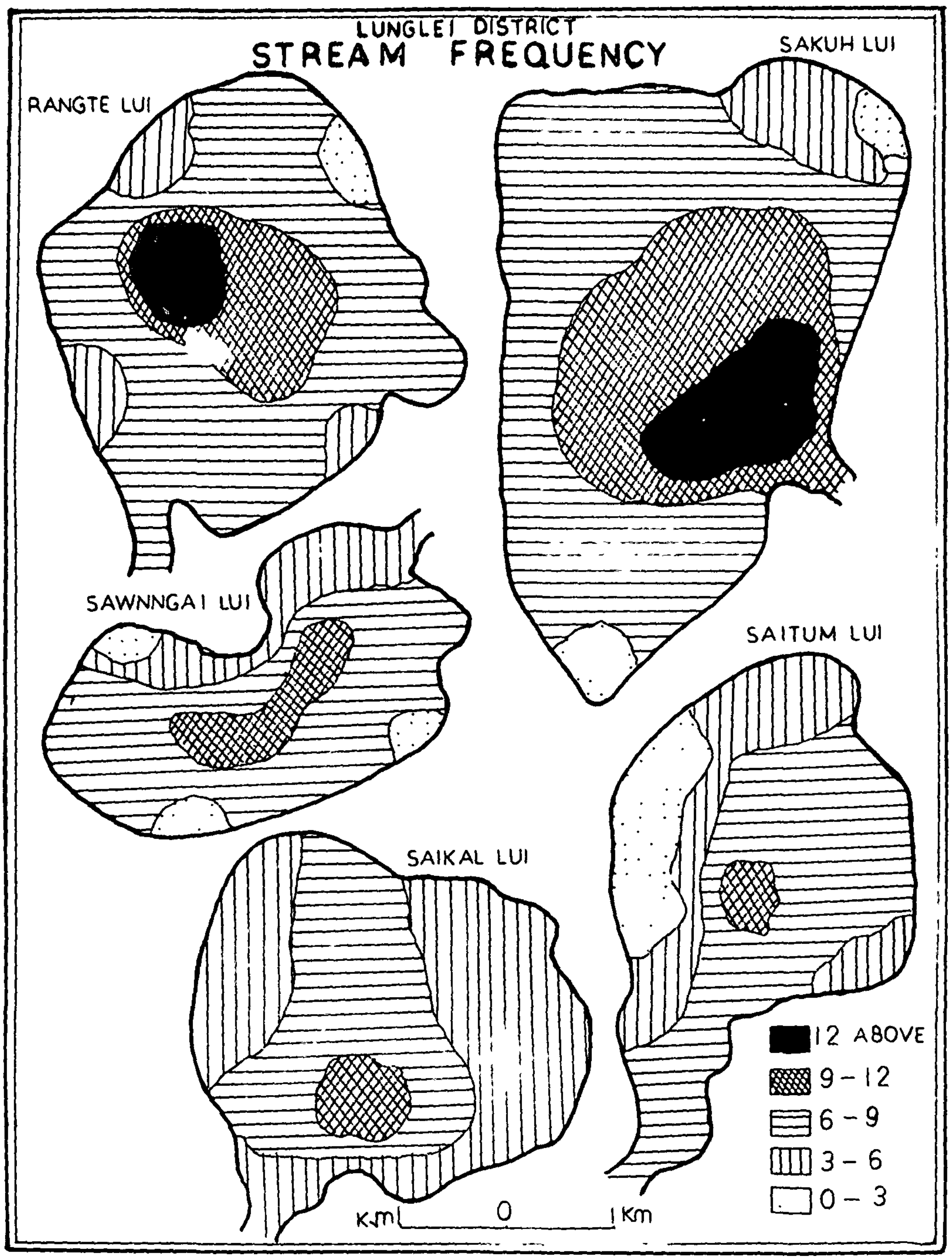

LUNGLEI DISTRICT
STREAM FREQUENCY
DARKHUANG LUI
SAZUK LUI
NGHACHHING LUI
VANKAI LUI
KHAWIVA LUI
12 Above
9- 12
6- 9
3- 6
0- 3
Km 1 0 1 Km

FIG-20a



LUNGLEI DISTRICT
STREAM FREQUENCY
RANGTE LUI
SAKUH LUI
SAWNNGAI LUI
SAITUM LUI
SAIKAL LUI
12 ABOVE
9 - 12
6 - 9
3 - 6
0 - 3
Km 0 1 Km

FIG-20b

Sazuklui basin this category surrounded extensively the whole basin excepting the eastern part of the basin. In Saikallui also this category of frequency covers very large area in the south, east and west. The Nghachhinglui basin also covers a large area by this category of stream in the southern part of the basin. In Khawivalui basin, it covers the watershed area in small patches right from north east to south west. In Sakuhlui basin this category covers small patches in the north east. In Vankailui basin this category of stream covers the whole western part of the basin excepting small patch of centre western part which is covered by coarse stream frequency. Sawnngailui basin shows in small patch the whole northern corner of the basin. Darkhuanglui shows this category in small patches in the north west and south east. In Saitumlui, this category is found in the western and south east. In the Rangtelui basin this category is found in small patches in the north west and south east.

(iii) Moderately High Frequency (6-9):

This category of stream frequency occupies very large area in all the basins excepting Vankailui basin, which has a small area in the eastern part of the basin. In Sakuhlui basin this category covers nearly two-third of the basin. In Darkhuanglui basin this category covers a little more than two-third of the basin area. Khawivalui basin is covered by this category of stream frequency half of the basin area. In Sawnngailui basin also this stream frequency occupies a little less than two-third of the basin area. In Sazuklui basin this category surrounded in small patches the high and very high stream frequency in the centre. Rangtelui basin is covered by this category *of stream extensively excepting the central part of the basin. In Saitumlui basin nearly the whole eastern part right from south to north is covered by this category of streams frequency. Saikallui and Nghachhinglui basins are also covered by this stream frequency extensively.*

(iv) High and Very High Frequency (9-12 and above):

In all the the ten selected small drainage basins of Lunglei district, this high frequency of stream is found in the centre of the basins. This seems to be due to the narrow valley that receives a large number of streams from all the sides, resulting high and very high frequency of streams of 9-12 and above 12 streams per sq. km. are found in the central part of the basins. Sakuhlui basin, Khawivalui basin and Vankailui basin have very extensive area of this category of stream frequency and it may be partly due to structural control.

Areal Aspect of Stream Frequency

(i) Coarse Frequency (less than 3):

Table 11 reveals that the only basin Saikallui does not have this category of stream frequency. In terms of area-wise distribution, Khawivalui basin occupies the highest place comprising 1.65 sq. km. i.e. 12.18 per cent of the total area of the basin and the lowest place goes to the Vankailui and Nghachhinglui basins comprising 0.30 sq. km. (2.94%) and 0.30 sq.km. i.e. 4.00 per cent of the total basin respectively. But in regard to the percentage distribution of stream frequencies, Saitumlui basin occupies the largest area of 13.51 per cent of the total area. It is noted that this category of stream frequency found mainly at the watersheds of the basins.

(ii) <u>Moderate Frequency (3-6):</u>

From the table 11 it reveals that the largest area covered by this category of stream frequency is found in Sakuhlui basin (5.85 sq.km) followed by Sazuklui basin (4.35 sq.km). The smallest area under this category of stream frequency is found in Rangtelui basin (0.90 sq.km.). In term of percentage Saikallui basin (54.18%) covers the maximum percentage of the area to the total area of the basin followed by Sazuklui basin (45.79%). The lowest percentage of area under this category is found in the Rangtelui basin (7.50%).

(iii) <u>Moderately High Frequency (6-9):</u>

The third category of stream frequency 6 to 9 stream per sq.km. i.e. moderately high. The table 11 reveals that the largest area covered by this category is found in Sakuhlui basin (7.90 sq.km) followed by Rangtelui basin (7.00 sq.km) of Bunghmun block. The lowest area covered by moderately high frequency is found in the Vankailui basin (0.75 sq.km). The percentage to the total area under this category is highest in the Rangtelui basin (58.33%) followed by Darkhuanglui basin (56.92%). The lowest percentage is found in the Vankailui basin (7.35%).

(iv) <u>High Frequency (9-12):</u>

This category is the areas drained by 9-12 streams per sq. km. Table 11 reveals that the Sakuhlui basin (5.25 sq.km) has the biggest area under this category of stream frequency, followed by Vankailui basin (4.85 sq.km.). The smallest area under this category found in the Saitumlui basin (0.25 sq.km) only. Percentage wise the Vankailui basin (47.55%) occupied the highest percentage of area under this category followed by Sakuhlui basin (30.88%).

The lowest percentage of area under this category is found in the Saitumlui basin (2.70%).

(v) Very High Frequency (12 and above):

The lowest category of stream frequency are the area drained by more than 12 streams per sq. km. This stream frequency is not found in Sawnngailui, Saikallui, Saitumlui and Nghachhinglui basins. The remaining six basins have this category of stream in a small pocket. The largest area covered by very high frequency of stream is found in the Sakuhlui basin (1.75 sq.km) of Bunghmun block and the lowest area under this category is found in Khawivalui basin (0.35 sq.km) of Lunglei block.

Factors Affecting Stream Frequency

The study of the stream frequency of the ten selected small drainage basins of Lunglei district cause to be seen that the frequency of streams in those basins depends upon a number of various factors, which may be divided into two factors:

(1) Environmental factors
(2) Map factors.

Environmental Factors

The important environmental factors which have affected the drainage frequency of these basins are as follows and the relative significance of these environmental factors varies from place to place and basin to basin:

(a) Climate
(b) Lithology and Structural characteristics of rocks

(c) Relief
(d) Infiltration capacity
(e) Vegetation.

From the spatial analysis of the ten small drainage basins of Lunglei district of Mizoram, it is clearly understood that the coarse and moderate stream frequencies are due to the lack of relief and absence of impermeable rocks on the surface. It is also partly because of rainfall.

It is also noticed that the regions of high and very high frequency have the relief of hilly dissected terrains. Such areas have favourable and structural features of underlying rocks. The two basins Sakuhlui and Khawivalui are located in such areas and receive high rainfall causing high and very high frequency of stream per sq. km.

It is also clear that the vegetation has played a great role in stream frequency of all the ten small drainage basins of Lunglei district. The coarse and moderate frequencies are found in the areas of less vegetation cover, on the other hand high and very high frequencies are noticed where favourable vegetations are prevailing.

The most important single factor influencing drainage texture in this area seems to be infiltration capacity or the permeability of the mantle rock and bed rock.

Map Factor

In the study of drainage frequency, the effect of the map factor also is of great significant. In the map, the most important factor determining *the frequency of drainage is the scale of the map. In a large scale map one will get a more accurate results of drainage frequency than from small scale map. In the present study the researcher has used the topographical sheet of scale 1:50,000 due to lack of larger scale and due to lack of aereal photographs.*

CHAPTER-VI

MICRO-GEOMORPHIC REGIONS

Introduction

To divide the world or a part of it into geomorphic regions or sub-regions, two points need to be borne in mind - the basis of classification and the factors to be considered, and nomenclature to be adopted. The basis of classification depends upon the size of the region under study, the real distribution of various structural, lithological, topographical and climatic elements. For instance, when large areas of continents and sub-continents sizes are considered, the climate is a common dominator. In other cases, geological structure, lithology, relief features and erosional peculiarities of the region are taken into account. While in a smaller area morphometric properties as slope, form of the ground quantitative properties of streams and surface morphology are used as important criteria of geomorphic divisions.

The regionalisation of the landform facies is not an easy task, because of the fact that process of evolution of landforms differs from place to place. There is no particular methodology which can be uniformly applicable for the purpose of regionalisation.

Importance of Geomrophic Regionalisation

Geomorphic regionalisation has multi-dimensional purposes, viz.

(i) *Recognition of landform characteristics needed for the purpose of land capability classification and landuse planning.*

(ii) *Maintenance, preservation and improvement of natural environment and geomorphic elements, and*

(iii) *Agro-economic planning.*

Geomorphic regions are helpful for the prevention and curative measures of continously degraded natural environment, viz., forests, soil landforms, etc. One of the great problems facing mankind today is to achieve a balance between a rapidly increasing world population and the natural resources available. Except for fish, all food is produced directly or indirectly from the land; it is of vital importance, therefore, that all the cultivable land on the surface of the earth should be conserved most carefully and that such land as is already under cultivation should be maintained in a state of fertility, for even the most fertile soil will degenerate and ultimately become sterile if it is ruthlessly exploited and no attempt is made to enrich, fertility and protect it.[1]

The young folded topographic elements of the tertiary rock formations of Lunglei district of Mizoram may require special attention for its maintenance, both within the region and its adjoining areas, as the area is highly prone to erosion under high rainfall conditions. If the vegetation cover, however, is preserved the rate of erosion can be significantly reduced. A consequence of such erosion of the exposed surfaces would result in carrying down of the fertile top soils of the hillsides rendering them useless

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[1]*Robinson, H. (1972), Biogeography published by Macdonald and Evans Ltd. Huddersfield.*

for the purpose of agriculture. Thus an attempt has been made to differentiate and identify different micro-geomorphic regions of the district. This would help in explaining the problems related to the agricultural and regional development planning at various geomorphic units. The effective and useful task of the production of renewable natural resources of the area in the field of agro-economy and natural environment is dependent on appropriate maintenance and utilisation of the micro-geomorphic units.

Nature established a delicate balance on all the soils which are capable of supporting plant, balance is achieved between the natural plant community and the organic and inorganic constituents of the soil. But as soon as man appears on the scene and begins to use the land, either for tillage, for grazing or for its raw materials such as timber, the delicate balance is disturbed. If man acts wisely he will, by means of careful husbandry, maintain or perhaps re-establish the balance; he may produce an entirely new but none the less stable plant-soil biological relationship. All too often in the past, however, man has treated the soil with little respect, he has used it for short-term gains and grossly neglected its condition. In many areas the soil has been robbed of its natural fertility, and never been rested nor replenished with manures and fertilizers; worse still in Lunglei district the soil has been allowed to waste away to be removed and frequently to be lost entirely. With the increase of population thrust on this study region, human interference in the land shaping geomorphic processes is steadily increasing, which requires appropriate adoptation in the natural landscapes. Though man can not control the geomorphic processes operating in the region in a categorical sense, yet, he can take some curative and preventive steps *by way of proper management, destruction of forests of the region for fire-wood, timber, housing, jhuming and cultivation a long hill slopes without soil protective measure accelerates the erosional processes and in turn retardates the eco-system.*

It appears that geomorphological regions have multipurpose planning among the single feature natural regions. The geomorphological regions can highlight the relationships between the natural resources and the people exploiting them and will secure the maximum returns with least friction, not only administrative friction but also the friction of man with his environment. No geomorphic regionalisation has so far been undertaken in the Union Territory of Mizoram and the present study may be very useful for the administrative purpose and various landuse purposes.

Methods and Basis of Classification of Geomorphic Regions

Landform classifications are done mainly on the basis of geomorphic facies as developed under the impact of the geomorphic processes as operating in a region as revealed by the geomorphic analysis, quantitative analysis, nature of fluvial erosion and climate. The complexity of the physical forces and their behavioural attitude towards the creation of numerous forms leads to the complications in the classification of land surface forms in the areea under study. As far as landforms are concerned, if explicitly demarcated it should be altogether different from its surroundings. But this is rather the ideal delineation, too difficult, if not impossible, to achieve as there is no well-marked difference in climate, lithology, geological structure, erosional peculiarities. Therefore, on the basis of superimposition of morphometric *maps, viz. relief, slope, drainage system, stream frequency and relevant profiles. Lunglei district is delineated into micro-geomorphic regions.*

Important Geomorphic Features

The important geomorphic features of Lunglei district are both structural and topographical high hill ranges with alternate deep narrow river valleys in between the hills. The slopes varying from gentle (0-5°) to very steep (40°). There are ten important north-south trending longitudinal hill ranges, nine important rivers and a large number of non-parennial streams. The area has tropical vegetation and tropical climate. It also receives high rainfall under the influence of south-west monsoon. The other important geomorphic elements are high dissected ridges with the formation of deep gorges, spurs and cols which developed due to intensive erosion. Under the heavy rainfall during the monsoon period that is mainly in the months of June to September, the rivers and even the dry streams swell up with enormous volume of water. This is mainly responsible for sculpturing of the topographic features both in linear and areal fashion.

Micro-Geomorphic Regions

In order to regionalise the study area into micro-geomorphic regions, geological map, average slope, drainage pattern, stream frequency, dissection pattern, nature of erosion, drainage density have been considered and examined. Keeping the above factors in mind Lunglei district has been divided into three micro-geomorphic regions, such as (i) moderately dissected undulating hill region of the west, (ii) highly dissected, denudated and sharp

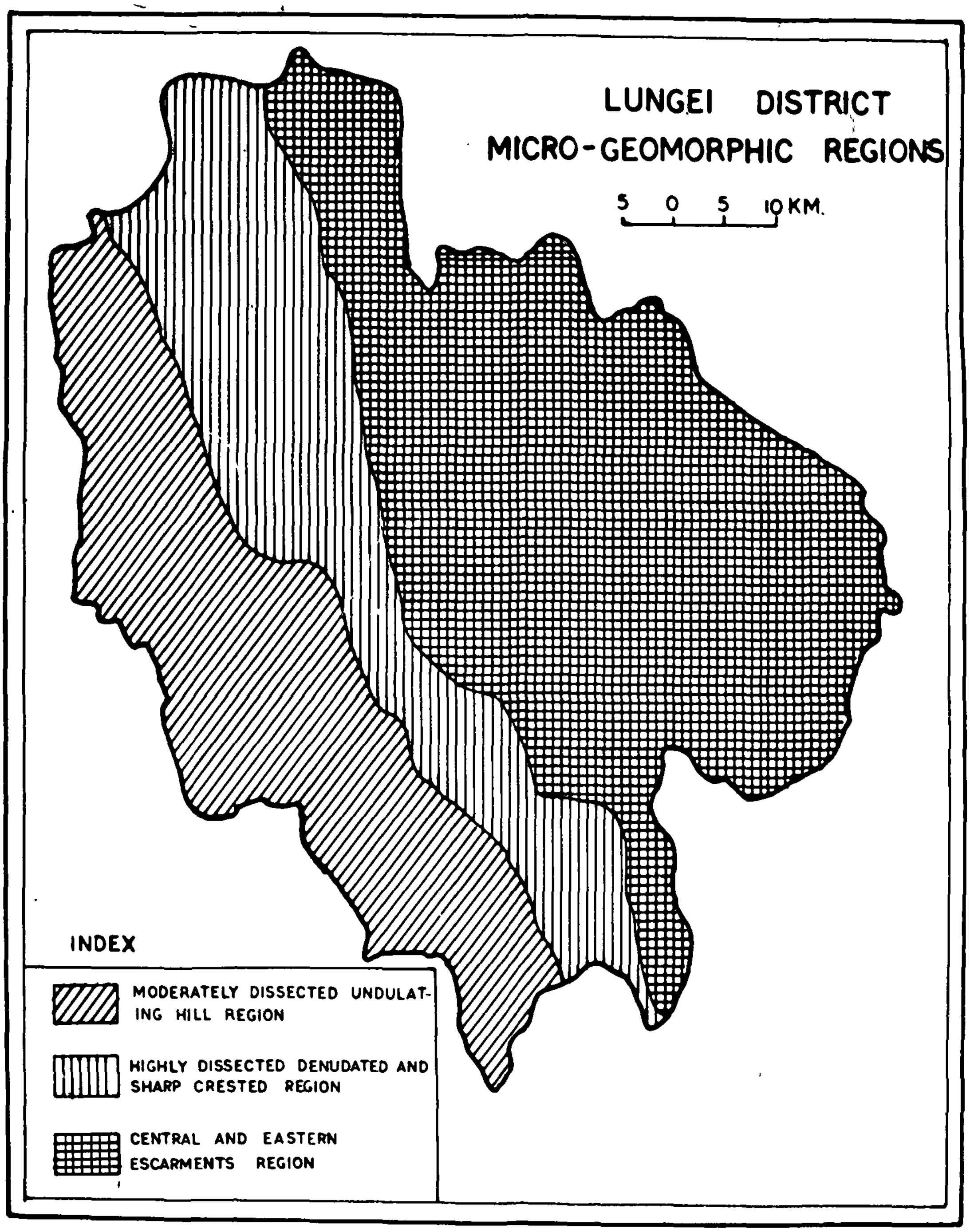
LUNGEI DISTRICT
MICRO-GEOMORPHIC REGIONS
5 0 5 10 KM.
INDEX
MODERATELY DISSECTED UNDULATING HILL REGION
HIGHLY DISSECTED DENUDATED AND SHARP CRESTED REGION
CENTRAL AND EASTERN ESCARMENTS REGION

FIG. 21

crested region and (iii) central and eastern escarpment region (Fig. 21).

The micro-geomorphic characteristics of each region has been put in table 12 which represents some important regional characteristics of the area.

(i) <u>Moderately Dissected Undulating Hill Region of the West:</u>

This region is situated in the western part of the area bordering Bangladesh. The geological formations of this region are mostly of upper Bhuban and Boka Bil formationof miocene and mio-pliocene period which mainly consist of sandstone, shale, siltstone and grey shale. This unit occupies about 1100 sq. km. area with 3-6 and 6-9 stream frequency per 4 sq. miles. Average slope ranges from 0-20° and includes most of the areas of gentle slope category of the region. The major structure of this micro-region is low to gentle dipping and folded structure. The nature of topography is moderately rugged and undulating. The region comes mainly in the height range of 50-300 metres at places some peaks have attained altitude even upto 800 metres. In the west there is more variation in topography. The drainage patterns are mostly rectangular and parallel pattern. As the terrain is more gentle, the flow of the water is more sluggis and some river deposits may be seen along river banks.

From the agricultural point of view this region have more prospects for the development of hill terrace and wet rice cultivation. But due to lack of proper planning the area remains under the most backward areas of the region. This area has also good scope for the construction of road

TABLE 12

Micro-Geomorphic Regions and their Characteristics

Regions	Geomorphic Characteristics					
	Major structure	Age of rocks lithology	Character of topography and elevation	Major geomorphic features	Average Slope	Stream ffequency
1. Moderately dissected undulating hill region of the west	Low to gentle dipping rocks folded structure	Surma group of upper Bhuban and Boka Bil formation	Moderately rugged and undulating mainly 50-300 metres	gentle slope and eroded anticlines	0 - 20°	Mostly 3-6 and 6-9
2. Highly dissected, denudated and sharp crested region.	High to steeply dipping folded and faulted structure	Mainly upper Bhuban, middle Bhuban and Boka Bil formation of rocks.	Highly dissected by ravine and gullies 300-1200 metres	Dissected by ravine and gullies, waterfall and rapids.	Mostly 20 - 35	3 - 12
3. Central and Eastern Escarpment region.	Very high to steeply dipping folded and faulted scarp structure	Mainly upper Bhuban formation of sandstone, shale and sand silt shale alteration.	Highly dissected narrow hill ranges with steep scarps, mainly 600-1600 metres	Strike ridges, eroded anticline, fault line scarp	Mostly 25-40° and at some places more than 40°	Mostly 3-6 and few patches 0 - 3

network along the foothill slopes as the terrain is less undulating.

(ii) Highly Dissected, Denudated and Sharp Crested Region:

This region occupies about 1184 sq. km. area which is about 25 per cent of the total study area. This region located to the east of the Lunglei-Sertlangpui hill ranges and in between high hill ranges of Lunglei in the east and Thorang hill in the north west. Due to fluvial erosion the hills are highly dissected and very much susceptible to weathering and erosion. Head-ward erosion and ravine erosion are active in this region. The crest lines are of often sharp crested with pointed hill tops. The differential erosion has given size to dissected topography. At places chemical weathering is more vigorous.

The major rock formations are dipping, folded and faulted. The rock formations are mainly sandstone, sandshale, silt-sand, silt-stone and mudstone of upper Bhuban and middle Bhuban formations. Average slope is mostly 20-35°. The general elevation is ranging between 300-1200 metres. The stream frequency is 3-12 category per 4 sq. mile.

(iii) Central and Eastern Escarpment Region:

This region has been identified along the anticlinal axis of the Lunglei, Sertlangpui, Darzo and Puruntlang hill ranges. Structural features and geo-morphic elements are quite prominent in this region. The rocks of this region are the oldest and hardest sedimentary rocks of the district. The slopes are very steep and average slopes are ranging from 25-40° and above 40°. In fact, at some places slopes are ranging from 60-80° along the high altitudinal *ridges. This region consists of well bedded hard grey sandstone, sandshale and sand-shale-silt alternation. This region represents the relief of high ridges ranging from 600 - 1600 metres. Crests are ranging from sharp to very sharp which have developed on and along the ridges of hard sandstone. These ridges are quite resistant to erosion. It constitutes run off zone with high annual rainfall responsible for the initiation of numerous minor streams. The prominent scarps are the long dissected wall like scarp extending from Thuampui village to Buarpui village in the Sertlangpui hill range, Lunglei scarp and Darzo scarp on the Darzo hill in the east.*

C H A P T E R - V I I

AGRICULTURE FRAMEWORK

In this chapter the study attempts to assess and analyse the impact of geomorphology on Agriculture in Lunglei district, Union Territory of Mizoram. Lunglei district is the second largest district in Mizoram next to Aizawl district of Mizoram. In the district of Lunglei, 78.74 per cent[1] of the total population live in rural areas which is about 99 per cent of the total geographical area of the district. "Spatially, the region can be divided into two broad categories, namely, rural or backward and urban or advantage areas."[2]

Lunglei district is the category of backward area because the district has no mineral resources and there is not a single major industry where a considerable percentage of total workers can be engaged. Here, more than 90 per cent of total workers are engaged in agricultural activities. All these show that Lunglei district is and has all along been an agricultural district. Its main bulk of people depending heavily on agriculture as their means of livelihood. Lunglei district is essentially an agricultural region where about 90 per cent of the population are directly or indirectly engaged in agriculture as cultivators, agricultural labourers and other workers. The various government services constitute 3.08 per cent of the total population of the district, and

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[1]*Statistical Hand Book of Lunglei District, Lunglei (1983), District Statistical Office, Lunglei.*

[2]*Jana, M.M. (1981), Perspective in Agriculture Geography, Volume II. Edited by Noor Mohamad, Concept Publishing Company, New Delhi (1981) p.42.*

about 6 per cent of the population are engaged in business and other allied services.[3] *Agriculture is the main occupation of the people. In this landlocked hilly region, agriculture is not merely an occupation but an established traditional and accepted way of life. People depend upon this occupation for sustanance.*

According to the available data, only 4 per cent of the total geographical area of the district is under cultivation and no area of the cultivated land is sown more than once.[4] *The area under shifting cultivation constitutes 3.30 per cent of the total geographical area of the district.*[5] *The small percentage of cultivated land under shifting cultivation is due to unfavourable geomorphic characteristics like steep slopes, deep and narrow valleys, cliffs, hydrological conditions and soil type etc.*

Agriculture in Lunglei district does not present a happy picture despite a great effort has been done by the state government to improve the situation. In Lunglei district as in other parts of the tribal areas of the north east region, the prevailing method of agriculture is shifting cultivation. The district is not self-sufficient in food production. The area produces only 30 per cent of the total annual rice requirements of the district and 70 per cent of rice which is the main staple food of the people is received from outside the state.[6]

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[3]*Statistical Hand Book of Lunglei District, Lunglei (1983), Op.cit.,*

[4]*Records of Agricultural Landuse, District Agriculture Office, Lunglei.*

[5]*Ibid.,*

[6]*Seminar on Strategy for Planned Economic Development of Mizoram, 1980, Aizawl organised by the Directorate of Information, Public Relation and Tourisom, Government of Mizoram.*

The growth and development of agriculture was not encouraging during the past decades due to several factors like (1) Geomorphic characteristics, (2) Pattern of human behaviour, and (3) Location in reference to market.

1. Geomorphic Problem

Geomorphic constraints are the most unfavourable factors in agricultural development in the district due to its nature of terrain, problems of irrigation, uncertainty of rainfall, uneven distribution of rainfall, frequency of cyclones, soil erosion and deforestation.

(a) Nature of Terrain: Here agricultural practices take place in catchment area of the rivers and streams. If we look the slope map of Lunglei district (fig. 6) a considerable portion of lands are covered by 20 degree slope and above. In the east, central and north western parts, quite a large areas are unfavourable for agriculture due to rugged and steep slope. In the whole area, the common feature is rugged topography with narrow valleys and as a result a sizeable percentage of land is not under cultivation. It is very difficult and at the same time very costly to convert these rugged terrains into agricultural land.

(b) Problems of Irrigation: In a dissected terrain like Lunglei district there is no extensive area with gentle gradient to facilitate the construction of irrigation canals. The high relief with numerous topographic obstructions within a small area in the forms of ridges and deep valleys form a strong limiting factor. The available irrigation for the terrace and wet rice cultivation are fed by the main streams and tributaries of the rivers during the monsoon

season, but the rivers and stre-ams are dried up in winter and summer seasons when the fields need water to cultivate the crops. It is also very difficult to reserve the river water due to high degree slope (fig. 6) of land. So, a major portion of the region faces the problem of irrigation which is very essential for crop production. The only possible cultivation in the present context is shifting cultivation.

(c) Uncertainty of Rainfall: Uncertainty of rainfall affects the agricultural operations in the district because the cultivators are very much depending on the rainfall for cultivation of jhum paddy and other food crops and cash crops. Monsoon is of immense importance for the cultivators because they practice dry farming which depends on the natural rain which comes from monsoon. Rice is the mainstay of the people and largely depends on the timely arrival of the monsoon. Some years due to untimely arrival of monsoon the paddy crops and other cash crops die out due to draught. So, the agriculture in the district is in the hand of monsoon rain. The late monsoon arrival means failure in the agricultural production which is the main sources of the income of the people.

(d) Uneven Distribution of Rainfall: A little more than 80 per cent of the total precipitation in the district is received during the four months i.e. June to September (fig. 4a). So, the rainfall in the rest of the months is negligible. Consequently the need for adequate water supply for crops on year round basis is very necessary for cultivation. Man can not control the rainfall and its deficiency, irregularities or super-abundance caused agriculture

failure. Due to heavy and concentrated rainfall for a number of days the district experienced landslide, mass-wasting and subsidence especially on the jhum fields which result great loss in the production of agriculture.

(e) Frequency of Cyclones: The area is hit by frequent cyclones from the Bay of Bengal in the months of late June to early November. The terrific and strong cyclone accompanied with rain destroyed the paddy and other crops which results disasters for many houses and shortage of food in the area.

(f) Soil Erosion and Deforestation: Soil erosion is a menance in agriculture. It depends on the resisting power of the soil and eroding power of the water. The factors responsible for soil erosion are climatic condition, topography of land area, drainage, nature and extent of vegetation cover and physico-chemical constituents of the soil. The hilly dissected terrain of Lunglei district suffers soil erosion. The various agents of erosion reduces soil fertility by removing the surface soil which is valuable for plant and it also increases the run off of the rivers and streams. The severe erosion is mainly due to heavy downpour within a short period, steep slope, continuous practice of jhuming and unplanned land management in the river basins and along the ridges. Yield of crops and area under cultivation have reduced significantly due to removal of top fertile soil.

Deforestation is the great problem in the central and eastern parts of the area. The area as a whole excepting Bangladesh border is dissected into narrow valleys. The continuous practice of shifting cultivation with heavy rainfall during the months of June to September result heavy soil erosion *in the area. The soil erosion is more vigorous in the places where vegetation cover is less in the district due to unchecked burning and cutting down of forest cover for firewood and building material. Soil erosion and soil creep is predominant in the hill ridges and a considerable amount of soil has been washed away from hilly areas to the river valleys and agriculture can not develop due to infertility of the soil.*

2. Pattern of Human Behaviour

Human behaviour is a complex factor and it depends upon the degree of modernisation, dietary habits, willingness to innovate and political influence. Most of the people in Lunglei district have deep rooted traditional societies and it is really difficult to modernise them and still subsistence farming prevails. As a result of this about 3.31 per cent of the total geographical area of the district is under shifting cultivation. The dietary habits of the people also exert great influence upon cropping pattern. Rice is the main staple food of the people of the area and they are never satisfied with other food crops like maize, yam, sweet potatoes and other food crops excepting rice. For various reasons, most of the farmers are not in a position to experiment with new crops and methods of production, a few who are willing to experiment have various obstacles which reduce the amount of courage in them. Two important obstacles are scarcity of capital and functioning of governmental machinery which act as an agent of innovation.

3. Location with reference to Market

Agriculture production depends also on the distance between the producing area and consuming centre. Area close to the market enjoys a *comparatively advantage over a similar area. The cost of overcoming distance exerts a pervasive influence upon agricultural landuse. Many villages are not linked by any road. Prior to the partition of India, the border areas of Lunglei district produced pineapples, jack fruits, chillies, sesumums, oranges, etc. and they enjoyed a flaurishing business with the people of the then East Pakistan where there was a ready market at Tlabung for these commodities. In exchange the people got building materials, fishes, agricultural implements and other essential commodities of daily use. Now the people face great problem in selling their agricultural products due to its inaccessible location from the market. For example, the areas along the road side produce quite a lot of pineapples, bananas and gingers but due to lack of transportation and market, large amount of pineapples and gingers are rotten up. As a result people abandon the cultivation of pineapples and gingers.*

General Land-Use Pattern

The study of landuse has been in progress in different parts of India for quite a long time, but the progress of landuse study is far behind in the Union Territory of Mizoram. Landuse is a significant aspect of agriculture study. In order to increase food production, a proper utilisation of land resources is very essential (Sharma 1979).[7] The regional study of landuse in Lunglei district indicates that planned use of land resources has not yet started. Still most of the parts, especially steep and gentle slopes, where the use of land is inadequate due to meagre water supply, presence of hilly rugged

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[7] *Sharma, H.S. (1979), Physiography of Lower Chambal Valley and Its Agricultural Development, Concept Publishing Company, New Delhi.*

terrain, severe erosion and ignorance of the cultivators.

The pattern of landuse in Lunglei district is conditioned by two sets of factors:-

1. *The physical factors like climate, topography and soils which set the broad limits upon the capabilities of the land.*
2. *The Human factors like length of the occupation of the area, density of population, socio-economic factors and the technological levels of the people which determine the extent to which the physical capabilities of land are utilised.*

It is very difficult to mention the trends of landuse because no proper survey of land utilisation was done before 1980. It is not possible to get comparable data for Lunglei district a sufficient long period to indicate the trends.

All the areas excluding reserved forests, cliffs, streams and riverbeds, roads, towns and villages including very steep slopes are used for shifting cultivation. The jhum lands are almost the same but gradually people search a good place for cultivation. The cultivated lands are slowly and gradually increasing by clearing the thick virgin forest but it is very negligible.

An attempt has been made here to work out the percentages of various uses of land 1980-'83 and the resulting figures have been given in Table 13. The percentage of the various use of land to the total area of the region have been shown in figure 22.

Forested Area

The coverage of forest is quite large in Lunglei district. The total area under forest in Lunglei district according to the data available from the office of District Forest Officer is 289750 hectares in 1983 (Table 13).

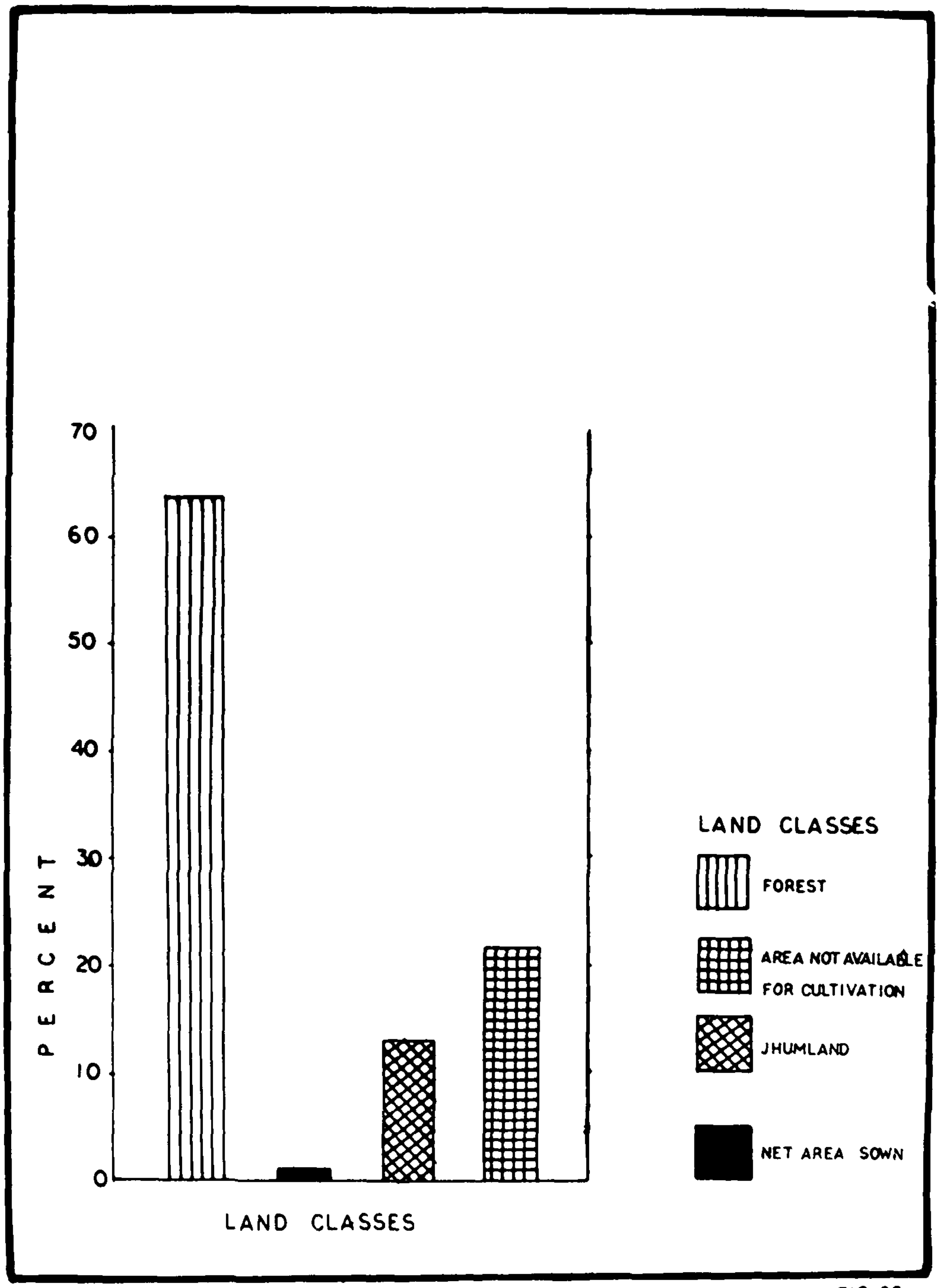

70
60
50
40
30
20
10
0
PERCENT
LAND CLASSES
LAND CLASSES
FOREST
AREA NOT AVAILABLE
FOR CULTIVATION
JHUMLAND
NET AREA SOWN

FIG 22

TABLE 13

Total Area of the Region 453800 hectares

Sl. No.	Land Classes	Area in hectares	Percentage of total area
1.	Forest		
	(a) Reserved Forest	34694	
	(b) Reverine Reserved Forest	43696	
	(c) Protected Reserved Forest	880	
	(d) Station Reserved Forest	1580	
	(e) Unclosed State Forest	208900	
		289750	63.85
2.	Net sown area	2029	0.45
3.	Jhum land	15000	3.30
4.	Area not available for cultivation	147027.25	32.40

Source: Records of Agricultural landuse. District Forest Office, Lunglei and the District Agricultural Office, Lunglei.

