LAND CLASSIFICATION IN THE HILL AREAS :
A STUDY OF WEST KHASI HILLS DISTRICT OF MEGHALAYA

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CERTIFICATE

This is to certify that the present thesis entitled **"Land Classification in the Hill Areas: A Study of West Khasi Hills District of Meghalaya"** submitted by **Mr. Munindra Konwar** for the **Degree of Doctor of Philosophy (Ph.D.) in Geography**, in the Department of Geography, School of Environmental Sciences, North-Eastern Hill University, Shillong, is a bona-fide study to the best of my knowledge and belief. Other academic studies referred to and cited in the thesis have been duly acknowledged.

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PREFACE

Understanding, management and preservation of a vital resource like land is of the greatest importance to man. Moreso, is the case of the developing countries, because of the overwhelming dependence of their population on land and soil resources. North East India is especially dependent on land resources, since nearly 90.0 per cent or more of the population depend on agriculture or land related activities. The problem becomes even more acute in the case of large tracts of areas inhabited by tribal population, principally in the hill district, like the West Khasi Hills of Meghalaya. The general level of backwardness in this district is even more striking. Unfortunately, the land resource which is the chief means of livelihood of the people is the least managed along scientific principles; rather it is subjected to fast ecological degradations due to the age old practice of shifting cultivation and rising population pressure.

The objective of the present study is very specific. The principal aim is land classification of the West Khasi Hills district of Meghalaya with the aim of providing a basis for environmental management as well as the agricultural management of land. There are three bases of land classification which has been attempted here: (a) Land Classification on the basis of the genetic and landscape characteristics; (b) Land Classification on the basis of land potential with a parametric approach, and (c) Land classification on the basis of policy objectives, specifically the environmental management policy in view. The other important objective is also the detailed land classification of the catchment area of Um Sohdkhiew and Umthied (two tributaries of the river Kynshi) which will provide indepth study since land classification at the level of the district can be considered as too broad a level only.

In Chapter I, the problem and scope of the study, hypotheses and the research issues have been outlined. The summary of the relevant literature available for the study and the details of methodology, data base and data analysis - methods and techniques have been critically discussed in the Chapters 2 and 3 of the dissertation, respectively. Chapter 4 provides the general information on population (growth, density, work force etc.), settlement distribution, settlement under shifting cultivation and the economy, mainly agriculture and forestry.

Chapter 5 deals with the genetic and landscape approaches to land classification in the district. Classifying the district into two levels - macro-regions (Ecological zones) and micro-regions (Landfacets). An analysis of evaluation of land potential by use of rating index based on detailed sampling of soils (382) covering the entire district has been attempted in the Chapter 6 of the dissertation.

A normative basis of land classification has been attempted for environmental and agricultural management and of the district in three categories; land classified as environmentally 'safe', 'vulnerable' and 'degraded'. Chapter 8 deals with a micro-level land classification of the combined area of two small river basins of the district which provides a basis for environmental as well as agricultural management of land. In Chapter 9, some tentative answers have been provided on a number of issues, raised in the dissertation. This chapter is largely, supportive and the arguments put forward are based on some of the findings of the author.

The researcher hopes that this attempt, rather in an unexplored territory, shall both be of academic interest as well as practical utility.

(MUNINDRA KONWAR)

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CHAPTER - 1

INTRODUCTION

INTRODUCTION

1.1. The Concept of Land

As circumscribed by the earth, the area, what is considered to be land is finite and fixed. Peoples' need for food, clothing, shelter and energy come from the land, as do many of their needs for the amenities provided by fields, landscapes, and forests.

The term 'land' is too complex to be defined adequately. Given our anthropocentric viewpoint, however, the following definition developed by the Food and Agriculture Organisation (FAO) of the United Nations can be considered as adequate:

> "Land is an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictable, cyclic attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and the underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man."1

One consequence of this definition of land is that many, and perhaps all, water bodies on the surface of the earth have to be considered as land. Sometimes, water is treated as that part of the earth's surface which is left after land has been

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1 FAO (1976), in Vink, A.P.A. (1983); Landscape Ecology and Land Use, Longman Inc., New York, p. 11.

considered. But there are good reasons to consider fisheries and other uses of aquatic systems by man as kinds of land use which should be treated at par with the terrestrial land utilization types.

The complexity of land and its uses give an introduction to the nature of land and the problems of identifying and classifying it. To summarise, it is necessary to place the relationship of man and land resources in perspective by considering some important human concepts about land and its uses that have had much influence on the development of present attitude towards land.

The Judeo-Christian tradition in the Western World gave rise to the concept that people were created separately, after other living things, and were not a part of Nature. People were admonished to "be fruitful, and multiply, and replenish the earth, and subdue it."[2] The idea that the earth and all upon it were for people has become a deeply entrenched concept. Recently, the source of authority has shifted from God to the 'State' or 'Society'. In any case, the notion of the supremacy of human beings has been widely used to justify conquest and exploitation of natural resources as an 'unquestioned right of the humans'.[3]

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2 K. P. Davis (1976); Land Use, McGraw-Hill Book Company, New York, p. 7.

3 Ibid., p. 7.

The legal point that things affixed by nature or by human beings to the land, go with the land. Legally defined, permanent buildings and other structures and trees are a part of the land and are bought and sold with it, unless otherwise specified and agreed. Thus, when a person buys a house, the title deed specifically defines only the land area but not the structures or trees affixed to it.

Since the production of our basic needs (food, fibre and shelter) are linked with the wise use of the land, it is imperative that we must conserve this basic resource, and care for it so that we and our future generations may live on it.

1.2. Statement of the Problem

Land is the ultimate resource. Man being a terrestrial being, his habitation and all his activities, economic or social are land based. In earlier times, land management did not get due attention due to the fact that with low world population it was thought to be inexhaustible. But, in the twentieth century, with manifold increase in world population (currently estimated over 5,000 million) the situation has changed. It is not because of the food requirement alone, but due to urbanisation, industrialization and other developmental impetus that have put increased pressure on land. Although, there are still areas and countries where land is abundant, international migration from high density to low density areas have practically ceased.

There are no vast new lands waiting to be discovered and conquered. Therefore, every society has to manage to live and manage with the land they have.

Each year, the world has over 80 million[4] more people to feed but less good soil to grow crops. The destruction of our soil cover is a truly world wide phenomenon. It is beyond our (India) capacity to feed a population expected to increase by over a billion by the year A.D. 2000. Many nations are responding to preserve top soil which can take nature upto a thousand year to accumulate to a hoe's depth. When robbed of its protective vegetation, raging monsoons or strong winds can remove the top soil to expose bed rock in a matter of days. More often the process of destruction is less dramatic, a steady dwindling of fertility to a point where the land becomes useless to the farmer. Soil erosion is a natural process. The action of people is speeding up this process far beyond regenerating capacity of nature. In USA, annually 40 million hectares[5] are damaged beyond any practical repair; in India, one-third of the arable land is threatened with total loss of top soil. The consequences can extend far beyond the areas seriously affected. The 'desertification'[6] turns 6 million hectares into sand, and a further

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4 M.K. Tolba (1984); "Soil Erosion Threatens World Agriculture" <u>Mazingira</u>, Indian Edition, Vol. 8, No. 3, p. 7.

5 <u>Ibid</u>., p. 7.

6 <u>Ibid</u>.

21 million hectares are reduced to zero productivity. World wide, the livelihood of some 850 million people are threatened.

Historical evidences indicate that in the Eastern Mediterranean Region during Roman times, millions of hectares of land became desert;[7] in China, vast areas became eroded and abandoned and as recently as 1934, records indicate that the Yellow River carried silt washed down from cultivated lands equivalent to soil one metre deep, over 1,45,000 hectares. In Latin America, there are densely populated areas where the soil is very susceptible to erosion and losses have been so high as to place at least three countries there, among the low caloric areas of the world.

It has been said 'desert is the cradle of civilization'. The existence of the civilized man also indicates the existence of the desert! On a world wide scale, deserts are probably expanding faster today than ever before in the history of mankind. They are even faster than they did between 1914 and 1934. During this period more soil was lost to the world through erosion than in the whole of previous human history. That was the time when the dust bowl of North America was created. The top soil without cohesion, blew away and the land became desert.

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7 FAO (1977 and 78); "Soil Conservation for Developing Countries", in Soil Bulletin, No. 30, Paris.

The immediate causes of desertification in the developing countries are well known - overgrazing, indiscriminate felling of trees for fuel, waterlogging, salinzation and faulty agricultural practices etc. Too much is taken from the soil, too little is put back. This, in turn, is largely the result of the sharp increase in human population and the consequent pressure on land. It must be remembered however, that desertification is also taking place in developed countries, such as Australia, China, USSR, and USA. It is indeed, taking place throughout the world, but it is accelerating most rapidly in the developing (countries) world. Table 1.1 shows the degree and extent of the hazard of desertification in the developing world.

In case of India also, it has been noticed that the good soils have been degraded due to climatic factors, its improper management and misuse. Here, in India, deforestation is a major cause of land degradation. The extent of annual deforestation of rainforest in India is about 80,000 to 1,00,000 sq. km.[8] This scale of deforestation, not only makes ecological imbalance in our country but also causes the soil erosion and degradation. India's forest cover in relation to total landmass is 19.52 per cent[9] which is much below the minimum requirement of 33 per cent for maintenance of ecological and environmental balance.

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8 FAO (1977 and 78), op.cit.

9 The Sentinel, Guwahati, August 21, 1986.

Table 1.1: Degree and Extent of Desertification Hazards in the Developing World.

Degree of Desertification Hazards	Australia		Asia		Africa		Europe	
	Km^2	%	Km^2	%	Km^2	%	Km^2	%
Very High	332,300	4.3	485,840	1.2	1,857,070	6.1	51,290	0.5
High	3,120,040	40.5	6,848,890	17.3	5,032,000	16.1	218,380	2.1
Moderate	2,904,432	37.7	5,176,880	13.1	3,838,870	12.6	678,430	6.5
Extreme Desert already	-	-	2,156,220	5.4	6,550,520	21.6	-	-

Note: Percentage of the total land surface.

Source: J.K. Jain (ed. 1986). Combating Desertification in Developing Countries, Scientific Publishers, India.

The main casuality of this process of desertification is occurring in the hill areas of North East Region of India, where land is being degraded quickly by its faulty use pattern (for example, shifting cultivation, popularly known as 'jhum' cultivation). The region has about 4.94 per cent of closed forests[10] cover, but of these forests are secondary vegetation, the 10 years old bamboo shrubs developing after shifting cultivation.[11] It is estimated that about 5.5 thousand sq.km. of additional forests are cleared every year in the region, 50.0 per cent of which is primary forest due to slash and burn practices.[12] At this rate, all the primary vegetation would vanish from the region within a span of 25-30 years. This will distort not only the ecology in this region but also will degrade the soil fertility.

The pressure of population on the land resources and land based resources are increasing with a exponential rate of growth of population at 3.0 per cent per annum in the North Eastern Hill Region of India. In the absence of any significant manufacturing activities, nearly 85.0 per cent of the population are rural based and depend on agriculture. Being a hilly region,

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10 National Remote Sensing Agency, Hyderabad, 1983.

11 P.S. Ramakrishnan (1985); "Tribal Man in the Humid Tropics of the North-East India", Man in India, Vol. 65, No.1, pp. 1-32.

12 Ibid., pp. 1-32.

availability of flat land is limited and the agriculture is dominated by shifting cultivation. With a steady increase of the population, the pressure on cultivable land has gone up tremendously. This has resulted in complete occupation of valley lands permanently. The slopes and crest lands have been occupied under shifting cultivation, resulting in severe soil erosion, land degradation and is threatening the very means of sustenance of the people.

For understanding the extent of forest cover and deforestation, agricultural land use and soil quality, no adequate information base exist for this region, since there are no land records and no cadastral survey having been carried out. The present study, therefore, mainly aims at providing a base for the study of land classification of the West Khasi Hills District of Meghalaya, one of the most inaccessible, vulnerable and backward districts of the State.

1.3. Conceptualisation of the Problem

In a country (India) and in a region (North East India) where land is the chief resource for the people, land classification becomes fundamental to any attempt of rural and agricultural development. Land classification can be viewed from three theoretical approaches (Mabbutt, 1968):

i) The Genetic Approach

ii) The Landscape Approach, and

iii) The Parametric Approach.

(i) The Genetic Approach

This approach of land classification "attempts to arrive at distinctive land units by repeated subdivision on the basis of causal environmental factors ...."[13] The main theoretical support to this approach are:

(a) the similarity of widely separated areas and thus, the preditable characteristics,

(b) scope for a rational hierarchy, and

(c) promise of universality.

Essentially, this approach deals with the tangible, a priori (given) physical characteristics of the land, but by the same logic, precise divisions, specifically at lower level of the hierarchy is of limited use.

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13 Mabbutt further states, "Attempts to arrive at distinctive land units by repeated subdivision on the basis of causal environmental factors may be grouped as the genetic approach. This has its origins in the development of physical geography in the nineteenth century under the influence of botanists and geologists concerned with the genetic groupings of natural phenomena and the environmental controls of their associations and distributions."