It occupies 63.85 per cent of the total geographical area of the district. It is distributed all over the area.

The available data of 1980-'83 (Table 14) reveals that the highest percentage of forest to the total forested area of the district was recorded in Bunghmun Community Development block with an area of 86896 hectares and (29.15%) of the total forested area of the district. Next comes Lungsen Community Development block with an area of 76574 hectares and (26.43%) of the total forested area of the district. The percentage of the remaining Community Development blocks of Lunglei and Hnahthial was recorded (22.46%) and (21.12%) respectively.

Amongst the forested areas of Lunglei district (Table 13) 34694 hectares is under reserved forest, 43696 hectares is under reverine reserved

TABLE 14

Blockwise Land Utilization

Sl No	Blocks	Land Area Under different Landuse (in hectare)													
		Jhum land	% of the total jhum land	Wet Rice Cultivation W.R.C.	% of the total WRC	Hill Terrace cultivation (HTC)	% of the total HTC	Cash Crops	% of the total Cash crops	Horticulture Plants	% of the total horticulture plants	Forest	% of the total forest	Area not available for cultivation	% of the total area not available for cultivation
1.	Lungsen	4205	28.03	244	36.15	58	78.38	90	9.04	40	14.08	76574	26.43	31394	21.35
2.	Lunglei	3584	23.89	195	28.89	4	5.41	96	9.64	154	54.23	65080	22.46	41325	29.11
3.	Hnahthial	3426	14.81	100	14.81	12	16.22	642	64.46	54	19.01	61200	21.12	42200	28.70
4.	Bunghmun	3785	33.70	136	20.15	-	-	168	16.87	36	12.68	86896	29.99	32102	21.83
Total		15000	3.30	675	-	14	-	-	996		284		28950	147021	32.40

Source: Office of the District Agriculture Officer, Lunglei and office of the District Forest Officer, Lunglei, Mizoram.

forest, 880 hectares is under protected reserve forest, 1580 hectares is under station reserved forest and 208900 hectares is unclosed state forest.

Although Lunglei district has very large area under forest cover but it can not be utilised properly because the forest covers mainly the rugged hilly terrain and very steep slope area. It is also due to inadequate transport network. The forest type is mainly bamboo and different spices of evergreen and decidous forests.

Area Not Available for Cultivation

The high percentage of 32.40 per cent of the total area lying uncultivable waste is a significant aspect of existing landuse situation in Lunglei district. In this category it includes land occupied by villages, towns, paths, roads, land under bed of streams and rivers, barren lands in the hill tops, cliffs, very steep slopes including scarps and other non-agricultural uses. The available data shows that this type of land is well distributed in the region. Maximum concentration is evidently found in the rugged hilly section along the anticlinal hills of Hnahthial and Lunglei Community Development blocks. In these sections stony nature of land, bold relief, continuous erosion by streams and rain water have collectively rendered greater proportion of land in this category.

The data of area not available for cultivation of the district reveals that it was somewhat greater in Lunglei and Hnahthial blocks and this high percentage is mainly due to the relief features as well as the population pressure which resulted the area not available for cultivation. The highest percentage of this category was recorded in Hnahthial Community Development block (28.70%) of the total area not available of the district, Lunglei (28.16%), Bunghmun (21.83%) and Lungsen (21.35%) of the total area not available for cultivation of the district.

Net Sown Area

The study of net sown area is the most significant aspect of landuse study because it clearly indicates the agricultural activities of Lunglei district. It represents net area sown with crops.

The available data as well as field study of the area indicates that net sown area occupies very small area. It occupies only 0.45 per cent (Table-13) of the total geographical area. The low percentage of net sown area may be explained by the occurance of poor soils, low moisture contents in the soil, absence of flat land, narrow and deep river valleys, dissected and rugged hilly topography of the area.

The available statistics of net sown area in the years 1980-'83 was interesting. All blocks have less than 1 per cent of net sown area. The highest percentage is recorded in Hnahthail Community Development block (0.16%) of the total geographical area. The other three Community Development blocks are recorded as Lunglei (0.08%), Lungsen (0.04%), and Bunghmun (0.09%) of the total geographical area of the region.

The net sown area under this study includes wet Rice cultivation in the river valleys, hill terrace cultivation along the gentle slope and other cash crops and horticulture plants grown near and around the villages.

Jhumland

Jhumland covers quite a considerable percentage of the area. The area covers roughly about 15000 hectares, that is 3.30 per cent of the total geographical area. This class includes the areas covering gentle and undulating hilly terrain excluding reserved forest, net sown area and other non-agricultural uses. It includes the current follow of such lands which is left for 4 to 7 years after being cultivated for a year.

The study of jhumland is the most significant aspect of landuse study because it forms the basis of all agricultural activities in the region. (Detailed discussion on the subject will be given in the Jhum section).

The area occupied by jhum land in each of the Community Development blocks is 15336 hectares in Lungsen, 14020 hectares in Lunglei, 12805 hectares in Hnahthial and 20802 hectares in Bunghmun block.

Cropping Pattern

Indian agriculture is crop oriented, and Lunglei district is not an exception. Major portion of the total cropped area in the region under study is devoted to food crops and the commercial crops occupy little area. The main crops are paddy, maize, yam, sweet potato, pumpkin, ginger, cucumber, watermelon, chilly, cotton, sesumum, tobacco in the Kharif (fur) and pulses, beans, tomato in the Rabi (thal). The Mizos and other tribes who inhabit the area practice mixed cropping. The choice of crops differs from family to family and is consumption oriented.

It is interesting to note that inspite of great efforts done by the State agriculture departments, the cropping pattern in Lunglei district could *not change from its traditional cropping pattern. In order to have a proper understanding of the agricultural characteristics in any region, one has to know the cropping pattern of an area particularly in a hilly rugged terrain like Lunglei district. In this region, most of the crops are unevenly distributed. This is so because in this region the physiographic characteristics mostly control the cropping pattern.*

While discussing the cropping pattern in Lunglei district, it should be remembered that the environmental condition of the region has greatly influenced the cropping pattern and yield of crops. Particularly the soil characteristics, nature of rainfall and relief features determine the intensity of cropping. For example, wet rice cultivation is practiced where flat land is available provided that sufficient water is available to irrigate the field, whereas jhum paddy is cultivated in the hilly terrain in the form of shifting cultivation during the monsoon period as it depends wholly on rain water. However, it may be stated that the geomorphic and hydrological features as have been studied in the forgoing chapters, limit and determine the degree and intensity of cropping pattern in various parts of the region.

Principal Cropping Seasons

The area is predominantly enjoying the two main cropping seasons. They are the Kharif (Fur) and the Rabi (Thal). The kharif season starts on the onset of pre-monsoon from late March and sowing is completed usually by the middle of May. In wet rice cultivation transplantation is done in the late June and early July. Distribution of rainfall is very important for the kharif crops in the region as rainfall is the only source of water to feed the *crops. Weeding starts only in the late May upto early September. Harvesting of kharif crops starts from the later part of July and it continues till December.*

The rabi season starts from the early September and sowing is completed by the end of October. The retreating monsoon feeds the rabi crops. Inadequate rainfall during this period results in the failure of rabi crops.

Cropping Techniques

In Lunglei district there are two principal cropping techniques viz. mixed cropping and crop rotation.

(1) Mixed Cropping: Mixed cropping is the most common practice in Lunglei district. In the kharif season the practice of raising a variety of crops as a mixture is common in jhum land. The combinations of mixed cropping are as follows: Paddy - Pumpkin - Maize - Cotton - Yam - Cucumber - Watermelon and other vegetables. In the rabi season Beans Cabbage and Mustard are grown in the same plot of land.

(2) Crop Rotation: Crop rotation is an important aspect of cropping pattern. In Luglei district the system of crop rotation is still traditional. In late March or early April, the jhumias cultivate mostly vegetables and maize, such as pumpkin, cucumber, brinjal and chillies. For the cultivation of cash crops like sesamum, tobacco and ginger the farmers select a fertile plot of land and these plants are not mixed with other vegetables and crops.

By the time of monsoon especially during the month of May, paddy seeds are sowed again along with cucumber, watermelon and other vegetables. However, the plants sowed earlier are not destroyed. Later, after the harvesting of maize, pulses, beans, soyabeans, etc. are cultivated. It should be noted that at the time of sowing paddy seeds, the seeds of cucumber, pumpkin and watermelon are mixed together and not sown separately.

Kharif (Fur) Crops

Kharif is an important agricultural season of the region where more than three-fourth of the cultivated land is sown. The main kharif crops are rice, maize, til (sesasum), yam, ginger, cucumber and sugar cane which are cultivated in the jhum land. Rice is also cultivated in the wet land and hill terrace (Plate No. 9 & 10).

The over all cropping pattern in this season shows that almost all the cultivated lands are devoted to food crops and only limited areas are given to non-food grain crops which include sugar cane, ginger, tobacco and cotton. The principal kharif crops are as follows:

Rice: Rice has the distinction being most extensive cultivated crop of the region and of being the staple food of the people. Although rice is the most extensive crop of the region, the straw from this plant is not utilised for many other purposes.

There are mainly two varieties of rice grown in this region viz. the early maturing variety which is sown from the middle of April to late April and is harvested by the later part of September, and the late maturing variety which is sown in the middle of May and is harvested in the middle of November.

Early and late maturing rice taken together in the jhum land covers 3.31 per cent of the geographical area of the district. Wet rice cultivation and hill rice cultivation covers 0.12 per cent of the total geographical area.

PLATE NO 9

Wet Rice cultivation in the source region of Nghasih stream east of Lunglei town

PLATE NO 10

Hill Terrace cultivation of Hnahthial village

In the jhum land there is one prevailing method of sowing the early and late maturing varieties in the region i.e. dry cultivation. In the dry cultivation, after drying the cutdown vegetation they burnt it in the month of March. Onset of the monsoon the paddy seeds are sown with a digging method, locally called 'buhtuh'. The farmers dig shallow hole with the help of iron spade, locally called 'Tuthlawh'. The seeding interval is at about 30 Cm apart. In the wet rice cultivation, the seedings are separately raised in a nursery and then are transplanted in the wet rice field at an interval of 12 x 20 Cm.

The per hectare yield of early jhum paddy is generally from 375 kg to 450 kg. This discrepancy in per hectare yield is owing to the variation of jhum cycle and the difference in the quality of soil. The per hectare yield of late maturity is generally 500 Kg to 600 Kg. This yield may also differ from one part to another part due to the variation of jhum cycle and the difference in the quality of soil.

Maize: Maize which is also known as Indian corn, is one of the important food crops of the region. It can be reaped in a short time and is, therefore, has a special value as one of the first crops available for food. It provides the cultivator and his family with food at a time when the reserves of rice grains are running short. Besides, it is also used as a food or crop and for feeding a poultry farm. Sometimes, the villagers pick up the immature cobs to be rosted and cooked for food.

Maize is sown generally after the burning of jhum field in late March and completed in April. The crop matures in late June and early August. A long break in the fainfall damages the crops and on the other hand, water-

logging is equally harmful. The gentle and steep slopes on the hill side with well drained soil of the region are very well suited for the cultivation of maize. Interculture is its chief features. Several vegetables like pumpkin, watermelon, cucumber and other crops like ginger, sesamum and chilly are grown along with maize. Maize is also grown along with rice. It can be reaped in a short time and it never disturbs the paddy field. The cultivation of maize is done exactly in the same process with jhum paddy but in order to get good yield of grain, the distance should be about 1 1/2 metre and therefore, the seeds have to be sown carefully. Maize seeds should be sown on a small hole so as to prevent from washing away by running water as the region receives very heavy rainfall during the rainy season.

Although maize is an important crop of the district, but it is not possible to give the exact area occupied by it. Maize is cultivated every where in the region along with other food crops and cash crops in the kharif season.

Sugarcane: Sugarcane is one of the most important cash crops of the region. The juice is extracted from sugarcane by pressing (locally known as 'Fuherkhawl') and is used for preparing gur locally named 'Kurtai'. Sometimes the villagers use to drink the extracted juice. Kurtai is used for the substitute of sugar in the villages. The green leaves are used as fooder.

Before sowing the cane, the gentle slope and undulating hilly area are cleared by cutting down the vegetation cover and the dry vegetation is burnt in early March. As the area receives heavy rainfall the plants grow luxuriously (Plate No.11). Sugarcane requires constant attention during the *first three or four months of its growth. Soon after planting weeding is done which is repeatedly done four to five times. The growing period of sugarcane takes minimum nine months. Sugar cane is quite adaptable to varying soil conditions. However, a growing period of nine months with adequate moisture followed by dry winter without severe cold gives a high yield in this region.*

Sugarcane covers roughly 195.5 hectares of the total geographical area of the district. The highest area under sugarcane is found in Hnahthial Community Development block with an area of 50 hectares. The other Community Development blocks like Lungsen, Lunglei and Bunghmun are 32, 7.5 and 20 hectares respectively.

Til (Sesamum): Til is also one of the main kharif crops in the district. It is an important oil seed grown under dry farming. Til is mostly grown in areas where soil is loamy or clayey loams with well drained gentle slope. The main areas where til is cultivated are Bunghmun Community Development block (26 hectares) and Lungsen Community Development Block (58 hectares). In other two blocks of Lunglei and Hnahthial it occupies a very small area. It is grown mixed with maize and other food crops. The yield per hectare is generally 100 kg to 150 kg.

Ginger: Lunglei district affords suitable environment for the cultivation of high quality of ginger. Since long time ginger is cultivated in this region along with other crops for domestic consumption. It was only since 1974 when the area was linked with good roads the cultivation of ginger has become one of the most important cash crops in the region. Recently, the cultivators who reside nearby roads earn quite a handsome money out *of this crop. It is quite true that ginger cultivation has a very good prospect in this region.*

Rabi (Thal) Crops: Rabi crops are not very popular in the district. Rabi crop occupies very small area of the region. The rabi crops grown in the region are mainly mustard, cabbage, beans, and tomato (Plate No.12).

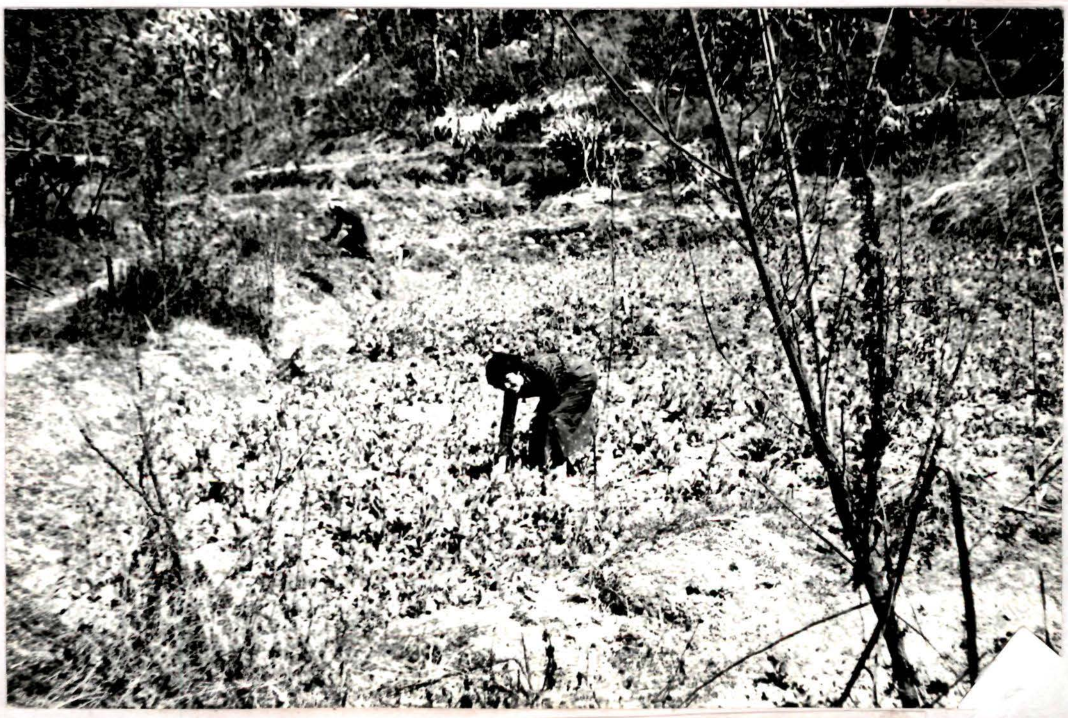
The river valleys where alluvium is deposited are ideally suitable for the cultivation of mustard, cabbage, beans and tomato. The sowing is done in late September and the plant becomes mature in the early February or upto early March. First of all, the river bank, where fertile soil is deposited, is cleared and the earth is ploughed with the help of spade, then the seed is broadcasted. In the case of cabbage and tomato, however, the method and preparation of field is carried out in the same manner with mustard but they dig some shallow holes at an interval of about 30 Cms and the seeds which are raised in the nursery are transplanted in the shallow holes where manures (especially cow-dung) are kept. Cabbage and tomato require constant attention during the first month of their growth. Soon after planting, great care is taken against the excess of heat. It requires frequent watering during the first three months.

In Lunglei district, mustard, cabbage, beans, and tomato are generally grown in every where, especially in river valleys and near the houses as kitchen gardens. It is interesting to note that the region has quite a number of rivers but many rivers are not suitable for the cultivation of such rabi crops due to deep and narrow valleys. It is very much clear that the geomorphic features

PLATE NO 11

Surgarcane cultivation in the western part of Pangzawl village

PLATE NO 12



Vegetable gardening near Zobawk village

play a negative role in the cultivation of rabi crops in the Lunglei district.

Agricultural Methods and Techniques

The regional economy of Lunglei district is dominated by agricultural and associated activities but the methods and techniques employed in the region are very backward. Backwardness in the agricultural practices are due to several physico-economic factors. The nature of relief, climatic factors, socio-economic background and the degree and extent of mechanisation individually or collectively influence agricultural methods and techniques in Lunglei district.

The study reveals that the agriculture in the region is dry farming i.e. in the form of jhuming. But there are some areas like river valleys and gentle slopes where settled agriculture is also practiced. The rugged topography, hydrological condition, absence of plain area, nature and extent of slope are the main factors which retard the implementation of new methods and improved implements in this area.

Land Holdings

Land holding is an important aspect of agricultural methods and techniques. It affects the yield per hectare as well as the types and quality of implements which the farmers use.

While land holding is an important aspect of agricultural methods and techniques but there is no land holding in Lunglei district. The land is the common property of the village and however, individuals have no separate *holdings. Recently, lands are being allotted to individuals so as to organise terrace cultivation, wet rice cultivation and orchard plantations in order to induce farmers to permanent settled agriculture.*

Agricultural Implements

The agricultural implements which are commonly used in Lunglei district are old fashioned and the improved agricultural implements like tractors, sprayer and rice huller, have recently come in vogue and are not in extensive use. A country plough 'Tuthlawh', hoe, doa, axe, spade, sickle and sowing buskets are the only equipments that the average farmer possesses (Plate No.13).

The modern implements are not common in the area. The main causes of unpopularity of modern implements are: firstly, the available land for cultivation in this hilly rugged terrain is inoperable. The available land for cultivation of wet rice is found in the lower reaches of the valley and intermount river valleys where infrastructure is the main hindrance. Secondly, the water table is very deep, irrigation facilities are limited, and the use of manures and fertilisers are uncommon. All these factors collectively affect the crop production adversely. The low production means the poor economic status of the peasants. Because of poor status, farmers of this area are unable to afford the cost and maintenance of tractors and modern implements as well.

Manures and Fertilizers

The use of measures and fertilizers is not a common practice in

PLATE NO 13

Agricultural Implements used by the Farmers *the district of Lunglei. In most of the areas, specially the steep slope and gentle slope where jhum cultivation is prevailing do not receive any kind of fertilizers either organic or inorganic. In some places people are using cowdung and organic fertilizer in the vegetable gardening to earn high yield.*

Jhum Cultivation

In most of the agricultural systems the same piece of land is cropped continuously with occasional fallows. Frequently the fields are bounded by hedges, fences, ditches and agricultural landscape is ordered and fermented. In shifting agriculture this is not so. The farmer chooses a patch of forest, secondary or primary, cuts down some of the trees with an axe, leaving only the larger and economically useful trees, clears the undergrowth with a doa and burns the debris. Crops are sown on the clearing or swidden with a minimum of preparation, and received only cursory attention during the growth.[8] After the first harvest crops are sown again for a further year or two and then the land is left uncropped and colonisation by the natural vegetation is allowed while another patch of land is cleared for cultivation. Ideally the first clearing will not be used for crops again until it has been under a natural fallow for some years and soil fertility restored. Thus, the essential features of shifting cultivation are - first, the rotation of fields rather than crops, with short periods of cropping alternatively with long periods of natural fallow; second, the use of slash-and-burn methods to clear the vegetation and third, the maintenance of fertility by allowing the vegetation to regenerate. Harvesting

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[8]Grigg, D.B. (1976), The Agricultural System of the World, New York, pp.57-60.

methods vary, some shifting cultivators pick cereal heads by hands, others reaps with sickles, while rootcrops are dug out with sticks and hoes.

Methods of cultivation are, at first sight, primitive. The axe, cutlass and fire are used to clear the garden or swidden. Latosals are friable and this property is further increased by burning so that seed is usually broadcast without cultivation, although in some places dibbling sticks are used, while in parts of Africa soil is heaped into rigdges or mounds with hoe. Intertillage or mixed cropping is common. A number of different crops are sown in the same patch; roots, cereals and shrubs sown together s imulate the original forest cover and protect the soil from erosion. Both sowing and harvesting are often staggered. But intertillage is by no means universal and often only one crop is grown in the swidden.

Once the crops are sown little cultivation is done during their growth. No animal manure is used and generally the only fertiliser the crops receive is the ash from the initial burning which provides potash.

Amongst many shifting cultivations land tenure is still commercial and there are frequently cooperative elements in working the land, particularly in clearing the vegetation. Shifting cultivation was once the characteristic of areas with low population density and thus abundance of land. This, combined with the need to move to new swiddens or gardens at regular intervals, means there is relatively little incentive to have private ownership of individual plots. On the other hand trees planted or merely protected in individuals swiddens often belong to the individual who planted them, even after the plot has been abandoned.

Each individual has the right to the products of his swidden-Cesufruit as long as it is being cropped. When the swidden is left to fallow, right to its lapse, except for the fruit of perennial trees. The idea of the alienation of land has been, until recently, completed unknown. Wherever shifting cultivation has been practiced the unit of ownership has been the village or tribe, and not the family. However, the system of land tenure among shifting cultivators in every part of the world has changed in this Century, increasing population and second, the introduction of cash crops.

The size and layout of the 'farms' of shifting cultivators vary. Each family may have a number of plots in crops at any one time, widely scattered around the village and often a considerable distance away. The size and number of plots vary according to the fertility of the soil, the density of population, the length of the fallow, and the degree of commercialisation

An important destination is related to the length of the fallow, which in turn is often linked to population density and the rate of increase. Where twenty or thirty years of fallow are allowed for the restoration of crops fertility, the land available for new swiddens becomes increasing scarce, and the farmers have to travel long distances to clear new swiddens. Here comes a point where it is more convenient to move the village rather than travel the long distances. This, true shifting cultivation, is rare. The movement of the village is clearly limited by the territories of neighbouring communities; and with any significant increase in population the group is compelled to reduce the period under fallow and clear the secondary vegetation before the restoration of soil fertility by natural fallow is complete. Villages then become fixed, and this type of farming, of far more importance than true *shifting cultivation.*

The study of agriculture system of a region constitutes one of the most important aspect of economic and regional planning. Man started utilisation of land in one way or the other. He domesticated plants and animals and manipulated them to such an extent that genetic changes have occured resulting into diversified pattern of agriculture, horticulture, mixed farming and herding. Of all the agricultural systems jhuming is very rudementary in which still work is done with man power applying indegeneous tools and techniques.[9] *In recent past shifting cultivation has attracted the attention of regional planners, as more of the farmers dependent on this type of agriculture are living at a fairly low standard and the growing population is aggravating their problem of food and other provisions.*

In India, like most of the developing countries of the world, human number has increased rapidly to such an extent that most of the land is being utilised to satisfy human need, of the many uses of which land is put under agriculture.

In most of the hilly slopes all over the world shifting cultivation is practiced, and Lunglei district which is full of steep and gentle hilly terrain is no exception. The essential feature of the system is to clear the natural vegetations and burn the forest debris and dibble seeds in the clearings. After a year or so the field is abandoned and farmer looks for a different plot of land for cultivation leaving the previous cultivated area for growth of fresh vegetation.

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[9] *Husain, Majid (1979), Agriculture Geography, Inter India Publication, pp.62-77.*

Jhum cultivation locally known as 'Thingtlang Lo' in Lunglei district is a method of agricultural productions evolved as a reflection to the surrounding ecology and things has become a way of life of the people in the area. It is a practical approach to certain inherent difficulties like preparing proper seed bed on the slope.

Driven from their original homes to the inhospitable mountains tract in Mizoram, the Mizos eke out a precarious existence by adopting the most primitive agriculture practices. The rapid exhaustion of the fertility of their rough and ready fields, lying on slopes often too steep to hold either soil or moisture, compels to look for fresh lands to raise their food crops. They turn to areas which benign the nature has clothed with luxurian forests, clear them of tree growth, burn the debris and dibbled their seed. The fertility built into the soil by long years of leaf-fall on the forest floor yields bumper crops, but only for a year or two. A more extravagant utilisation of the rich forest soil is difficult to imagine. The fertility stored into the soil for decades is soon squandered away without enriching any body. For much of it is lost with the soil washed down the slopes into streams. And the cultivator must need shift to other forest lands for sustanance. In his trial, he leaves behind abandoned patches of cultivation, with badly hacked, charred and topped trees dotted here and there. Climatic conditions are so conducive to the growth of vegetation in this hill that within a short period the damage is repaired and the abandoned fields are covered with plant growth of sorts. In this destructive processes, the character of vegetation undergoes a drastic change. The regression proceeds a pace and the forest of high trees gives place to low vegetal cover, such as bamboos, grasses and shrubs.

In Lunglei district, farmers constitutes about 80 per cent of the total population.[10] *Due to inhospitable nature, environment and difficult terrain about 90 per cent of the total farmers practices jhum cultivation. Out of the total 4,53,800 hectares of land, only 1500 hectares or 3.30 per cent is under jhum cultivation (i.e. for a year). According to the available data from District Agriculture Office, Lunglei only 0.15 per cent is under Hill Terrace Cultivation, 0.21 per cent is under cash crops and 0.66 per cent under horticulture plants.*

Operation Cycle in Jhuming

The agricultural operations in shifting cultivation are marked by the following stages:

First comes the selection ofland in the forested hilly areas. The village council (Upa) goes to the forest for the selection of plot near the hill side of the jungle. The selection is made during the month of November-December.

After selection of the field the land is distributed to the cultivators on the basis of workforce available in the family by draw of 'lot' (Lo-number pawh). A person who pick up the number 1 will chose first and so on. In the later case, it is interesting to note that before the allotment of the land, the village council keeps a dead line for the people to go and select it. This results in a great rush to get the best land for himself. However, it is important to know here that the first priority is given to the council members. The

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[10] *Records of Agriculture Landuse in Lunglei district, District Agriculture Office, Lunglei.*

people of the village or community cultivated jointly. Each family however has individual plots.

After demarcation of land according to the need of the family, the next step is the clearing of the forest with the help of 'Dao' and 'Axe' (Plate No.14). The trees, wild plants, bamboos, and any vegetation are cut down. Very large trees, however, are not felled but the branches are often lopped. These trees are later killed by firing. This stage usually takes place in the month of January or early February. Clearance of jungles for a new jhum paddy is the most laborious part of the jhuming processes. The clear growth is then allowed to dry on the fields. The process of clearing being labour intensive takes over a month's time.

The dried trees and branches standing in the clearance, then are set on fire in the month of March or early April. The fires rarely remains confined to the jhumland but spreads over the whole country side being stopped only by natural barriers like streams or rivers or low lying areas. The cultivators sees that the fire does not spreads into the neighbouring jungle. The unburnt branches are later collected, piled and set on fire for the complete burning - which is locally called "Mangkhawh". The ashes are then scattered by wind over the land, and soaked in by the first rains to provide manure for the field. 'Chapchar Kut' (Chapchar 'Festival') is celebrated after the completion of clearing jungle. This operation is their arduous task of jhum operation. Now the Mizo abandoned this festival as to when they accepted christianity.

After the process of burning the dibbling and seeding takes place with the first monsoon shower. The cultivator construct small hut for *shelter in the jhum field with bamboos and thatch (Plate No.15). Just after burning the cultivators sowed the seeds of maize, cucumber, watermelon, and other vegitables to get an early harvest. Here it is important to know that the soil becomes soft after heavy burning and the cultivator takes this opportunity in sowing the seed which is locally called 'Kangvar'. In the middle of April and early May the cultivator sowed the seeds by digging with 'Tuthlawh'. (a special implement made of iron) shallow holes in a row. Mixed cropping of maize, rice, vegitables, pumkin, beans, cucumber, brinjal, arum, chillies, etc., cotton and tobacco is practiced.*

Unlike other tribal communities, practicing jhum, the Mizo do not perform any sacrifices or worships before the sowing practice. After the seeding, the farmer have to look after the crops till the harvesting time against the wild plants. Weeding is generally done four to five times.

The harvesting season of early paddy normally starts in the month of late August and early September. The late paddy harvesting season starts in the month of early November and completed in the middle of December which is the period of enjoyment festivity and prosperity for the jhumias. The rejoicement 'Pawlkut' (Straw Festival) is celebrated by drinking of rice beer locally made in every house. The harvesting is followed by stocking of food grains and thrasting. And lastly, comes the fallowing of land and later selection of new plot of land for the next year. After abandoning the jhum land the Mizos select a fresh site and the cycle is repeated.

Jhum Cycle

Jhum cycle is the period by which time the villagers return to the same plot of land from another plot of land for cultivation. This is the period *during which a land is left fallow for vegetation growth and later brought under cultivation, when it has regained its fertility of the soil. The interval at which the same plot of land for jhum land used to be quite long in the past, 20-30 years were kept vacant as the population was sparse. Due to increase in population now this cycle has been reduced to 3-9 years. However, this cycle of fallowing varies from village to village. A village having more population has much pressure on land resulting in a short cycle, while the villages having sparse population have a larger jhum cycle.*

As mentioned above, the cycle of shifting cultivation varies from village to village. The cycle of shifting cultivation also varies from Community Development Block to block. During the course of field work it was noticed that Bunghmun Block has the longest jhum cycle of 7-8 years. Next comes Lungsen Block 6-7 years, Hnahthail Block 5-6 years and Lunglei Block the lowest being 3-4 years. Available information of the hill areas in Lunglei district shows that 48 per cent of the area in the hills are either barren or uncultivable due to rugged topography. Therefore, the increasing population effects the carrying capacity of land and also presumably the jhum cycle adversely. The soil is not improved much during this short interval and the people now has to take larger areas.

PLATE NO 14

Clearing of the forest growth for Jhum field.

PLATE NO 15

Temporary Hut for Jhumfield

CHAPTER-VIII

IMPACT OF MORPHOMETRIC ELEMENTS ON AGRICULTURAL LANDUSE IN LUNGLEI DISTRICT (A CASE STUDY OF FIVE SELECTED VILLAGES)

Introduction

The agricultural landuse pattern indeed is the result of interaction of the physical and the historico-socio-economic factors.[1] Although the types and development of agriculture of a region are related to both the physical and socio-cultural processes, and the tempo of life, yet the prominently governing factors of agriculture are the various morphometric attributes like relief, fertility of the soil, gradient or slope, drainage system and to some extent micro-climatic condition of the region. It is no doubt true that man and his activities tend to modify the physical elements of his environment but eventually a line has to be drawn somewhere - nature does set a limit beyond which it is not possible for man to go.

Bernhard Von Votta (1808-1897) was certainly one of the first geologists to recognise that environment has a profound influence on man. Cotta's observations are a perview of modern interest in geologic effects on human beings, animals and plants. He notes that geologic and geomorphic factors are involved in the location and forms of settlements, agricultural pattern and other types of aesthetic expression of any region.

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[1]Dhillon, S.S. (1977), The Impact of Landform on Agricultural Landuse in Mahasu District, Geog. Rev. India, Vol. XXXIX, 2 (1977), p.183.

Geomorphology has a profound influence on the pattern and destiny of agriculture in the region (Ahmed 1981).[2] *This is true on macro-regional as well as micro-regional scales because of the fact that agriculture system differs from mountain, plateau and plains. It is also quite true that scarps, pediments, valley flanks, flood plains and basins are characterised by different types of agriculture. Other things being equal i.e. latitudinal location and stage of development including technological inputs, the geomorphology influencing the entire agriculture structure, makes mountain agriculture differ from plateau or plain agriculture. In mountain i.e., highland of steep slopes mostly more than 2000 metres (above sea level) the steepness of slopes is the greatest physical dominant (Ahmed).*[3] *It affects the availability of soil the amount of solar radiation, the feasibility of terracing, field pattern, agriculture transport, possibility of irrigation, the size and distribution of holdings, continuity of cultivation and most important aspect of agriculture i.e., the crops, their nature, yield and outcome.*

After analysing the morphological characteristics of Lunglei district, it becomes pertinent to emphasize its significance for human welfare. The interrelationship between landform and cultural features or physical environment and human society are the important aspect of the geographical study. Agriculture pattern of a particular region reflects man's relationship with the environment. The study of Agriculture as a permanent element of the landscape is most important for the purpose of terrain evaluation. The response

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[2] *Enayad Ahmed, (1981), Geomorphology and Agriculture Perspective in Agriculture Geography, Vol. II, Concept Publishing Company, New Delhi 1981, pp.59-67.*

[3] *Ibid.,*

of man to his surroundings is a vital factor which can not be overlooked in a geographical study. The Geomorphic features of any region have a direct impact on the human life of the region.[4]

Sampling Technique and Sample Size

As regards technique and methodology in landuse surveys there are three main examples i.e. Prof. Stamp's survey of Great Britain, Prof. Buck's monumental work on China, and the surveys done in the United States either at State or regional level. Mention may also be made to the landuse survey of Poland, conducted under the direction of Professor Kastrowicki and Professor Dzewnki. Primarily all these surveys have tried in their respective ways to record the use of land on maps but the objective and methods are quite different from one another due to the varying conditions prevailing in the areas of the study.

The land utilization survey of Great Britain which is considered to be unique and fundamental, was carried out in the thirties under the direction of Prof. Stamp. The main objective of this survey was to find out the use of every piece of land of the country. With this view, the then existing use of every piece of land was recorded on the British ordinance survey maps on a scale 1:10,560, which shows field boundaries together with other features in detail. After recording the use, these maps were reduced to a scale of one inch to a mile suitable colours were also assigned to different features. The survey, as it was done by a large number of helpers from schools, Colleges

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[4]*Rai, R.K. (1980), Geomorphology of Sonar Bearma Basin Concept publishing Company, New Delhi, p.115.*

and Universities, provided first hand factual information by recording the facts on maps.[5]

Professor J.L. Buck's land use survey of China was carried out in thirties with a view to train the students in the method of research in land utilization and to make available to the people of other countries certain elementary information about land utilization food and population. Data were collected by sampling method from 16,786 farms scattered in 168 localities which were a part of 154 hsien lying in 22 provinces. The collection of data relating to population, food, standard of living, marketing and price, were also included in the survey.[6]

Another important land use survey was Michigan land Economic survey which was started in 1922 with a view to evaluate the relative merits of the northern Michigan in respect of agricultural, recreational or other uses. Information relating to soil, slope, Vegetation, and similar other natural features, was collected and analysed.[7]

However, the above mentioned land use surveys were taken after a full consideration of the need, the purpose expected to be served and the available resources in the country of study. It is, therefore, essential that while chalking out a plan for landuse surveys in India, all relevant factors should be taken into consideration.

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[5] *Stamp, L.D. (1962), The Land of Beritain - Its Use and Mis-use (London).*

[6] *Buck, J.L. (1937), Land Utilization in China (London), pp. vii-viii.*

[7] *Barnes, C.P., Land Resource Inventory in Michigan, Economic Geography Vol. V, No.1, January 1929, pp.22-35.*

It will be seen that a landuse survey on the lines done in the United States may not be suitable for India as the country has neither the resources nor the technical skill to take up such a project. The British model may well be adopted but here also there are many difficulties. As compared to Britain, India is a vast country, about fifteen times bigger in area, and perhaps, nowhere in the world, the landuse pattern is so complicated as it is in India. Therefore, in view of the vastness of the country, the paucity of the trained personal and the extent of time and expenditure involved, it will be necessary to introduce modifications in the deisgn and the execution of the survey methodology of Britain.[8]

In India cadastral maps showing the field boundaries and other features in detail, on a scale 1:3960 are maintained by the village accountants. It is difficult to have a copy of these cadastral maps without the permission of the relevant authorities. In Lunglei district no cadastral map is available. Besides cadastral map, there is no proper land use survey, no climatic data, there is no any soil survey, and other reliable informations etc. In view of these difficulties, sampling techniques seems to be the best for obtaining factual information in regard to the geomorphic characteristics and existing patterns and problems of landuse.

In view of the above statement and to be more precise and to get satisfactory results, the researcher has selected five villages from all corner of the district for detail analysis. The selected villages are randomly selected

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[8]*Shafi, M. (1966), Techniques of Rural Land Use Planning with reference to India. The Geographer, Vol. XIII, (Aligarh, 1966), p.16.*

to represent the various geomorphic characteristics of the region under study. Thingfal village is selected to represent the micro-geomorphic region of highly dissected, denudated and sharp crested region. Lungsen village is selected to represent the moderately dissected undulating hill region of the west, and the villages of Zobawk, Thingsai and South Vanlaiphai are selected to represent the central and eastern escarpments region which occupies the maximum areas of Lunglei district.

Methodology Applied:

Keeping in view the complexity of the geomorphic characteristics, Agricultural landuse and due to unavailability of any information of the region, it will not be correct to take only one factor. Therefore, all the analytical and mapping works are based on the 1:50,000 topographical sheets of survey of India, geological map and field evidences. Various morphometric techniques has been applied to find out to what extent morphometric elements dominate in controlling the pattern and development of Agriculture in Lunglei district. The morphometric techniques applied in the present study are Average slope analysis (Wenthworth method), Relative Relief and Drainage analysis. The Agricultural landuse maps are prepared with the help of 1:50,000 topographical sheet of survey of India after visiting the fields in different seasons. The agricultural land use maps are superimposed upon each morpho region, viz. Relative Relief region, drainage texture region, slope region and agricultural land use of each morpho-region have been examined.

Average Slope and Agriculture

Average slope of an area is the most important controlling factor *for agriculture. Concave and gentle slopes, alluvial fans, tillage fans, and river-flat terraces have comparatively deeper soil deposits and they provide most suitable sites for agricultural field terracing. Concave slopes are either made gentle by back-breaking human labour or are avoided. Steep scarp slopes are generally avoided for agricultural practices.*

Successful agriculture is possible only on reasonably level ground. In sloping terrain such level land has been found by terracing. Such terraces are found in all sloping Mountain, Plateau or hill area of the world since time immemorial (Ahmed).[9] Originally when the farmer built a terrace field he must cut the earth from the part of the slope and place the earth immediately below so that a part of the field was cut and part filled. If the slopes were gentle the terrace could be wider with the same amount of labour. The above facts show how geomorphology influenced the operation and size and maintainance of terracing. Terracing which is probably as old as agriculture itself mitigates the thickness of soil veener at any part and for the growth of normal agricultural crops which are generally shallow rooted, the average thickness is sufficient. Even a slope of 2°-3° makes terracing inevitable particularly for the cultivation of transplanted paddy which requires level ground in which water should stay.

In Lunglei district the average slope is mostly between 20°-40° (fig.6). The average slope at some places actually exceeds 60°. Due to its steep and narrow valleys the area has a limited possibility of cultivable land which needs level ground. When we superimposed the average slope maps (fig. 24a,

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[9] *Enayed Ahmed (1981), Op.cit., p.59.*

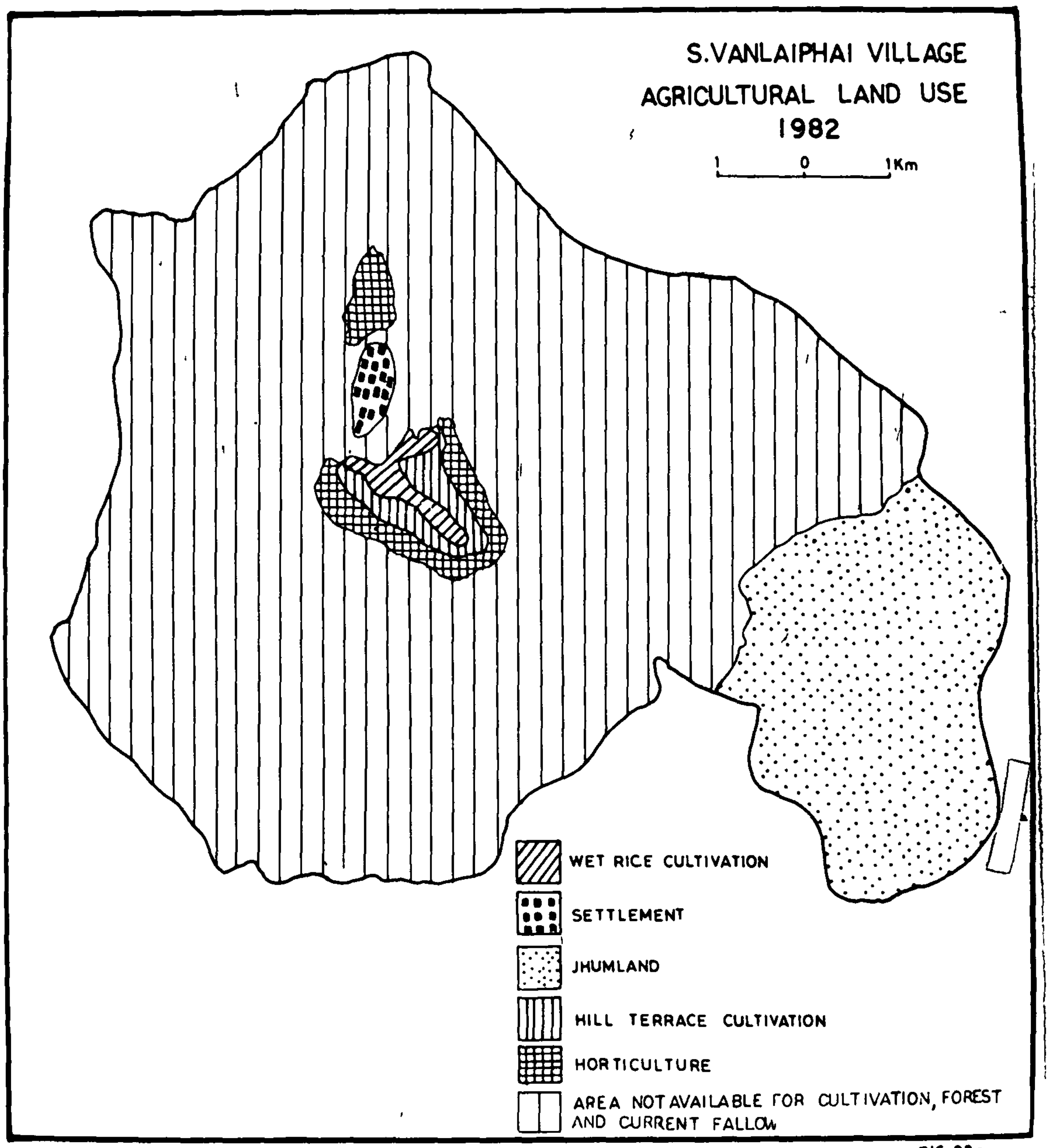

S.VANLAIPHAI VILLAGE
AGRICULTURAL LAND USE
1982
1 0 1Km
WET RICE CULTIVATION
SETTLEMENT
JHUMLAND
HILL TERRACE CULTIVATION
HORTICULTURE
AREA NOT AVAILABLE FOR CULTIVATION, FOREST AND CURRENT FALLOW

FIG 23a

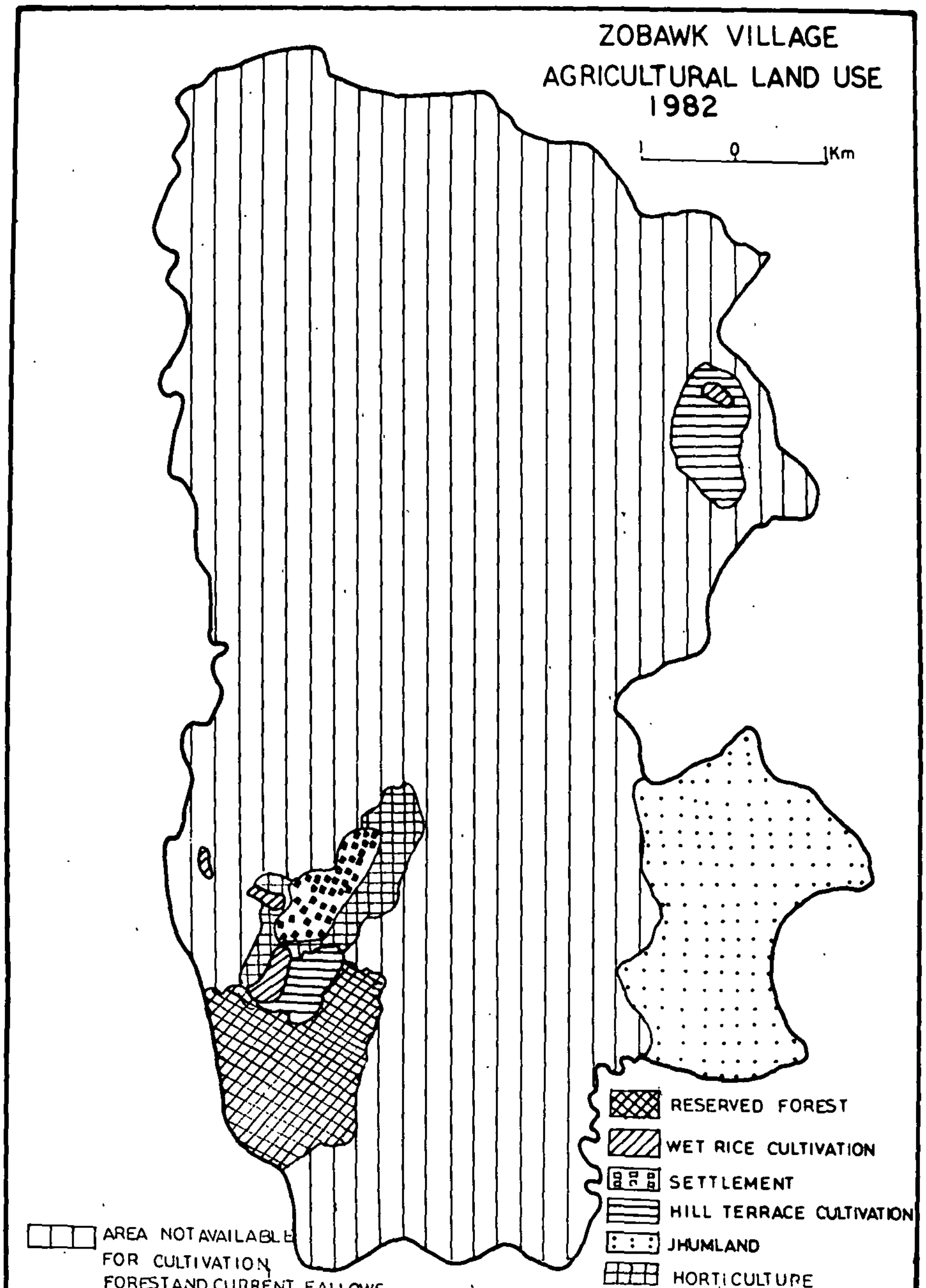

ZOBAWK VILLAGE
AGRICULTURAL LAND USE
1982
1 0 1Km
RESERVED FOREST
WET RICE CULTIVATION
SETTLEMENT
HILL TERRACE CULTIVATION
JHUMLAND
HORTICULTURE
AREA NOT AVAILABLE FOR CULTIVATION FOREST AND CURRENT FALLOWS

FIG. 23 b

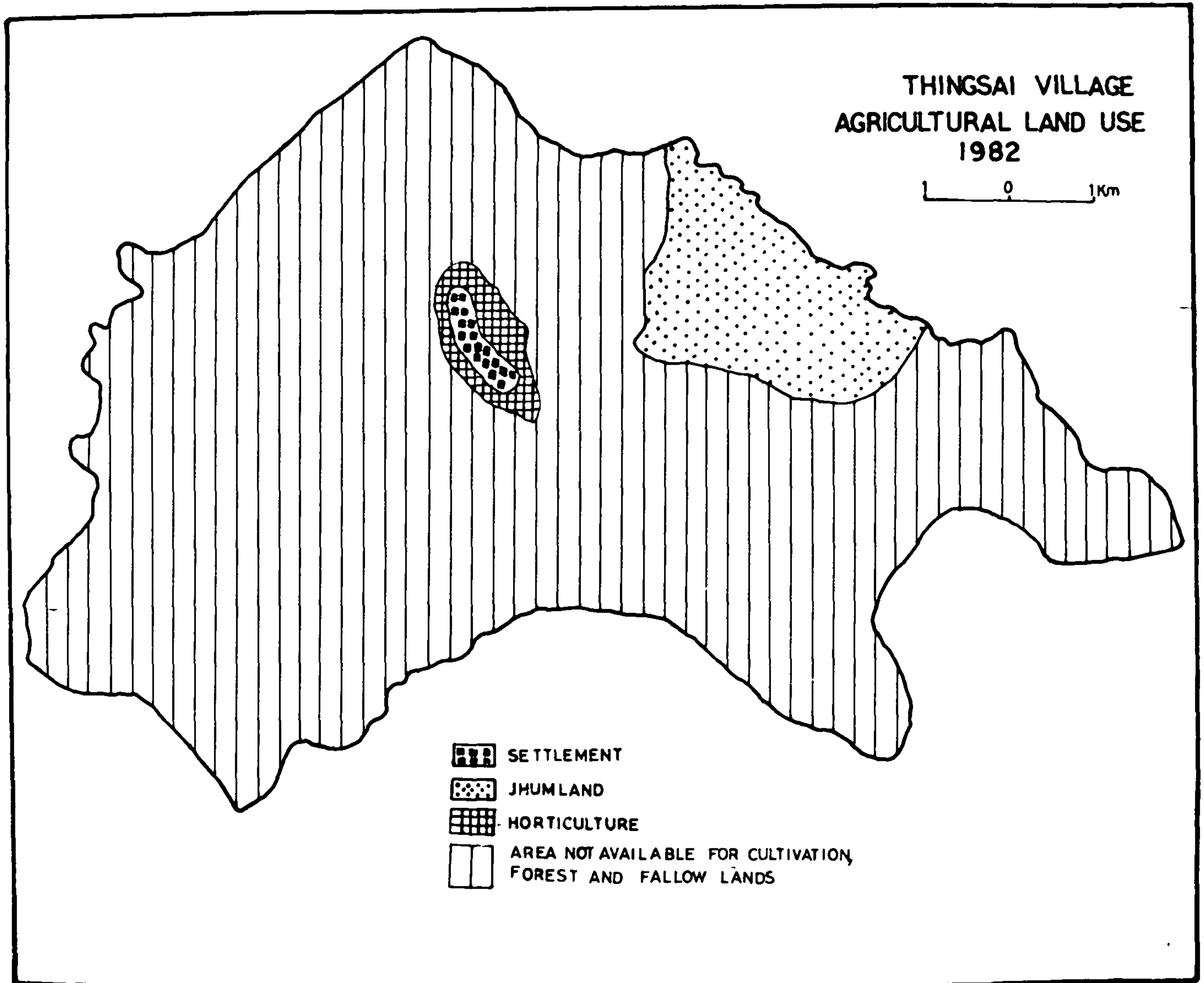
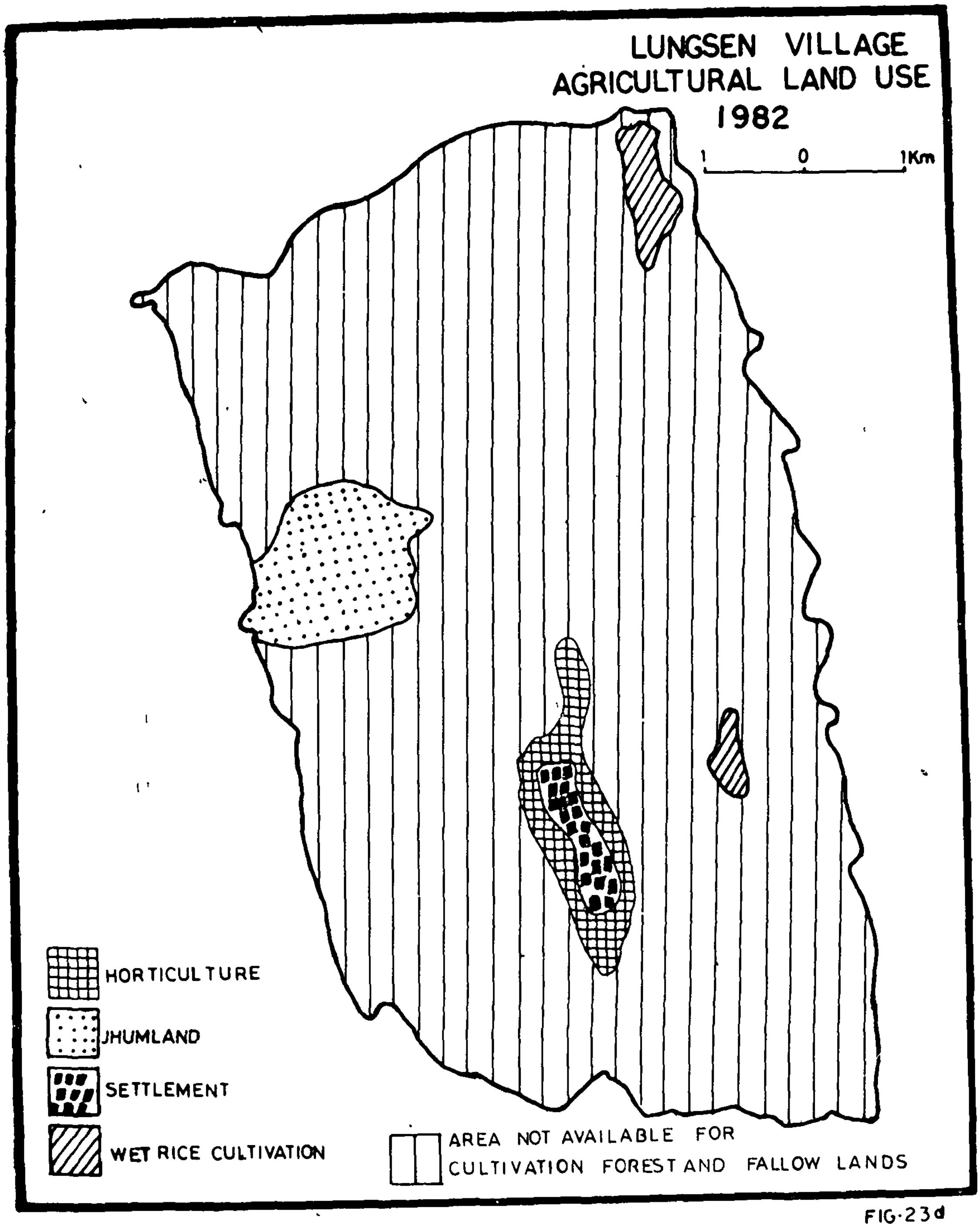
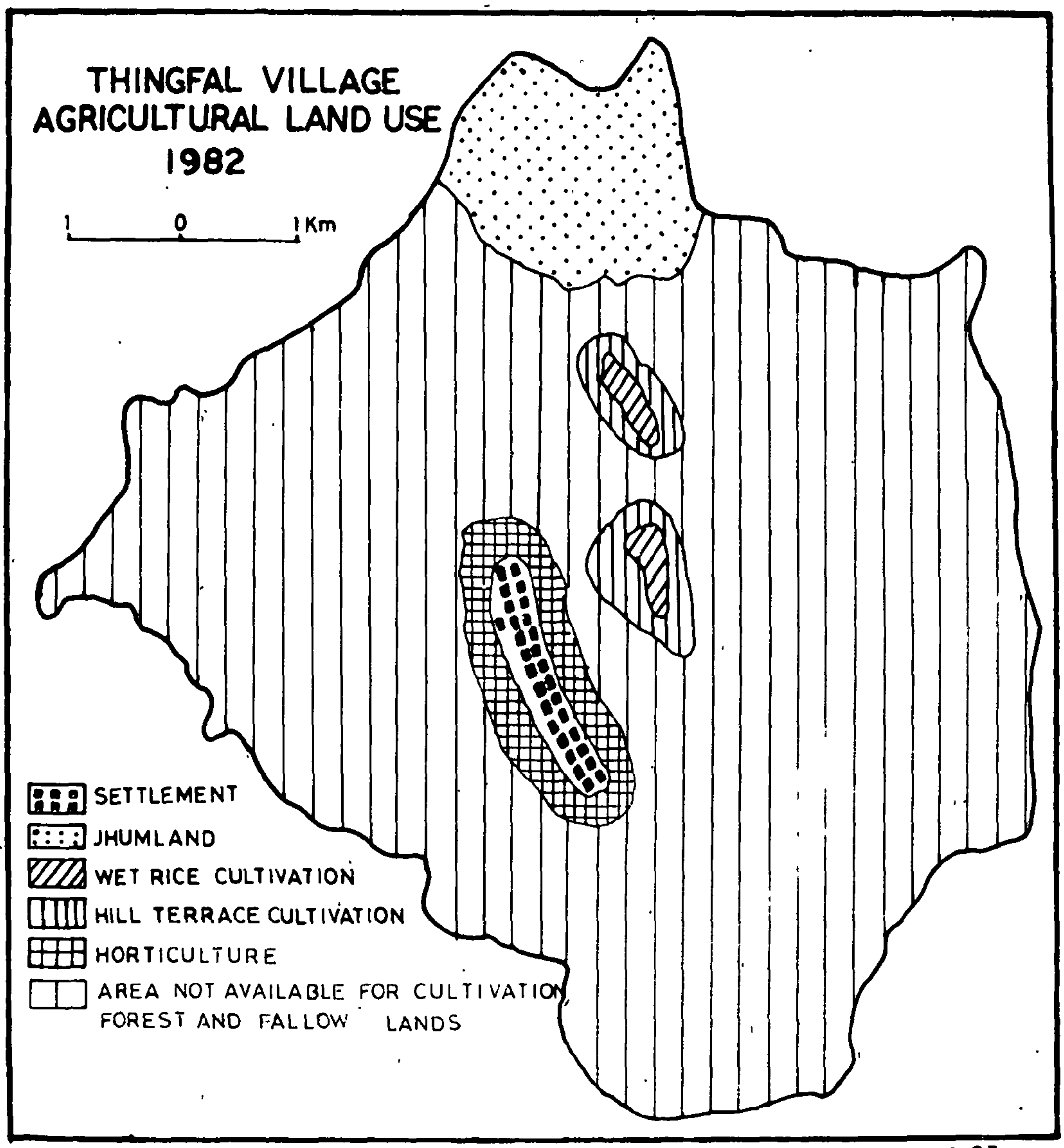

THINGSAI VILLAGE
AGRICULTURAL LAND USE
1982
1 0 1Km
SETTLEMENT
JHUMLAND
HORTICULTURE
AREA NOT AVAILABLE FOR CULTIVATION,
FOREST AND FALLOW LANDS

FIG 23c


LUNGSEN VILLAGE
AGRICULTURAL LAND USE
1982
1 0 1Km
HORTICULTURE
JHUMLAND
SETTLEMENT
WET RICE CULTIVATION
AREA NOT AVAILABLE FOR
CULTIVATION FOREST AND FALLOW LANDS

FIG·23d


THINGFAL VILLAGE
AGRICULTURAL LAND USE
1982
1 0 1 Km
SETTLEMENT
JHUMLAND
WET RICE CULTIVATION
HILL TERRACE CULTIVATION
HORTICULTURE
AREA NOT AVAILABLE FOR CULTIVATION, FOREST AND FALLOW LANDS

FIG·23e

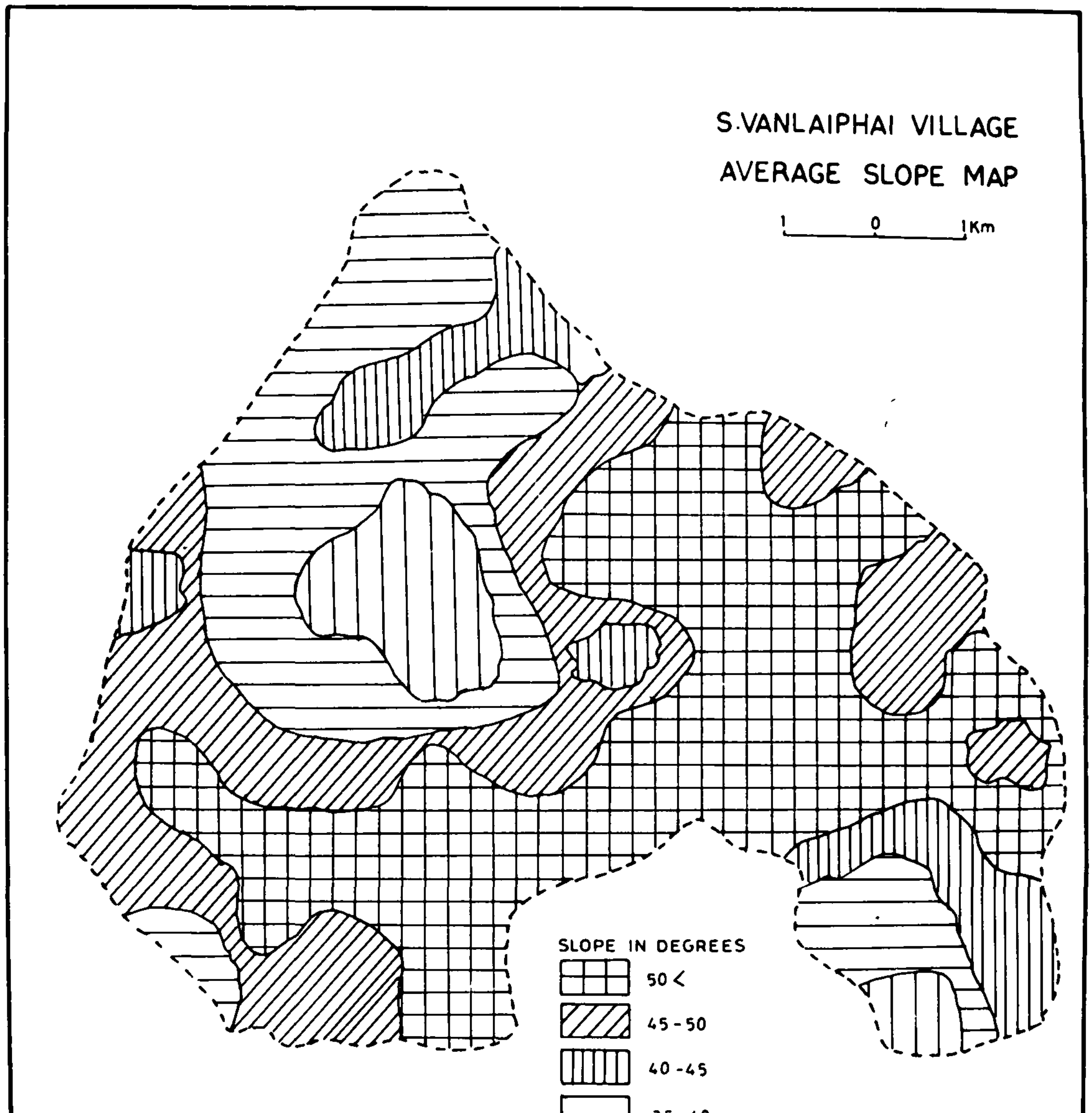
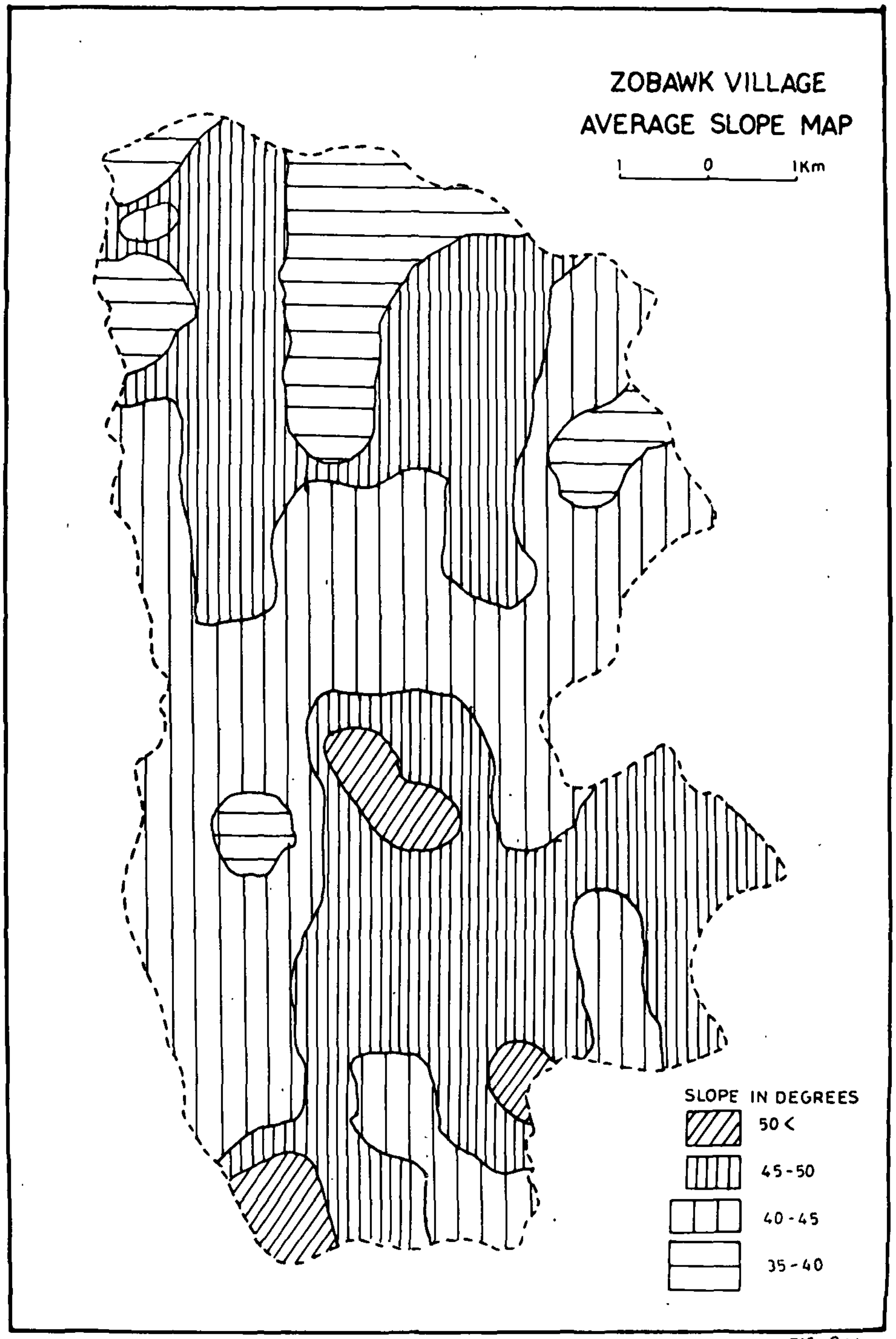
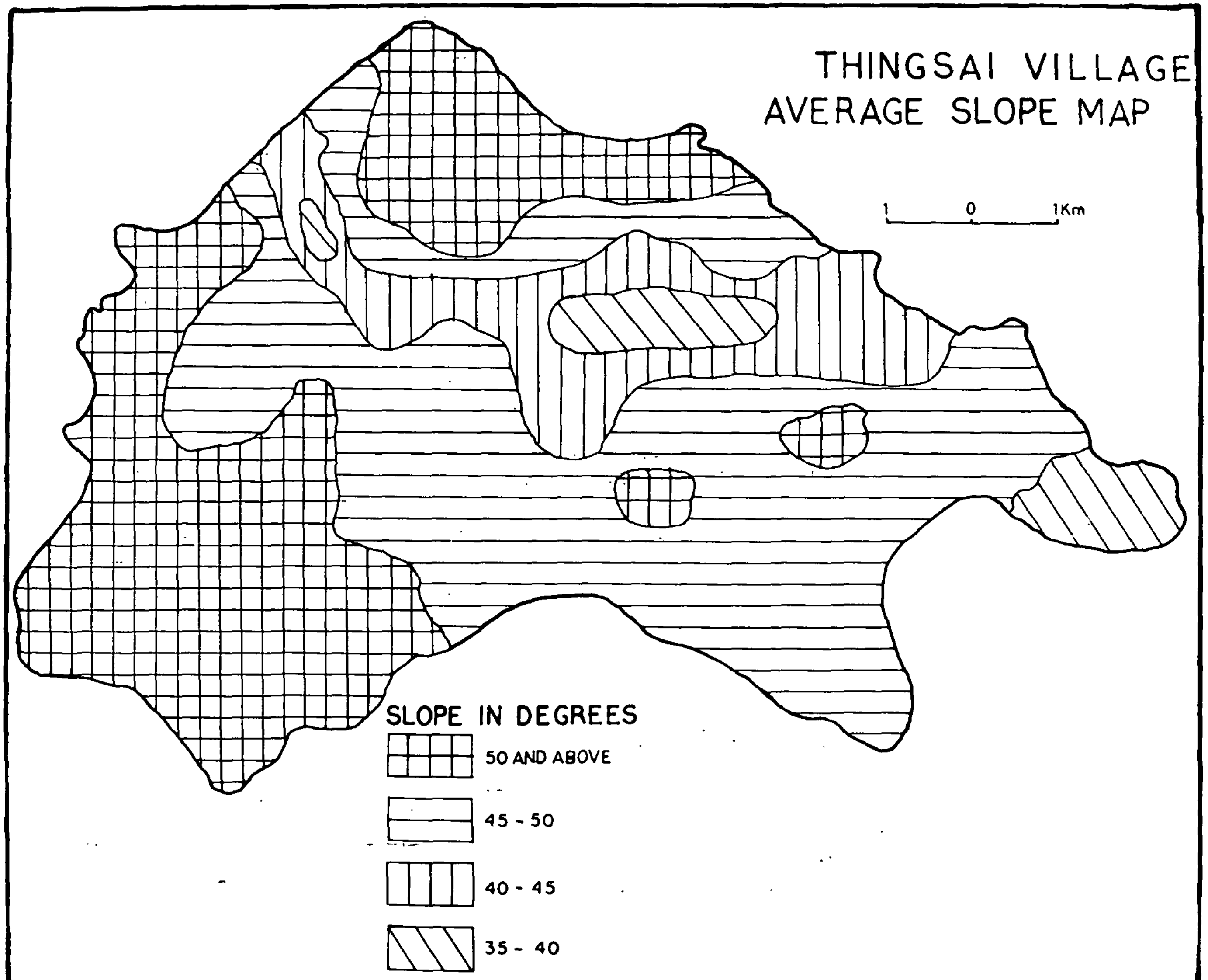

S.VANLAIPHAI VILLAGE
AVERAGE SLOPE MAP
1 0 1Km
SLOPE IN DEGREES
50 <
45 - 50
40 - 45
35 - 40
30 - 35

FIG. 24a



ZOBAWK VILLAGE
AVERAGE SLOPE MAP
1 0 1Km
SLOPE IN DEGREES
50 <
45-50
40-45
35-40

FIG. 24 b


THINGSAI VILLAGE
AVERAGE SLOPE MAP
1 0 1Km
SLOPE IN DEGREES
50 AND ABOVE
45 - 50
40 - 45
35 - 40

FIG·24c

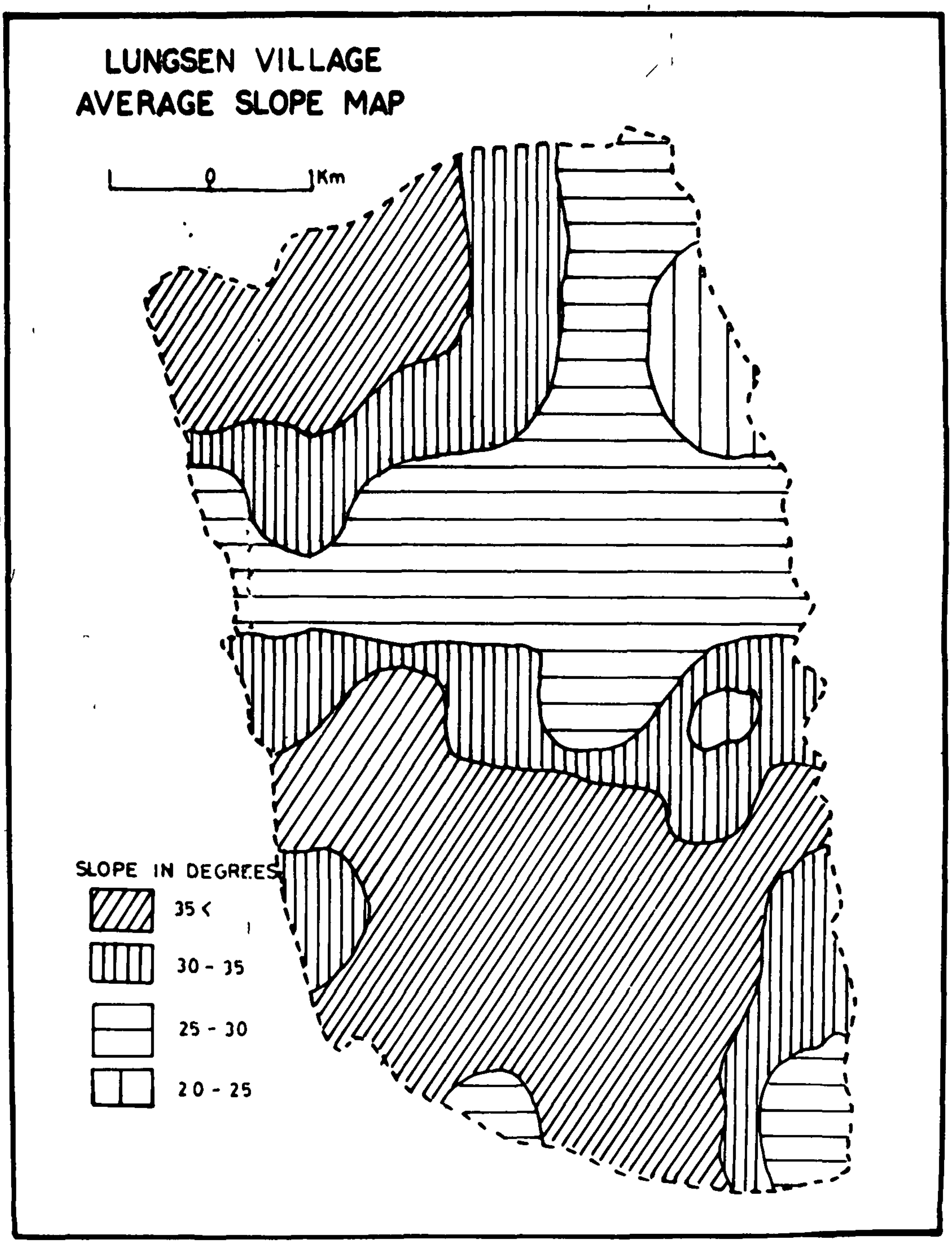

LUNGSEN VILLAGE
AVERAGE SLOPE MAP
0
Km
SLOPE IN DEGREES
35 <
30 - 35
25 - 30
20 - 25

FIG 24d

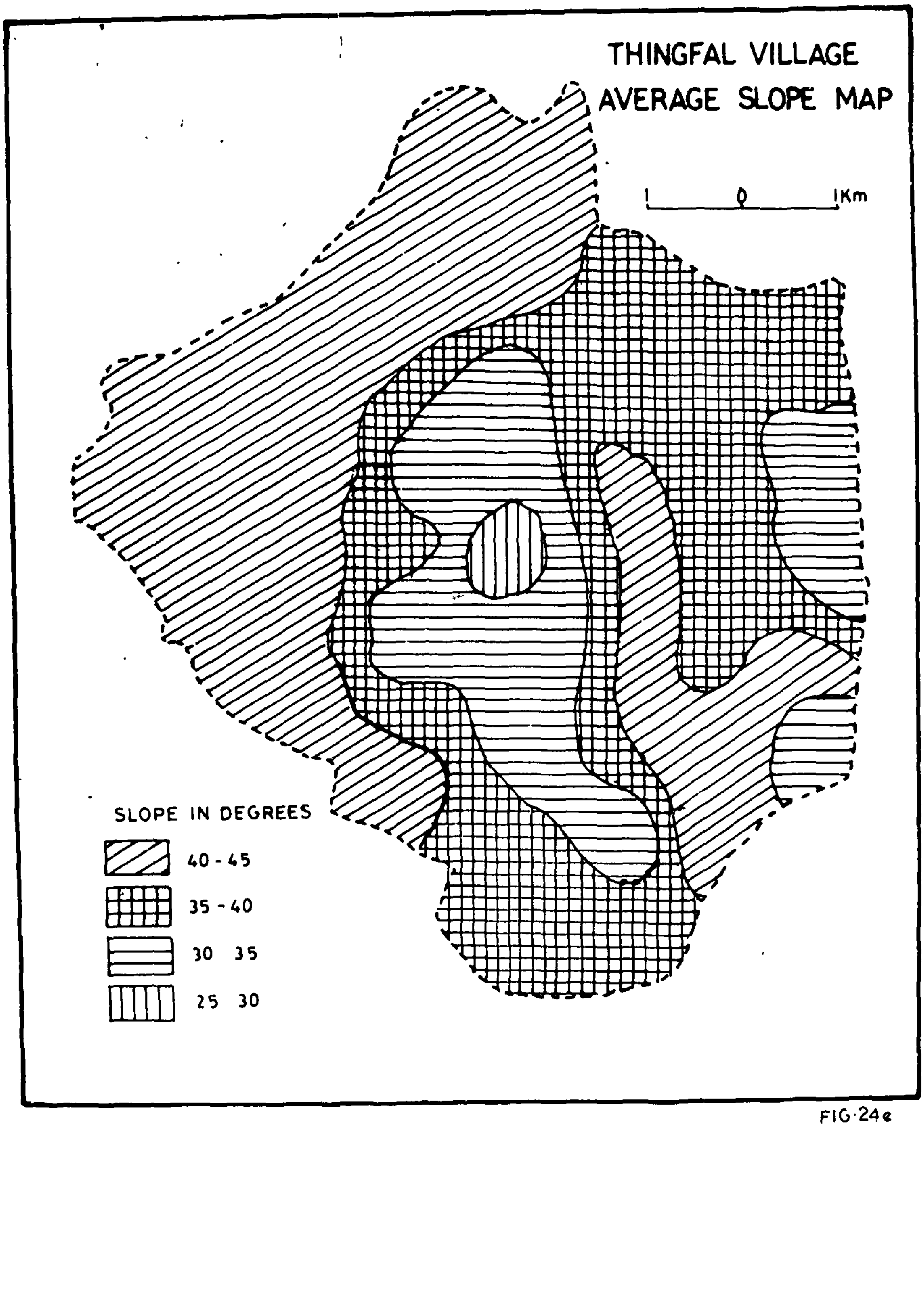

THINGFAL VILLAGE
AVERAGE SLOPE MAP
1 0 1Km
SLOPE IN DEGREES
40 - 45
35 - 40
30 35
25 30

FIG-24e

24b, 24c, 24d & 24e) and agricultural land use maps (fig. 23a, 23b, 23c, 23d & 23e) of five selected villages of Lunglei district, it reveals an interesting relationship between average slope and pattern and nature of agriculture practices.