"Reconciliation of this outlook with a primary aim of the geographer, namely the recognition of unity in diversity as shown in the distinctive character of portions of the earth's surface, led to the concept of genetically based 'natural' regions." J.A. Mabbutt (1968) in "Review of Concepts of Land Classification", in Stewart, G.A. (ed) 1968, Papers of the CSIRO Symposium, organised in cooperation with UNESCO, 26-31 August, 1968, Macmillan, Victoria, p.12.

(ii) The Landscape Approach

This is essentially a qualitative approach to land classification, based on the manifest differentiation of land at the micro-level through aerial photograph or satellite imageries, and then aggregation of the land units to higher levels[14] (Unstead, 1933). The landscape approach involves the recognition in the landscape of distinctive components with only a limited variation of those attributes important to land use. The most important factors in this approach is to identify the smallest

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14 J.F. Unstead (1933) further states, "Tired of fitting boundaries which did not exist around areas which did not matter, regional geographers abandoned the search for the elusive 'natural region' and sought real objects of study in distinctive parts of the observed environment. As a system of regional geography, the method is particularly associated with Unstead (1933), who aimed to show how the small regions so identified could be combined into areas of successively higher order ... "to a system of regions developed in this way the term 'synthetic' may be applied ... the process is one, not of division and subdivision of areas, but of combination of the smaller regions in order to arrive at the larger ones. By this means more accuracy is assured...."

"Unstead's primary units had to be small enough for detailed scientific investigation and at the same time be distinctive geographical entities. He proposed for them the term 'stow', identified by unity of relief, though with characteristic structure, hydrology, plant cover and land use. Nevertheless he recognized that the stow was made up of yet smaller components or 'features' of the status of minor land forms. His second order unit, the 'tract' consisted of a grouping of types of stow, and its unity might derive from one or all of relief, structure, and soils. Above the tract were levels of regional grouping expressive of characteristic relief type or climate". J.A. Mabbutt, op.cit., p. 15.

land units, the 'landfacets' (Bourne, 1931)[15] or 'facies' (Prokayev, 1962),[16] which distinctly manifest a complexity of physical, climatic, and environmental factors giving a particular character to the smallest land unit.

(iii) The Parametric Approach

The approach attempts land classification based on selected quantifiable attributes of land and thus amenable to statistical manipulations and more precise classes. As Mabbutt refers, "being quantitative, it allows comparisons between and affords greater consistency within land evaluation projects...."[17]

All the above three approaches to land classification have their advantages as well as limitations. Adoption of any

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15 Bourne defines the fundamental components of 'landfacets' as the 'site'. He further stated that "an area which, for all practical purposes, provides throughout its extent similar conditions as to climate, physiography, geology, soil, and edaphic factors in general". J.A. Mabbutt, op.cit. p. 17.

16 Prokayev further suggested, "that the definition of the facies should be based on the character and thickness of surface deposits, the redistribution of moisture and of heat within it as controlled by local relief, and corresponding properties of soil and vegetation cover and of animal life," in J.A. Mabbutt, op.cit., p. 17.

17 Mabbutt states that "one may define the parametric approach as the division and classification of land on the basis of selected attribute values. For instance, a hypsometric map demonstrates a classification of land based on elevation, with class limits at chosen contours. Employment of the parametric approach ranges from general purpose surveys considering many attributes, to classification for special purposes and on a narrower basis, and also includes the stiffening of more qualitative systems through the infusion of parametric ingredients". J.A. Mabbutt, op.cit., p. 19.

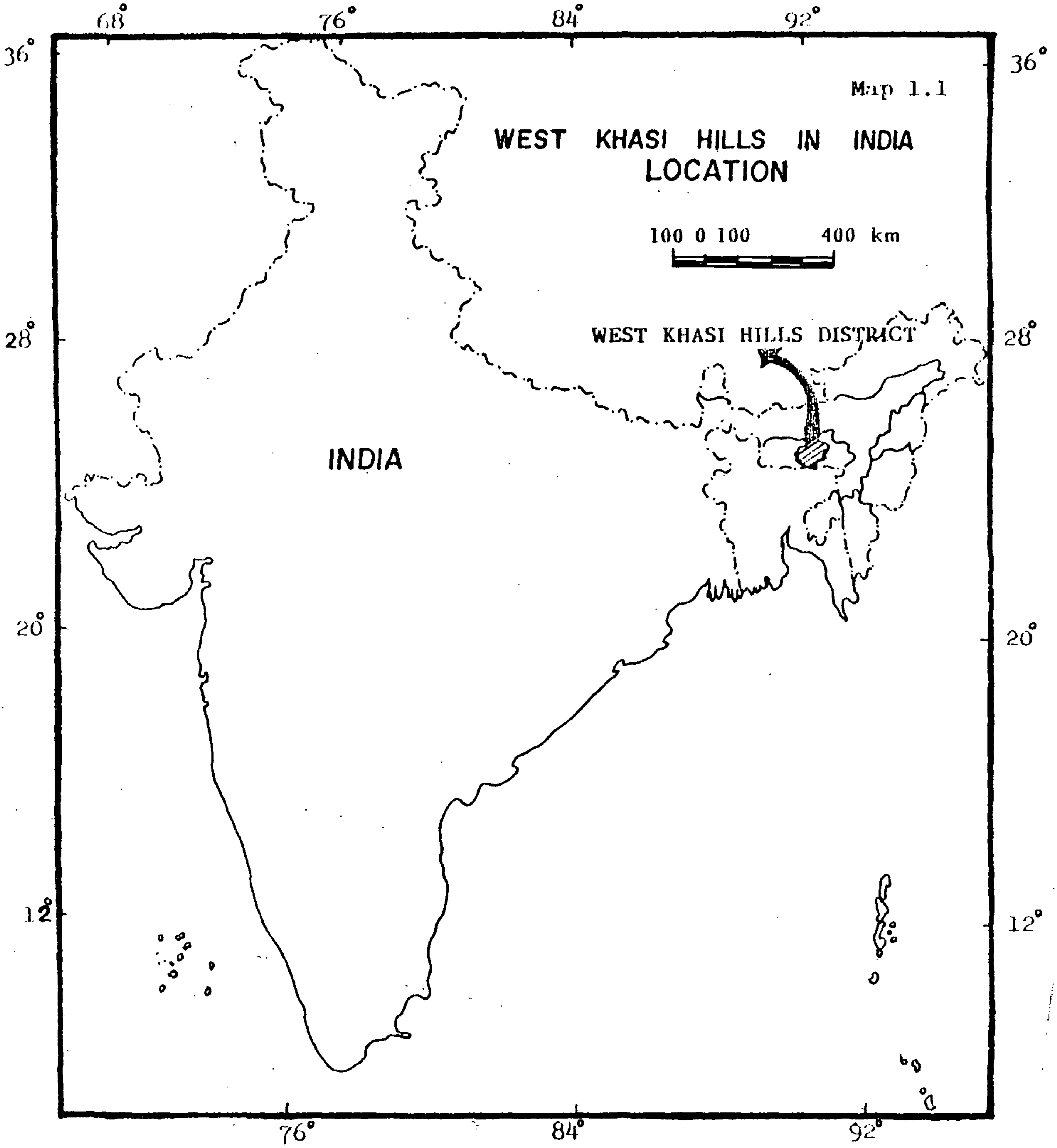
one or rejection of the other has specific problems. In the present study, an attempt has been made to use all the three approaches in combination (and synthesis) for different sections and requirements of the study. Moreover, an additional approach has been developed due to the specific demands of the study. This approach may be called the 'normative approach'. A detailed discussion on this approach has been dealt with in Chapter 3, i.e. Methodology.

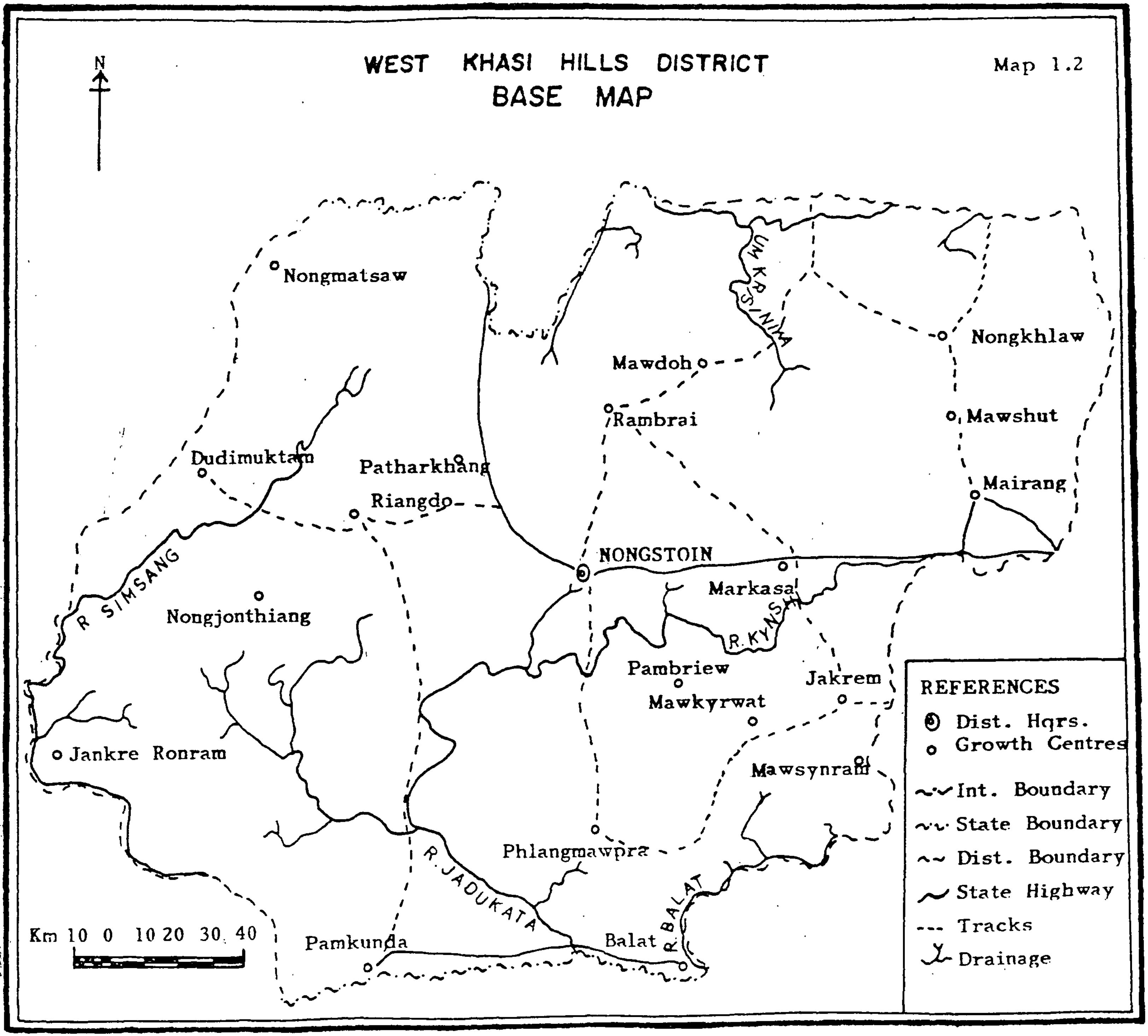
1.4. Study Area

For the present analysis, the study area chosen, is a district of the State of Meghalaya, i.e. West Khasi Hills District.

1.4.1. Location

The West Khasi Hills district is situated in the central part of the State of Meghalaya. The district lies between 25°51' North Latitude and 90°45' East to 91°52' East Longitude covering an area of 5,247 sq.km. occupying about 24.0 per cent of the total geographical area of the State. The district headquarters is located at Nongstoin, at a distance of 96 km from Shillong, the capital of the State. The district is bounded by Kamrup district of Assam to the North, East Garo Hills and West Garo Hills districts of Meghalaya to the West and Bangladesh to South. Map 1.1 and 1.2 show the location and the base map of the West Khasi Hills district of Meghalaya, respectively.


Map 1.1
WEST KHASI HILLS IN INDIA
LOCATION
100 0 100 400 km
WEST KHASI HILLS DISTRICT
INDIA
68°
76°
84°
92°
36°
28°
20°
12°


WEST KHASI HILLS DISTRICT
BASE MAP
Map 1.2
N
Nongmatsaw
Nongkhlaw
Mawdoh
Rambrai
Mawshut
Mairang
Dudimuktam
Patharkhang
Riangdo
NONGSTOIN
Markasa
R SIMSANG
UM KRISNIMA
R. KYNSHI
Nongjonthiang
Pambriew
Mawkyrwat
Jakrem
Jankre Ronram
Mawsynram
Phlangmawpra
R. JADUKATA
R. BALAT
Pamkunda
Balat
Km 10 0 10 20 30 40
REFERENCES
Dist. Hqrs.
Growth Centres
Int. Boundary
State Boundary
Dist. Boundary
State Highway
Tracks
Drainage

In the district, there are four Community Development Blocks; they are, Nongstoin, Mawshynrut (Sonapahar), Mawkyrwat and Mairang C.D. Blocks. They provide the operational jurisdiction of the district. The district had a total number of 710 villages[18] having some of the most backward villages of the State. In 1975-76, the Government of Meghalaya declared 432 villages of the district as 'most backward' and another 105 villages as 'specially backward'.[19]

1.4.2. Historical Background of the Study Area

On ethnological grounds there are reasons for supporting that the Khasis and Syntengs have been living in these hills for many centuries. Due to the isolation in their mountain strongholds, little is known of their early history. At the end of the eighteenth century, they harried the plains on the north and south of the District, and their raids were thus described by Pemberton in 1835:

> "They descended into the plains both of Assam and Sylhet, and ravaged the villages fire and sword the villages which stretched along the base of this lofty region. Night was the time almost invariably chosen for these murderous assaults, when neither sex nor age spared."[20]

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18 Government of Meghalaya (1981); Socio-Economic Review, West Khasi Hills District, District Statistical Office, West Khasi Hills, Nongstoin.