The average slope map of the five selected villages of Lunglei district reveal that the average slopes of these village lands ranges from 22 to 50 degrees and above. The average slope of Thingsai village (22°53' - 22°57'N and 93°3' - 93°10E) ranges from 35° - 50° and above (fig. 24c), Zobawk village (22°50' - 22°56'N and 92°43' - 92°52'E) ranges from 35°-50° (fig. 24b), Lungsen village (22°50' - 22°56' and 92°33' - 92°37'E) ranges from 20°-35° and above (fig. 24d), South Vanlaiphai (22°45' - 22°56' and 92°58' - 93°4'E) ranges from 30°-50° and above (fig. 24a) and Thingfal village (22°35' - 22°40'N and 92°51'- 92°55'E) ranges from 25°-45° (fig. 24e).

It is interesting to note that the 25°-40° category of slope found only in the source region of the important streams of all these villages excepting Lungsen village. These areas are characterised by intermont valleys, which support the maximum concentration of Wet rice cultivation and hill rice cultivation. After superimposing the agricultural land use maps of five selected villages (fig. 23a, 23b, 23c, 23d, 23e) and average slope maps (fig. 24a, 24b, 24c, 24d & 24e) it shows that there are small intermont valley plains such as at the source region of Ngengrual stream within average slope ranges of 25 to 35 degrees (Plate No.16) in the Thingfal village. The Tlawng river in its source region at Zobawk village, has formed small intermont valley plain (Plate No.17) within average slope range of 35-45 degrees. In South

Vanlaiphai village, it is noticed that in the average slope range of 30-40 degrees the Hnahchang stream in its source region formed flat area of half sq. km. which is the largest wet Rice Cultivation in the district, (Plate No.18). In the western part of the district i.e., Lungsen village has low angle average slope and undulating terrain. The meeting point of three small rivers, Kau, De and Phairuang formed small patches of flat lands which are utilized for wet rice cultivation. The selected village of Thingsai does not have any wet rice cultivation nor any terrace cultivation as the average slope is very high.

If we examine the agricultural land use maps of the selected five villages (fig. 23a, 23b, 23c, 23d, 23e) and average slope maps (fig. 24a, 24b, 24c, 24d & 24e) one can recognise that Horticulture plants and paddy are mainly cultivated along the margin of the settlements wherever they found suitable land. The researcher during the course of field study observed that the present pattern of agriculture is not promising due to steep slopes.

The forgoing discussion brings out an interesting point between average slope and agriculture relationship. It is clear from the analysis that the lesser slopes support wet rice, Hill terrace and other cash crops. Whereas the steep slopes do not favour the development of agriculture. The highly dissected terrains, the deep narrow valleys and scarps are the main factors which control the types and pattern of agriculture land use in the district. Due to above reasons the area lacks good land for cultivation and as a consequence the tribal people practice shifting cultivation in the region.

Relief and Agriculture

Since man's use of land for agriculture does not means a piece of *land, but the total relief, drainage, physico-chemical constitution of the material with which the land is built etc. In short, the geomorphologist can play, perhaps, a better role in understanding the problems and even suggest some solution to it. Because it is with the form, material and processes of the earth's surface that geomorphology is concerned (Cooke and Doornkamp, 1974).[10] Topography affects cultivation, and limits in several manners. First, the alternate distribution of valley and spur it creates an interlocking of contrasted climates. Secondly, the contrast of level land and slope so steep as to be prohibitive for field cultivation is a matter of great significance (Roderick, 1936).[11] An obvious limit to the amount of production land in hilly region is the degree of slope. Nothing is more valued in hilly region than level land.*

Water supply or irrigation is very much influenced by the form of land. The amount of ground moisture varies indirectly with the degree of slope. Low gradient ensures slow discharge and the effect of steep slopes is to wash away the flowing water by quick run off. Dissected terrain is a great impediment in the provision of irrigation to agriculture. In very dissected terrain like Lunglei district, there is no extensive area with gentle gradient to facilitate the construction of long irrigation canals. Much of the topography is dissected into isolated hills. These hills are separated by deep narrow valleys. Thus these isolated hills have limited land for cultivation.

The contour maps of the five selected villages of Lunglei district reveal that the elevation of these village lands ranges from 200 metres to

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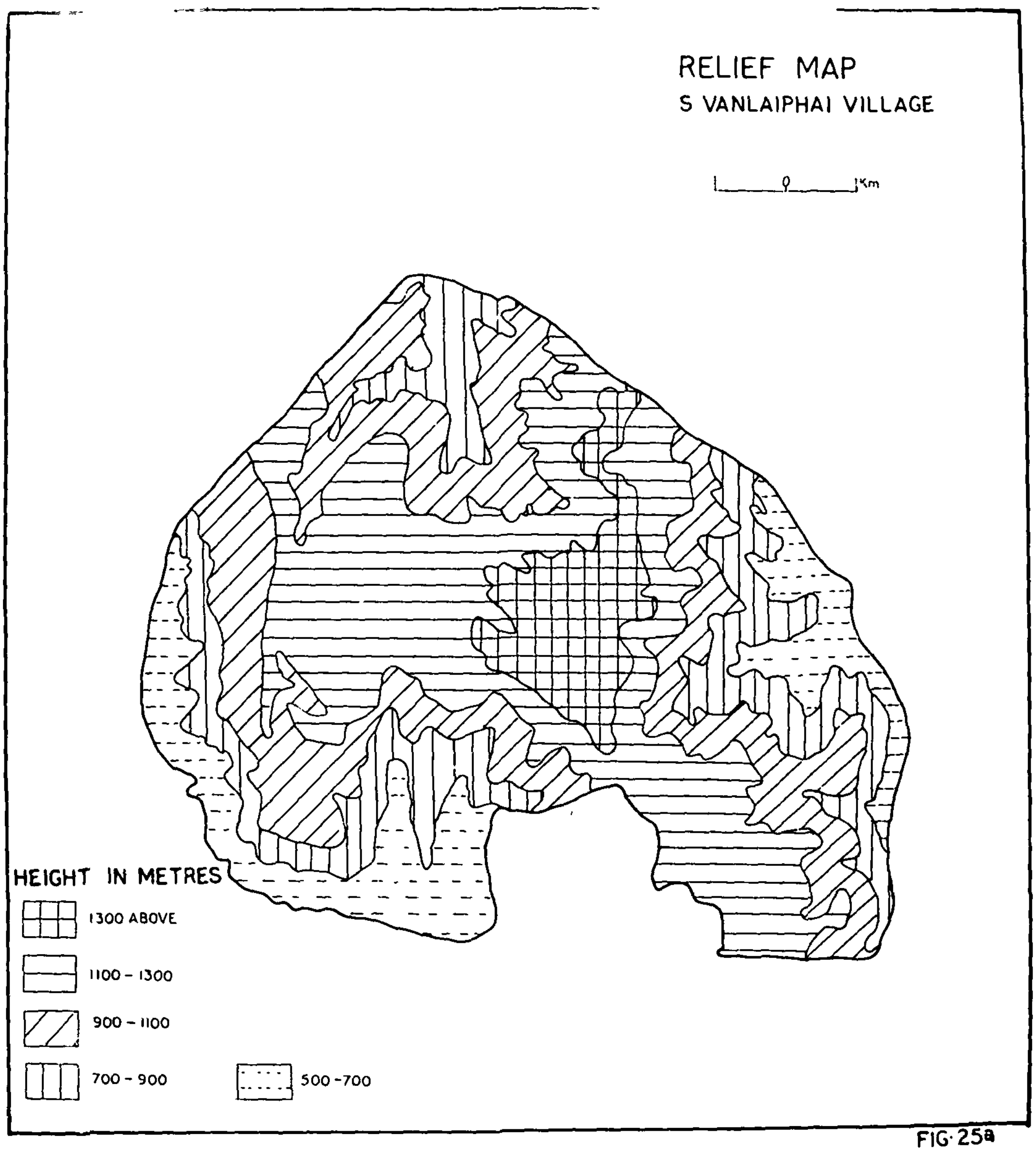
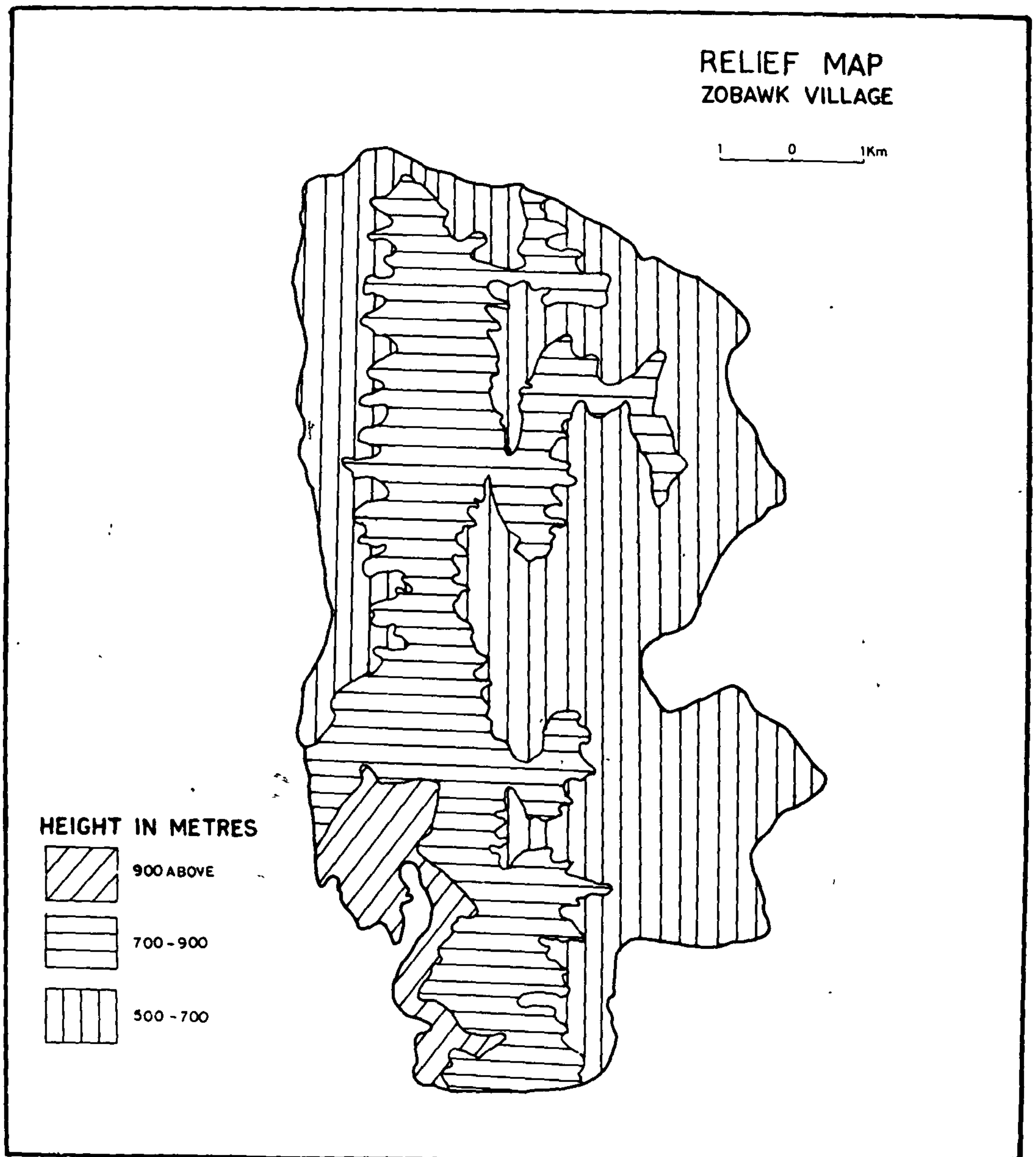
[10] *Cooke, R.U. and Doornkamp, J.C. (1974), Geomorphology in Environmental Management - An Introduction, pp.7-8.*

[11] *Roderick Peattic (1936), Mountain Geography, Greenword Press, Publishers, New York, p.86.*


RELIEF MAP
S VANLAIPHAI VILLAGE
0
Km
HEIGHT IN METRES
1300 ABOVE
1100 - 1300
900 - 1100
700 - 900
500 - 700

FIG·25a


RELIEF MAP
ZOBAWK VILLAGE
1 0 1Km
HEIGHT IN METRES
900 ABOVE
700 - 900
500 - 700

FIG·25b

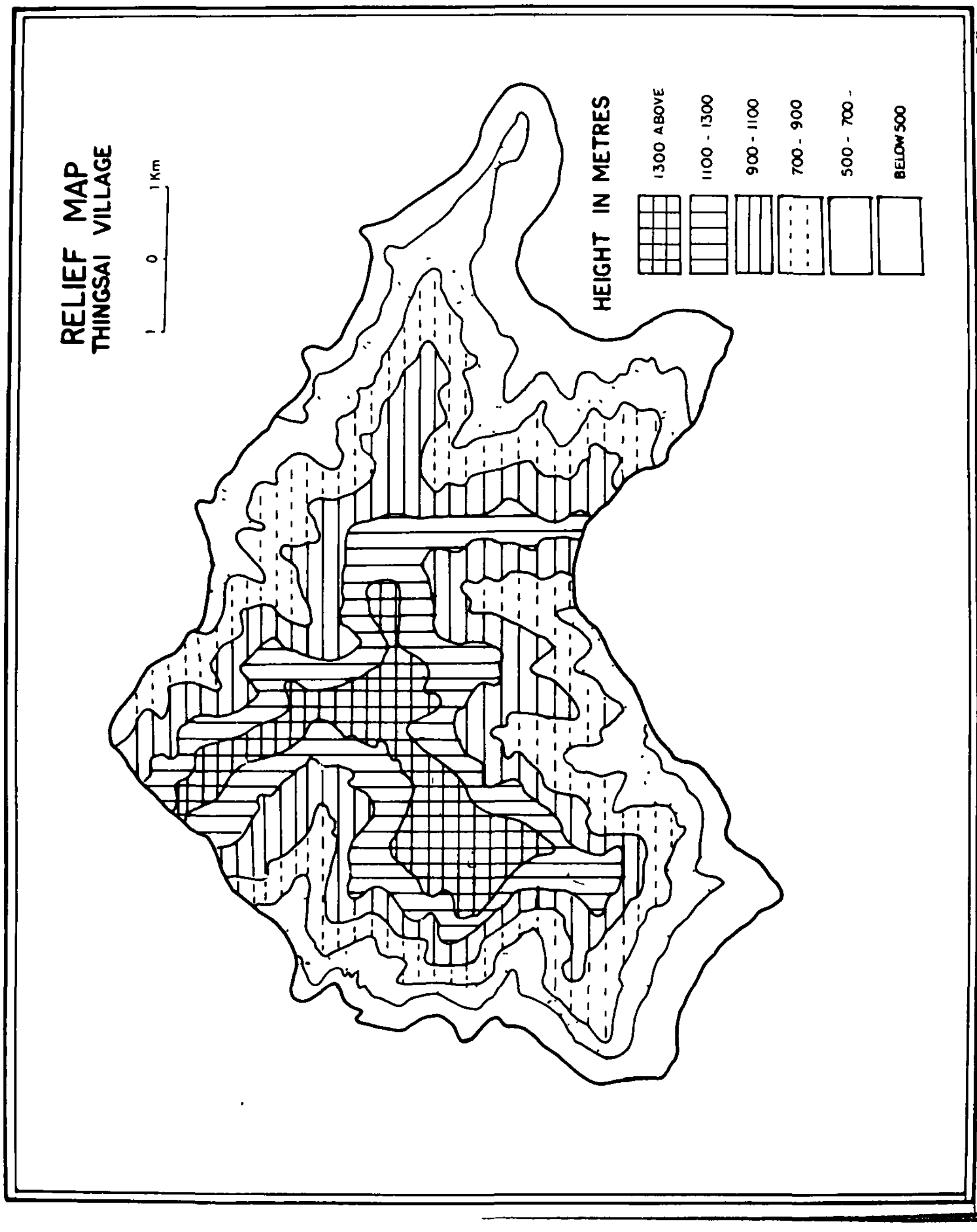
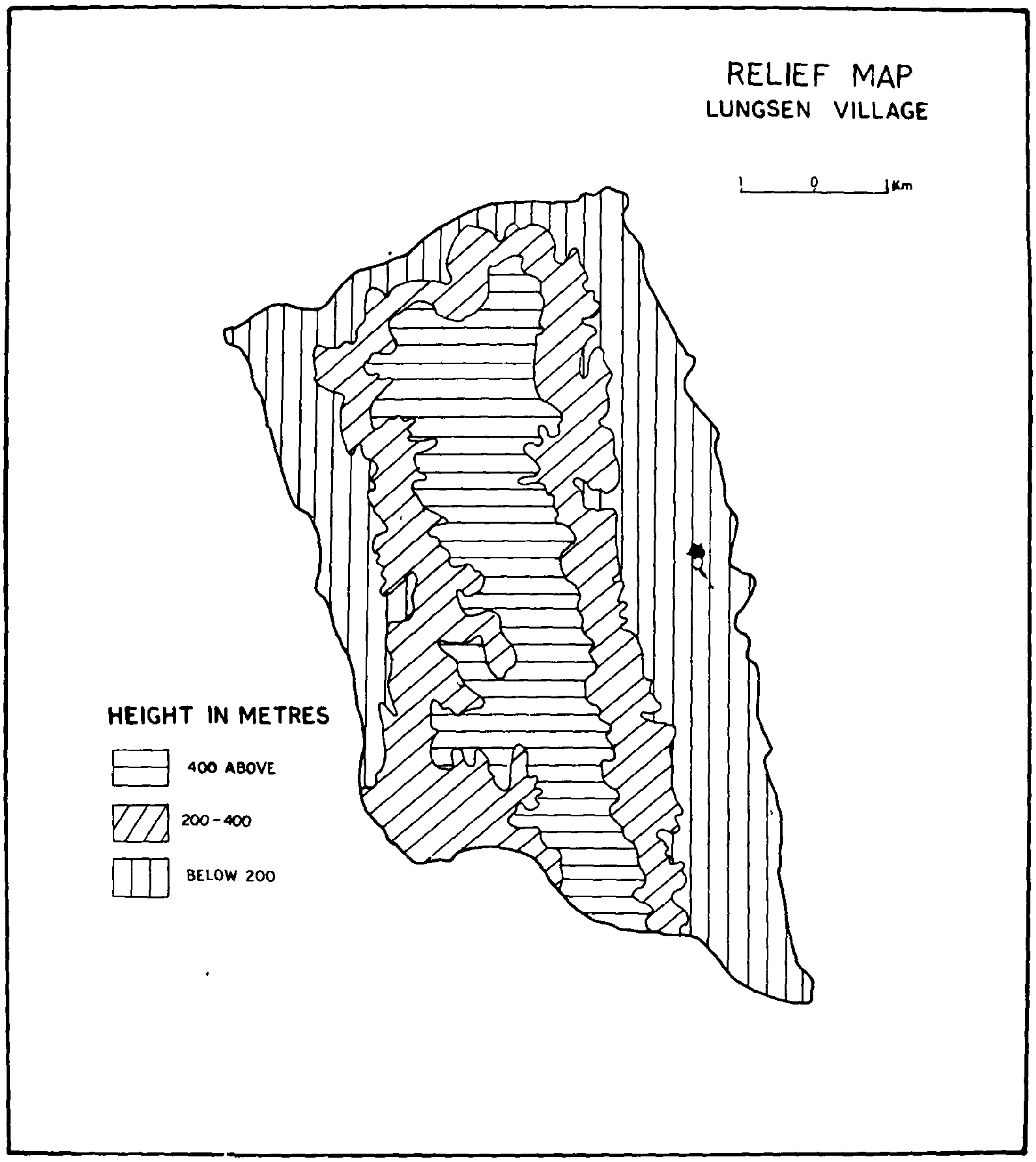
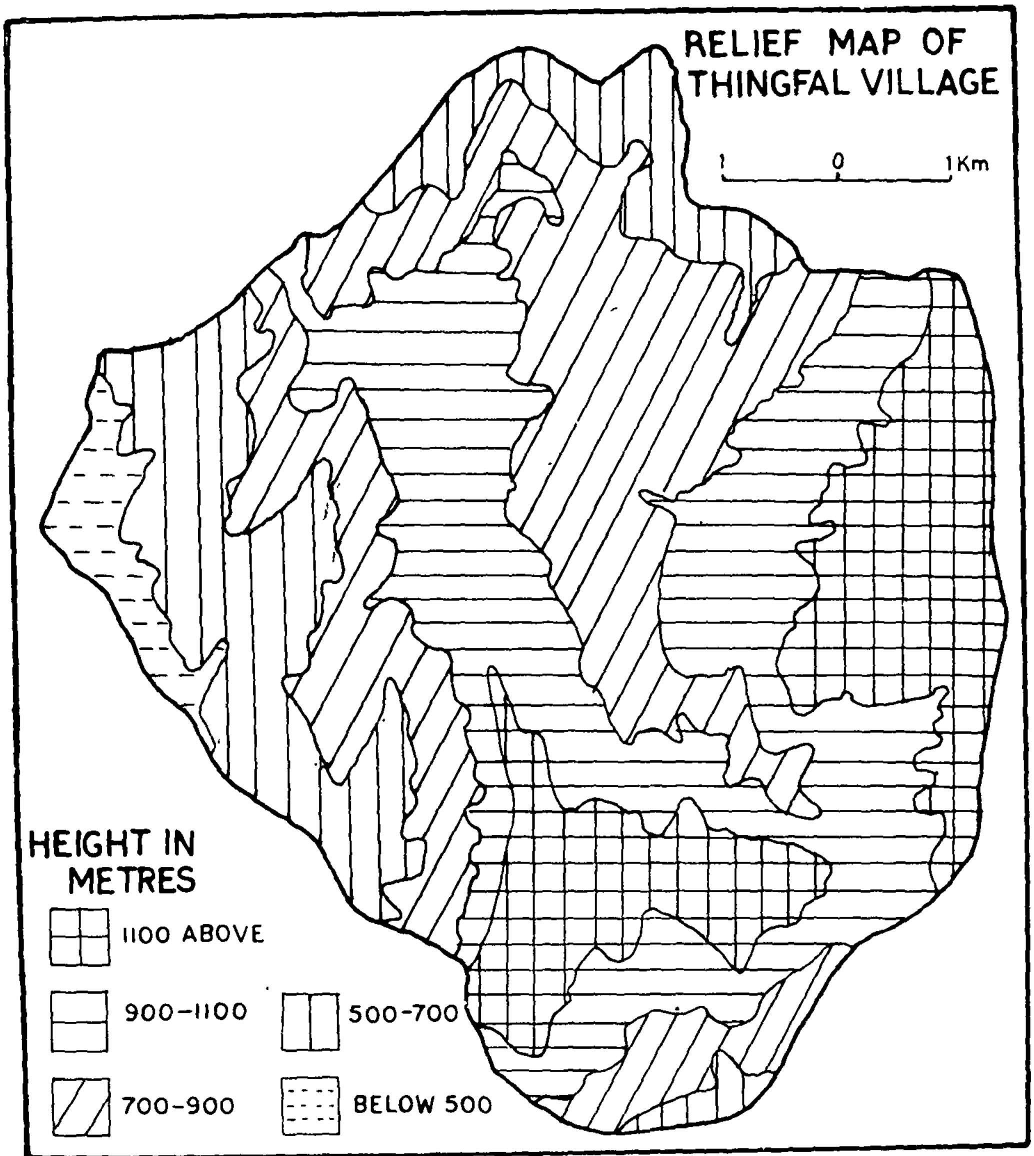

RELIEF MAP
THINGSAI VILLAGE
1 0 1 Km
HEIGHT IN METRES
1300 ABOVE
1100 - 1300
900 - 1100
700 - 900
500 - 700 -
BELOW 500

FIG 25c


RELIEF MAP
LUNGSEN VILLAGE
1 0 1 Km
HEIGHT IN METRES
400 ABOVE
200 - 400
BELOW 200

FIG·25d


RELIEF MAP OF
THINGFAL VILLAGE
1 0 1Km
HEIGHT IN
METRES
1100 ABOVE
900-1100
500-700
700-900
BELOW 500

FIG·25e

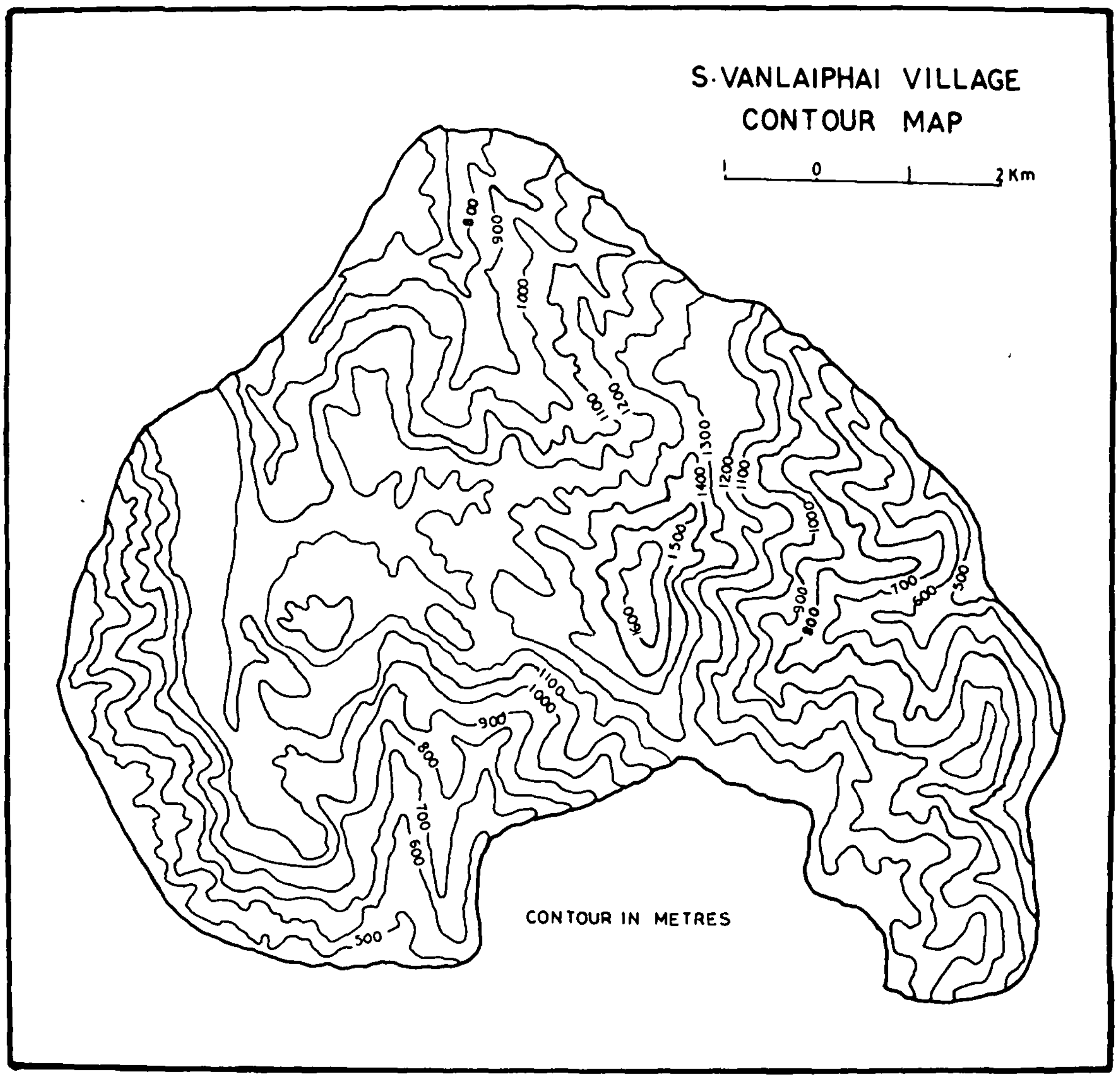
1500 metres (Fig. 26a, 26b, 26c, 26d & 26e). The elevation of Lungsen village ranges from 200 metres to 500 metres (fig. 26d), Zobawk village ranges from 500-1100 metres (fig. 26b), South Vanlaiphai village ranges between 500-1600 metres (fig. 26a), Thingsai village ranges between 300-1300 metres (fig. 26e).

From the above figures all the villages excepting Lungsen village has very high and different categories of elevation. As such, except Lungsen village, the other four vilalges are negative from the agricultural point of view.

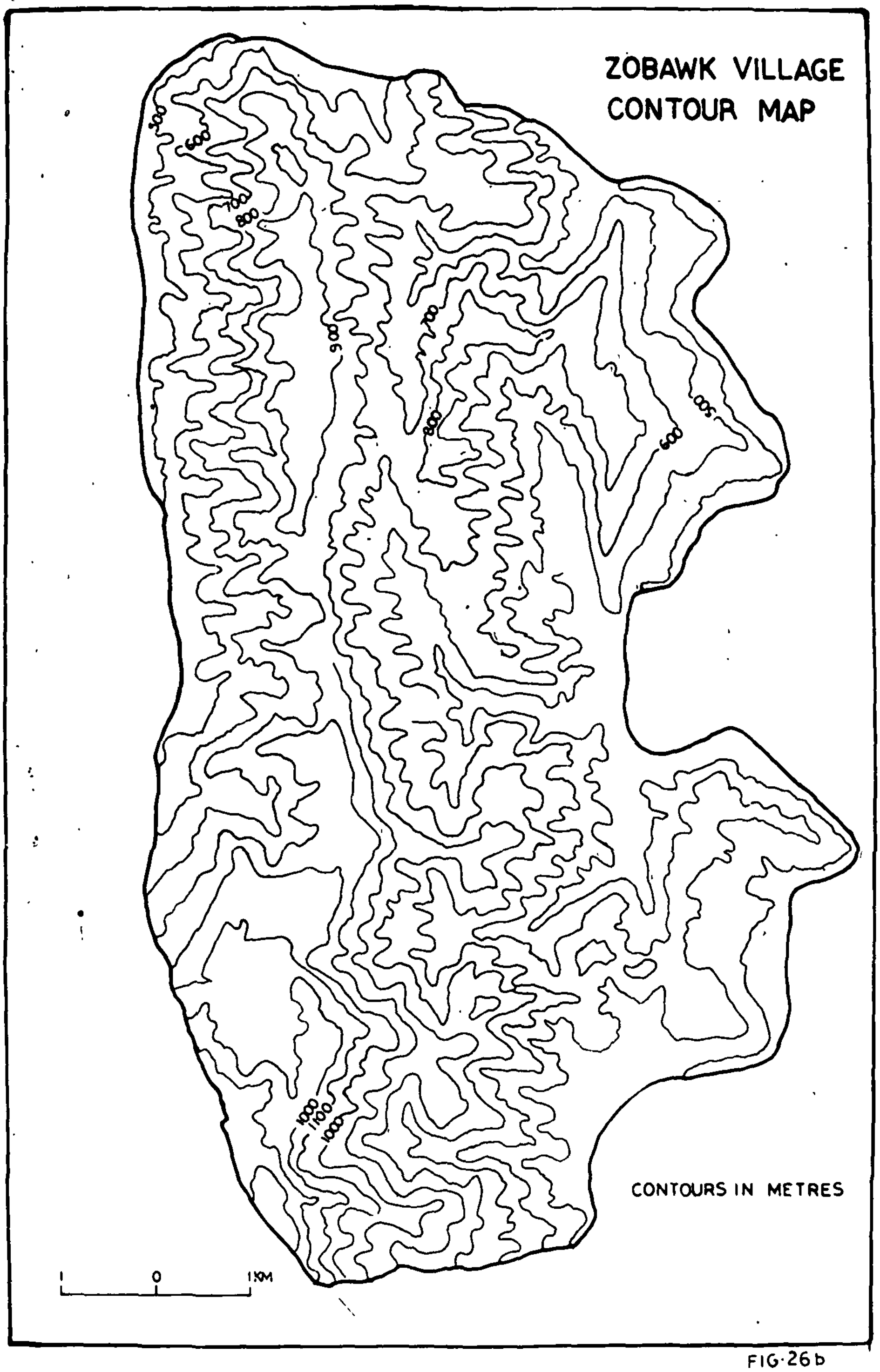
The agricultural landuse study of five villages of the district reveals that the agricultural fields of the villages aree unevenly distributed. There are a number of physiographic as well as geomorphic factors influencing this unevenly distribution of agricultural landuse.

The relief maps of five selected villages of Lunglei district (fig. 25a, 25b, 25c, 25d & 25e) show that except Lungsen village, the relief features of all the four villages are very dissected and hinders the development of agriculture. It is handicapped by steep slopes and resultant hill wash, lack of irrigation facilities and the surface soil seems to be inferior and less productive. In rainy season, much of the surface soil is washed away by sheet and gully erosion. Due to the varying degree of headward erosion, the debris slopes has been much reduced, and the hills have been severely cut to form ridges and spurs.

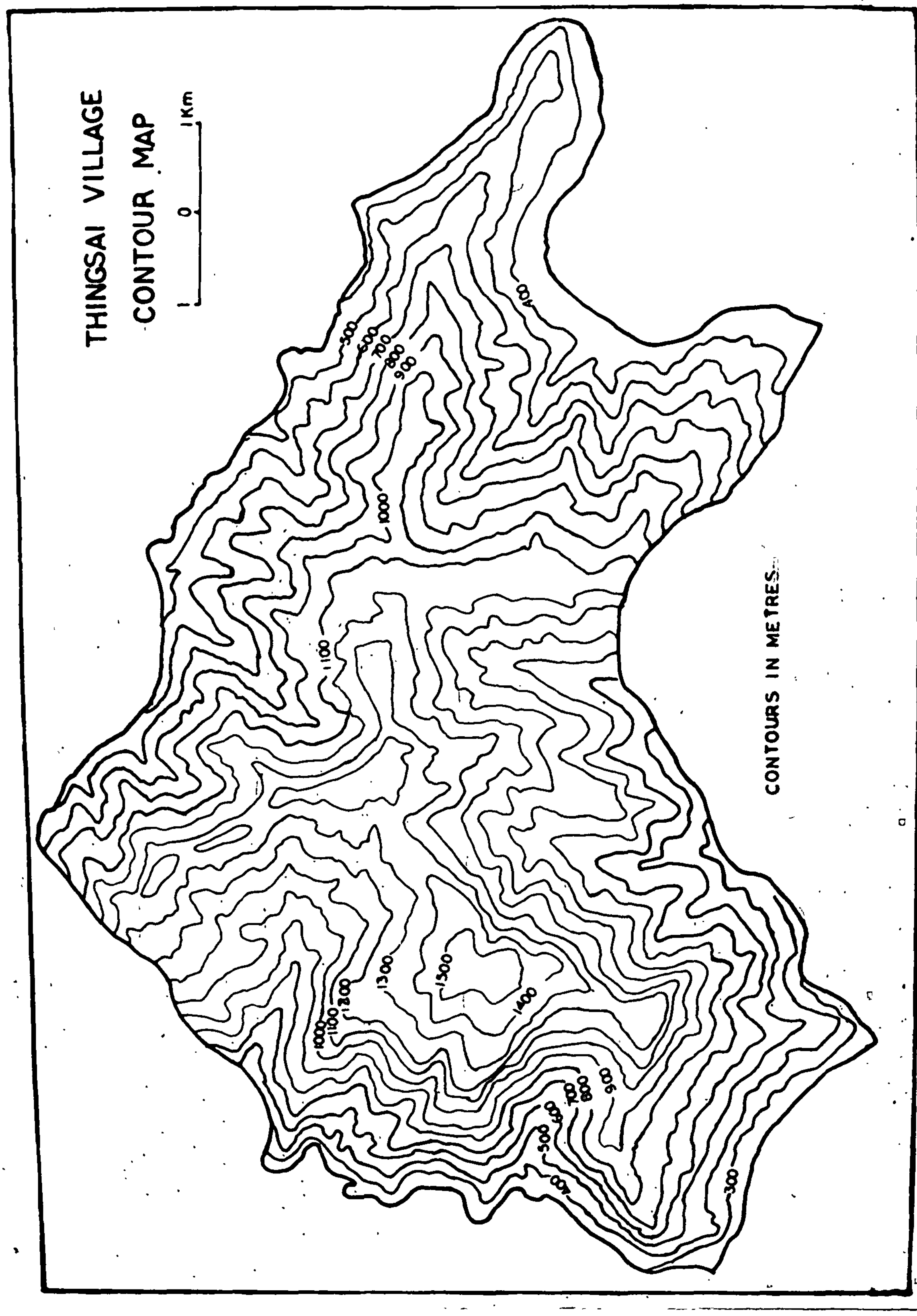
Among the several indirect effects of relief of these villages is the hindrances on the accessibility through road. Large areas in all the villages are lying unapproachable and are beyond the reach of modern technical advantage


S·VANLAIPHAI VILLAGE
CONTOUR MAP
1 0 1 2 Km
CONTOUR IN METRES
800
900
1000
1100
1200
1300
1400
1500
1600
1200
1100
1000
900
800
700
600
500
1100
1000
900
800
700
600
500

FIG·26a


ZOBAWK VILLAGE
CONTOUR MAP
500
600
700
800
900
700
800
500
600
1000
1100
1000
CONTOURS IN METRES
1
0
1KM

FIG·26b


THINGSAI VILLAGE
CONTOUR MAP
1
0
1Km
CONTOURS IN METRES
300
400
500
600
700
800
900
1000
1100
1200
1300
1400

FIG·26c

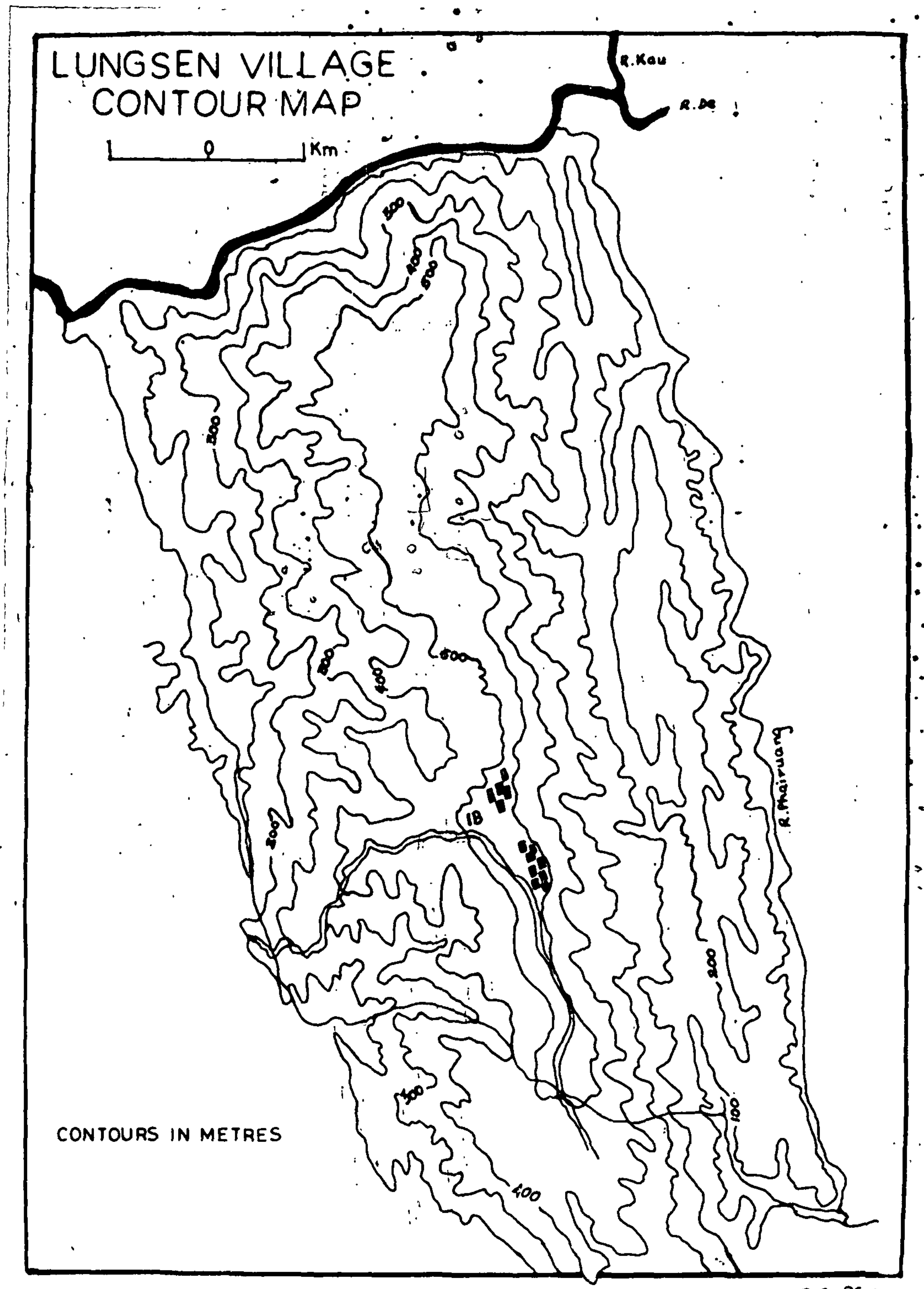

LUNGSEN VILLAGE
CONTOUR MAP
0
Km
R. Kau
R. De
R. Phairuang
IB
CONTOURS IN METRES
500
800
700
600
300
400
200
100

FIG. 26d

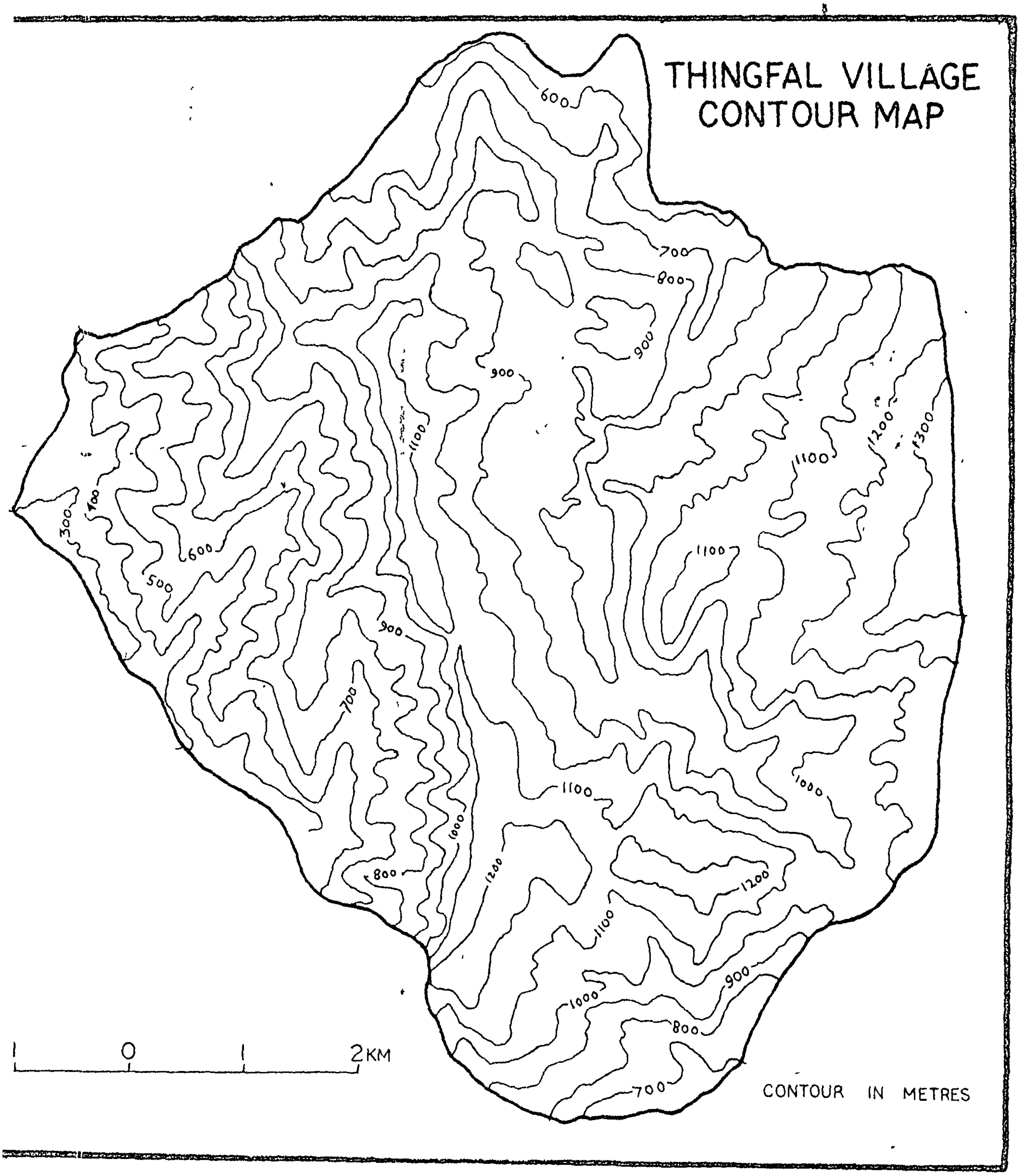

THINGFAL VILLAGE
CONTOUR MAP
600
700
800
900
900
1100
1100
1200
1300
1100
300
400
600
500
900
700
1100
1000
1000
800
1200
1200
1100
900
1000
800
700
0
1
2KM
CONTOUR IN METRES

FIG 26e

of agricultural implements due to dissected terrain.

Drainage and Agriculture

Drainage is the study of the manner in which water flows over an area. In Geography drainage is a comprehensive expression. It includes surface as well as underground drainage (Enayet Ahmed, 1981).[12] The surface drainage is of two types. One is the drainage that occurs during the precipitation of moisture. Falling rain water flows according to the slope of land along the established channels of water flow viz. streams or nullas. At the time of rain, all the rain that falls in the upper catchment also passes through a particular area.

River, along with their numerous affluents and tributaries form the principal features of the area. Not only the surface drainage but even underground drainage bears a profound influence upon the landuse patterns and capabilities in the region. It has been firmly recognised that the fundamental factor permitting or prohibiting cultivation is water, ground water, flood water or rain water (Jha, 1979).[13] Therefore, any attempt to study landuse patterns and problems of a region has to take drainage factor into consideration.

Lunglei district is drainage by Tlawng, Khawthlang tuipui and Chhimtuipui rivers with their numerous large and small tributaries (fig. 5). The drainage of Lunglei district is closely related to the structural characteristics and relief of the area. The rainfall is generally torrential. Similarly, the surface

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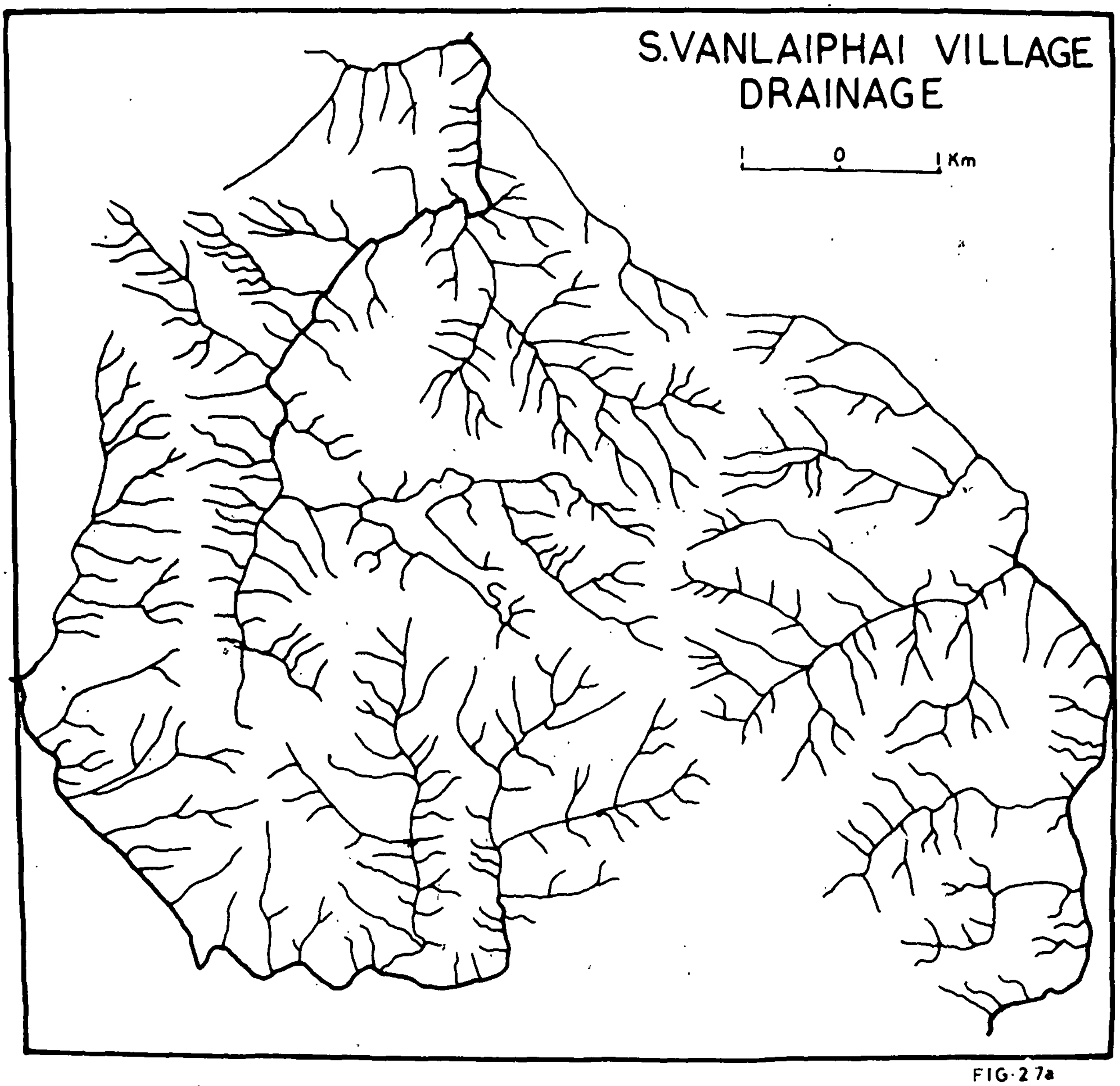
[12] *Enayet Ahmed, (1981), Op.cit., pp.183-185.*

[13] *Jha, B.N. (1979), Problems of land Utilization - A Case Study of Kosi region, Classical Publication, New Delhi, p.16.*



FIG·27a

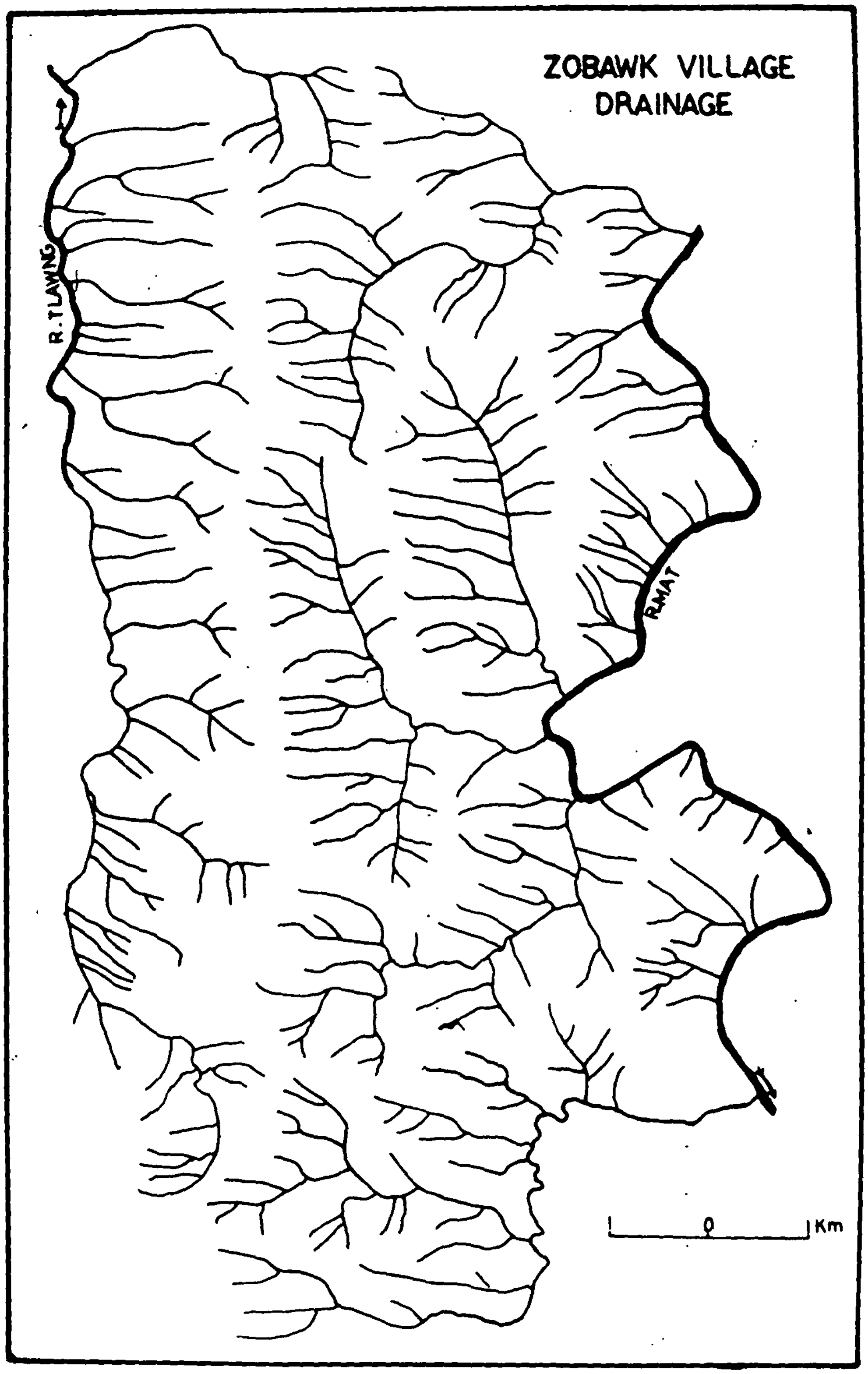


FIG. 27b

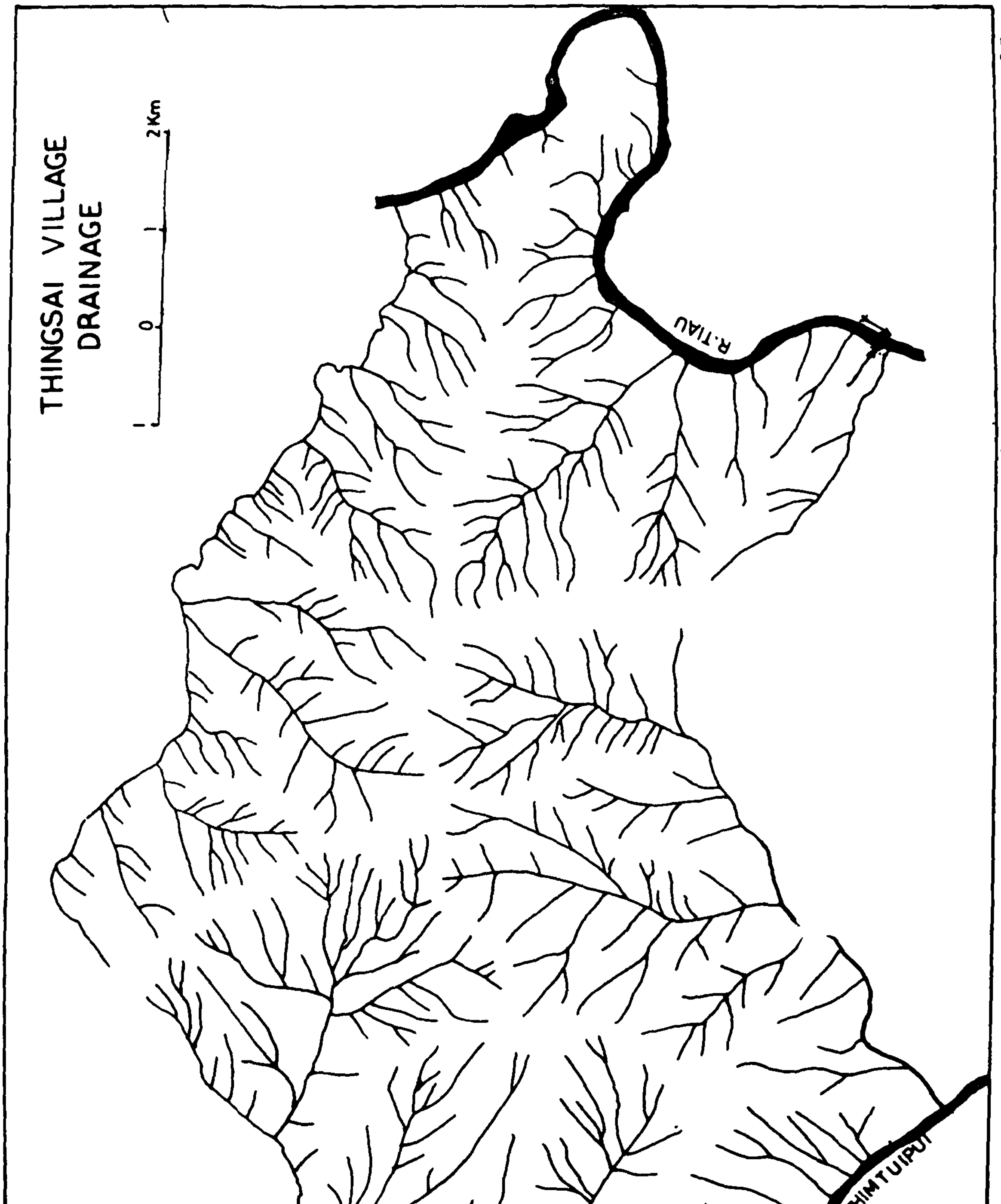


FIG 27c

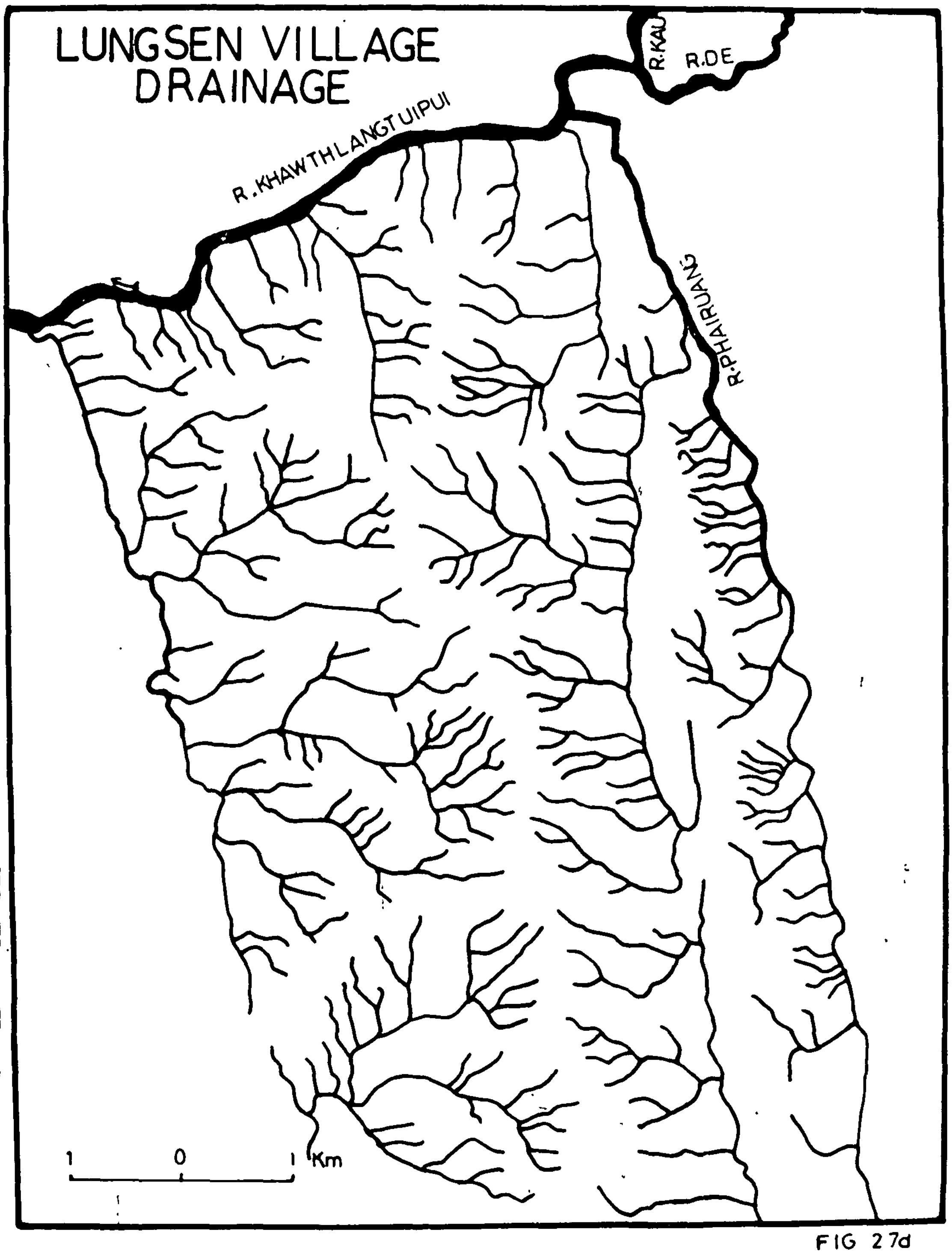

LUNGSEN VILLAGE
DRAINAGE
R. KHAWTHLANGTUIPUI
R.KAU
R.DE
R.PHAIRUANG
1 0 1 Km

FIG 27d

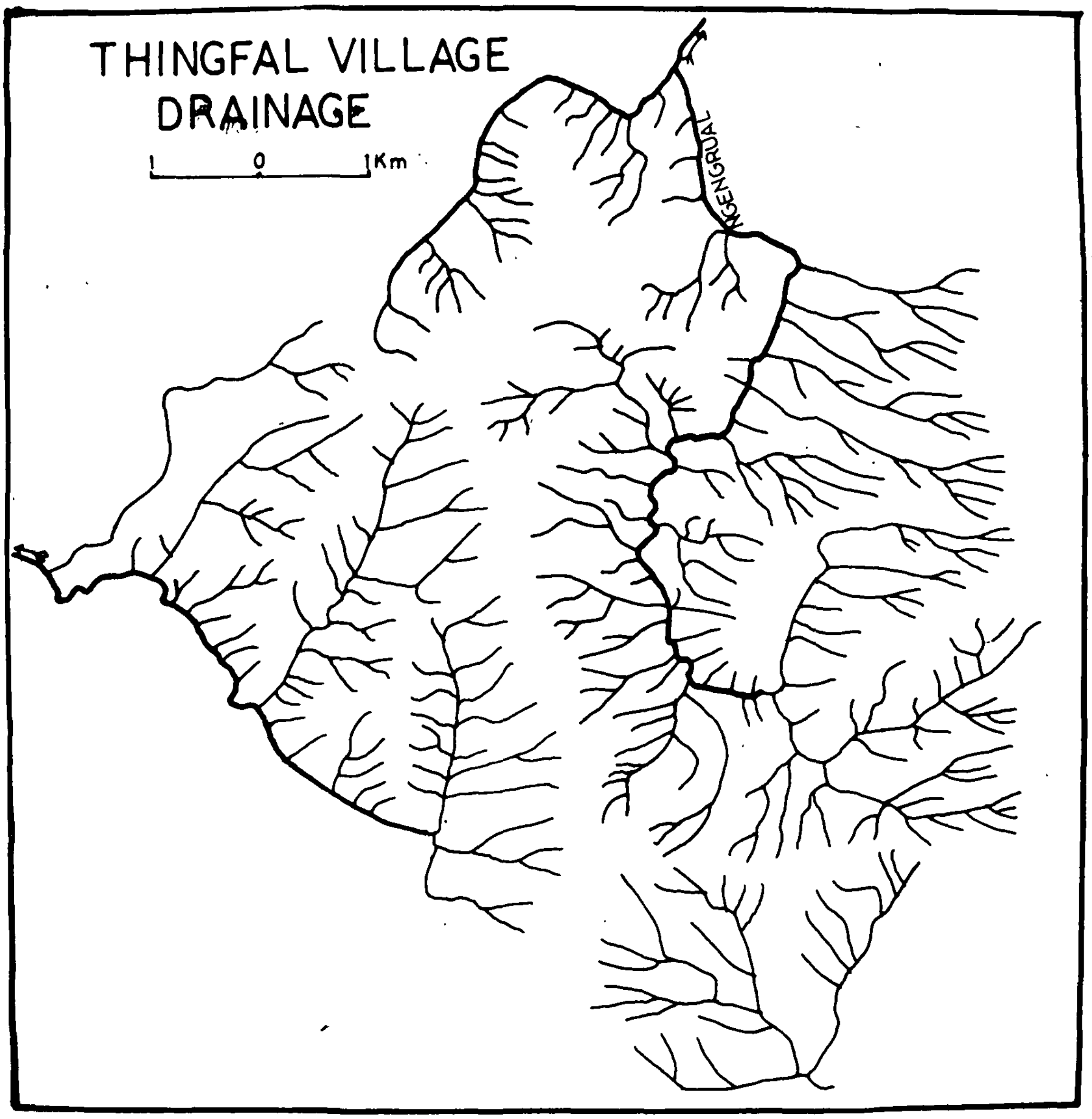


FIG. 27e

configuration, because of market steep slope leads to rapid run off of water.

It can be seen from the stream frequency maps of five selected villages of Lunglei district (fig. 28a, 28b, 28c, 28d & 28e) that the stream frequency is ranging from below 6 to 12 and above per 1 sq. km. If we superimposed the stream frequency maps of five selected villages (fig. 28a, 28b, 28c, 28d & 28e) and Agricultural land use maps of the same villages (fig. 23a, 23b, 23c, 23d & 23e) it is interesting to note that the stream frequency and agricultural land use has interesting relationship.

The agricultural landuse viz. wet rice cultivation, hill terrace cultivation and Horticulture of Zobawk, Thingfal and Thingsai villages are covered by the high stream frequency of 8-12 and above per 1 sq. km. Whereas the other two villages of Lungsen and South Vanlaiphai are covered by medium stream frequency of 6-8 per 1 sq. km. This is due to the fact that the stream frequency increases with the increase of relief.

From the above analysis, it is clear that drainage lines are numerous in number in all the five selected villages, but they are intricate in pattern and their behaviour is erratic. The greater is the number of streams, the greater are the prospects of moisture supply. But this advantage is obstracted by rugged terrain which hardly allows water to be stationary along the courses of the rivers. Rainfall is also the most important source that provide the indispensible moisture to land but the study area receives more than 80 per cent of rainfall only during the four months of June-September. After rainy season, the streams are completely dry.

The drainage maps of five selected villages of Lunglei district (fig. 27a, 27b, 27c, 27d & 27e) reveal that the streams of all the villages are the typical hilly streams and the characteristics of a hilly streams are worth recording.

Firstly, the hilly streams like the present one tend to cut the surface vertically because of the steeper gradient and soft rock formations.

Secondly, the underground water table is very low. When the rain falls the surface runoff is more due to steep slopes.

Thirdly, the water partings that separate one sub-catchment from another are well defined. The streams have smaller catchment area in comparison to plain streams. This is because of the structure of the rocks which permits but restricts widening of channels.

Fourthly, the streams show the presence of rapid and waterfalls and therefore, there is lack of irrigation and navigational advantages. Much of the benefits to agriculture are lost.

The superimposition of the drainage maps of four selected villages of Zobawk, Thingfal, Thingsai and South Vanlaiphai (fig. 27a, 27b, 27c, & 27e) and agricultural land use of the same village (fig. 27a, 27b, 27c & 27e) reveals that these villages have limited agricultural land. As these villages are located in the micro-geomorphic regions of Highly dissected, sharp crested region and central and Eastern Escarpment region. Essentially the river and streams show youthful characteristics which flow between the high hills and joining the main streams. This fact actually necessitates the construction

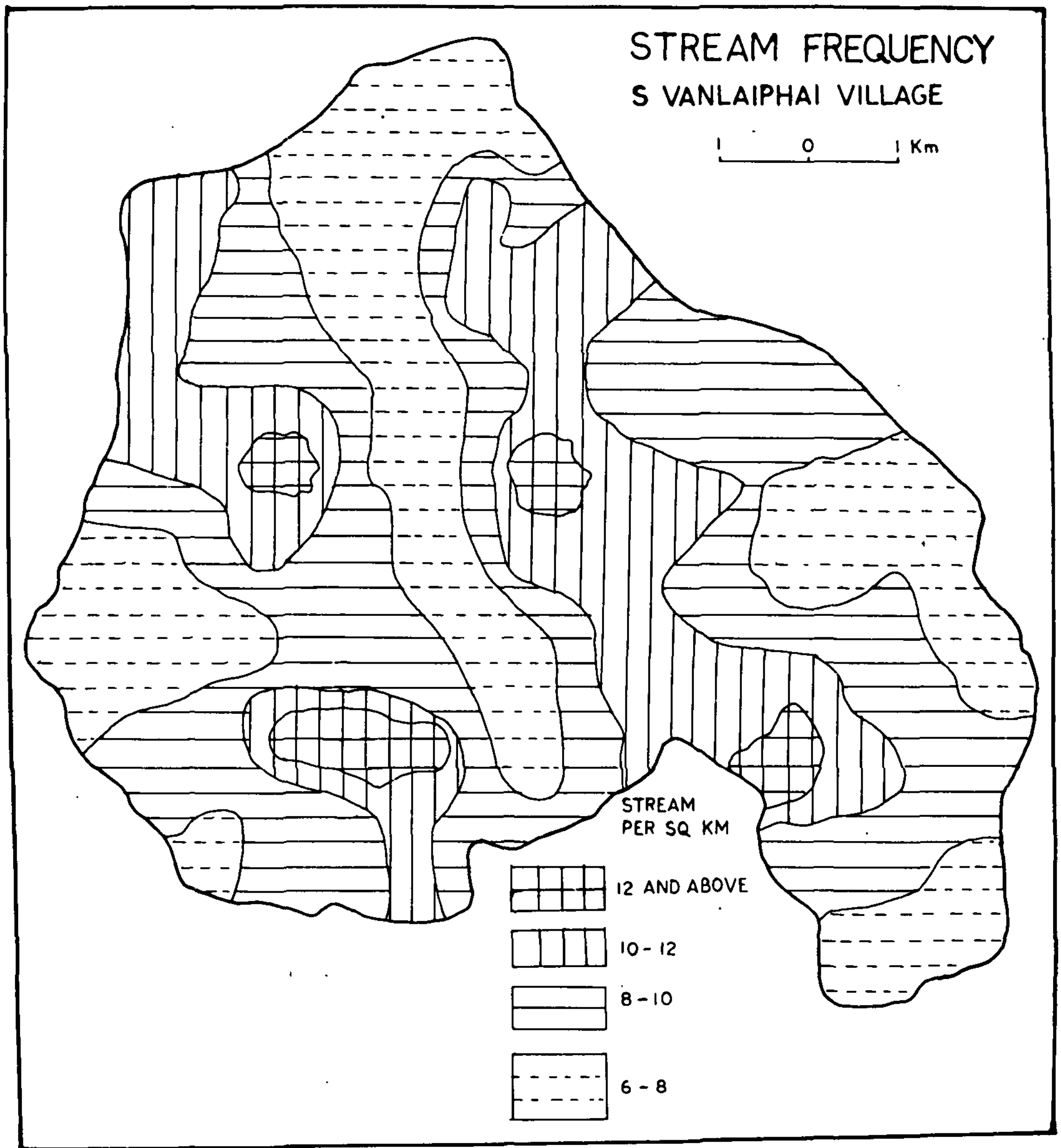
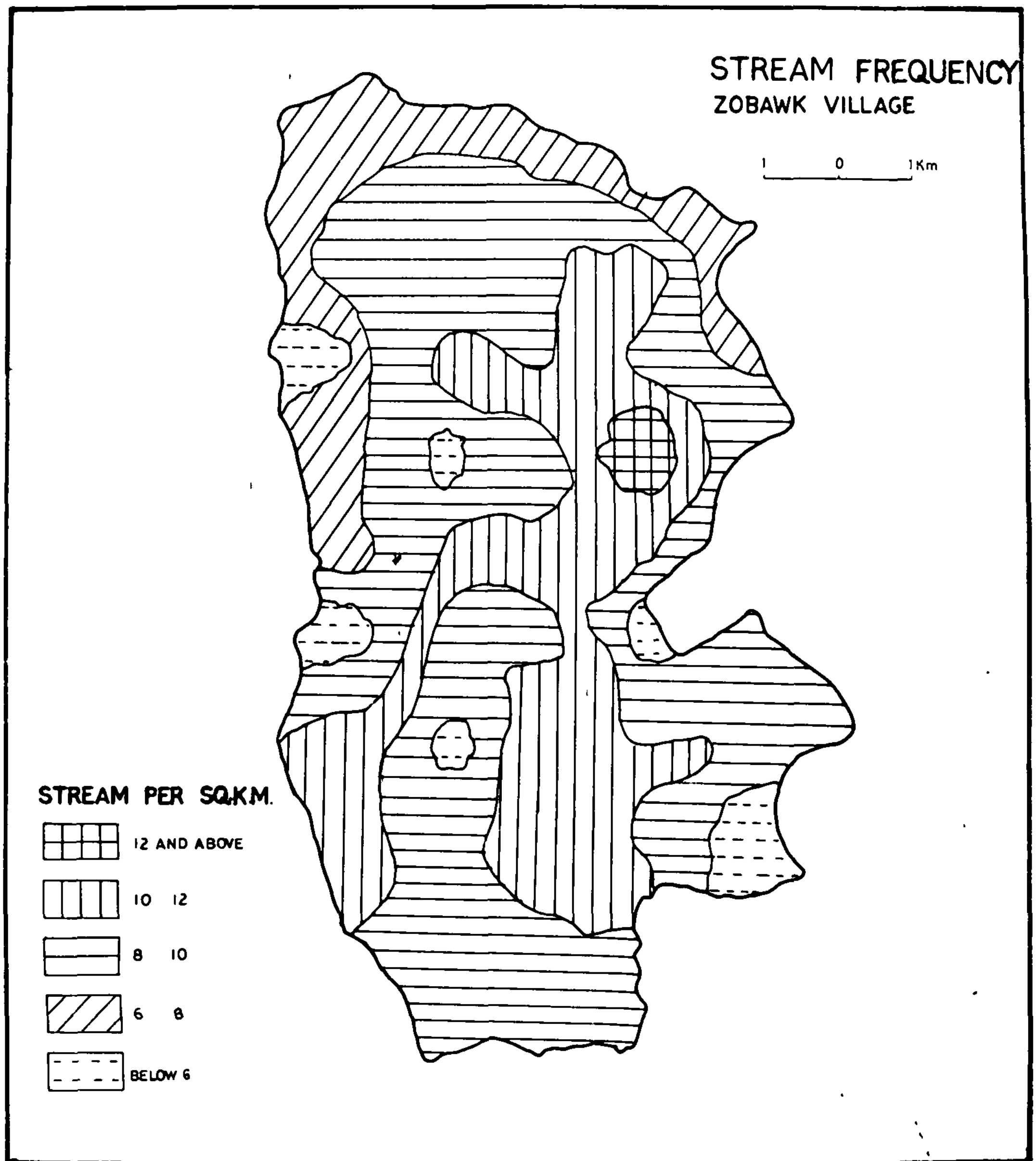