19 Government of Meghalaya (1981), op.cit., p.2.

20 R.B. Pemberton (1835); Report on the Eastern Frontier of British India, Calcutta, p. 221.

In 1826, the Europeans first visited in the Khasi Hills. Among the Europeans, David Scott first entered into the District with the help of local chiefs for the construction of a road through their territory from Assam into Sylhet. The construction work could not be finished due to the threats of the Bengali Chaprasi, who declared that the hills were to be brought under taxation. The tribes suddenly rose and massacred two European Officers, Lt. Bedingfield and Burlton, near Nongkhlaw, with about 60 of their native followers. Military operations were commenced, but were protracted through several reasons, and it was not till 1833 that last of the Khasi Chiefs tendered his submission. Engagements were then entered into with the heads of the various Khasi States. Government abstained from imposing any taxation upon their subjects and their independence was recognised. Since, that date the history of the Khasi states has been one of peaceful development, checked only by the great earthquake of 1897.

Originally, Cherrapunji was selected as the Headquarters of the hills, but due to the excessive rainfall the then District Officer had to move to Shillong in 1864 and Shillong was declared the headquarters of the administration when Assam was formed into a separate province ten years later.

1.4.3. The State of Meghalaya

The State was created by the North-Eastern Areas (Reorganisation) Act 1971, which gave it the status of a full-fledged

State with effect from January 21, 1972. Prior to 1970, the areas now constituting the State of Meghalaya formed part of the state of Assam. The State of Meghalaya was declared as an autonomous State of Meghalaya within the State of Assam on January 12, 1970. Initially, the State had only two districts namely, United Khasi and Jaintia Hills District and the Garo Hills District. In 1972, the erstwhile United Khasi and Jaintia Hills district was bifurcated into two districts namely, Jaintia Hills District with headquarters at Jowai and Khasi Hills district with headquarters at Shillong. Thereafter in 1976, Khasi Hills District and Garo Hills District were bifurcated to form two ditricts each, viz. East Khasi Hills district with headquarters at Shillong, West Khasi Hills district with headquarters at Nongstoin, East Garo Hills district with headquarters at Williamnagar and West Garo Hills district with headquarters at Tura.

1.5. Objectives

1. Since, the study is of taxonomic type, the overall aim is land classification of the West Khasi Hills district of Meghalaya which is one of the most backward district of the State, with the aim of providing a basis for environmental management as well as the agricultural management of land. There are three bases of land classification which has been attempted here:

   (a) Land classification on the basis of the genetic characteristics and landscape characteristics;

(b) Land classification on the basis of land potential with a parametric approach; and

(c) Land classification on the basis of policy objectives, specifically the environmental management policy in view.

2. The other important objective is also the detailed land classification of the catchment area of Um Sohdkhiew and Umthied (two tributaries of the river Kynshi) which will provide indepth study since land classification at the level of the district can be considered as too broad a level only.

1.6. Hypotheses and Research Questions

As mentioned earlier, the study is essentially of taxonomic character and therefore, exploratory in nature. The major tasks, therefore, will be to explore the pattern and nature of land classes in their horizontal and generic levels, whether on the basis of existing situation of land as has emerged over the long interaction of man and nature or from the point of view of policy intervention in the situation. Therefore, no major hypothesis has been planned to be investigated. However, a number of secondary hypotheses have emerged during the study. These hypotheses can be outlined in the following manner:

(1) that soil fertility declines with slope. This is indicative of erosion of top soil from higher slope zones and deposition in the valleys.

(2) that land potentiality declines with altitude and slope. Thus, the valley and gentle slopes are suitable for agricultural occupance and intensification of cultivation.

(3) that vulnerability of land arises out of intensification of land use on slopes, deforestation and reduction in the shifting cultivation cycle.

(4) that land degradation is a consequent stage of non-management of vulnerable land and not isolated land units.

(5) that deforestation is an accelerating process. This needs occupational shift and management of land.

(6) that vulnerability and degradation of land arises out of improper or under-utilization of the existing valley land. If, the potentiality of valley land is fully exploited in the district the pressure on slopes and forests can be considerably reduced.

Moreover, a number of information on varied aspects of the land quality, land potential and the pattern of land classes have been systematically studied and summarised in the relevant chapters of the thesis.

1.7. Justification of the Present Study

The understanding, management and preservation of the vital resource i.e., 'land' is of the greatest importance to man now. More so, is the case of the developing countries, because of the overwhelming dependence of their population on land and soil resources. The North East Region of India is especially dependent on land resources, since nearly 90.0 per cent or more of the population still depend on agriculture or land related activities. The problem becomes even more acute in the case of the large tracts of areas inhabited by tribal population, principally the hill district of the West Khasi Hills of Meghalaya. The general level of backwardness in this district is even more striking. Unfortunately, the land resource which is the chief means of livelihood of the people is the least managed along scientific principles; rather it is subjected to fast ecological degradations due to the age old practices of shifting cultivation and rising population pressure.

In India, few studies have been attempted on land classification. Most of the studies on 'land' for the purposes of classification have been based on two approaches. Firstly, land classification has been attempted on the basis of potentiality and capability of land. The criteria for the assessment of land potentiality and capability are either soil quality or the production capacity of the soil. Secondly, many of the studies on land classification have been carried out by land use related studies. Such land use related studies can be classified into two classes: (a) agricultural land use, and (b) general land use. A detailed discussion on these approaches of classification especially for India, have been dealt with in Chapter 2 of the thesis.

Unfortunately, not much information nor sustained studies have been attempted on the West Khasi Hills district, particularly on land and soil quality to understand the problems related to land classification in the district. Being part of the non-land record, non-cadastral surveyed areas of the country, most of the information compiled by different official sources are at best informed guesses. Therefore, the present study can be considered as a pioneering work of its kind, especially in the North East Region of India, so also to the country.

CHAPTER - 2

SURVEY OF LITERATURE

SURVEY OF LITERATURE

2.1. Introduction

A considerable amount of work on land use has been done at various levels in the world. But, the number of studies devoted, particularly to land classification are not substantial. A brief survey of the earlier studies has been attempted in this chapter, which can be split into three parts. Part one deals with the studies concerning land classification based on global studies. The second part examines the contributions and trends in research on land potentials especially soils as the major evaluation factor in India. The third part surveys the studies on land classification in relation to North East Region of India.

2.2. Prior to the Second World War, in the Great Britain under the guidance of Sir Dudley Stamp,[1] the 'Land Utilization Survey' was conducted and a simple classification of land was arrived at. This classification was used as a basis for delimitation of the tracts of good agricultural land which could be avoided during development projects. According to Kellong,[2] the first requirement for the successful development and application of any technical system of land classification is a clear understanding of the problems for which the classification

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1 L.D. Stamp (1960); Applied Geography, Penguin Book Ltd., London.

2 C.E. Kellong (1940); "The Theory of Land Classification", Missouri Agricultural Bulletin, No. 421, pp.164-173.

is needed. Gray and Regan[3] are of the opinions that land classification is aimed at the determination of the best use from the enterpreneurial and social standpoint. Zvorykin[4] has tried to assess the worth of individual land in terms of its value with a view to recommend measures for increasing yields from different classes of land. He suggested that mapping of the land on the basis of its physical attributes and quality of existing cultivation is the first stage in the land classification work.

A good number of studies on land classification have been studied by Mabbutt,[5] Christian,[6] Prokayev,[7] Unstead,[8] Parry[9]

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3 T.R.G. Gray (et al.) (1971); Soil Micro-Organisms, Longman Groups Limited.

4 K.V. Zvorykin (1967); "Scientific Principles for an Agro-Production Classification of Lands", Soviet Geographer, Review and Translation, Vol.4, pp. 3-10.

5 J.A. Mabbutt (1968); "Review of Concepts of Land Classification", in Stewart, G.A. (ed.) 1968, Paper of a CSIRO Symposium, organised in cooperation with UNESCO, 26-31 August, 1968, Macmillan of Australia, Victoria, pp.11-27.

6 C.S. Christian (1958); "The Concept of Land Units and Land Systems", Proc. 9th Pacific Sci. Congr., 1957, Vol.20, pp. 78-81.

7 V.I. Prokayev (1962); "The Facies as the Basis and Smallest Unit in Landscape Science", Soviet Geographer 3, pp.21-29.

8 J.F. Unstead (1933); "A System of Regional Geography", Geographer 18, pp. 185-187.

9 J.T. Parry, J.A. Heginbsttom and W.R. Crown (1968); "Terrain Evaluation in Mobility Studies for Military Vehicles", In Stewart, G.A. (Ed.), Land Evaluation, Macmillan of Australia, Victoria, pp. 160-170.

(*et al*.), Siderius[10] (Ed) and King.[11] Among these studies, the studies of Mabbutt, Christian, Prokayev and Unstead are very relevant for the present study.

Mabbutt has reviewed the concept of land classification in detail. He has discussed the problems of complexity, extent and association of land classification. There are three approaches of land classification, namely - the genetic approach, the landscape approach and the parametric approach. A detailed discussion on the three approaches have been attempted in his study. The study shows the clear idea about how to select the attributes of land and what are the advantages and disadvantages. Moreover, the study also deals with the comparison and combination of those attributes which are taken for land classification. The landscape approach of land classification has been attempted by Christian. He has admitted that most of the 'land systems'[12] are complex or compound, that is combinations of of simple land systems based on close relationship. This simple

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10 W. Siderius (ed) (1986); "Land Evaluation for Land Use Planning and Conservation in Sloping Areas", Proc. Int. Workshop, ILRI, Enochede, The Netherlands, 17-21 December, 1984, p.334.

11 R.B. King (1970); "A Parametric Approach to Land System Classification", Geoderma, 4, pp. 37-46.

12 Land System is "a composite of related units ... an area or group of areas, throughout which there is a recurring pattern of topography, soils and vegetation...." Christian and Stewart (1953) in Stewart, G.A. (ed) 1968, Paper of a CSIRO Symposium, organised in cooperation with UNESCO, 26-31 August 1968, Macmillan, Victoria, p. 18.

land system of 'land unit'[13] provide a convenient ar`angment of components - the workable land units which aids in recognizing the land system.

Since the landscape approach involves the recognition of different landfacets in the landscape with a limited range of variation. Therefore, the attention lies on the recognition of landfacets. From the suggestion given by Prokayev, the definition and identification of landfacets become easier for the study. He has discussed that the landfacets are controlled by local relief and corresponding properties of soil and vegetation cover and of animal life. Unstead has tried to identify small regions with the aggregation of different landfacets. His main idea was to combine the small regions into areas of successively higher order.

Assessment of soil quality and classification is an important component of evaluation of land potentials evaluation. Soil classification is a most basic and complex subject and has a long history of development. A new and comprehensive system was adopted by the U.S. Department of Agriculture[14] in

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13 Land Unit is a small land system which has independent character. The difference between 'land system' and 'land unit' is that the former includes different types of land units to form a 'land system'.

14 U.S. Department of Agriculture Soil conservation Service; Soil Taxonomy, A Wiley - Interscience Publication, John Wiley and Sons, New York, 1968.

1960. This system is based on soil properties as they occur and on soil genesis - how soils were formed. The older system placed more emphasis on soil genesis.

The basic classification unit is the soil series,[15] which describes a generally similar group of soils in particular place. Over 8,000 series are recognized in the United States. The name of the series in the United States is taken from a city, river of other name in the area in which the series is located and described. The U.S. Department of Agriculture Soil Conservation Service[16] has given the present status of the soil taxonomy being used to make and interpret soil maps in the United States and other countries. It discusses the two preliminary approximations, the soils and the classification systems used in Western Europe. The arrangement of orders is alphabetic. Within each order, suborders are also arranged and 'great groups' are similarly arranged within each suborder. Sub-groups have an alphabetic arrangement such that the typical subgroup always comes first. Soil families and series are listed systematic ways.

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15 "A group of Soils that formed from a particular kind of parent material .... Chemical Composition" (U.S. Department of Agril, 1960).

16 U.S. Department of Agriculture Soil Conservation Service; op.cit., 1968.

Apart from usefu', updated textbooks on the geography of soils, Bunting,[17] Buckman,[18] Donald,[19] Duchanfour,[20] Eyre,[21] Hunt,[22] Millar[23] etc, incorporate the recent advances in the field, a large number of scholarly papers have been appeared in research journals such as the Soil Science, Journal of Soil Science, Soviet Soil Science and the like.