STREAM FREQUENCY
S VANLAIPHAI VILLAGE
1 0 1 Km
STREAM PER SQ KM
12 AND ABOVE
10 - 12
8 - 10
6 - 8

FIG.28a


STREAM FREQUENCY
ZOBAWK VILLAGE
1 0 1Km
STREAM PER SQ.K.M.
12 AND ABOVE
10 12
8 10
6 8
BELOW 6

FIG·28 b

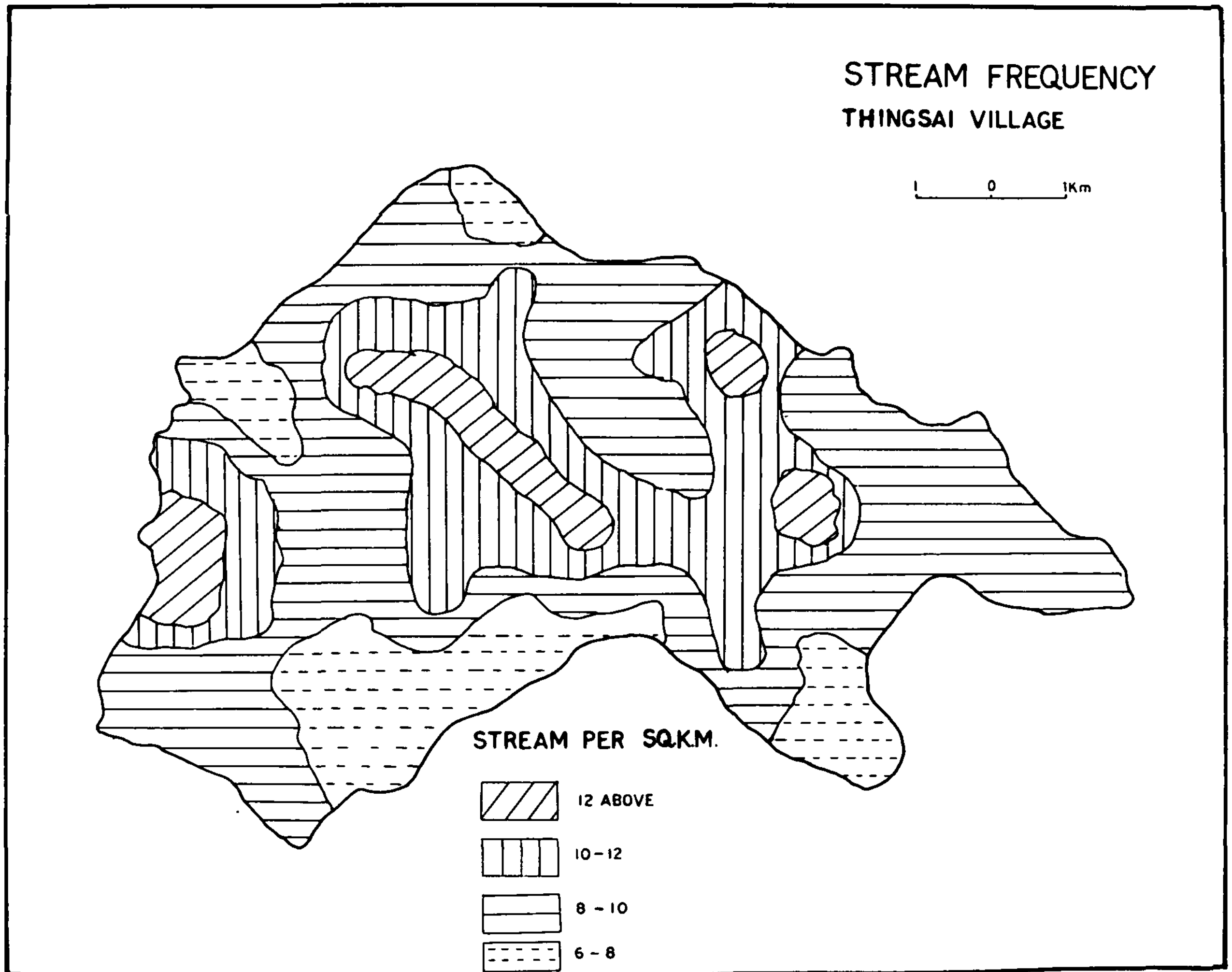

STREAM FREQUENCY
THINGSAI VILLAGE
1 0 1Km
STREAM PER SQ.K.M.
12 ABOVE
10 - 12
8 - 10
6 - 8

FIG 28c

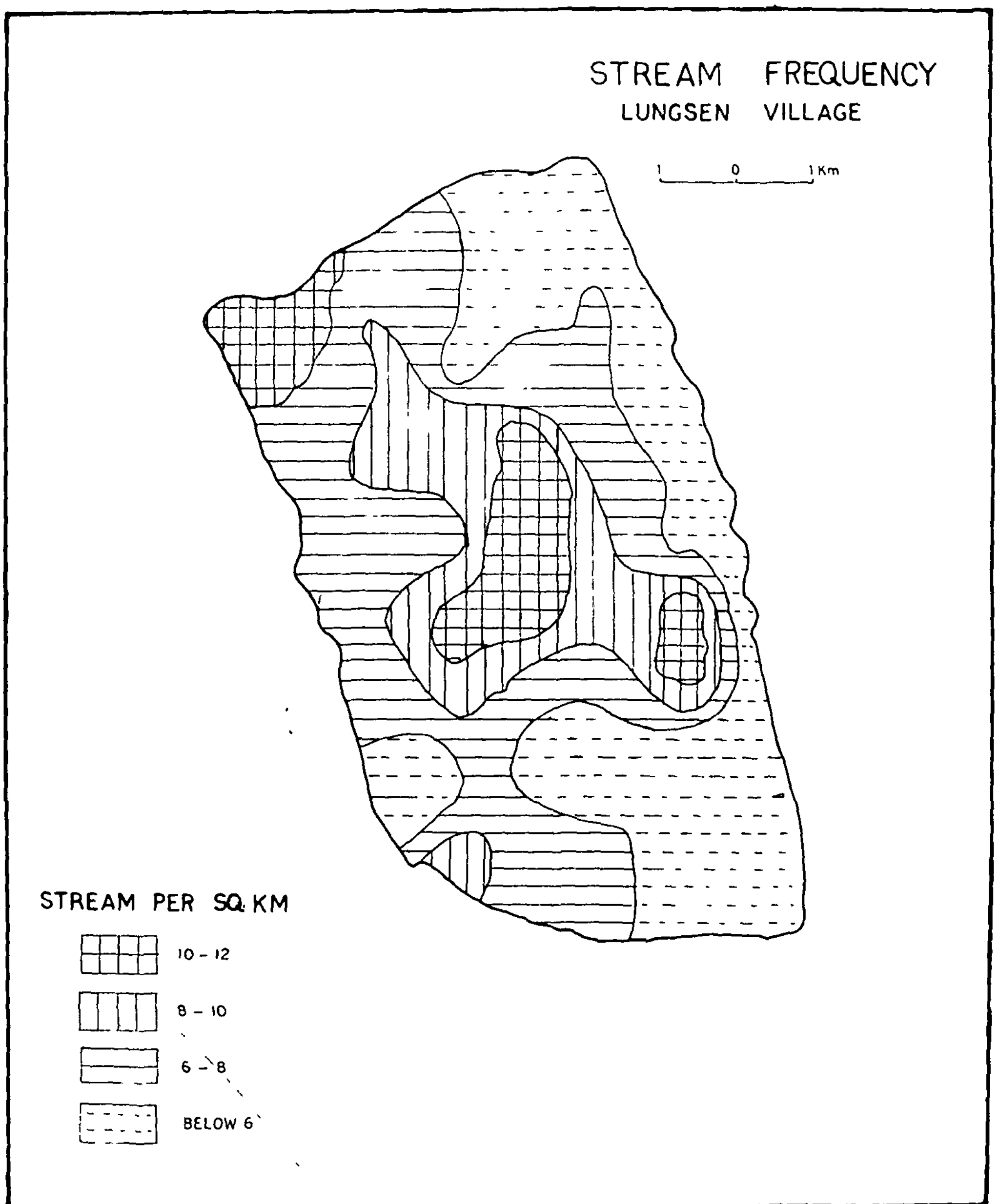
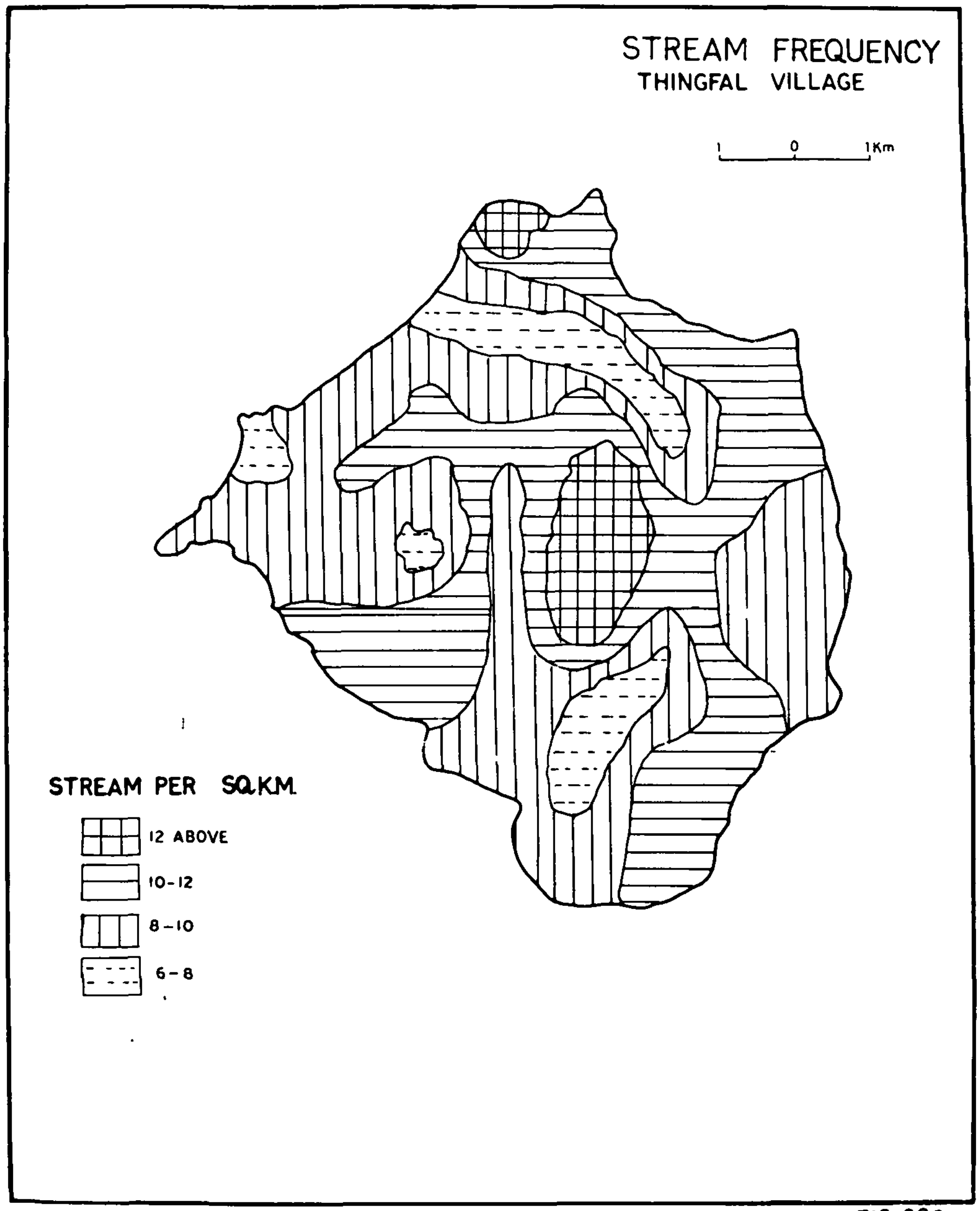

STREAM FREQUENCY
LUNGSEN VILLAGE
1 0 1 Km
STREAM PER SQ.KM
10 - 12
8 - 10
6 - 8
BELOW 6

FIG.28a


STREAM FREQUENCY
THINGFAL VILLAGE
1 0 1Km
STREAM PER SQ.KM.
12 ABOVE
10-12
8-10
6-8

FIG·28e

of dams across the rivers and its tributaries but it is practically impossible due to steep slope. Another notable impact is that of erosion. The steeper gradient has naturally led to the flowing of streams at a high velocity. Heavy erosion of steeper surfaces and moderately to less steeper surfaces naturally therefore follows. Various types of erosion depending on the degree of slopes of the land are found in all the villages e.g., gully erosion, rill erosion, and sheet erosion. The result has been not only the appearance of unproductive land over the surface but also disappearance of valuable soil. The headward erosion which typical of a younger terrain is very pronounced and is rapidly eating back the land. The impact of such a feature is really distressing to agricultural land use in these villages.

The superimposition of drainage map of Lungsen (fig. 27d) and agricultural land use map (fig. 23d) reveals that Lungsen village, which is located in the moderately dissected undulating hill region of the west have better agriculture lands. Lungsen village is situated at the confluence of two small rivers of Phairuang and Tuichawng. Here due to marked undulating surface, the river water can be utilized for agricultural purposes.

From the above discussion, the drainage is speedy except the south western part of Lunglei district. Underground reservoir is limited by folded and faulted structure and marked slope adding quick run off. Divides are well-marked in the region of marked relief. Although the density of streams is quite high it is of little significance to agricultural land use owing to the fact that the rugged terrain does not allow the water to be stationary along the courses. As the area is one of the marked relief amplitude the high velocity *of water flow with deep gorges has resulted into erosion-gulling near the stream banks and still sheet erosion further away causing serious depletion of fertility and loss of agricultural land.*

Land Capability Classes

Land capability classification is a systematic segregation of different kinds of lands which are distinguished from one another by variation in the kind and degree of use imposed by soil characteristics, slope, climate, degree of erosion and other factors (Sharma 1968).[14] The different kinds of land according to their properties determine the ability of the land to produce virtually on permanent basis Jagadesh (1983).[15] The specific appraisal of physical attributes of any area is important for the balanced agricultural development.

The determination of capabilities of land in a particular area calls for a variety of factors to be taken into consideration. Broadly, these factors are of two types viz. (a) External and (b) Internal. The external group includes such factors as topography, drainage, degree of slope, stoniness and ruggedness, texture and yield of crops. The other type i.e., internal includes such points as mechanical and chemical properties of soil, soil reaction, permeability, aggregation, water holding capacity. Land capability classification based on only one of these types will obviously be incomplete and inaccurate. It is only by taking all the variables belonging to both groups that we may reach

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[14] Sharma H.S. (1968), Land capability classification of the Lower Chambal valley, Proc. symp. Land use in Developing Country, Aligarh Muslim University, pp.173-79.

[15] Jagadesh, J. (1983), Landforms and settlements in Varada River basins. Ph. D. thesis Karnataka University, Unpublished Ph.D. thesis, p.290.

a desirable level of accuracy in suggesting any worthwhile land capability classification. Factors in the external group are, however, easier to assess which has also been the practice of geographers till now. The Geographers of today are contended with only the visual aspects of soil and obliged to do so in view of their limitation. Hence, the capability classification does so far has been one of approximation and inadequacy (Chaudhury 1982.)[16]

The determination of land capability classes is a relatively a new concept in land use geography. It indicates the potential productivity of the land by taking into consideration the different physical condition of land viz. nature of soil productivity, soil depth, its degree of rock exposure and extent of erosion. The land capability map of any region gives a complete appraisal of land conditions and also indicates possible lines of more intensive development of land use in future Jha (1979).[17] *Therefore, the determination of land capability classes forms an integral part of land use study of a region. The Soil Conservation Department, Government of India have recognised a series of seven land capability classes following the genral pattern adopted by the U.S. soil conservation Service. These Seven land capability classes broadly come under two groups. (i) land suitable for cultivation (ii) land unsuitable for cultivation. The first four classes stand for land suitable for cultivation, whereas the last three classes are unsuitable for cultivation, while the first four determine the comparative suitability of land under arable farming, the last three indicates capability of land for non-arable*

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[16] *Chaudhury, B.N. (1982), Land Utilization in Subarnekha Basin. Classical Publishing Company, New Delhi, p.218.*

[17] *Jha, B.N. (1979), Problems of Land Utilization : A Case Study of Kosi Region, Classical Publications, New Delhi, p.62.*

farming. In all the lands of Lunglei district excepting a small area are unsuitable for cultivation and hence they have been classified into last three classes i.e., land unsuitable for cultivation.

The major factors, which determine land capability are the mechanical and chemical properties of soil, soil reaction, permeability, aggregation, water holding capacity etc. Owing to the lack of data of above factors, the researcher has taken the land capability of the five selected villages of Lunglei district from the factors as topography, drainage, angle of slope, stoniness and ruggedness. On the basis of this the researcher has explained the land capability of the selected villages of the district.

Having found out the details of external characteristics of the village lands the researcher has divided the five selected villages of Lunglei district into three capability classes. Following are the factors that have been taken into account for demarcating land capability classes in the villages. These factors are:

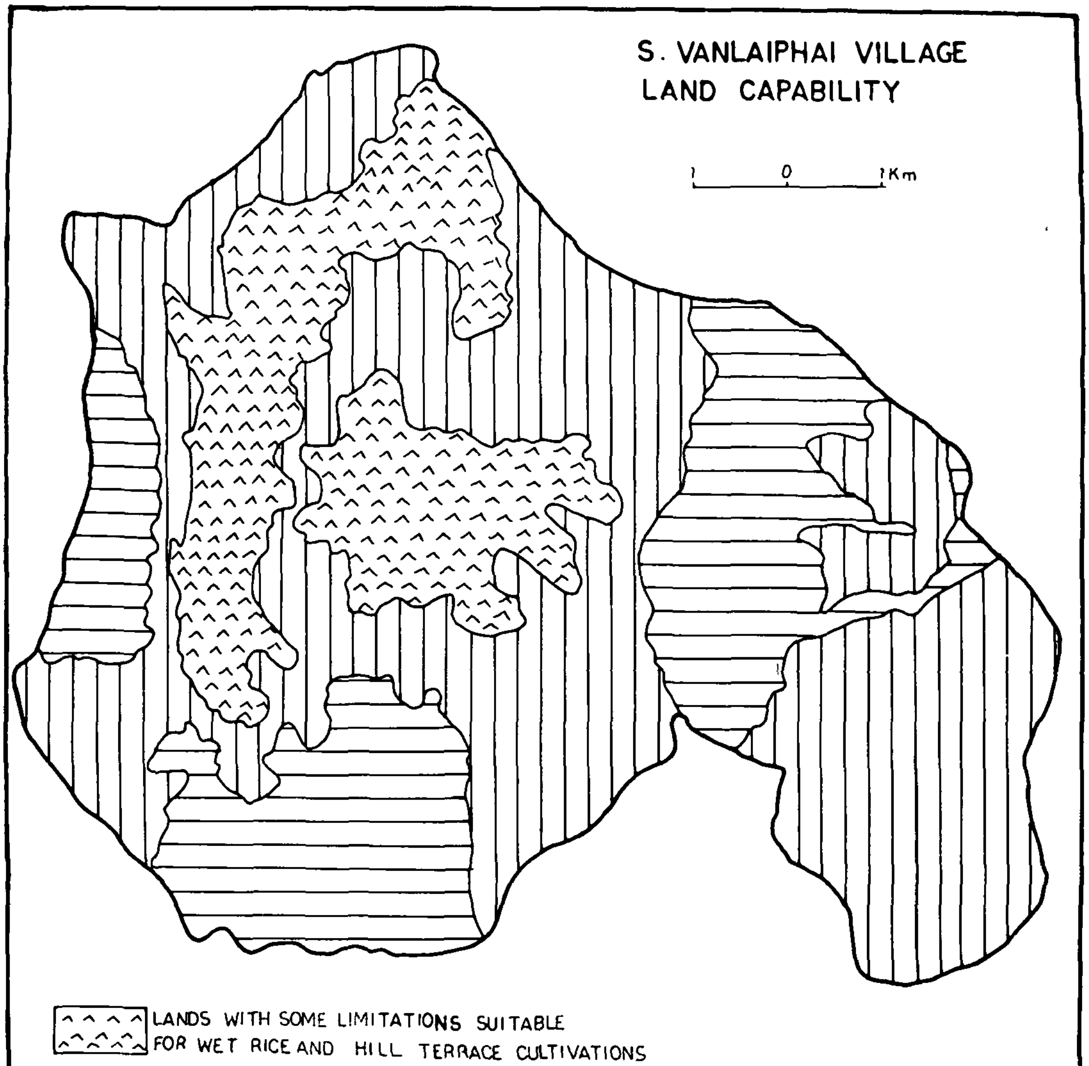
(i) Topography: The lowlands receive washings from uplands and are thus more fertile.

(ii) Drainage: Lands near to drainage lines are more potentially rich because of irrigation prospects. The drainage also influences the extent of erosion.

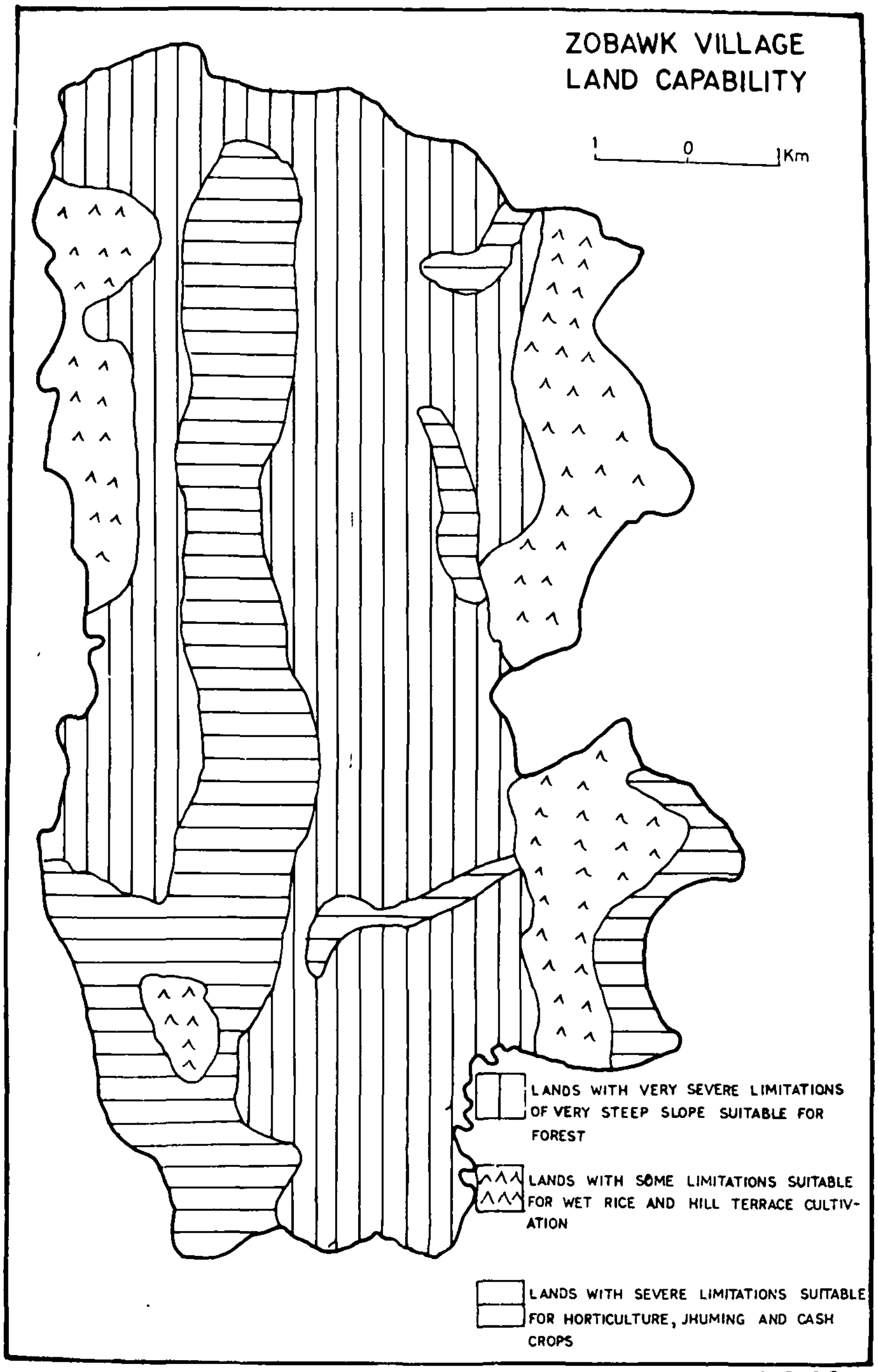
(iii) Angle of Slope: The lands which have low gradient are more suitable for cultivation.

(iv) Ruggedness and Stonniness: The lands which have rugged surfaces always stonny and are not suitable for cultivation.

Land capability classes have been determined on the basis of 1:50,000 topographical sheets of the Villages and intensive field work.


S. VANLAIPHAI VILLAGE
LAND CAPABILITY
1 0 1Km
LANDS WITH SOME LIMITATIONS SUITABLE FOR WET RICE AND HILL TERRACE CULTIVATIONS
LANDS WITH SEVERE LIMITATIONS SUITABLE FOR JHUM AND CASH CROPS
LANDS WITH VERY SEVERE LIMITATIONS BY STEEP SLOPE SUITABLE FOR FOREST & HORTICULTURE

FIG·29 a


ZOBAWK VILLAGE
LAND CAPABILITY
1 0 1 Km
LANDS WITH VERY SEVERE LIMITATIONS OF VERY STEEP SLOPE SUITABLE FOR FOREST
LANDS WITH SOME LIMITATIONS SUITABLE FOR WET RICE AND HILL TERRACE CULTIV-ATION
LANDS WITH SEVERE LIMITATIONS SUITABLE FOR HORTICULTURE, JHUMING AND CASH CROPS

FIG·29b

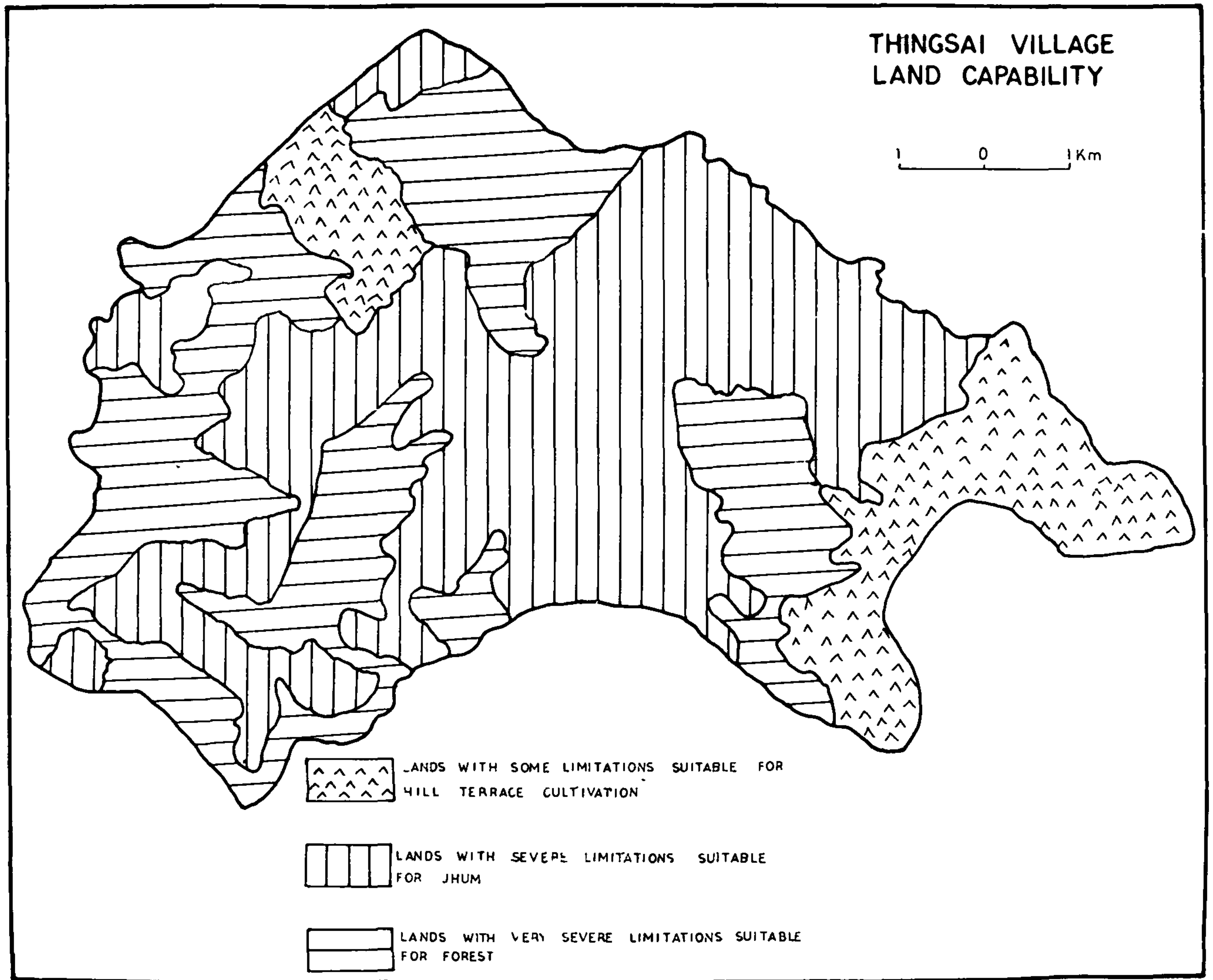
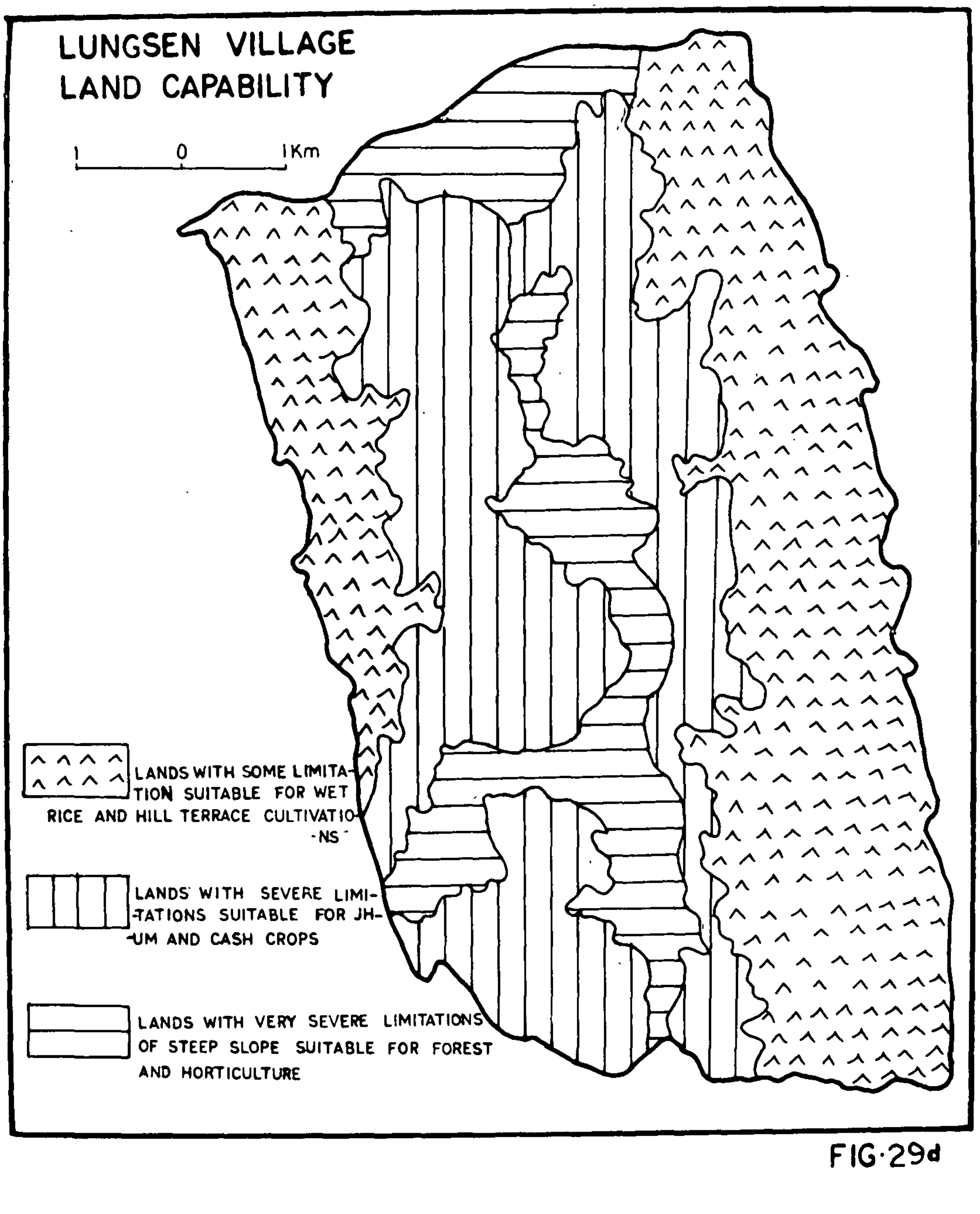
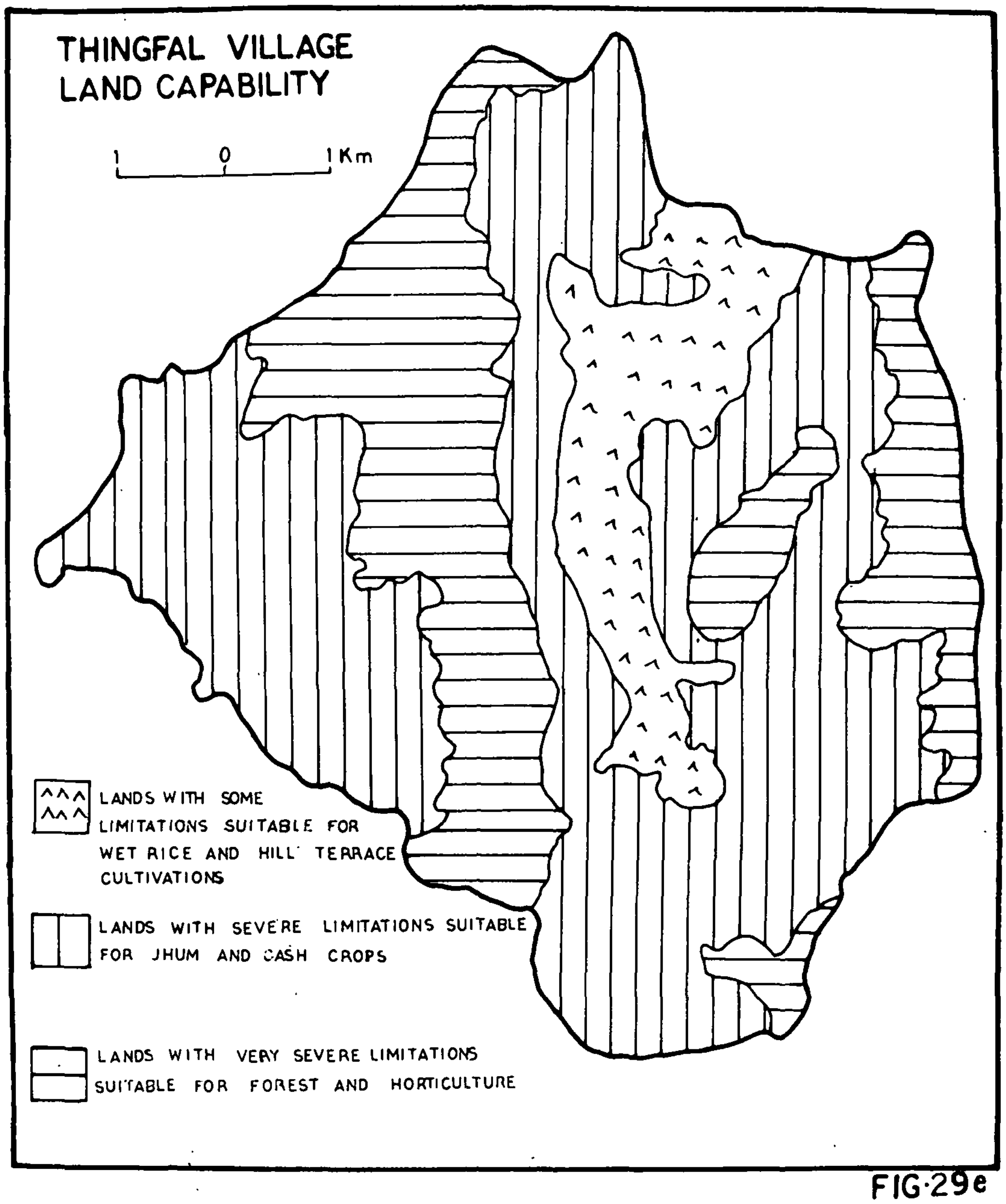

THINGSAI VILLAGE
LAND CAPABILITY
1 0 1Km
LANDS WITH SOME LIMITATIONS SUITABLE FOR HILL TERRACE CULTIVATION
LANDS WITH SEVERE LIMITATIONS SUITABLE FOR JHUM
LANDS WITH VERY SEVERE LIMITATIONS SUITABLE FOR FOREST

FIG.29 c


LUNGSEN VILLAGE
LAND CAPABILITY
1 0 1Km
LANDS WITH SOME LIMITATION SUITABLE FOR WET RICE AND HILL TERRACE CULTIVATIONS
LANDS WITH SEVERE LIMITATIONS SUITABLE FOR JHUM AND CASH CROPS
LANDS WITH VERY SEVERE LIMITATIONS OF STEEP SLOPE SUITABLE FOR FOREST AND HORTICULTURE

FIG·29d


THINGFAL VILLAGE
LAND CAPABILITY
1 0 1 Km
LANDS WITH SOME LIMITATIONS SUITABLE FOR WET RICE AND HILL TERRACE CULTIVATIONS
LANDS WITH SEVERE LIMITATIONS SUITABLE FOR JHUM AND CASH CROPS
LANDS WITH VERY SEVERE LIMITATIONS SUITABLE FOR FOREST AND HORTICULTURE

FIG·29e

The above mentioned factors have been very reliably assessed and on this basis the map of land capability classes have been prepared by the author. As mentioned above the scheme of this classification follows the pattern of capability classes adopted by the U.S. Soil Conservation service. The three capabilities into which these five selected villages of Lunglei district have been divided are as follows:

(i) Lands with some limitations suitable for wet rice and hill terrace cultivation.

(ii)Lands with severe limitations suitable for Jhum and Cash crops.

(iii)Lands with very severe limitations suitable for forest and horticulture.

The land capability maps (fig. 29a, 29b, 29c, 29d, & 29e) of five selected villages of Lunglei district reveals that the areas having a plot of lands with some limitations suitable for wet rice and hill terrace cultivation is extremely limited in all the villages excepting Lungsen village. The other classes of land, the lands with severe limitations suitable for Jhum and Cash crops and lands with very severe limitations suitable for forest and horticulture are extensively shared by all the villages.

In these three classes of lands the villagers practise Jhum cultivation and not a considerable lands are utilized for wet paddy, and hill terrace. The lands with some limitations is invariably suitable at lower level and low gradient especially along the intermont valley plain. The moisture retention as well as the water supply of these lands are better than the other two categories. These lands can be fully or partially utilized for wet rice and hill terrace cultivation. The farmers are not utilizing properly otherwise this class of land can be developed. The lands with severe limitations occupies *the maximum areas in all the five selected villages excepting Lungsen village. As it is now practicallyimpossible to change suddenly the occupationof the tribal who inhabits the area. Jhuming is not only an occupation but their traditional way of life. This lands may be suitable for Jhum cycle and also for the cash crops like ginger, sugar cane, Tobacco, etc. The lands with very severe limitations occupies scarps, barren lands, forested area, deep gorges and very steep slopes. This land can be allotted for forest and horti-culture crops.*

THE INFLUENCE OF GEOMORPHOLOGY ON DISTRIBUTION OF POPULATION, SETTLEMENT AND TRANSPORT AND COMMUNICATION

The geomorphic features of any region has a direct impact on the human life of the region.[1] *If we examine the human and economic characteristics of Lunglei district in the Union Territory of Mizoram, we can find a considerable influence of geomorphic features on the distribution of population, settlements and transport and communication.*

Geomorphology and Distribution of Population

Lunglei district has a total area of 4538 sq. km. with a total population of 86,511 persons according to 1981 census.[2] *In the district there are four Community Development Blocks such as Lunglei, Hnahthial, Lungsen and Bunghmun. According to the census of 1981 the average density of population in the district is 19 persons per square kilometre, which is lower than the Union Territory of Mizoram average of 23 persons per square kilometre.*[3] *The density of population amongst the four blocks in the district is uneven. This unevenness may be correlated with the nature of relief, slopes and climatic factors.*

In order to have a clear picture of the distribution of population, the analysis of population has been done on the Block level data.

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[1] *Rai, R.K. (1980), Geomorphology of Sonar-Bearma Basin. Concept Publishing Company, New Delhi, p.115.*

[2] *Census of India, 1981. Paper I of 1981 supplement, Provisional Population Totals Series 31 Mizoram.*

[3] *Ibid.,*

TABLE 15

Block-wise Density of Population per sq. km. of rural area, 1981.

Blocks	Rural area (Sq. km.)	Rural population (1981 Census)	Density
Lunglei	1181	17325	15
Bunghmun	1323	12239	9
Lungsen	1122	21127	19
Hnahthial	912	18615	20

From the above given table, the correlation between the density of population and the physical factors viz. drainage, relief, nature of slope and climatic factors may be made.

The census of 1981 shows that in the rural areas of Lunglei district, the main economic activity is agriculture. 72 per cent of the total workers are engaged in agriculture and agricultural labourers.[4] The distribution of population in Lunglei district, according to 1981 Census, is 19 persons per square kilometer.

If we examine the Block level distribution of population in Lunglei district, according to 1981 Census, we can find that Hnahthial Community Development block has the highest (20 persons per sq. km.) followed by Lungsen Community Development Block (19 persons per sq. km.) and Lunglei Community Development Block (15 persons per sq. km.). The lowest (9 persons per sqk. km.) is noticed in the Community Development Block of Bunghmun. To some extent , cultural and social factors play important role in the distribution

[4]Census of India, 1981, Paper I of 1981 supplement, Provisional Population Totals Series 31 Mizoram.