The Soil Society of America[24] has compiled an exhaustive glossary of soil science terminology as a standard references manual of good use to all soil scientists. Fitzpatrick[25] has also attempted to clarify soil nomenclature and classificatory system. Kovda[26] et al. have provided a useful summary of the Russian Scheme of genetic classification of the soils of the world on a macro-regional frame. The comprehensive soil

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17 B.T. Bunting (1967); The Geography of Soil, Chicago.

18 H.O. Buckman and N.C. Brady (1971); The Nature and Properties of Soils, Macmillan, New York.

19 S. Donald (1976); The Geography of Soils, Prentice Hall.

20 P. Duchanfour (Ed.); Pre'cis de Pedologie, 2nd Edition, Massot, Paris.

21 S.P. Eyre (1971); Vegetation and Soils, Arnold, London.

22 C.B. Hunt (1972); Geology of Soils: Their Evolution, Classification and Uses, Freeman, San Francisco.

23 C.E. Millar, M. Turk and H.D. Foth (Edited, 1963); Fundamentals of Soils Science, Wiley-Inter-Science Publication, New York.

24 Soil Science Society of America (1973); Glossary of Soil Science Terms, Wisconsin.

25 E.A. Fitzpatrick (1967); "Soil Nomenclature and Classification" Geoderma, Vol.1.

26 V.A. Kovda, Y.V. Lobova and V.V. Rozanov (1967). "Classification of World Soils", Soviet Soil Science.

classificatory scheme Seventh Approximation prepared by the Soil Survey Staff of the U.S. Department of Agriculture[27] and its supplement have been reviewed in detail by Webster.[28] Stance[29] (*et al.*) have compiled a manual of the Australian soils. The National Cooperative Soil Survey Unit of the U.S. Government has also brought out a manual on soil taxonomy. Drew[30] in an edited compilation presents selected papers on soil formation and classification. The periodic FAO[31] publications and soil bulletins cover a wide range of useful themes of practical nature such as land classification, land evaluation, land reclamation and improvements, guidelines for the watershed management, soil conservation measures etc. The Commission for Technical Cooperation in Africa has produced a soil map of Africa. D'Hooke[32] accompanied with the Commission has prepared an explanatory monograph on the soils of Africa. In the developing world, the countries like Sri Lanka & Malaysia have

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27 U.S. Department of Agriculture (1960); Soil Conservation Service - Soil Classification, A Comprehensive System, 7th Approximation, Washington.

28 R. Webster (1968); "Fundamental Objections to the 7th Approximation", Jr. of Soil Science, 19 .

29 H.T.C. Stance, G.I. Hubble, R. Brewer, K.H. Northcote, J.K. Sherman, M.J. Mulbahy and E.G. Hallosworth (1968); A Manual of Australian Soils, Adelaide.

30 Drew (1967); "Selected Papers in Soil Formation and Classification", Soil Science Society of America, Madison.

31 FAO (1977); Conservation Guidelines, Guidelines for Watershed Management and also Soils Bulletin, Paris.

32 J.L. D'Hooke (1963); Soil Map of Africa-Explanatory Monograph, Commission for Technical Cooperation in Africa, Lagos.

brought out detailed soil maps of their countries based on soil survey data and use of air photography.

Maignien[33] has reviewed the available research material, as on data, on laterites, in a special UNESCO[34] publication. Arkley[35] has been examined the climate of the Great World Soil Groups as recorded in the western parts of the United States of America. In the fifth edition of Foth and Turk[36] show the importance of soils in civil engineering, landscaping, geography, geology, biology, history and social sciences.Bohn[37] (et al.) have shown comprehensive introduction to the subject for the students needing a thorough grounding in soil chemistry and an invaluable reference to the latest scientific data for researchers in the field of agronomy, ecology and soil science. Smith[38] provides basic theory for each technique with diagrams and fundamental formulas clarifying instrumental design, features available methods and instruments and their suitability

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33 R. Maignien (1966); "Review of Research on Laterites", UNESCO, Paris.

34 UNESCO (1969); "Soils and Tropical Weathering", Proceedings of the Bandung Symposium, UNESCO Natural Resources Research, Paris.

35 R.J. Arkley (1967); "Climates of Some Great World Soil Groups of the Western United States", Soil Science, 103.

36 H.D. Foth and L.M. Turk (5th edn. 1972); Fundamentals of Soil Science, Wiley Eastern Private Ltd., Indian Publication, New Delhi.

37 H.L. Bohn, B.L. Mcneal and G.A. O'Connor (2nd edn. 1985); Soil Chemistry, A Wiley Interscience Publication, New York.

38 K.A. Smith (et al. 1983); Soil Analysis - Instrumental Techniques and Related Procedures, Marcel Dekker, Inc., New York.

for particular applications. Thompson's[39] second and large edition has emphasized on soil structure and related physical properties. The relationship of fertility of soil moisture has been developed and emphasis has been placed on water conservation and management. Pitty[40] provides a comprehensive, introductory text for undergraduate and postgraduate geographers with a basic but thorough knowledge of soil properties in any major world region. He emphasizes the significance of the spatial changes in soil patterns, the environmental influence on soils and their temporal changes. His main attention on the systematic examination of soil properties and their reciprocal effects. Donahue[41] (et al.) have emphasized on the basic principles underlying soil science and soil ecology and their relationship to the growth of plants and their environment. He has discussed the dynamic character of soils and encourages the reader to enjoy studying the soil as a cultural subject. It is also important to know the soil biology for which nature and properties of soils are solely dependent. Burges and Raw[42]

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39 L.M. Thompson (et al. 1957); Soils and Their Fertility, Second Edition, McGraw-Hill Book Company, New York.

40 A.F. Pitty (1979); Geography and Soil Properties, Methuen and Co. Ltd.

41 R.L. Donahue, J.C. Shickluna and L.S. Robertson (3rd edn., 1958); Soils: An Introduction to Soils and Plant Growth, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

42 A. Burges and F. Raw (1967); Soil Biology, Academic Press, London and New York.

have analysed soil biology. It is recognised that the soil cannot be studied solely from a chemical, micro-biological, botanical or zoological standpoint. The ever changing pattern of processes going on in the soil is made up of elements from many disciplines, inextricably interwoven, which must be synthesized and not studied in isolation. Unless this is constantly borne in mind, the scientific understanding of the soil will cease to advance and will stagnate. His aim is to bring together the micro-biological, botanical and zoological aspects of soil biology in a way that provides information and ideas for the specialist in his own and related field. Baver[43] (*et al.*) provide the most comprehensive treatment of soil physics. He discusses the details of basic principles of physics and physical chemistry as applied to those processes which involve practical use of the soil as a structural material and as a medium for plant growth. Particular emphasis is given to the fundamental principles of water retention and flow and their combined effect upon biological organisms living in and depending upon soil. Dent and Young[44] describe the related techniques of soil survey and land evaluation which play an essential part in the planning

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43 L.D. Baver, W.H. Gardner and W.R. Gardner (4th edn., 1972); *Soil Physics*, John Wiley & Sons, Inc., New York, London, Toronto.

44 D. Dent and A. Young (1981); *Soil Survey and Land Evaluation*, George Allen and Unwin, London, Boston and Sydney.

and management of land resources. They provide a concise and practical introduction to these techniques and procedures, for professional surveys, students and potential users of surveys.

The concepts of land evaluation are discussed, including a review of established methods and more detailed account of how to put into practice the more recent approach of land suitability evaluation. Haans[45] (et al.), present an overall view of the current situation of land evaluation and its application in the European community. He illustrates the progress which has been made, since the European Community Land Resource Evaluation Symposium of Wexford in 1978. Butler[46] has developed a substantial critique of soil classification. The classification of soils, that is the recognition and definition of groups of soils with properties in common, which has proved more difficult and controversial than most. According to him, the best schemes of classification have provided useful frameworks for generalizing the results of research and experience.

Bridges[47] (et al.) provide an understanding of the scientific aspects of soils which is fundamental to an understanding of pattern of soil distribution throughout the world.

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45 J.C.F.M. Haans, G.G.L. Steur, and G. Heide (1984); "Progress in Land Evaluation", Proceedings of a Seminar on Soil Survey and Land Evaluation, Wageningen/Netherlands/ 26-29 September, Published by A.A. Balkema, Netherlands.

46 B.E. Butler (1980); Soil Classification for Soil Survey, Monograph on Soil Survey, Clarendon Press, Oxford.

47 Bridges (et al. 1978); World Soils (2nd end), Cambridge University Press, Cambridge.

Methods used in the compilation of soil maps have been explained and the development of soil classification is traced using a selection of historically important and modern classifications. He describes the earth's soils within a broad geographical framework and also describes the local variations from the world zonal soils.

Soil is a heterogeneous mixture of most of the chemicals known to man. This, coupled with a tremendous diversity in physical conditions, results in soil becoming the home of a greater variety of micro-organisms than any other environment. Gray and Williams[48] have studied the soil micro-organisms and their ecology. They have emphasized new assessment of micro-flora and stress the interrelationships between microbes, plants and organic debris. After a review of the principles of micro-scopic examination of soils, Kubiena[49] describes the environmental factors, and primitive biotic activity which lead to the development of soils on bare rock. In an unusual series of microphotographs he shows the pathways of organic decomposition and how plant and animal residues are converted into humus.

Soil erosion is a serious problems and is likely to assume a great threat in future as the exploitation of resource

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48 T.R.G. Gray (et al.) (1971); Soil Micro-Organisms, Longman Group Limited.

49 W.L. Kubiena (1970); Micromorphological Features of Soil Geography, Rutgers University Press, New Brunswick, New Jersey.

for production expands. Kirkby[50] (et al.) describe the mechanics and processes of soil erosion, methods of measuring erosion and the carrying out of laboratory and field experimentation. His approaches to erosion modelling and the implications of these to practical erosion control.

Americans have earned an unenviable reputation for wasteful utilization of their natural resources. Unfortunately, the soil, the most essential of all our resources, is one that suffered severely from misuse. Although millions of hectares that offered small resistance to depletion or erosion have been exploited and abandoned, there remain many more millions that have resisted erosion in varying degrees. This land must be managed in a way that will maintain or increase their productivity if the increasing population of the 'planet earth' is to remain relatively self-sufficient in supplies of food. It is possible and desirable that large areas of depleted land can be brought again to such a state of fertility that they may be profitably farmed. Cook[51] discusses the principles and practices of soil management that lead to an intelligent practical and profitable use of land.

2.3. In a predominantly agricultural country like India, the use of soils over centuries and the aggravating problems

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50 M.J. Kirkby and R.P.C. Morgan (1980); Soil Erosion, A Wiley-Interscience Publication, John Wiley and Sons, Chichester, New York.

51 R.L. Cook (1962); Soil Management for Conservation and Production, John Wiley and Sons, Inc., New York.

arising out of misuse and overuse of soils, demand the making of an early inventory of the soil resources of the country. This is indeed for studying the present status of the soil resources and for policy making towards efficient and optimal utilization of these resources. It should enable us to think of ways and means for enriching our already impoverished soils the mainstay of the impoverished masses.

The National Commission on Agriculture[52] has reported about soil survey and soil map of India. They stressed the need and objectives for a soil resource inventory of the country. The Commission has examined the present status of soil surveys in the country and has drafted proposals for soil survey, classification and mapping. During the Fifth Plan period, the National Bureau of Soil Survey and Land Use Planning[53] has been entrusted with the task of conducting reconnaissance soil survey and mapping of all States and Union Territories. Soil and Land use maps have been prepared at Tehsil, district, state and national levels. These are compilation of 1:1 million scale soil and land use map of India. In addition, detailed maps of project areas are also being worked out, making use of topographical maps and remote sensing

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52 The National Commission on Agriculture (1972); Reports on Soil Survey and Soil Map of India.

53 The National Bureau of Soil Survey and Land Use Planning. Reports During Fifth Plan Period.

satellite imageries. The survey has issued about 130 soil survey reports and has come out with some state soil maps.

Several State Governments have already taken steps in this regard. The first soil maps of Karnataka and Kerala and soil map of India in a generalized form are already available. The All India Soil and Land Use Survey Organisation[54] is carrying out standard soil surveys of a reconnaissance type in different parts of the country in order to identify soil profile character and to classify them into different soil maps. This organisation is also carrying out on a priority basis studies on soils and soil mapping of watershed areas of river valley projects.

The Central Soil Mechanics Research Station of Central Water and Power Commission[55] has carried out irrigation soil surveys on grid patterns in command areas of irrigation projects. This is for classifying the areas suitable for irrigation, agriculture, reclamation, identification of waterlogged areas etc. The State Departments of Agriculture and Soil Conservation carry out soil surveys mainly for the purposes of specific development programmes and a state level soil classification based on broad criteria. The Central Arid Zone Research

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54 The All India Soil and Land Use Survey Organisation (1907); Reports on Soil Surveys and Soil Profiles in India, IARI, Delhi.

55 The Central Soil Mechanics Research Station of Central Water and Fower Commission (1967); Reports on Soil Surveys Irrigated Areas.

Institute has also initiated integrated soil surveys in the arid and semi-arid areas of India.

In India, few studies have been attempted on land classification. The majority of the studies on land are based on land use and land capability. The studies related to land use can be classified into two types of studies; agricultural land use and general land use. It may be mentioned that no studies have so far been attempted on directly related to land classification in India.