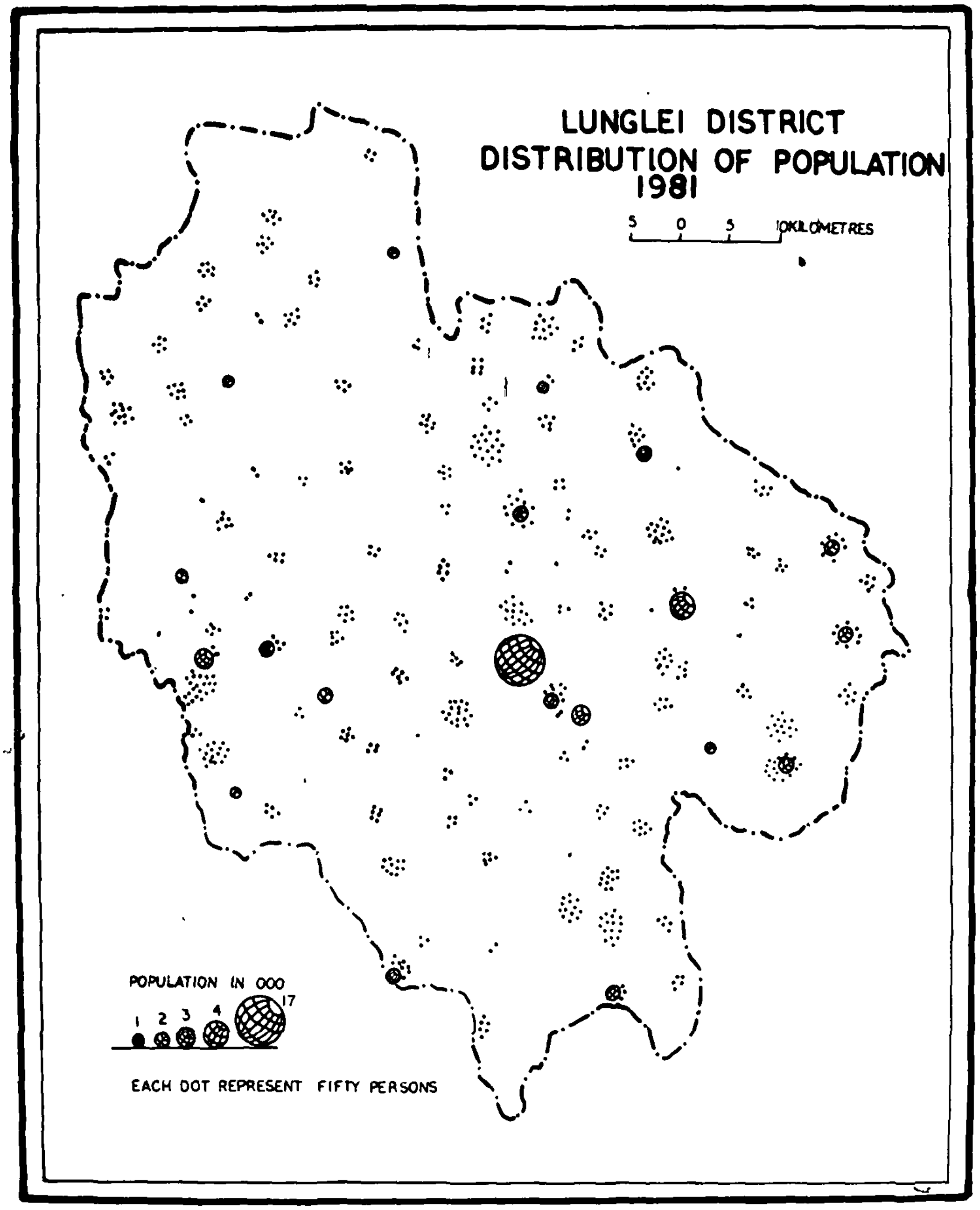
LUNGLEI DISTRICT
DISTRIBUTION OF POPULATION
1981
5 0 5 10KILOMETRES
POPULATION IN 000
1 2 3 4 17
EACH DOT REPRESENT FIFTY PERSONS

FIG 30

of population in this region but the more important factors are relief, drainage, nature of topography and the most important being climatic factors.

The density of population decreases from east to west (fig. 30). The most important factor behind this trend is a east-west increase in humidity and temperature which results into a general unsuitability of the climate for human habitation. The high density of population in Lungsen Block is mainly because of the rapid influx of Chakmas from Bangladesh. In the eastern part i.e. Hnahthail Block where the topography is rugged with narrow valleys. The stream valleys are inhospitable due to their harsh climate, hill-crests and hill-slopes offer good sites for settlement. On the other hand in the western part of the district, the river valleys are favourable for the growth of human settlements but due to harsh climatic conditions like hot, saulty, weather and malarias the population is less distributed.

Urban Centre

The percentage of urban population indicates that only 21.52 per cent of the total population of Lunglei district live in urban centre. There is only one urban centre in the district, i.e. Lunglei town, the headquarters of Lunglei district. All the agricultural products as well as raw materials for cottage industries are provided by the adjoining rural areas. Unfortunately, this region is not rich in agricultural products nor there is mineral resources and only a small population is engaged in other non-agricultural activities. Lunglei, the lone urban centre of the whole district is directly interdependent with rural areas. It is the centre of collection of food grains and other forest products. In the same way, other daily requirements and essential commodities *are brought to this centre. Goods collected at Lunglei town from outside are distributed to the adjoining villages.*

At the same time, cultural factor also plays a role in the distribution of population. The villages located near Lunglei town like Zobawk, Theiriat, Hauruang, Pukpui and Hrangchalkaen expanded into big villages. An important attraction is the opportunity of the employment. The villagers of these villages go to the town for employment and return in the evening. The village people supply vegetables, firewood and other essential commodities to Lunglei town.

Geomorphology and the Distribution of Rural Settlements

The study of settlements is important as the various aspects of settlement in a region reflect man's relationship with the environment. Settlements have gradually evolved over a long period of time and by analysing their sites, types, spatial pattern and functions one could decifer the history of man's exploitation of the surrounding environment and resources.[5]

It is difficult task to trace the origin and evolution of settlements in this region, because there is no integrated historical account of the region as it is occupied by ignorant tribals who have lived for a long time in physical isolation and have no scrips of their own. There is no evidence of pre-historic settlement of this region. Before the advent of the British in this region, the people were isolated from each other due to difficult terrain, dense forest and lack of transport network. The lack of interaction with the outside

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[5]*Bhakta, G.P. (1979), Regional Structure of Meghalaya (Unpublished M.Phil dissertation), p.95.*

world added by inaccessibility of the land left them comparatively untouched and therefore, they remain primitive in character.

It is believed and accepted that in the 17th century the Mizos, a Mongoloid group of people, came to this region from the centre of Asia (China) through Mekong valley (Burma) and probably settled down in groups at different places, forming villages. They were predominantly agriculturists in the form of shifting cultivation. They reside usually in a single collection of houses, situated on the hill tops than a low level ground with a view to secure easy defence purpose. Before the advent of the Britishers in the present Union Territory of Mizoram, Mizos were head-hunting tribes. The selection of sites for settlements was always on the hill tops where they could have a better defence of their villages.

A variety of geomorphological factors weights heavily in the present day in the choice of sites of settlements, for example, dry and healthy surface of ground, easy accessibility, perennial and unfailing supply of water for domestic uses as well as other purposes, proximity to natural routes in the past or lines of modern transport, grounds of moderate slope, safety from defence points of view, particularly in the pre-British period where there was insecurity and political instability. Since they are predominantly agrarian community as much cultivable land as possible is spared for cultivation by selection of elevated sites for settlement on less fertile or sterile patches of land.

The settlement distribution map (Fig. 31) of Lunglei district reveals clearly the influence of physical factors on the distribution of settlements.

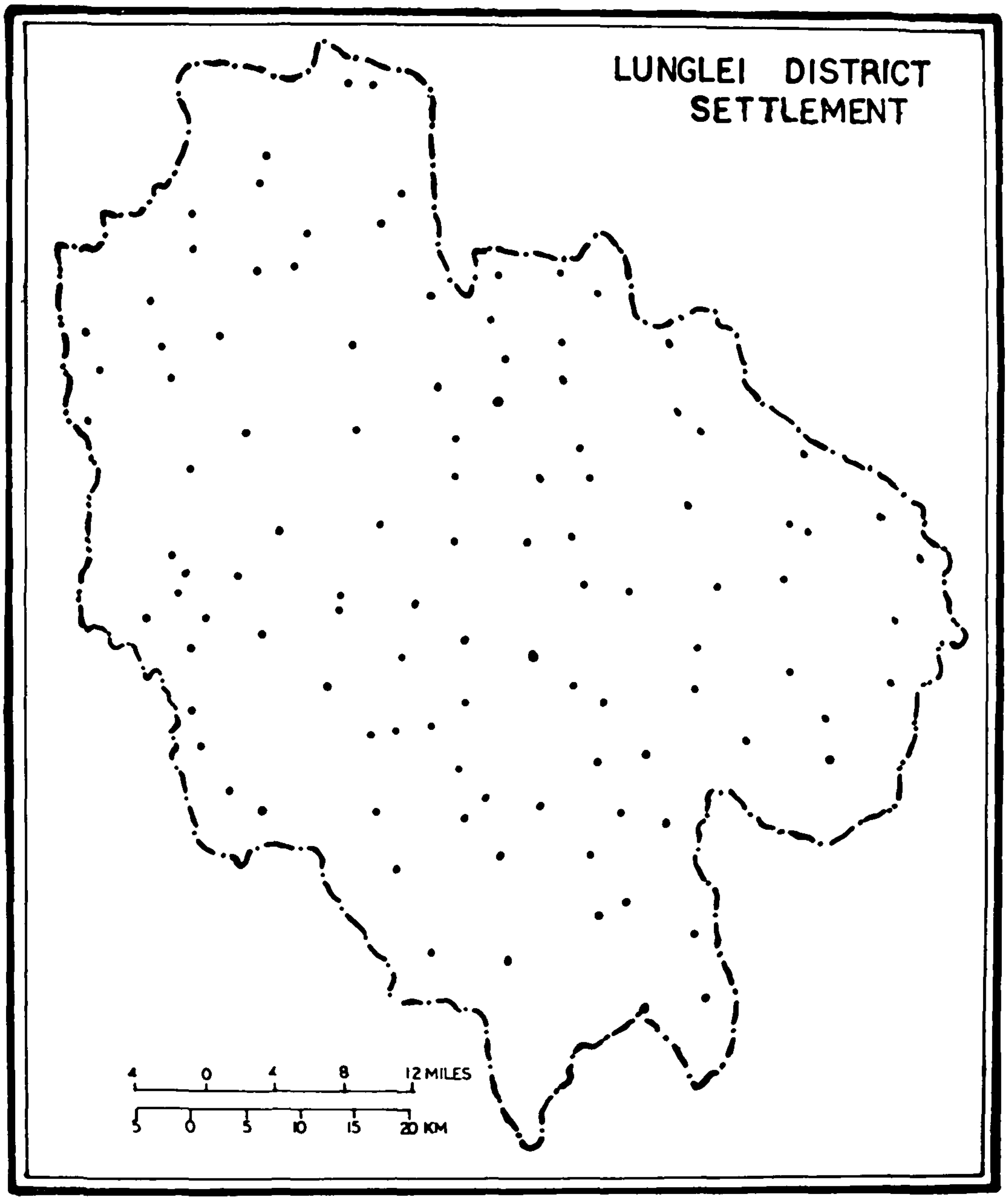

FIG-31

The north-western part of Lunglei district is thinly settled, indicating dispersed or random distribution. This part of Lunglei district is thickly forested and the topography is very much dissected, with a number of large and small streams flowing south-wards direction with deep narrow gorges. Settlements are mainly located on the hill tops. The important settlements found in this part are Bunghmun, Laisawral, Lungchem, Kauchhuah, Puankhai, Changpui and Sachanlui.

The central hill ranges of Lunglei and Sertlangpui hills are more thickly populated with compact, semi-compact and linear settlement pattern. The settlements found here are mainly in the hill tops and on the water-shed areas. The settlements which located on the hill tops are Sairep, Haulawng, Zero, Hlumte, Mualcheng, Ralvawng, Chengpui and Theiriat. The villages like Zobawk, Tawipui, Thingfal, Mualthuam, Vanhne, Thuampui, Buarpui, Lungdai and Sertlangpui are located in the watershed areas.

In the western part of Lunglei district, the settlements are compact and linear pattern. This part of Lunglei district had lower elevation with undulating terrain. It is covered by thick forest with a number of large and small streams flowing generally northward direction. Settlements are generally located near the streams and on the hill slopes.

The eastern part of Lunglei district represents a dissected topography with narrow deep valleys. As the valley sites are unhealthy for human habitation all the settlements are located on the hill tops and gentle slopes. The settlement patterns are mainly scattered and linear pattern.

Distribution of Rural Settlement According to population size (Block Level)

The study of the distribution of rural settlements, according to population size, may be very significant in Lunglei district as in hilly terrains the development of settlements is influenced by the physical and geomorphic factors of the region. In the present study, an attempt has been made to explain the possible geographical and geomorphological factors which favour as well as restrict the growth of settlements of various population size. The researcher has taken the number of settlements according to the population size for three census 1961-1981 for the better understanding of the distribution.

The following table 16 reveals that the total number of inhabited villages had decreased from 1961 to 1971 and increased again in 1981. The decrease of villages was due to compulsory grouping of villages by the Indian army in 1967. In 1981 the number of inhabited villages has gone up with the creation of new villages (Thlawhbawk) mainly for the purpose of jhuming.

TABLE 16

Number of Inhabited Villages in Lunglei District

Year	Number of inhabited Villages	Increase or Decrease
1981	163	+134
1971	29	- 87
1961	116	

Source: Census of India 1961-1981.

TABLE 17

Number of villages classified according to size of population (Lunglei district) 1961 to 1981

Year	Total no of inhabited villages	Less than	100 to 499	250 to 499	450 to 999	1000 to 1999	2000 to 4999
1961	116	-	30 (25.76)	76 (65.76)	9 (7.86)	1 (0.86)	-
1971	29	-	3 (10.34)	2 (6.89)	4 (13.79)	13 (44.68)	7 (24.28)
1981	163	30 (17.73)	52 (31.90)	47 (28.83)	19 (11.84)	12 (7.86)	3 (1.84)

*(Figures in Parenthesis indicates percentage to total).

Source: Census of India 1961-1981.

The above table shows that in 1961 there were as many as 116 villages in the district. But there were only 29 villages in 1971. This was due to grouping of the villages by the Indian government. There was compulsory grouping of villages in 1967. Before grouping of the villages there were no villages which fall below hundred population. There were 30 villages with a population of 100 to 249, 76 villages with a population of 250 to 499, 9 villages with a population of 450 to 999 and 1 village with a population of above 1000. In 1981 there were 30 villages with a population of less than 100. This clearly shows that when government authority allowed them to form new villages the people who are very hungry for land automatically formed new villages. The formation of small village is in fact conducive to the successful operation of cultivation i.e. jhuming as the farmer can fully attend to their jhuming in the nearby village site.

From the study of the location of settlements, it is clear that most of the settlements found in Lunglei district are located mainly on the hill tops, hill slopes, watershed area, along the main road and river valleys are noticed in the western part of the region bordering Bangladesh. As the valleys are deep and narrow provided with unhealthy climatic condition people selected the site for settlement in the hill top, hill slope and the watershed area where the climatic condition is better. The people of this region practice shifting cultivation and this type of cultivation can not support big villages. Therefore, wherever they found suitable land for shifting cultivation they settled there forming a small size village. The other factors being the dissected topography and steep slopes restrict the growth of large settlements. In

Lunglei district, though some large villages are found, they are only administratively headquarters along the main roads where people come to work in the government offices and further education. It is, therefore, clear that small size villages are much more than large size villages.

Distribution at Block Level

The distribution of villages, according to population size in block level shows more clearer picture (fig. 32a, 32b, 32c, & 32d). According to 1981 Census, there are four blocks in Lunglei district in the Union territory of Mizoram, viz. Lunglei, Hnahthail, Lungsen and Bunghmun. The table 24 represents the distribution of villages according to population size of all the four blocks.

TABLE 18

Number of villages according to population size

Blocks	Area in Sq.km.	Total No. of villages	Less than 100	100-249.	250-499	500-999	1000 and above
Lunglei	1181	43	12	10	10	6	5
Lungsen	1122	55	9	20	16	5	5
Bunghmun	1323	39	5	18	13	3	-
Hnahthial	912	26	4	4	8	5	5

Source: Statistical Hand Book, Lunglei district (Mizoram) 1981, Office of the District Statistical Officer, Lunglei.

(i) Bunghmun Block: Bunghmun Block has the largest land area in Lunglei district with an area of 1323 sq. km. According to 1981 census, the total population of Bunghmun Block is 12,239 persons and it has smallest population in the district. From the contour map of Lunglei district, it is

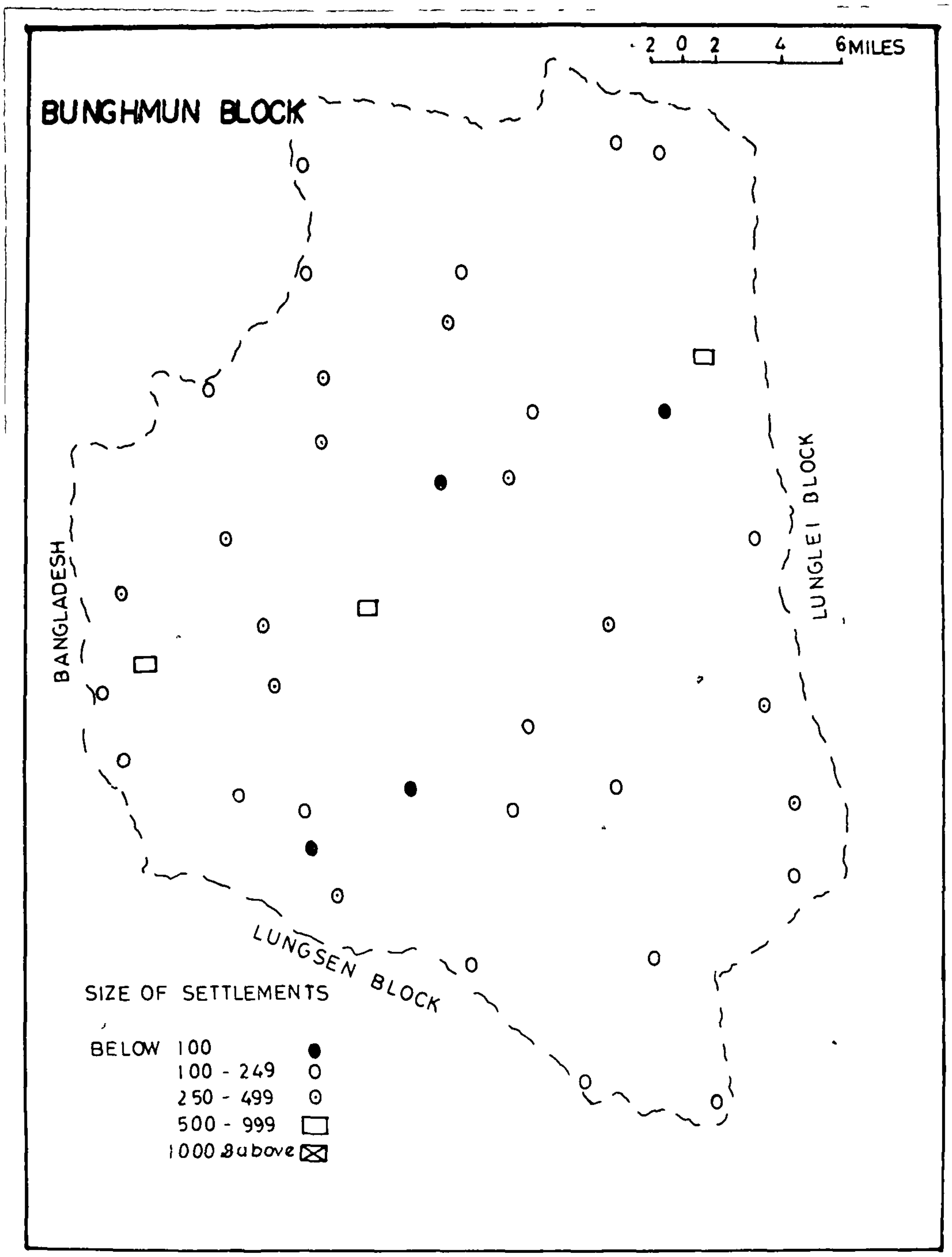
2 0 2 4 6 MILES
BUNGHMUN BLOCK
BANGLADESH
LUNGLEI BLOCK
LUNGSEN BLOCK
SIZE OF SETTLEMENTS
BELOW 100
100 - 249
250 - 499
500 - 999
1000 & above

FIG. 32a

clear that Bunghmun block has a maximum elevation of 1380 metres. In the central, northern and eastern parts the elevation is ranging between 700 - 1100 metres. Due to rugged topography and deep valleys in the northern and central part of the block settlements are comparatively less. Most ov the settlements are comparatively less. Most of the settlements are having 100 to 249 and 250 to 499 population and are located in the watershed and on the hill tops. In the western part bordering Bangladesh the maximum elevation is 684 metres and due to gentle slope settlements are more evenly distributed. Table 17 reveals that 59 per cent of the total villages are having population less than 250 persons, 33.33 per cent of total villages are having population less than 500 persons and 7.57 per cent of the villages are having a population less than 1000 persons.

(ii) Lunglei Block: Lunglei block occupies the central part of the district with an area of 1181 sq. km. According to 1981 census, it has a total population of 34,530 persons. Out of this, 17,325 persons are living in rural areas. It has a maximum elevation of 1555 metres. Lunglei hill range is the second highest hill range in the region. In most of the hill ranges the elevation is ranging between 1000 to 1300 metres. Due to rugged terrain and high degree of slope 35 to 40 degrees, most of the settlements are located in the watershed and hill tops. The settlement patterns are compact, semi-compact and linear pattern along Lunglei-Tuipang road and Lunglei-Aizawl road. The important settlements are Zobawk, Tawipui, Thingfal, Haulawng, Theiriat, Mualthuam and Zote villages. Table 24 reveals that 51.18 per cent of the total villages have less than 250 persons, 24.26 per cent has less than 500 persons, 14 per cent has less than 1000 persons and 11.27 per cent

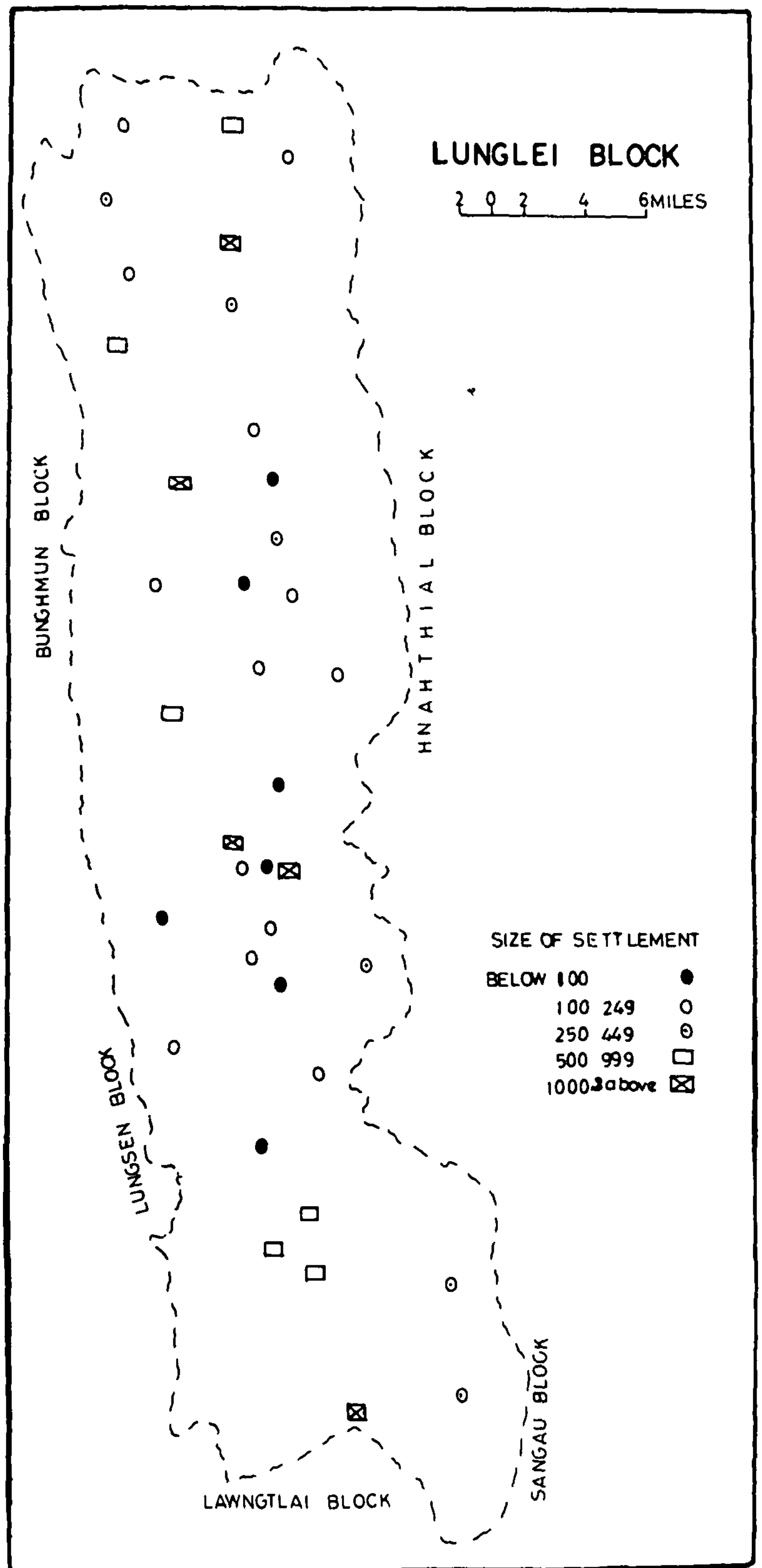
LUNGLEI BLOCK
2 0 2 4 6MILES
BUNGHMUN BLOCK
HNAHTHIAL BLOCK
LUNGSEN BLOCK
SANGAU BLOCK
LAWNGTLAI BLOCK
SIZE OF SETTLEMENT
BELOW 100
100 249
250 449
500 999
1000 & above

FIG 32b

of the total villages having population more than 1000 persons.

(iii) Lungsen Block: Lungsen is the western most block of Lunglei district with an area of 1122 sq. km. According to 1981, it has a total population of 21,127 persons. In the western part of the block bordering Bangladesh the elevation is below 100 metres. Due to gentle slopes and less gradient flowing rivers and streams concentration of settlements is more than any other parts of the district (fig. 32c). Tlabung, Sub-divisional headquarters, is located on the river bank of 'Khawthlangtuipui' at an elevation of 21 metres. The other settlements are also more or less evenly distributed along the Tuichawng and Khawthlangtuipui rivers. The eastern part of the block bordering Lunglei block is relatively steep and the settlements are randomly distributed. Compact type of settlements are found on the hill tops. Lungsen, Thehlep, Vanhne, Runtung and Chithar are the important settlements. Table 18 reveals that 52.78 per cent of the total villages are having less than 250 persons, 29.11 per cent are having less than 500 persons, 9.99 per cent are having less than 1000 persons and 9.99 per cent of the total villages are having more than 1000 persons.

(iv) Hnahthail Block: Hnahthail block is the smallest block in the district with an area of 912 sq. km. This block is in the eastern most part of the Lunglei district bordering Burma in the east. It has a total population of 18,615 persons according to 1981 census. In most of the eastern part the elevation is more than 1300 metres and the maximum elevation is 1758 metres. Almost in the whole eastern part of the area the average

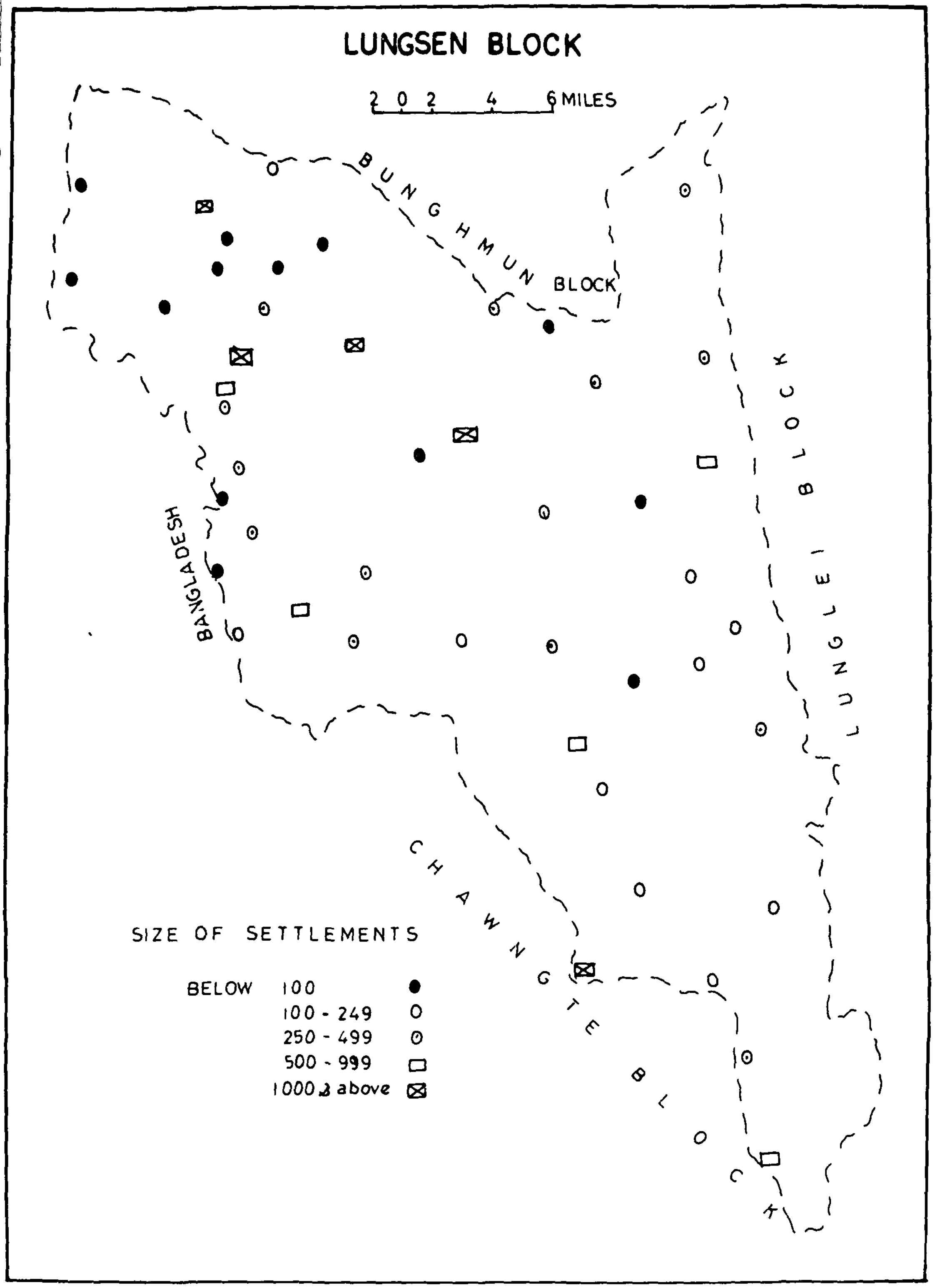
LUNGSEN BLOCK
2 0 2 4 6 MILES
BUNGHMUN BLOCK
LUNGLEI BLOCK
BANGLADESH
CHAWNGTE BLOCK
SIZE OF SETTLEMENTS
BELOW 100
100 - 249
250 - 499
500 - 999
1000 & above

FIG 32c

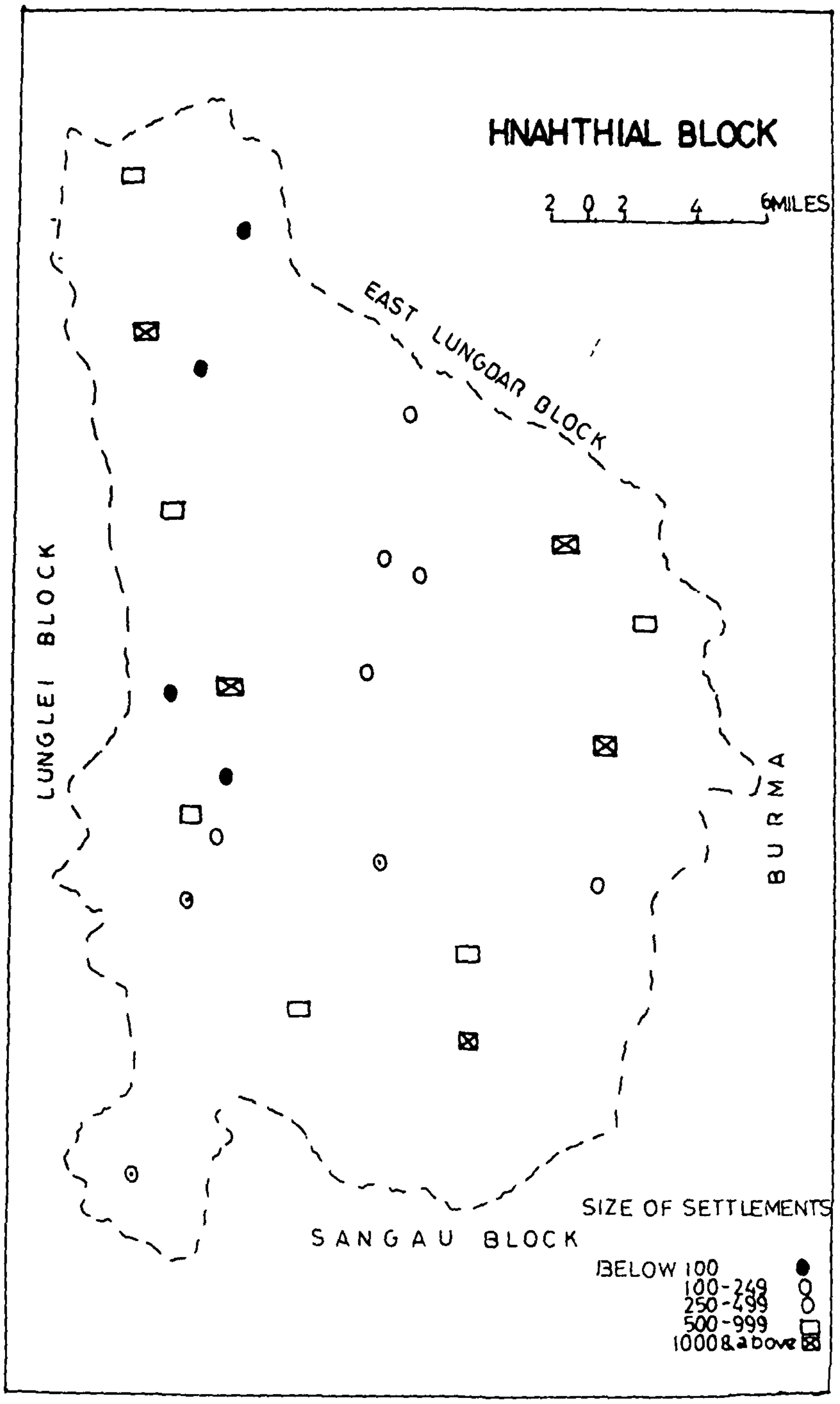
HNAHTHIAL BLOCK
2 0 2 4 6MILES
EAST LUNGDAR BLOCK
LUNGLEI BLOCK
BURMA
SANGAU BLOCK
SIZE OF SETTLEMENTS
BELOW 100
100-249
250-499
500-999
1000&above

FIG 32d

slope is 45° and above. The Valley sites are inhospitable for settlements and all the settlements are located on the hill slopes and hill tops. The only settlement located in the river valley is Tuipuikai where Kutkawk-Sangau road crosses Chhimtuipui river. In the western part, i.e. Hnahthial hill ranges, most of the areas have an elevation of less than 1000 metres. Most of the settlements are located on the hill slopes, hill-tops, watershed and along the Lunglei-Aizawl road. The important settlements are Hnahthial, Leite, Pangzawl and Rawpui villages. Table 18 reveals that 33.33 per cent of the total settlements have less than 500 persons, 16.67 per cent of the total settlements have less than 1000 persons and 16.67 per cent of the total settlements having 1000 and above persons.

Geomorphology and Location of Rural Settlement

The first settlers in a new and virtually undeveloped environment have to exist in a self-sufficient manner.[7] *This was just true of the early and isolated settlers of Lunglei district in Mizoram. The first inhabitants, with their necessary limited knowledge, made more or less rational judgement concerning choice of sites for their villages. Important to them was the availability of cultivated land and close supply of water. In addition, building materials and fuel were also important. The first settlers in a place must often have made false start and sometimes settled down permanently on a less good site even with a better site closeby. In a similar way, mistakes might have been made which could be seen clearly in the light of later*

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[7] *Panda, P. (1980), Geomorphology and Settlement Pattern in Khasi & Jaintia Hills, Meghalaya (Unpublished M.Phil dissertation), p.208.*

developments. Thus, we find in some areas a division of the original settlements into two with the prefix 'old' and 'new' attached to the original name.

The first five fctors are really the basic elements of an agricultural settlers economy. As the early inhabitants, viz. Mizos, were head hunting tribe before the advent of British to the area defence could become the determining factor in deciding the site for settlements. They normally selected hill-tops as the site for settlements. Besides, the early settlers were always looking for a healthy site, i.e. hill-tops as the valleys were unhealthy and abounds in Malarial diseases.

According to Rai (1980)[8],

> *"The location of settlements are the expression of the geographical fctors favourable at a particular spot in the landscape. In an agricultural country like India, the factor determining man's choice of a site for location of a village is the site which is near to his agricultural land. The site should also be favourable from the point of view of the physical factors, such as the level ground, the year round availability of water, high ground in relation to its surroundings in term of safety from floods, fodder and fuel from the forest and grasslands. The accessibility from the point of view of means of transport and communication lines is also an important factor in the location of settlements."*

Taking the above factors, the location of settlements in Lunglei district are as follows:

(i) The settlements on the hill-tops and hill-slopes.
(ii) The settlements along the rivers.
(iii)The settlements along the watershed.