There are quite a large number of studies on agricultural land use in India. Among them, the studies of Mohammad (ed); Amani, Roy, Raghavaswamy (et al.), Srivastava (et al.), Chansarkar, Tiwari, Godfrey, Shafi and Raza (et al.) are important one.

In the edited work of Mohammad[56] (ed), a good number of articles dealing with concepts, theories and models of land use, land classification, land capability, dynamics of land use and cropping patterns in different regions of India were discussed comprehensively. Most of the articles have been attempted on the studies related to general and agricultural land uses. Very few articles were attempted on land

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56 Noor Mohammad (ed, 1981); Perspective in Agricultural Geography, Vol. III, Concept Publishing Company, New Delhi.

capability classification. Amani[57] conducted a study related to agricultural land use at the village level. In his study, a number of maps were prepared to show the uses of land in different seasons. Roy[58] focused on certain aspects of changing land use in Middle Ganga Valley of Azamgarh district (U.P.).

With the help of aerial photographs, many studies on land use and land capability have been attempted in India. Raghavswamy[59] (et al.) interpret the various types of land uses and land systems of a part of Visakhapatnam District (A.P.) from the air photos. He has identified seven types of land use, fifteen types of land cover, and five types of Geomorphic units of land. The mapping of various uses of land of Dehra Dun city were prepared by Srivastava[60] (et al.) on the basis of air photos. Both agricultural and general use classes of land were identified in the study. The study on

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57 K.Z. Amani (1968); "Land Utilization in Village Golgarhi (1926-27 - 1966-67)", The Geographer, Vol. XV, pp.57-73.

58 B.K. Roy (1968); "Measurement of Rural Land Use in Azamgarh, Middle Ganga Valley (U.P.)", The Geographer, Special Number, Land Use, Vol. XV, Nov. 1968, pp.74-100.

59 V. Raghavswamy and R. Vaidyanadhan (1980); "Land Use Studies from Aerial Photographs: A Case Study of Visakhapatnam and its Environs", Geographical Review of India, Vol. 42, No.1, March 1980, pp. 1-15.

60 R. N. Srivastava and L.R.A. Narayan (1974); "An Attempt Towards Mapping of Land Use of Dehra Dun City Using Aerial Photo Interpretation Techniques", Photo-Nirvachak, Jour. Ind. Soc. Photo. Int., Vol.2(1), pp. 19-27.

terrain evaluation was conducted by Chansarkar.[61] The terrains were classified into various groups for the defence purposes only. A general classification of land was done by Tiwari[62] with the help of air photos. The role of physiography on land use planning was discussed by Godfrey.[63] In his discussion, he mentioned about the physical features (like topography, vegetation cover, slope, etc.), which are the controlling factors for various kinds of land uses. The methods and techniques of land use planning, land classification and land capability were discussed by Shafi[64] in detail. He has elaborated on the various methods and techniques used in USA, USSR, Poland and Britain in case of land classification and land capability classification. The land capability classification was studied by Raza[65] (et al.) using Bennet's method based on site peculiarities and physical factors. They classified the Kashmir Valley into seven land capability classes.

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61 R.A. Chansarkar (1976); "Aerial Photo Interpretation as an Aid in Terrain Studies", S.M. Ali Memorial Volume, Department of Applied Geog, Univ. of Sagar, pp.91-102.

62 A.K. Tiwari (1977); "Air Photo and Rural Land Use Analysis", Geographical Review of India, Vol. 39, No.2, pp. 156-163.

63 A.E. Godfrey (1977); "A Physiographic Approach to Land Use Planning", Jour. Env. Geol., Vol.2, pp. 43-50.

64 Mohammad Shafi (1969); "Land Use Planning, Land Classification and Land Capability: Methods and Techniques", The Geographer, Vol. XVI, pp. 1-8.

65 M. Raza, A. Ahmad and A. Mohammad (1978); The Valley of Kashmir, Volume I: The Land, Vikas Publishing House Pvt. Ltd., New Delhi.

2.4. In the North Eastern Region and specially in the hill tracts there are practically no systematic study on land quality. The sample studies carried out by ICAR also pertains to only agricultural land and not for land under other uses or proposed uses. Prasad and Ram[66] have studied the fertility status of soils of North East Hill Region of India. The soils of North Eastern Hill Region and their properties have been analysed by Prasad, Ram and Ram.[67] In the research Bulletin,[68] the ICAR Centre for Tripura has discussed the soils of Tripura and their fertility management. Likewise, soil erosion hazards in North East Hill Region has been studied by Singh and Singh.[69] They have also studied the farm in relation to soil and water conservation for this region taking a case study of different farmsteads.[70]

There is no specific study on land classification of West Khasi Hills district of Meghalaya. A study on soil

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66 R.N. Prasad and R.Ram (1981); "Fertility Status of Soils of North East Hill Region", Journal of NEC, Vol.IV, No.1.

67 R.N. Prasad, R. Ram and M. Ram (1980); "Soils of North Eastern Hill Region and their Properties", Journal of Meghalaya Science Society, Vol. 4, pp.39-46.

68 ICAR (1983), "Soils of Tripura and their Fertility Management", Research Bulletin, No. 23, ICAR, Shillong.

69 A. Singh and M.D. Singh (1981); "Soil Erosion Hazards in N.E. Hill Region", Research Bulletin No.10, ICAR, Shillong.

70 A. Singh and M.D. Singh (1984); "A Case Study on Farmstead Development in Relation to Soil and Water Conservation in N.E.H. Region of India", Journal Soil Conservation, Vol. 12, No. 2 and 3.

rating status of the district ha. been attempted by Konwar.[71] This study was based on the field collection of soil samples under various ecological zones/regions and landfacets of the district. In another study, Konwar[72] has tried to study the agricultural landuse and cropping pattern of the district, showing the various changes in agricultural landuse with its cropping pattern. The causes of land degradation, the area affected by land degradation and classification of land for policy measures have been attempted by Mohapatra[73] (et al.) They have suggested the appropriate policy measures for land development, maintenance, preservation and regeneration of land in West Khasi Hills district.

Due to the absence of any specific study on land classification (particularly, on the West Khasi Hills district and the North East Region) the present study is a pioneering attempt in approach, methodology and significance.

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71 M. Konwar (1987); "Soil Rating Status in Different Ecological Zone: A Field Based Study of West Khasi Hills District, Meghalaya", an unpublished M.Phil Dissertation submitted to NEHU, Shillong.

72 M. Konwar (1988); "Land Use and Cropping Pattern in West Khasi Hills District, Meghalaya", Paper accepted for publication in The Proceeding of the Seminar on "Problems of Hill Area Development with Special Reference to the N.E. Region", March 1988 (in Press).

73 A.C. Mohapatra and M. Konwar (1989); "Environmental Planning for a Hill District, West Khasi Hills, Meghalaya", The Journal of Regional Science, IIT, Kharagpur (accepted for publication in '89: 2).

CHAPTER - 3

METHODOLOGY

METHODOLOGY

3.1. Plan of Study

Any study of land classification or land evaluation at the macro-level (like, the study of a district, as in the present case) will involve taxonomy (of area) into generic classes. However, any attempt of taxonomy has to be based on certain criteria, one or a combination of a few. The land classifier faces certain fundamental problems[1] which arise from the nature of the land itself. These fundamental problems are:

(a) The problems of 'complexity',

(b) The problems associated with 'extent', and

(c) The problems of 'association'.

It may be mentioned that each spot on the earth surface is in the last degree unique and not to be compared with any other. But, the scientific approach to land involves the establishment of principles which enable us to understand the nature of land and to compare it from place to place. Therefore, any land classification imposes a framework of generalization about land attributes which enable common characters to be defined and described, and to be related, although geographically the attributes are separate from one another.

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1 J.A. Mabbutt (1968); "Review of Concepts of Land Classification", in Stewart, G.A. (ed.) 1968, Papers of a CSIRO Symposium, Organized in cooperation with UNESCO, 26-31 August 1968, Macmillan, Victoria, pp. 11-12.

The second group of problems is associated with 'extent'. Difficulties here, arise from the differing spatial expression of land attributes. Some properties like slope for instance, tend to be recorded in relation to a facet or sector of land, others like soil potential, refer to a point only.

The third is the problem of association. The character of land cannot be understood fully in terms of local controls acting in isolation. But, it can be determined by examining the relationships with adjoining areas since, the attributes of land are interrelated and interdependent on each other.

Keeping in view the problems and the necessity of land classification of the West Khasi Hills District from the (environmental) land management point of view, three broad theoretical groups of criteria have been chosen. They are:

1. The land classifications based on genetic and landscape approaches i.e., based on the 'given' (*a priori*) environmental parameters;
2. The land classifications based on parametric approach or based on the evaluation of potentials of land; and
3. The land classifications based on the normative evaluation of land from the point of view of environmental land management.

The first two provide a positive analytical approach, the latter, a normative approach. In case of the first set of criteria, i.e. the a priori parameters, what is meant is the regional division of the district based on given environmental (geographical) parameters like the geology, the physiography (including topography, relief, slope, drainage etc.), the vegetation types, climatic parameters (rainfall and temperature).[2] At the first level of the generic division of the district, first the individual criteria are studied and then combined by superimposing the relevant maps of the district to arrive at broad 'macro-regions' or 'ecological divisions' or 'zones'. At the second level, the classification is at the micro-level, where the main controlling characteristic becomes the slope[3] which helps in identifying the micro-regions (or 'land facets') by dividing the given region into broad five classes of slopes;

(a) Valley (flat) land (less than 2° slope).

(b) Gentle slope (2° - 10° slope).

(c) Medium slope (10° - 20° slope).

(d) Steep slope (20° and above).

(e) Crest Land: Generally, mildly undulating.

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2 The data on rainfall and temperature on the district is extremely limited, which are available for only three stations for a relatively short span of time. This renders preparation of any climatic map difficult for any practical purpose.

3 At the first level the 'slope' means average slope, but at the second level it is the actual slope zones.

It is clear that at one hand the different slope zones are 'given' and on the other, in the given situation (of a plateau area), the micro-use of land depends largely on the slope characteristics. Such micro-regional identification is given the nomenclature, 'land facet'[4] (Bourne 1931, Brink et al. 1966, and Prokayev 1962) because of the small areal extension as well as their unique environmental characteristics.

Secondly, land classifications based on the 'parametric approach' i.e., evaluation of the potentials of land on the basis of values of selected attributes. For example, a hypsometric map shows a classification of land based on elevation, with class limits at chosen contours. The advantage of this approach ranges from general purpose surveys considering many attributes to classify for special purposes and on a narrower basis. It also includes the stiffening of more

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4 Land classification based on landscape approach involves the identification of distinctive components with only a limited range of variation of those attributes important to land use. This fundamental components identify as 'land-facet' by various scholars. According to Bourne (1931), "an area which, for all practical purposes, provides throughout it extent similar conditions as to climate, physiography, geology, soil, and edaphic factors in general." Most of the scholars admit the degree of variation of landfacet; for example, Brink (et al. 1966) stated that the 'landfacet' as being made up of simpler 'land elements'. Moreover, Prokayev (1962) further stated, "that the definition of land facies should be based on the character and thickness of surface deposits, the redistribution of moisture and of heat within it as controlled by local relief and corresponding properties of soil and vegetation cover and of animal life."

qualitative systems through the infusion of parametric ingredients. Moreover, it gives a more precise definition of land and being quantitative, it avoids the subjectivity of the landscape method. The attributes for the parametric approach must be suitable for the operation. They must be quantifiable and either directly scannable in quantitative terms or capable of being reliably read from other association with other obvious features.

It may be mentioned here that the major concern in the present study is to assess land by the nature of soil and classification of the district into soil quality zones (regions) on the basis of soil ratings. Under the three groups of soil characteristics, twelves attributes/variables have been selected for this purpose. These groups are:

Group A: Physical characteristics of soil.

X_1: Texture

X_2: Structure

X_3: Colour

Group B: Chemical characteristics of soil.

X_4: pH

X_5: Kg/Ha of Nitrogen

X_6: Kg/Ha of Phosphorus

X_7: Kg/Ha of Potassium

X_8: % of Organic Carbon

Group C: Site characteristics of soil.

X_9 : Altitude

X_{10}: Degree of slopes

X_{11}: Vegetation cover, and

X_{12}: Topography.

Finally, the land classification was done by a normative basis; i.e. how the present uses of land, for example, may affect the quality of land from the environmental policy point of view, i.e. whether some areas are 'safe' for the current use point of view; whether they are ecologically 'vulnerable' because of particular agricultural practices; and finally, what policy measure can be adopted towards the 'vulnerable' and 'degraded' lands of the district.

3.2. Data Base

Keeping in view the objectives of the study, three types of information and data have been used for the purpose. These are:

1. Secondary information on general characteristics of the population, agriculture, land use and settlement pattern, economy, etc. for the West Khasi Hills district.
2. Map based information (including air photos and satellite imageries) on relief, vegetation, drainage, slope and other ecological parameters for the study area, and

3. Primary data, i.e. collection of field samples of soils on the various macro and micro ecological conditions.

In connection with the general characteristics of population, agriculture, landuse and settlement and economy, major source of information have been:

(i) various census publications particularly District Census Handbook[4] and Village Directory for 1971 and 1981. Apart from this source, other secondary and tertiary sources like, the District Statistical Handbook[5] and data collected from the Department of Agriculture, Government of Meghalaya, Geological Survey of India (N.E. Region, Shillong) and Department of Forestry, Government of Meghalaya have been used also.