(i) <u>The Settlements on Hill-tops and Hill-slopes:</u>

The location of settlements on flat hill-tops and gentle hill-slopes terrain was the marked characteristic feature of the hills as defence in

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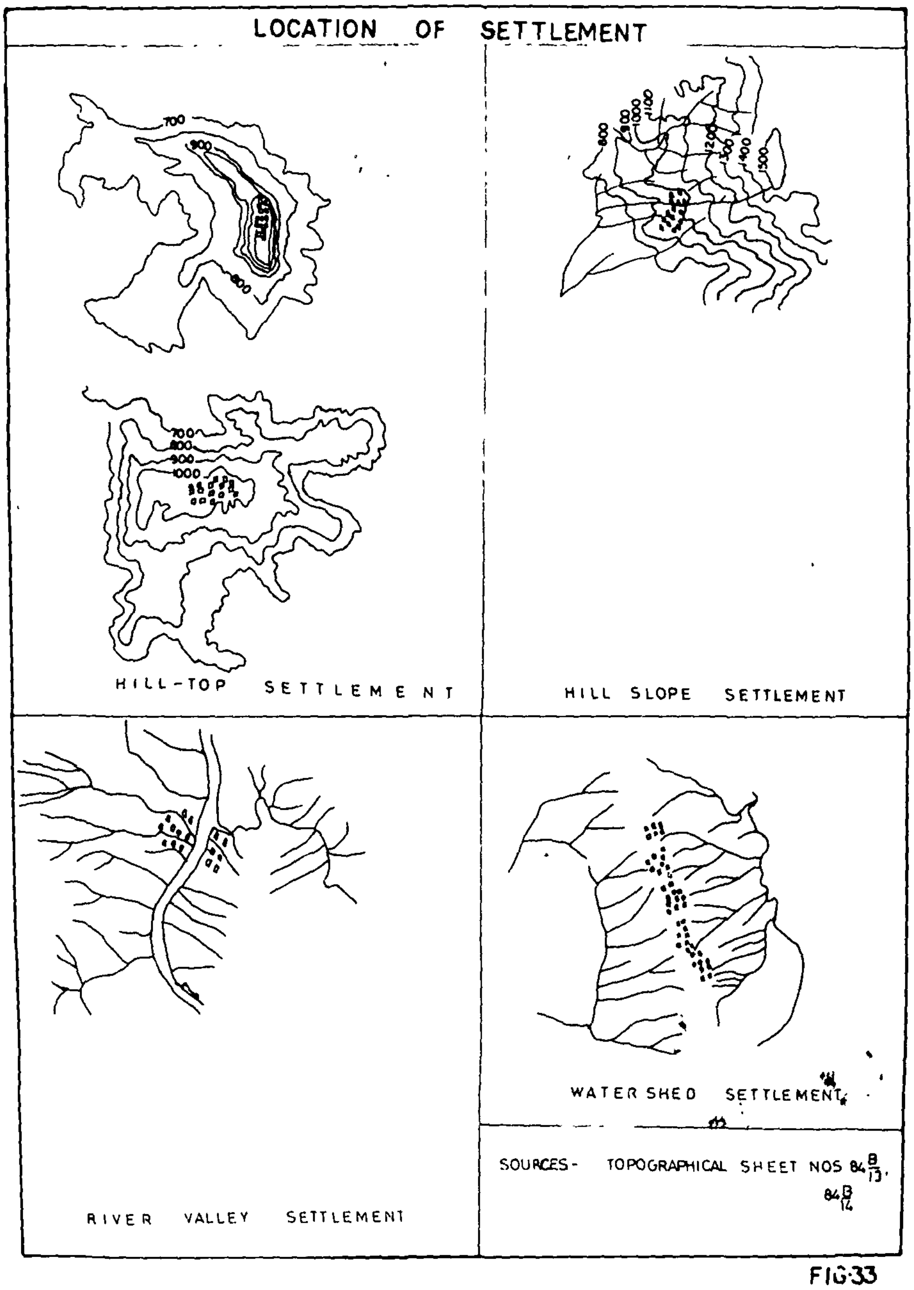
[8]Rai,R.K. (1980),. Geomorphology of Sonar-Bearma Basin, Concept Publishing Company, New Delhi.


LOCATION OF SETTLEMENT
700
800
900
1000
HILL-TOP SETTLEMENT
HILL SLOPE SETTLEMENT
RIVER VALLEY SETTLEMENT
WATER SHED SETTLEMENT
SOURCES- TOPOGRAPHICAL SHEET NOS 84 B/13, 84 B/14

FIG·33

the pre-British period being the most decisive factor in the selection of sites for settlements in the early period.

A large number of settlements both large and small size settlements are located along the hill-slopes and hill-tops of this region. From the settlement map (fig. 31) it is clear that nearly 55 per cent of the total settlements are located on the hill-slopes and hill-tops. The eastern part of the district in the east of Chhimtuipui and Tuichawng rivers are predominantly occupied by hill-slopes and hill-tops settlements where the average slope is more than 45°.From the average slope map (fig. 6) of Lunglei district, it is clear that Lunglei hill ranges, Hnahthial hill ranges, Thorang hill ranges and Sertlngpui hills are represented by high degree of slopes and rugged topography and compels the settlers to construct their houses on hill-slopes and hill-tops. (Plate No.19).

(ii) The Settlement along the River Valleys:

A large number of settlements are found located along the river valleys (Fig. 31). In the district of Lunglei the river valley of Tuichawng, Tuilianpui and Khawthlangtuipui in the west support quite a large number of valley settlements. The important villages situated along the Tuichawng river are Chawngte and Tuichawng villages. The important settlements along the Tuilianpui river are Sachan, Devasury, Thingkhim, Tuikawi and Sumasimi while along the Khawthlangtuipui river Dinthar, Tlabung, Nunsury and Lamthai villages are situated.

(iii) The Settlements along the Watershed:

The settlements along the watershed are quite large in number and the distribution varies from place to place (fig. 31). If one examines

1:50,000 topographical maps of Lunglei district, the area covered by topographical sheet No. $84\frac{A}{12}$ shows clearly a number of small rural settlements as Buarpui, Sertlangpui, Lungdai and Thumpui. The small settlements are found located at or near the watersheds formed by numerous tributaries of Tlawng and De rivers. Again, the area covered by topographical sheets No. $84\frac{B}{14}$ and $84\frac{B}{13}$ of Lunglei district show the distribution of watershed settlements. The important amongst them are Tawipui, Thingfal and Thlengang villages.

Settlement Patterns

The factors which have led to the variations between different settlement patterns are many and varied. It is important to realise that the pattern so produced is a result of a number of forces, working either in conjunction or in opposition, over a long period of time. Some of these factors are still at work, the pattern in this region is largely a result of forces acting due to climatic factors, nature of slopes, relief and newly development of road network.

In the district, generally two types of settlement pattern are noticed - (1) Semi-Compact and Compact pattern and (2) Linear Pattern (Fig. 34).

(1) Semi-Compact and Compact Pattern:

The study of 1:50,000 topographical sheets and extensive field study of Lunglei district reveals that a little more than 50 per cent of the total settlements are semi-compact and compact pattern of settlements

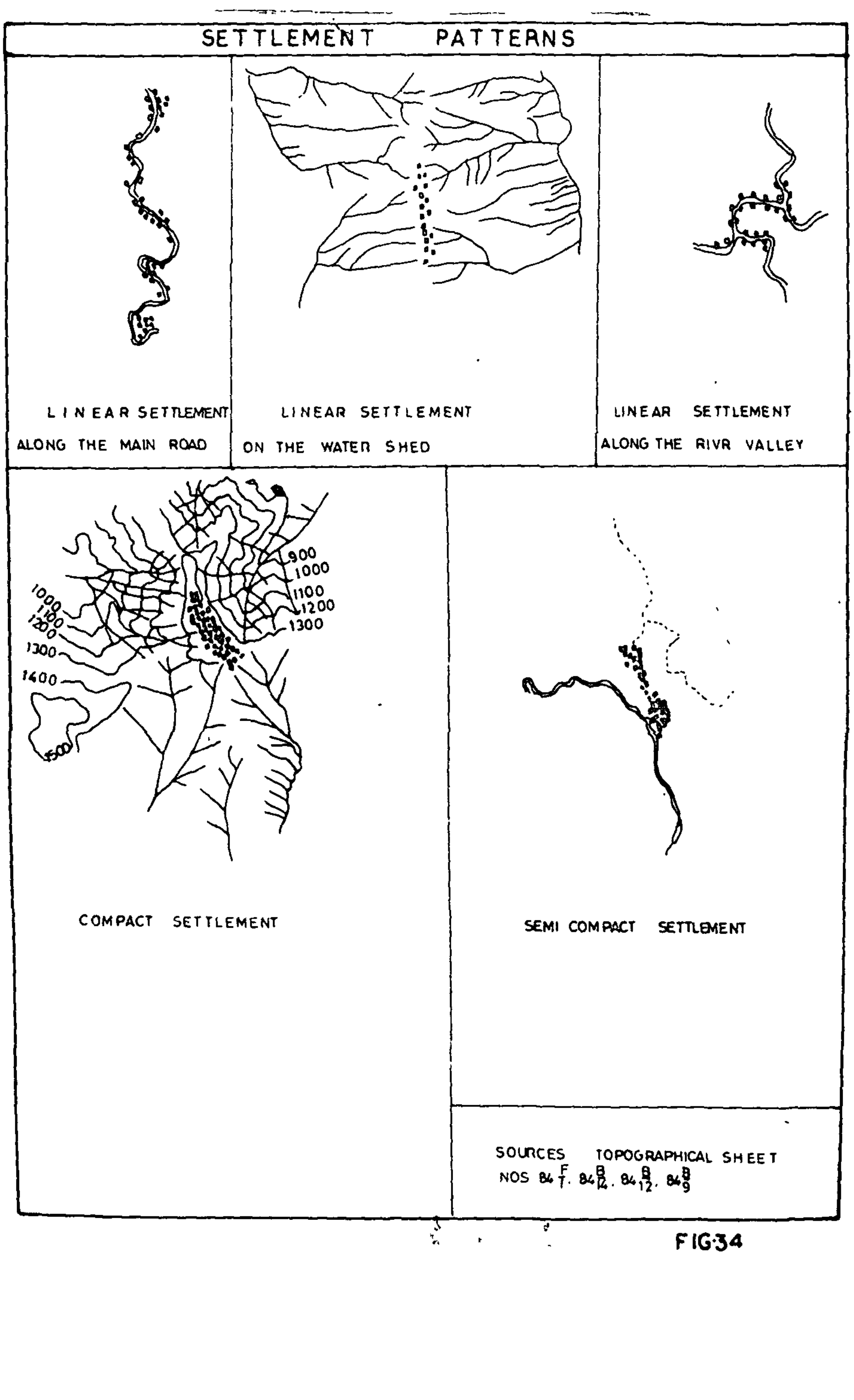

SETTLEMENT PATTERNS
LINEAR SETTLEMENT
ALONG THE MAIN ROAD
LINEAR SETTLEMENT
ON THE WATER SHED
LINEAR SETTLEMENT
ALONG THE RIVR VALLEY
900
1000
1100
1200
1300
1000
1100
1200
1300
1400
1500
COMPACT SETTLEMENT
SEMI COMPACT SETTLEMENT
SOURCES TOPOGRAPHICAL SHEET
NOS 84 F/1. 84 B/14. 84 B/12. 84 B/9

FIG.34

(Plate No. 20). The factors responsible for the development of semi-compact and compact seems to be several patches of gentle and undulating terrain left for agriculture which depends on rain water and continuous paractices of shifting cultivation. The settlements are located at the hill-tops and hill-slopes where agriculture practices could not be done (Fig. 33).

(2) Linear Settlement Patterns:

Linear settlement patterns are located in areas of elongated watershed areas where easy availability of drinking water and sunny sides of the slopes seems to be important factors. It is also found along the river valleys as well as along the main roads where easy transportation is available. Broadly three types of linear settlements are found in Lunglei district viz. (a) Linear settlements along the watershed (b) Linear settlements along the river valleys and (c) Linear settlements along the main roads.

(a) Linear Settlements along the Watershed:

A number of linear settlements along the watershed are situated in the elongated narrow hill ranges of Sertlangpui and Khojoisury in the western part of the district bordering Bangladesh. The factors influencing watershed linear settlements are mainly due to availability of water and good climatic condition. In this regard, the watershed areas are elongated narrow ridges, and both the sides have very steep slope which resulted the growth of linear settlement patterns along these watersheds. Some examples of this type of settlement patterns are Sertangpui, Lungdai, Thuampui and Khojoisury.

(b) Linear Settlements along the River Valleys:

A number of large and small linear settlements along the river valleys are found located in the western part of the region. The Chakmas tribe, who inhabited the western part of the region does a little care about the climatic condition of the area, formed a number of large and small linear pattern of settlements along the Tuichawng, Tuilianpui and Khawthlang-tuipui rivers (Fig. 34). The valley are wider and more healthy than the eastern part of the area. A few examples of this type of settlements are Nunsury, Devasury, Dinthar and Kauchhuah.

(c) Linear Settlements along the Main Roads:

The growth of linear settlement patterns along the main roads has economic importance. The villages serve as the centre for economic activities to the neighbouring villages. Agricultural products and other commodities meant for export and import are generally done through these villages. Few examples of this type of settlement patterns are Pangzawl, Rawpui, Zobawk and Leite along the Lunglei-Aizawl road and Tawipui, Thualthu and Thingfal along the Lunglei-Tuipui road (Plate No.21).

Geomorphology and Transport and Communication

In the present generation, the transport and communication network is one of the most important factors for the development of an area. The present study is not directly concerned with transport and communication. As such, the relationship between the topography, drainage network and the development of transport and communication lines may be discussed.

In Lunglei district road transport is the only and important means of transport and communication system. There is no railway transport in this region. The main roadway is the B.R.T.F. road (Border Road Task Force) which passes through this region from Aizawl town through Lunglei and reaches upto Tuipang in the southern most corner of Mizoram. Other major district road is Lunglei-Tlabung road. This shows that Lunglei is the centre which connects the important places of the district. These roads have great significance in economic development of this region. In addition, there are other roads, viz. kutcha roads such as Lunglei-Thenzawl road, Zobawk-Haulawng road, Lungsen-Chawngte road, Kutkawk-Sangau road, Lunglei-Buarpui road and Tuichawng-Marpara road (under construction) and all these roads are fair weather roads.

Due to rugged topography and dissected terrain with numerous narrow deep river valleys and escarpments the development of roads and communication lines is very difficult. The hill ranges are generally trending from north to south with narrow and deep gorges in between the hill ranges accompanied by steep slope on both sides of the hill ranges. The existing road system has been constructed through natural gaps and by cutting such hill ranges. In such topography the construction of roads, embankments, bridges and culverts need heavy expenses. Besides, the hill tracts are thickly covered by forest and they have loose poor sandstone. The rock formations are young in age and soft and less stable. Along the road sides, during rainy season, there are large number of landslides which obstruct the road traffic. Thus landslides which obstruct the road traffic. Thus landslides are the serious problem during the rainy season.

Though roads are the only important means of transport in Lunglei district, the road map of Lunglei district (Fig. 35) shows that a large number of ares are not still connected by any road. More roads need to be developed in the whole region and the existing roads need further improvement.

Along with the study of existing pattern of transportation network, to discuss the accessibility and inaccessibility in the study area is more important. In the present study an attempt has been made to mark out the accessible and inaccessible areas. In Lunglei district roads are constructed along the hill ranges and this caused higher road accessibility. Here, the roads are constructed along the north-south trending hill ranges. But in the north western and estern parts of the area there is higher inaccissibility of roads due to highly dissected and deep narrow valleys.

(i) Lunglei-Tlabung Road: This is the only truckable road which connects Lunglei town, the district headquarters of Lunglei, at an elevation of 1105 metres and Tlabung, the important village in the western part of the district, at an elevation of 20 metres. This road crosses Phairuang and Tuichawng rivers and anticlinal ridges of Runtung and Lungsen. This road has been constructed by cutting steep hill slope and to minimise the steep gradient the road is zig-zags along the foot hill slope. During rainy season it is often affected by major landslides and mudflow thus hampering the movement of traffic. The main agricultural products like cabbage, tomatoes, sesumum, etc. and fishes are moved to the mrket centre, i.e. Lunglei through this road.

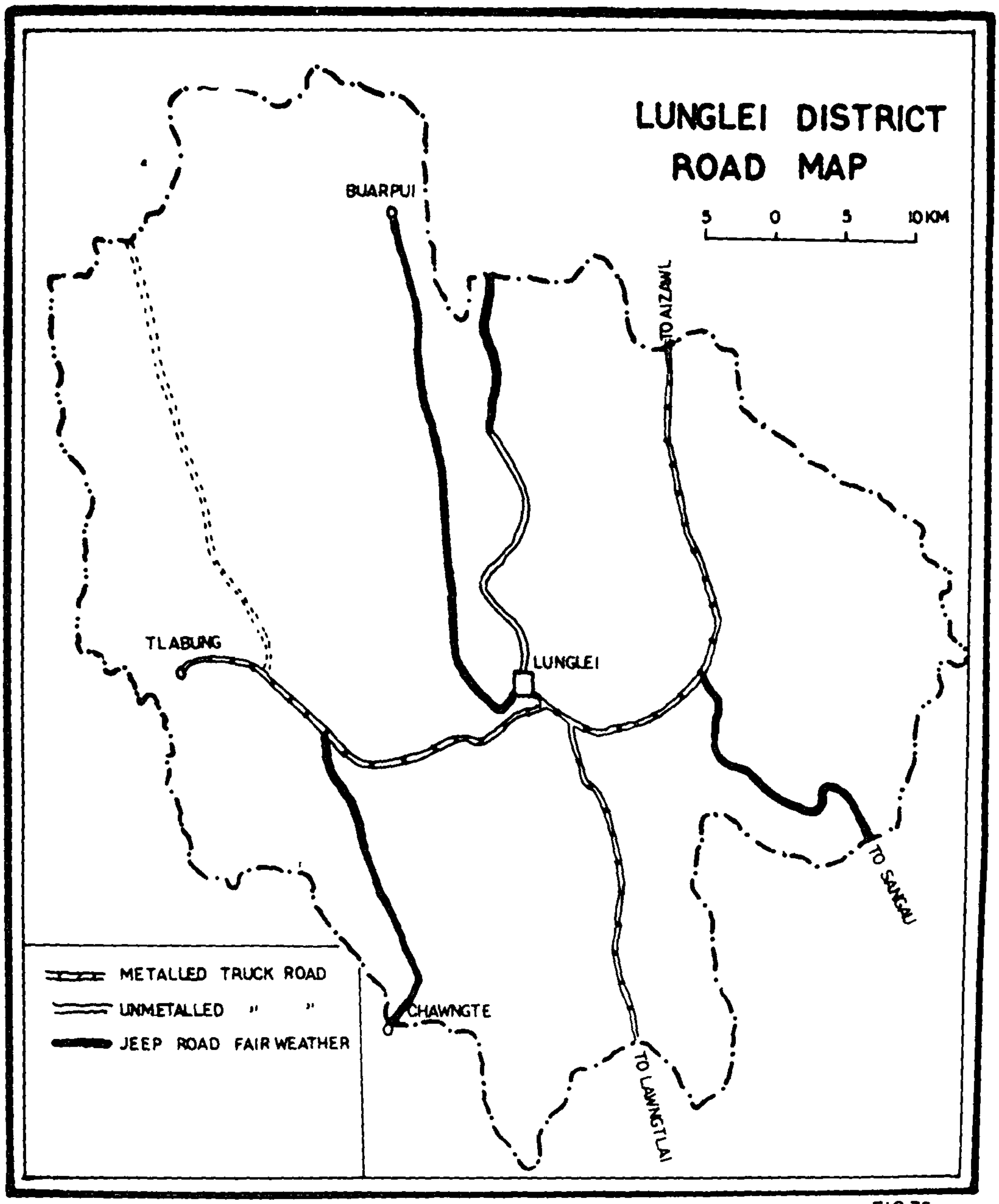

LUNGLEI DISTRICT
ROAD MAP
5 0 5 10 KM
BUARPUI
TO AIZAWL
TLABUNG
LUNGLEI
TO SANGAU
CHAWNGTE
TO LAWNGTLAI
METALLED TRUCK ROAD
UNMETALLED " "
JEEP ROAD FAIR WEATHER

FIG-35

(ii) <u>Lunglei-Aizawl Road:</u> This road is the most important road in the district which connects Aizawl town. It has heavy traffic, both passengers and goods. All the necessary commodities are brought from other states of India through this road to the district. This road needs further improvement as the road crosses a number of escarments between Zobawk and Hnahthial villages.

(iii) <u>Lunglei-Tuipang Road:</u> Separated from Lunglei-Aizawl road after 8 kms from Lunglei town this road runs to southern direction upto Tuipang village in the southern most corner of Mizoram. This road passes through hilly tract of soft and less stable sedimentary rock formations with very steep hilly slope. This road experiences heavy landslides between Thingfal and Lawngtlai villages during the rainly season and there used to be difficulty in traffic movement.

(iv) <u>Lunglei-Thenzawl Road:</u> This road is fair-weather kacha road and this road is decending down from Lunglei town towards deep narrow Tlawng river syncline. During rainy season it is very often affected by soil creep and landslides which, as a result, retarded the movement of traffic. The important settlements located along this road are Haulawng, Mualthuam and Ramlaitui.

(v) <u>Kutkawk-Sangau Road:</u> Separated from Lunglei-Aizawl road after 60 kms from Lunglei town this road runs eastwards upto Sangau village, the block headquarters of Sangau block of Chhimtuipui district. Here, the great obstrucles are the construction of Chhimtuipui bridge and the deep

scarp slope of Darzo hill. After reaching Chhimtuipui river the road climbs up the Darzo hill making so many zig-zags and reaches Darzo village at an elevation of 1414 metres. Then the road passes through South Vanlaiphai village and connects Sangau village. This jeepable road is open only during dry season due to absence of bridge over chhimtuipui river and highly dissected terrain with unstable loose sedimentary rock formation.

(vi) Lunglei-Buarpui Road: This road connects Lunglei town and Buarpui village which is in the north west of the district. This jeepable road passes through Vanhne, Thuampui, Lungdai, Serte, Sertlangpui and Kawlhawk villages and reaches Buarpui village. This road is constructed along the watershed of Sertlangpui hill range which has no scope for improvement of the road as the ridge is very narrow and very steep on both the sides of the road.

(vii) Lungsen-Chawngte Road: This fair-weather jeepable road connects Lungsen village and Chawngte village in the west of the district. The road runs towards southern direction following the watershed zones of Phairuang river and Tuichawng river. The important villages located along this road are Lungrang and Rualalung. This road could be improved as the gradient of slope is more gentle.

Transport and communication are indispensable infrastructure for the development of agriculture. The trading of Mizoram main produces like ginger, chillies, etc. are dependent on market outside Mizoram. On the other hand, Lunglei district has to import cloth, rice, salt, sugar, pulses, *edible oil, spicies, footwear, drugs and medicine, cement, C.I. sheets, stationeries, etc. from other parts of India. Due to lack of transport infrastructure, there has been a great scarcity of essential commodities in the area. Therefore, the cost of living is much higher in the district than in the rest of the country.*

The road system in Lunglei district plays a vital role of strategic and economic importance in intrastate and inter-regional traffic. But the development of roads in the district is not adequate. A large proportion of villages is not even connected with unmetalled roads. Out of 163 villages, 123 villages (72 per cent) have no transport facility whatsoever. The number of villages connected by all-weathered motorable roads stood at only 19 representing only 10 per cent of all the villages. Extension of the road transport system to the interior villages of the area is highly essential for agricultural development.

CONCLUSION

Lunglei district, one of the three districts of Union Territory of Mizoram is the extension of Himalayan-Patkoi hills and the area forms a part of the Indo-Burman orogenic belt. The area falls within the part of Tripura-Mizoram miogeosynclinal basin (southern extension of Surma valley) which evolved after the regional upliftment of Barail group of sediments and thus was related with the plate behaviour in the subduction zone of west Arakan-Yama, after the spreading of Indian Ocean. This region, in course of Himalayan upliftment has been uplifted to its present height and the geomorphic processes are still in its initial stages.

The stratigraphic sequences of Lunglei district is represented by five main geological sub-groups as follows:

i)	*Boka Bil*	*Mio-pliocene*
ii)	*Upper Bhuban*	*Miocene*
iii)	*Middle Bhuban*	*Miocene*
iv)	*Lower Bhuban*	*Miocene*
v)	*Barail*	*Oligocene*

The structural characteristics of rock formations of Lunglei district reveal that this region has witnessed a number of earth movements. Its tectonic history begins after the upliftment of Barail geosyncline in a great tectonic trough of miogeosynclinal character. Structurally the whole region *is discontinuous N-S to NE-SW trending anticlines and synclines involving mio-pliocene sediments of the Surma and Barails. The structural trend coincides with the regional tectonic lineaments.*

The study of evolution of landforms and geomorphic characteristics of Lunglei district reveal that the area predominates by hilly dissected landform. There are a number of parallel hill ranges running from north to south separated each other by deep narrow valleys.

The study of geomorphic processes and fluvial geomorphic cycle reveal that the mechanical weathering predominates mainly in the steep and gentle slope where Jhum cultivation is practised. The repeated processes of heating and cooling of sandstones and shales which are poor conductor of heat, give rise to stress and strain the upper layers of rocks mass in the temperature thus disintegrate the rock surface due to excessive burning for the Jhumland.

Chemical weathering predominates mainly in the steep slope, in the form of hydration and solution upon the softer materials. In the rainy season, many places where the hill slopes are quite steep, the rainwater disintegrate and decompose the rock into fragments. The fragmental rocks fall down from the slopes and scarps in tabular and bedded pieces through various mass-wasting agents and accumulate in the valley sides. It is also noticed that surface landslide is a common feature throughout the region.

From the analysis of fluvial geomorphic cycle, it may be concluded that the cycle of erosion is still in its youthful stage. Enormous short tributaries *and gullies extending themselves by headward erosion and 'V' shaped profiles of the rivers show that the cycle of erosion is still in its youth stage.*

The average slope of Lunglei district varies from 5° to 40° and above. The variation in slope degrees is directly influenced by the topography, lithological and structural characteristics of the underlying rocks. It is very clear that in the initial stage there was a tremendous faulting and folding took place in the area. Gradually due to some agents of erosion the landscape changes to its present form.

The hillslope elements of Lunglei district indicates the immature topography. It is interesting to note that the pediment is missing in all the hillslopes. Being a young topography of the region the slopes are still in the developing stage.

The stream frequency in Lunglei district varies between less than 3 to 12 and above streams per 4 sq. miles. It is found that the variation in stream frequency is directly influenced by the topography and structural controls; due to differences in rock resistant to erosion which are expressed in the landforms themselves. Climate plays a very important role in this region as far as the stream frequency is concerned. The concentration of rainfall during the four months of June to September, relief structural and lithological characteristics of rocks, vegetation, infiltration capacity and nature of slopes of this region accounts much for the development of stream and drainage patterns.

The drainage patterns of Lunglei district reflects the influence of initial slope, inequalities in the rock hardness, structural controls, folded *and faulted topography, infiltration capacity and the geomorphic history of the region. The researcher has identified mainly two drainage pattern in the region such as parallel and sub-parallel and rectangular drainage pattern.*

The quantitative analysis of ten selected small drainage basins reveals that there is no direct relationship between the area and number of stream segments, while the area is directly correlated with the length of the streams. The hypothesis, that the bifurcation ratios within a basin decreases with the increasing order has been confirmed.

Empirical data from ten selected basins in the Lunglei district allow evaluation of relief and the laws of stream number and laws of mean stream lengths on erosion surface. Information from these basins indicates that due to the dissected topography and lack of well developed relief, the valley network is not complete.

The standard sinuasity index indicates that only saitumlui and Darkhuang lui streams flow in straight course, while the rest eight streams flow in a sinuas course. All the ten selected small drainage basins with a high topographic sinuasity and high hydraulic sinuasity index indicates that these basins are still in their early stages of development.

The study of drainage density brings out an interesting relationship with the relief. It has been found that a rise in drainage density occurs with increasing relief in all the ten basins of Lunglei district. The increase in relief is supported with steep slopes and total precipitation also effected the drainage density of these basins. About texture ratio, the study reveals *that all the ten basins show less than 5 drainage density representing course drainage texture. The drainage density and constant of channel maintenance shows an inverse relationship between each other, i.e., the basins which are having high drainage density have low constant channel maintenance figure.*

The study of micro-geomorphic regions of Lunglei district reveals that after superimposing the stream frequency map, relief map, average slope map, drainage pattern, nature of erosion, structural characteristics of rock, dissection pattern and Geological map of Lunglei district is delianeated into 3 micro-geomorphic regions, such as -

- *i) Moderately dissected undulating hill region of the west.*
- *ii) Highly dissected, denudated and sharp crested region, and*
- *iii) Central and eastern escarpments.*

The study of Agriculture framework in Lunglei district reveals that nearly 90 per cent of the total workers are engaged in Agriculture but the district produces only 30 per cent of total food requirements. The growth and development of agriculture was not encouraging during the past decades due to several factors like - (i) Geomorphic characteristics (ii) Location with reference to market. (iii) Pattern of human behaviour. Among these Geomorphic problems like (a) Nature of Terrain (b) Problems of Irrigation (c) Uncertainty of Rainfall (d) Uneven distribution of Rainfall (e) Frequency of cyclones and (f) Soil erosion are the main problems of agriculture.

The regional study of landuse in Lunglei district indicates that *planned use of land resources has not yet started. The different categories of landuse in the district are as follows:*

Land Classes	*Area in hectares*	*Percentage of total area*
1. Forest	*289750*	*63.85*
2. Net sown Area	*2029*	*0.45*
3. Jhumland	*15000*	*3.30*
4. Area not available for cultivation	*147027*	*32.40*

The major portion of the total cropped area in the region is devoted to food crops and the commercial crops occupy little area. The main crops grown in the area are paddy, maize, yam, sweet potato, pumpkin, cucumber, watermelon, chilly, cotton, ginger, sesumum and tobacco in the Kharif season and pulses, beans, cabbage and tomato in the Rabi season. The cropping pattern is mixed cropping and crop rotation. Most of the crops are spatially very unevenly distributed. This is so because in this region the physiographic characteristics mostly control the cropping pattern.

The study reveals that the agricultural methods, techniques and implements employed in the region are very backward due to several physico-economic factors. There is no land holding in the district, the land is the common property of the village and however, individuals have no separate land holdings. The agricultural implements which are commonly used in the district are old fashioned. The agricultural implements are hoe, doa, axe, spade, sickle and bamboo basket. Due to inhospitable nature, environment and difficult terrain about 90 per cent of the total farmers practice jhum cultivation. The Jhum cycle has decreased due to increase of population. The Jhum cycle varied from village to village as well as from Community

Development Block to Block. It was found out that Bunghmun block has the longest Jhum cycle of 7-8 years. Next comes Lungsen block 6-7 years, Hnahthial block 5-6 years and Lunglei Block the lowest 3-4 years.

The study of landforms characteristics and agricultural land use from the selected five villages of Lunglei district brings out interesting findings. Rugged topography is the formost factors. It is handicapped by steep slopes and resultant hillwash, lack of irrigation facilities, headward erosion and the scarp land etc.

The analysis of geomorphology and Distribution of population, settlement and transport and communication reveals that the density of population decreases from east to west. The most important factor is a east-west increase of humidity and temperature which results into a general unsuitability of the climate for human habitation.

A variety of geomorphological factors weights heavily in the region in the choice of sites of settlements such as dry and healthy surface of ground, easy accessibility, perennial and unfailing water for domestic uses as well as other purposes, proximity to natural routes in the past or lines of modern transport, grounds of moderate slope, safety from defence points of view particularly in the pre-British period of insecurity and political instability.

From the study of location of settlements of Lunglei district, it is clear that most of the settlements found in the district are located mainly on the hilltop, hill-slope, watershed area, and along the main roads. Due *to climatic factor people selected the site for settlement in the hilltop, hill-slope and the watershed area where the climatic condition are better. The people of this region practice Jhum cultivation and this type of cultivation can not support big village. Therefore, wherever they found suitable land for shifting cultivation, they settled there forming a small size village. The dissected topography and steep slopes restrict the growth of large settlements. The settlement pattern is largely a result of forces acting due to climatic factors, nature of slopes, relief and newly development of road network. Generally two types of settlement pattern are noticed (i) semi-compact and compact pattern (ii) linear pattern.*

Though roads are the only important means of transport in Lunglei district, a large number of areas are not connected by any road, Due to rugged topography and dissected terrain with numerous narrow deep valleys and escarpments the development of roads and communication lines is very difficult. The hill ranges are generally trending from north to south with narrow and deep gorges in between the hill ranges accompanied by steep slope on both sides of the hill ranges. The rock formations are young in age and soft and less stable. Along the roadsites during the rainy season, there are a number of landslides which obstruct the road traffic.

Suggestions

Based on a detailed study of Geomorphology and Agricultural resources of Lunglei district Union Territory of Mizoram and their land-use, the following suggestions may be proposed for agricultural development in the district.

Lunglei district as a whole is not prosperous in agriculture due to absence of flat land, presence of hilly dissected terrain, narrowness and deep gorges and steep slopes. In spite of all these problems, some problems may be tackled by the following measures.

- *i) The existing agriculture system i.e. shifting cultivation should be modified.*
- *ii) The available river flat areas should be reclaimed for wet rice cultivation provided there is water supply to irrigate the field.*
- *iii) Hill terrace cultivation may be practised where the gradient of slope is gentle, provided with easy availability of water to irrigate the field.*
- *iv) Gravity irrigation and lift irrigation project is very much essential to irrigate the agricultural field. To fulfil this dams may be constructed to generate hydroelectricity.*
- *v) Proper land use survey should be undertaken immediately throughout the area.*
- *vi) Socio-economic status of the various categories of the villagers should be collected in order to trace out their indifferent attitude towards the adoption of various governmental plannings.*
- *vii) Metrological observatory station should be introduced at least at Lunglei town to maintain the various climatic data of the region.*
- *viii) The area urgently need to identify and map out the physical based of the region, highlighting such aspects as the hydrological regimes, soil resources, climatic rythms and associated bio-geographical characteristics of the region. Due emphasis should be given to depict on maps the various natural hazards which*

need to be adequately taken care of in the region where it is always affected by other natural hazards.

ix) *The degree of slope and the degree of stoniness should be the fundamental points of consideration when planning land use in these scarp lands; especially where several steep slopes are almost bare rocky exposures. Controlled cultivation in a gentle slope lands, thick forest growing, soil conservation, development of sericulture, fruit gardening and commercial crops on steep slopes are some of the remedies which immediately need to be enforced for a better prospect of agriculture in the region.*

x) *The topography and the agro-climatic conditions of the area are more suitable for the growth of other crops and plant rather than rice.*

xi) *Rice being a crop which required good supply of water is unsuitable in the area where there is no sufficient rainfall.*

xii) *Because of its peculiar terrain, rolling topography, and very heavy rainfall, the entire district is in urgent need of a comprehensive programme for soil conservation and water management. The district should be fully alive to problem of soil erosion and take appropriate steps, whenever necessary.*

xiii) *Among the several indirect effects of topography in the region, one of the most important is the hindrance on the accessibility through road. Being a young topography the road system had to be planned in the light of the characteristics of topography.*

xiv) *Surface landslides are the common feature throughout the district especially on the steep slopes. To prevent this Jhuming should not be prcticed on the steep slopes and along the road section.*

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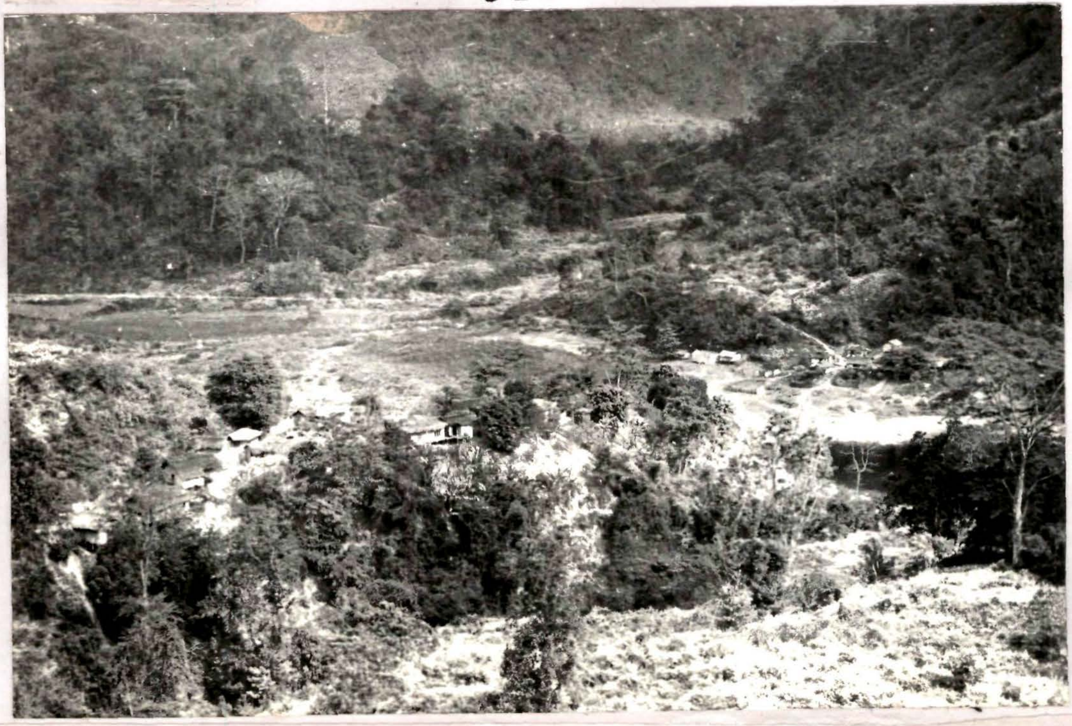
PLATE NO 16



Intermont valley plain near Thıngfal village in the source region of Ngengrual stream

PLATE NO 17

Flat river plain near zobawk village in the source region of Tlawng river

PLATE NO 18

Flat river plain of south Vanlaiphai village in the source region of Hnahchang stream.

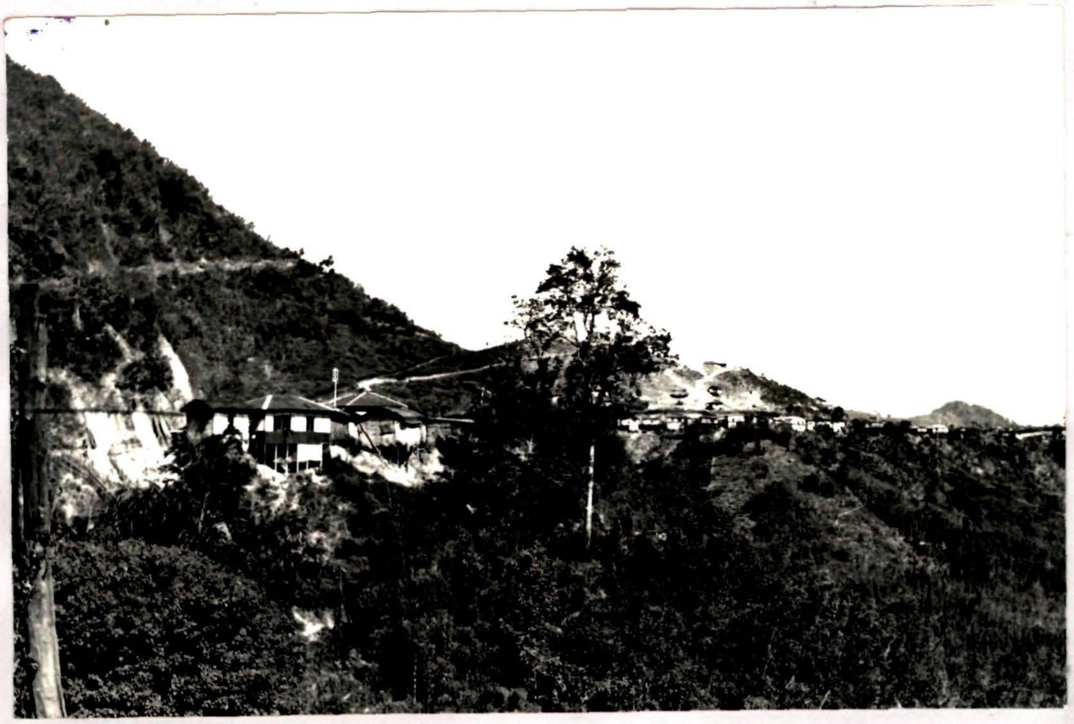
PLATE NO 19

A hilltop settlement of Belkhai village

PLATE NO 20

A compact settlement of Bunghmun village

PLATE NO 21



A linear settlement of Pangzawl village along Lunglei - Aizawl road section.