In the circumstances of the weaker data base of the entire North Eastern Region, particularly, information on agriculture and land use etc., which are largely gross estimated figures, it remains a major limitation of any substantive work based on secondary information. However, in the present study, the uses of such information are only limited to providing a general background to the study and therefore, it may not hamper in any serious manner, the scope and generalisations of the study.

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4 Government of Meghalaya (1984); Statistical Handbook, Director of Economics, Statistics and Evaluation, Meghalaya.

5 Ibid.

In connection with map related information, there are three major sources:

(a) Topographical sheets[6] of both 1:63,360 and 1:50,000 scales of 1910 to 1911 and subsequently revised version of 1966-67 published by Survey of India.

(b) Satellite imageries pertaining to West Khasi Hills District. The scale of the available satellite imageries is 1 to 1 million or 1:1,000,000 provided by the National Remote Sensing Agency, Hyderabad.

(c) Aerial photos pertaining to the catchment area of Um Sohdkhiew and Umthied (tributaries of Kynshi river). Both the scales of 1:50,000 (1983-84) and 1:25,000 (1963-64) have been used.

The topographical sheets provide basis, first, for a base map for the entire district showing broad relief, drainage, settlement pattern and road network. It may be mentioned that no such detailed base map was available. The base map was prepared both at 1:50,000 and a reduced scale of 1 cm to 10 km. The satellite images were used to identify 'land facets' and vegetation cover.

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6 Topographical Sheet Nos -

Scale, 1:63,360 - 78(0/1, 0/2, 0/3, 0/4, 0/5, 0/6, 0/7, 0/8, 0/9, 0/10, 0/11, 0/12, 0/13).

Scale 1:50,000-78 (K/3, K/5, K/10, K/13, K/14, K/15, K/16). Published by G.S.I. 1910-11 and 1966-67 (revised).

In connection with primary collection of soil samples, it may be mentioned that about 400 soil samples and samples of profiles were collected through a number of field trips covering nearly the entire West Khasi Hills district. Both physical and chemical analysis of soils, particularly relating to texture, structure, colour, pH, NPK status and organic carbon were obtained by the researcher by analysing these samples at the soil laboratory, Department of Geography, NEHU, Shillong. Some additional help however, was taken from the Soil Analysis Laboratory of Department of Agriculture, Government of Meghalaya.

3.3. Data Analysis - Methods and Techniques

Geographer makes use of statistical techniques for drawing graphs, cartograms and map showing distribution, variations and associations. The method of representation will depend on the types of the statistics. For example, climatic statistics, like temperature, pressure, rainfall, etc. may lead to the drawing of isotherm, isobar, and isohyet maps, respectively; while agricultural and industrial statistics may be represented in a different way - by dots, symbols, colour, shading etc. Their use is made in drawing other illustrations also. The method of drawing not only varies with different statistical aspects, but a single fact may also be represented in different ways in accordance with its type, intensity, and time factor. For the present study, an attempt has been made to use different methods and techniques for representing given data in the following way:

3.3.1. Land Classification Based on Genetic Approach

It has already been stated in the earlier part of this chapter that the land classification has been attempted under the three approaches. These three approaches have their advantages as well as limitations. Therefore, an attempt has been made to use all the three approaches in combination (and synthesis) for different sections and requirements of the study.

In the genetic approach to land classification, the concept of genetically based 'natural' regions (Mabbutt, 1968), the researcher had to classify the district into broad 'ecological' zones 'macro-regions'. The following maps have been chosen for the demarcation of 'ecological' zones/'macro-regions' in the district:

1) Geology,
2) Relief,
3) Slope,
4) Drainage, and
5) Vegetation.

Since, maps are the tools of geographical analysis, it is with the help of maps and diagrams that many complicated landforms may be explained in a simplified manner. Moreover, land classification is the unique result of the interrelated factors: like - relief, vegetation, climate (temperature and rainfall), geology or parent rock materials, drainage, slope, landuse etc. Therefore, it was necessary to make a good estimate of the topographic maps for genetic approach to land classification in the district.

(1) Geological Map

Geological map shows the geographical distribution of different rock formations or strata. Its interpretation leads to an understanding of the lithology and structure of the underlying rock which in turn, helps in the study of the evaluation of landforms in a particular area.

The development and formation of soil depends upon the parent rock materials. The parent material refers to the unconsolidated mass from which the solum develops. It includes the C-horizon and other materials above the C-horizon from which the solum developed. In many soils the solum is underlain with an unconsolidated non-conforming geological stratum. Such geological strata have an influence on the genesis and behaviour of the soil.

The Geological Survey of India (GSI)[7] has prepared

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7 GSI (1977); Geological and Mineral Map of Meghalaya, Scale; 1:50,000 or 1 cm to 5 km.

the geological and mineral map of Meghalaya (district wise). The scale is 1:50,000 or 1 cm to 5 km. The district geological map of West Khasi Hills has been prepared and it had to be reduced (for the district map) to a scale of 1 cm to 10 km.

(2) Relief

The term relief indicates the variation in the nature of the land surface or in other worlds, the lie of the land. It shows the broad features and relative heights of high and low lands which are portrayed by such term as hills, knolls, spurs and valleys etc.

Methods of Representation

Among the three methods, i.e. pictoral, mathematical and combination of the previous two, 'contours' method of mathematical method is the standard method of representing relief. Therefore, this method has been used for preparing the relief map of West Khasi Hills District of Meghlaya (for detail method see appendix 3.A.1).

(3) Slope Map

The analysis of the gradient of slope in a region makes landform classification easier. But, in any area the gradient of slope is seldom uniform. Its irregularities are apparent from the contour maps. Therefore, it is necessary to calculate the average slope of a region.

In defining land classificational units, slope of the land is given special attention. As with other important land parameters, the relative significance of differences in slope depends upon the other parameters of the land.

There are several methods of average slope determination of which Wentworth's *method* (*for detail see Appendix* 3.A.2) is a 'general and random' method and is easier to follow. Using this method, a choropleth technique map has been prepared for the district. The slope classification has been made in the following manner:

(a) Not Surveyed (NS) Category: There are some areas where contours are not available. It is not because of the lowlying area but might be other reason which was not mentioned in the topographic sheets.

(b) Below 2° slope.

(c) 2° - 10° slope.

(d) 10° - 20° slope.

(e) 20° - 30° slope.

(f) Crest Land: Generally, mildly undulating, > 30°.

(4) Drainage Map

Drainage map is important not only for the sake of convenience trace out important rivers and their tributaries but their impact on social life also. Drainage conditions are necessary in both soil descriptions and definitions. Drainage, primarily relates to the soil, water and its effect on the profile development through weathering and erosion and producing their soil cover on steep slopes and deposition of soil materials on the downward areas. The direction, intensity, frequency and distribution of drainage influences the course of soil formation.

Preparation of Drainage Map

For the preparation of drainage map of West Khasi Hills district, both 1:63,360 and 1:50,000 scales of topographic sheets were used. The major rivers and their tributaries were used for the preparation of drainage map and the scale of the map has been reduced to a scale of 1 cm to 10 km.

(5) Vegetation Map

Vegetation map shows the overall distribution of vegetation in a particular area of the earth surface. The importance of vegetation map is to correlate the nature of vegetation with the type of climate prevailing there. It has to study, for example, where the pine forests are found much, whether it is on the slopes of the hills, on highlands or in the river valley.

Considering the above mentioned criteria, an attempt has been made to prepare the vegetation map of West Khasi Hills district, with the help of topographic sheets and satellite imageries pertaining to the district. Both 1:63,360 and 1:50,000 scales were used for this purpose. In case of satellite imageries 1:1 million photographs both coloured as well as black and white satellite imageries were used. With the help of stereoscope and magnifying lens, it was possible to identify the vegetation cover of the district.

On the basis of altitude and climatic variations, the forest types of the district could be classified into four forest types. These are:

(i) Sub-tropical high altitude pine forest.

(ii) Moist mixed deciduous forest (with sal).

(iii) Very humid sal forests, and

(iv) Reserved forests.

3.3.2. Land Classification Based on Landscape Approach

In this classification, an attempt has been made to identify the 'landfacets' in the district using the available satellite imageries and topographic sheets pertaining to the West Khasi Hills district. 'Landfacet' is a nomenclature given to small land units with homogeneous environmental (or geographical) characteristics. Such characteristics may be the geology, the predominant soil type, the slope or vegetational cover. In the present situation of a plateau area, the major control characteristic in determining the landfacets is found to be the 'slope', of course, the other parameters are assessed, too. But,'slope' is the dominating factor. As stated earlier five types of landfacets have been identified in the district. These are:

(i) Flat and Valley land (<2° slope)

(ii) Gentle slopes (2° - 10° slope)

(iii) Medium slopes (10° - 20° slope)

(iv) Steep slopes (20° + slope), and

(v) The Crest Lands: generally undulating or domal but is not essentially determined by slope alone. It may have some features of the flat land but its ecology is distinctly different due to outward draining compared to the inward draining character of the valley.

By using this principles the entire district has been identified into detailed landfacets (and also 'ecological' zone/'macro-region' wise).

3.3.3. Land Classification Based on Parametric Approach

The main focus in this approach is to evaluation of soil quality inform of a soil rating indice covering the whole district of the West Khasi Hills which shall help in identifying the land potential of the area.

3.4. Soil Rating Index

There are two standard methods to prepare Soil Rating Index. The Storie Multiplication System (1954) and the Clarke Index (1951).

3.4.1. The Evaluation of Land According to the Storie Index

The index for rating of soil which has been developed by Storie (1954) has been widely used in North America and elsewhere. The Storie index is a numerical rating of the degree to which a particular soil has physical, chemical and biological properties suitable for the growth of crops. It is basically an index which reflects the soils potential utilization and productive capacity.

Three principal factors are considered in computing the Storie Index of a soil unit. These are:

(a) The characteristics of the profile as reflected in texture, structure and inherent fertility (i.e. depth and colour).

(b) Topography, and

(c) Other modifying factors like, climate, salinity/alkalinity, degree of stoniness and susceptibility to erosion. Each of these three factors (a, b, and c) is rated on the basis of 100 points for the most favourable or ideal conditions.

3.4.2. Soil Rating According to Clarke Index

Clarke Index is suitable for evaluating soil quality in the field. This points system gives a numerical rating to a soil profile on the basis of the physical characteristics of texture, depth and drainage status.

Clarke's Index is defined as:

Profile Value = Texture Value (V) x Drainage factor (G).

Where, Texture Value (V) = Depth (D) x Texture Rating (T). The Texture Rating (T) is derived from the field textural designation.

3.4.3. In this study, rating index has been prepared by using Storie Multiplication Index of soil rating. Since, the study deals with twelve variables which could be rated only by this method. Moreover, the Storie Multiplication System is not a rigid system which is applied directly and unchanged to any area. Depending on the soil climatic conditions of the region under study, it was necessary to rearrange some factors and to add others in order that a more accurate expression of prevailing environmental conditions is reflected in the rating.

3.5. Soil Sampling

"The Analysis can be no better than the Sample."[8]

The sampling of soils is a challenging problem, worthy of detailed consideration. The general problem of soil sampling

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8 M.L. Jackson (1977); Soil Chemical Analysis, Second Indian Reprint, Prentice-Hall of Indian Private Ltd., New Delhi, pp.10-11.

has been summarized by the Association of Official Agricultural Chemists as follows:

> "In view of the variability of soils, it seems impossible to devise of the procedure should be determined by the purpose for which the sample is taken."9

The above passage brings into focus the twin problems of soils variability (Sampling 'all out-of-doors') and the divergency of types of analyses to be performed on samples. Soil sampling includes taking the soil material so as to take into account the variability of soil, handling and processing the samples for actual analytical determination.

Method

The method which was applied for sampling for this study is known as Composite Soil Sampling Method.[10] It gives a mean analytical value representative of the soil sampling volume from which the composite sample was drawn, using this method, the top soil from different landfacets with a depth of 6-9 inches have been collected from each sample.

3.6. Analysis of Soil

According to the soil characteristics, the analysis part can be divided into two, i.e.

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9 M.L. Jackson (1977); Op.cit., pp. 10-12.

10 Ibid., pp. 12-13.

(i) Physical, and

(ii) Chemical Analysis of Soil.

3.6.1. Determination of Physical Characteristics of Soil

Before going into a discussion on the method of determination of physical characteristics of soil, it is important to discuss the significance of the physical characteristics.

The soil is a complex mechanical system consisting of three physical states. These three physical states are solid, liquid and gaseous. The bulk of the solid phase, occupies approximately fifty percent of the total volume of soil. It consists of primarily of the mineral materials and organic matter. The rest of the volume makes up for the pore space being occupied by liquid and gaseous substances. Thus, the proportion of the four major components of soil - inorganic particles, organic particles, water and air - vary greatly in different kinds of soil and from place to place and also with difference in the depth of the soil.

The physical properties of soil depend on the amount, size, shape, arrangement and mineral composition of its particles. The kind and amount of organic matter and the volume and form of its pores are related to its physical properties. The particle sizes of the solid material is extremely important in the process of cation exchange i.e. leading to circulation of nutrients in the soil. Therefore, this colloidal property is important in texture determination of the soil. In this study, some important physical properties of soil like - Texture, Colour and Structure have been analysed.

3.6.2. Mechanical Analysis and Soil Texture

The mineral component constitutes the largest volume of soil mass and plays a vital role in determining most of the physical properties of soil. This mineral component consists of particles of various sizes. According to the sizes, the soil particles are termed as soil 'separate' or 'fractions'. The proportionate composition of various separates in soil, defines the soil texture which can be determined by mechanical analysis of the sample.

3.6.3. Soil Texture

The soil texture refers to the relative percentage of sand, silt, and clay below 2 millimetre in diameter in a solid state. Natural field soils are always mixtures of soil separates. The relative percentage of the various soil separates in the field soil are almost infinite in possible combinations. It is, therefore, necessary to establish limits of various sizes among the soil separates so as to group them into textural classes, such as sandy, silty loamy and clayey etc.

The Table 3.1 shows the more common textural classes in order of increasing fineness.

Table - 3.1: Common textural classes in order of increasing fineness.

1. Sands	7. Sandy clay loam
2. Loamy sands	8. Clay loam
3. Sandy loams	9. Silty clay loam
4. Loam	10. Sandy clay
5. Silt loam	11. Silty clay
6. Silt	12. Clay

To determine the textural name of a soil, an equilateral triangle can be used. This triangle is known as the 'Textural Triangle' (Fig. 3.1). The three sides of the triangle can be used to represent a three coordinate system representing the percentage of all the three size classes of particles in the sample, i.e. sand, silt and clay, by graduating each size from origin, zero to minimum hundred and thereby determining a single point inside the triangle representing values of all the three attributes. The U.S. Department of Agriculture Scale has been used for measuring the soil texture.

Materials and Methods

There are two methods to determine the percentage of various particle sizes in soil. The International Scale (International Society of Science) and the U.S.D.A. Scale (U.S. Department of Agriculture). For detail, see Appendix 3B.

Table - 3.2: The Size Grades of Mineral Material

Fraction	International		U.S.D.A.	
	mm	µm	mm	µm
Coarse Sand CS	2.2 -0.2	2000-200	2.0 - 0.2	2000 - 200
Fine Sand FS	0.2 -0.02	200- 20	0.2 - 0.05	200 - 50
Silt Z	0.02-0.002	20- 2	0.05- 0.005	50 - 2
Clay C	<0.002	<2	<0.002	<2

Source: Smith, R.T. and Atkinson, K. (1975): Techniques in Pedology, A Handbook for Environmental and Resource Studies, Paul Elek Ltd., London.

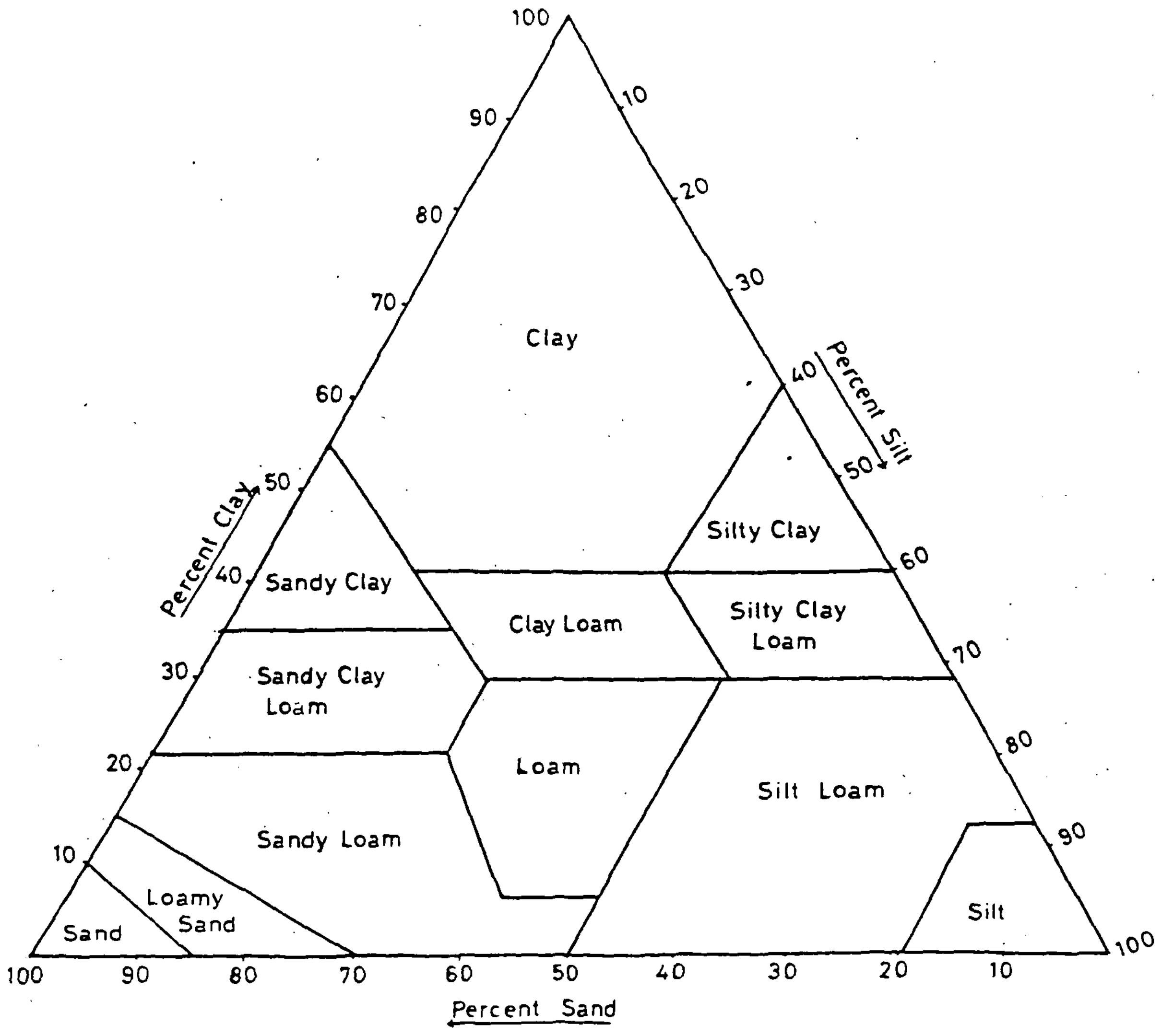
3.6.4. Soil Colour

Soil colour is the most obvious and easily determined of soil characteristics. It is an easily observable characteristic and is an important criterion in description and classification of soils. It could be named in many soil groups after prominent soil colours such as Black soils, Red-Yellow Latosols, Brown soil etc.

The content of organic matter in soil is mainly responsible for soil colour. Generally, in temperate climate dark coloured soils are relatively higher in organic matter than light coloured soils. The surface horizon of soil is commonly darkest due to the presence of organic matter. Red colour is associated with unhydrated ferric oxides, whereas yellow colour indicates some degree of hydration.

Fig.3.1

TEXTURAL TRIANGLE



Determination of Soil Colour

The soil colours are most conveniently measured by comparison with standard colour charts. The 'Munsell'[11] Soil Colour Chart was used for this purpose. The colour of soil is the result of the light reflected from the soil and it depends upon the combination of three simple variables of colours namely - 'Hue', 'Value', and 'Chroma'. 'Hue' is the dominant spectral colour. 'Value' is the brilliance or total quality of light. 'Chroma' is the relative purity or saturation of the dominant spectral colour.

To determine the soil colour, the 'Munsell' Soil Colour Charts has been used and various types of colours have been identified for the samples.

3.6.5. Soil Structures

The primary soil particles - sand, silt and clay - usually occur in the form of aggregates. The arrangement of these individual particles and their aggregates into certain defined patterns is called structure. Structure is best studied in the field under natural conditions and it is described under three categories:

(i) Type - Shape or form and arrangement pattern peds.
(ii) Class - Size of Peds.
(iii) Grade - Degree of distinctness of peds.

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11 Munsell Soil Colour Charts, Munsell Colour Company Inc. Baltimore 2, Maryland, 1975.

(i) Types of Structure

There are four principal geometric form of soil structure:

(a) Plate-like,

(b) Prism-like,

(c) Block-like, and

(d) Sphere-like spheroidal.

(ii) Classes of Structure

Each primary structural type of soil is differentiated into five size-classes depending upon the size of the individual peds. The term commonly used for the size classes are:

(a) Very fine or very thin.

(b) Fine or thin.

(c) Medium.

(d) Coarse or thick.

(e) Very corase or very think.

(iii) Grades of Structure

Grade indicates the degree of distinctness of the individual peds. It is determined by noting the stability of the aggregates and the ease with which they separate from other peds. Grade of structure is influenced by the moisture content of the soil. Under moist conditions the soil structure is usually not very distinct. Four terms commonly used to describe the grade of soil structure are:

(a) Structureless

(b) Weak

(c) Moderate

(d) Strong

3.7. Chemical Characteristics of Soil

The chemical analysis have become an integral part of soil classification. It helps to study the available nutrients in the soils, the leaching process and soil genesis. The growth of a plantis directly dependent upon soil nutrients and its formations. Therefore, one should study the chemical composition of soil for better understanding of soil classification and genesis.

Soils are chemically a heterogeneous medium. It is more important to measure a particular fraction of an element in the soil than to know its total concentration. Therefore, the most essential elements like, nitrogen, phosphorus, potassium and organic carbon are selected for this study. Soil reaction or pH is also taken to be an overall indication of chemical status of a soil.

3.7.1. Nitrogen in the Soil

"Nitrogen - essential link in protein".[12]

Among the various plant nutrients, nitrogen probably has been subjected to the greatest amount of study and still

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12 M.L. Jackson (1977); Op.cit., p. 183.

receives much attention. The amount in the soil is small, while the quality withdrawn annually by crops is comparatively large. Sometimes the soil nitrogen is too readily soluble and is lost in drainage, at other times, it suffers volatilization, at still other times it is definitely unavailable to higher plants.

Forms of Soil Nitrogen

There are three major forms of Nitrogen in mineral soils:

(a) Organic nitrogen associated with the soil humus,

(b) Ammonium nitrogen fixed by certain clay minerals, and

(c) Soluble inorganic ammonium and nitrate compounds.

Most of the nitrogen in soils is associated with the organic matter. Relatively small amounts ordinarily occur in ammonium and nitrates, the available forms.

There are two types of analytical procedures, which are widely used - the Kjeldahl conversion of Nitrogen to $(NH_4)_2SO_4$ and the Dumas conversion to nitrogen gas. The Kjeldahl method is employed in macro, micro and ultramicro procedures. For the estimation of total nitrogen in soil the Kjeldahl Digestion Distillation Method[13] has been followed. (For detail, see Appendix 3.C.1).

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13 M.L. Jackson (1977); Op.cit., pp. 183-193.

3.7.2. Available Phosphorus in Soils

Phosphorus rarely comprises more than 0.1 per cent of the soil and only a small amount of plant available inorganic orthophosphate iron is present at any time. The bulk of phosphorus is usually unavailable. It is fixed either as Ca-phosphate at high pH or Alluminium and Iron phosphate at low pH. Measurement of total phosphorus is, therefore, of limited value in determining phosphorus availability except that low concentration usually indicates dificiency. For estimation of available phosphorus in soil, Bray's Method No.1 have been used. (For detail, see Appendix 3.C.2).

3.7.3. Available Potassium in Soil

There is some mechanism in the soil that fixes available potassium in a form which is not available to plants. The factors influencing the amount of potassium fixation are:

1. The kind of clay minerals present. Kaolinite does not appear to fix potassium, while large quantities are fixed, by montmorillonite.
2. The relative amount of exchangeable K. The greater the percentage of exchangeable K in relation to the total exchange capacity, the greater the K fixation.
3. Wetting and drying of soil. Soils that are wetted and dried fix large amounts of exchangeable potassium. One explanation for this mechanism is that K-ions move inside

the clay-crystal lattice, when it is wet and expanded, and upon drying, the ions are trapped inside.

4. The presence of organic matter.

Determination of Exchangeable K in Soil

The exchangeable 'K' has determined by Flame Photometer *method using ammonium acetate extraction solution as* outlined by Jackson (1973). (For detail, see Appendix 3.C.3.)

3.7.4. Available Organic Carbon in Soil

"Organic matter... a distinction of soil from rock."[14]

Carbon occurs in soils in four forms of mineral and organic matter:

1. Carbonate mineral forms, chiefly $CaCo_3$ and $MgCo_3$,
2. Highly condensed, nearly elemental organic carbon (charcoal, graphite, coal).
3. Altered and rather resistant organic residues of plants, animals and micro-organisms, sometimes termed 'humus' or 'humate', and
4. Little altered organic residues of plants and animals, and living and dead micro-organisms, subject to rather rapid decomposition in soils.

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14 M.L. Jackson (1977); <u>Op.cit.</u>, p. 205.

The total carbon of soils obviously includes all four forms of carbon. The organic carbon includes the three forms except the first one. Here, the total organic carbon in soil has been determined by the Walkly and Black's (1934) rapid titration method. For detail, see Appendix 3.C.4.

3.7.5. Soil pH

The importance of soil pH is the classification of soil. It is, perhaps the most important chemical property of soil as a medium for plant growth, which depends its pH value or 'hydrogen ion activity'. The activity in soils of the twelve or more other ions that enter into plant nutrition is highly dependent upon that of the hydrogen ion. The time requirement of soils depends upon the adjustment of the hydrogen ion activity and the associated activities of metallic cations and anions, although it also involves adjustment of the calcium and sometimes magnesium ion activities as such.

Table 3.3 shows the corresponding terms to use for range in pH. The soil pH values have been determined by using pH Meter Method (for detail, see Appendix 3.C.5).

Table 3.3: Determination of Soil pH Values

Acid Group	pH	Alkaline Group	pH
Extremely Acid	4.5	Neutral*	6.6-7.3
Very strongly acid	4.5-5.0	Mildly alkaline	7.4-7.8
Strongly acid	5.1-5.5	Moderately alkaline	7.9-8.4
Medium acid	5.6-6.0	Strongly alkaline	8.5-9.0
Slightly acid	6.1-6.5	Very strongly alkaline	9.1 and above

*Strict Neutrality is pH 7.0.

3.8. Since, the variables represent a wide variety of attributes of a given soil sample, often on subjective basis, composite characteristics, etc. There is the need of conversion of the primary pedological attributes into ratio scale or cardinal scale, so that it becomes easier for statistical manipulation of data. The detailed basis of conversion of data into variables is given below:

3.8.1. Group A: Physical Characteristics

(1) Texture: This factor has a maximum rating of 100 points.

Textural Name (Soil Class)		100 points
(i)	Sand	10 - 20
(ii)	Loamy sand	15 - 25

Textural Name (Soil Class)		100 Points
(iii)	Sandy loam	30 - 35
(iv)	Loam	40 - 60
(v)	Silt loam	50 - 70
(vi)	Silt	45 - 65
(vii)	Sandy clay loam	60 - 80
(viii)	Clay loam	65 - 85
(ix)	Silty clay loam	50 - 70
(x)	Sandy clay	30 - 40
(xi)	Silty clay	50 - 60
(xii)	Clay	35 - 55

The texture of a soil horizon is an almost permanent character, as texture does not change over a period of time. It also indicates the weathering stage to some extent. The textural class name is suggestive of many properties that have bearing on its management and productivity. Sandy soil are of open character, possesses good drainage and aeration, and are usually loose and friable. It is easy to handle in tillage operations. Clayey and silty soils, owing to their large surface area possess high absorptive and retention capacities for moisture, gases and nutrients. They usually have fine pores, are moderate to poor in drainage and aeration. It is relatively difficult to handle for cultivation purposes.

It is, therefore, the conservation scores which have been assigned on the basis of the characteristics of the soil textural name (soil class). In the above table, the clay loam has got the highest score value since it contains 27 to 40 per cent clay and 20 to 45 per cent sand, which is considered as good for cultivation purposes.

(2) Structure

It has a maximum rating in a 10 point scale.

Grade	10 points
(i) Structureless	4
(ii) Weak	6
(iii) Moderate	9
(iv) Strong	7

The grade indicates the degree of distinctness of the individual peds. Among the four terms commonly used to describe the grade of soil structure, the moderate is the best for plant growth which has been assigned a score of 9 out of 10 point scale. The peds are well developed and are quite durable and distinct.

(3) Colour

The maximum point assigned is 2.5.

	Colour	2.5 points
(i)	Black to Grey	1.5 to 2.5
(ii)	Light, White and Grey	1.25 to 1.75
(iii)	Red, Brown, Yellow	1.00 to 1.5
(iv)	Brown colour	1.5 to 2.0

From the above conversion table, the highest rating point has been given to the Black to Grey colour soils, followed by Brown colour soils and light, white and grey colour soils. This is due to the variations in soil colour are due mainly to the organic matter content which generally imparts black to dark grey tinges. The iron compounds which are responsible for red, brown, and yellow tinges, and silica, lime white, and grey tinges. Brown is the most common soil colour and is due to a mixture of the organic matter and iron oxides.

3.8.2. Group B: Chemical Characteristics of Soils

There are five variables under this group. They are:

(i) pH value.

(ii) Nitrogen.

(iii) Phosphorus.

(iv) Potassium.

(v) Organic carbon.

Though the variables are in quantitative values but in case of pH value, it has been converted as in a 10 point scale on the basis of its capacity of cation exchange.

Types of pH	pH Value	10 points
(i) Extremely acid	Below 4.5	1
(ii) Very strongly acid	4.5 - 5.0	2
(iii) Strongly acid	5.1 - 5.5	3
(iv) Medium acid	5.6 - 6.0	5
(v) Slightly acid	6.1 - 6.5	7
(vi) Neutral	6.5 - 7.5	9
(vii) Slightly alkaline	7.6 - 8.0	7
(viii) Medium alkaline	8.1 - 8.5	5
(ix) Strongly alkaline	8.6 - 9.0	3

Soil reaction is the most important single chemical characteristic influencing many physical and chemical properties of the soil. Suitability of soil as a medium for the growth of plants and desirable micro-organisms depend upon whether the soil is acid, neutral, or alkaline. In the conversion table, neutrality gets highest points i.e. 9, does not mean that it is the best for all practical purposes. The pH range[15] from 5 to 8.5 in the soil which is available and

15 The 1975 Yearbook of Agriculture; United States Department of Agriculture, Washington, D.C.

suitable for agricultural activities. Therefore, from the neutrality point, the pH values have been decreased for the both cases, i.e., acid group and alkaline group of pH values.

3.8.3. Group C: Site Characteristics

There are four variables in this group. They are:

(i) Altitude.

(ii) Slope.

(iii) Vegetation, and

(iv) Topography.

(i) Altitude: With the help of Altimeter, the altitudes for all the relevant samples have been collected. No conversion figure has been used for this case.

(ii) Slope: Using the Clinometer, the slopes of the various sample locations of the district have been calculated in the field itself. To get the conversion figure, the following formula has been used.

$$\text{Converted value} = \frac{1}{\theta^{\circ} + 1}$$

Where, θ° is the degree of slope. The above inversion formula explains that the higher the slope, the lower the score value and vice-versa. It is, also true that for all kinds of uses (especially agriculture) the higher slope is not more suited than the low slopes, which have got higher score value.

(iii) Type of Vegetation: There is a scale of 0 to 100 points.

	Types of Vegetation	100 points
(i)	Barren	10
(ii)	Wildgrass	10 - 20
(iii)	Grasses and Shrubs	15 - 25
(iv)	Mixed forests and shrubs	30 - 40
(v)	Temperate vegetation mainly pine	20 - 30
(vi)	Mixed deciduous forests	50 - 70
(vii)	Cultivated fields	50 - 70
(viii)	Marshy uncultivated fields	25 - 35

Vegetation is an active soil forming factor which greatly influences soil evolution. Correlations between vegetation and soil types or other and classification units have three important purposes:

(1) For an understanding of soil genesis, since vegetation is one of the most important dynamic factor in soil formation.

(2) For aid in recognising soil boundaries, and

(3) For making predictions about the kind and growth of natural vegetation from soil maps.

Keeping this in view, the available vegetation of the district has been rated.

(iv) Topography: The Storie Multiplication system[16] has been used for topography where maximum rating assigned is 100 points.

	Topography	100 points
(i)	Flat to depression	10 - 80
(ii)	Gently undulating	90 - 100
(iii)	Moderately undulating	80 - 90
(iv)	Very gently rolling	70 - 80
(v)	Gently rolling	60 - 70
(vi)	Strongly undulating	40 - 60
(vii)	Moderately rolling	40 - 60
(viii)	Strongly rolling	30 - 40
(ix)	Hilly	20 - 30
(x)	Steep slopes	10

3.9. Once, all the variables are available they have been composited into soil rating indices using Kendall's Principal Component Analysis Technique (see in Chapter 6 and Appendix 6.A) at two levels; at the group level and then, a combination of the group level indices into a final composite score (index).[17]

16 R.T. Smith and K. Atkinson (1975); Techniques in Pedology, A Handbook for Environmental and Resource Studies, Paul Elek Science, London.

17 M.G. Kendall (1957); A Course in Multivariate Analysis, Griffin, London.

In the present study, there are a total of 382 soil samples and a total of 12 variables divided into three groups. The adoption of the principal component technique to make the composite indices of soil rating has obvious advantages, like the index such arrived at shall explain 'maximum sum of squared correlation' and weighting system on variables shall be dependent on 'factor independence' of the variable.[18] The advantages of this techniques are well known.

The analysis of the samples has been done in four stages. First, the intercorrelations of the variables have been studied to help in understanding the nature of relationship between the variables and their level of statistical signficance. At the second stage, the variables have been combined into composite indices using the first two principal components and the weight vectors derived from the respective characteristic roots. At the third level, the three group indices representing the physical, chemical and site characteristics of the samples have been combined into a single composite score representing all the 12 soil variables.

3.10. Land Classification Based on 'Normative Approach'

As mentioned above the three approaches of land classification have their advantages as well as limitations. Under

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18 M.G. Kendall (1939): "The Geographical Distribution of Crop Productivity in England", Jour. Ro. Stat.Soc. 102; 21.

the genetic approach a theoretical solution is sought and an attempt made to particularize by degrees, using environmental controls as successive criteria. The landscape approach offers a largely empirical solution. The character of land is sought through its appearance as in an aerial view. It is claimed that with an understanding of the genesis or dynamics of the land, we may understand the inherent character from the external forms. The types of the land can be discovered after closer analysis and experimentation of the attributes. The parametric approach is prepared to sacrifice biasness and ease of recognition for the reliability and quantative output of a definition based on measured properties. In any case, the picture offered by parametric approach is becoming increasingly complete and readily obtained with new techniques of scanning and computing.

The limitation of the genetic approach that it fails to deal with the problem of delimiting land types on a scale realistic for land use. The remaining approaches offer different solutions. The landscape approach distinguishes units of land which are invested with an overall character, while the parametric approach ascertained patterns of occurrence of selected attributes which may be combined into areal complexes. The landscape units are of realistic size for land use planning and their delimitation presents little problems. Areas defined under the parametric approach will be of high reliability, but their mapping may present problems.

Keeping in view the above, the researcher had to develop an additional approach of land classification due to the specific demands of the study. This approach may be called as 'normative approach'. Under this approach an attempt has been made to use all the three approaches in combination (and synthesis) to arrive at normative classification of land of the district from the environmental management point of view, so that effective policy measures can be undertaken by the appropriate authorities for land development, maintenance, preservation and regeneration, the land being the sole important resource base for the population. Broadly, three types of normative classes of land have been identified, viz. (a) relatively 'safe', (b) the 'vulnerable', and (c) the 'degraded' areas of the district which will help in actual conservation and management practices.

3.11. Micro-Level Land Classification

As mentioned earlier that the land classification at the level of the district can be considered as meso-level land classification. Due to the complex nature of land, the meso-level is too broad a level for detailed land classification. Therefore, an attempt has been made to study in detail land classification of the basin area of Um Sohdkhiew and Umthied (the two tributaries of river Kynshi) at micro-level. Since, the river basin is a very convenient area or region, appropriate policy measures for environmental and agricultural land management can be taken at this level.

3.11.1. Data Analysis: Methods and Techniques

The study has been carried out under the landscape approach of land classification, which was used for the land classification in the district. The study was based on purely the aerial photo intepretation pertaining to the basin areas. Since, the approach involves analysis of visible features, the relief of the area provides vantage points. It is also true that the worker may gain this perspective from the ground, as Bowman[19] did in his Andean studies. But where relief is strong, a topographical map can provide a picture of land forms, but will probably be deficient in respect of surface cover. Bruhnes long ago compared this study of the anatomy of the landscape with the experience of looking out from a balloon, and in his much-quoted early account of the practical uses of the method.[20] Bourne[21] (1931) stressed the value of air photography as showing 'scenic region' or characteristic assemblages of landscape features. Air photo-interpretation has since come to distinguish this approach to land classification. It is enough to state that tone, texture, pattern, and stereoscopic image combine to offer to the interpreter

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19 I. Bowman (1916); "The Andes of Southern Peru", Am. Geog. Soc. Publ. 2, New York.

20 J.A. Mabbutt (1968); Op.cit., p. 15.

21 R. Bourne (1931); "Regional Survey and its Relation to Stocktaking of the Agricultural Resources of the British Empire", Ox. For. Mem. 13, pp. 16-18.

an expression of land units, both individually and in their groupings, on a scale which is particularly appropriate to this approach.

CHAPTER - 4

POPULATION, SETTLEMENT PATTERN AND THE ECONOMY

POPULATION, SETTLEMENT PATTERN AND THE ECONOMY

4.1. Population

4.1.1. Introduction

Man constitutes not only an integral part of the nature but also is an important element in changing the nature and in the process he changes himself. Therefore, any study of environment has to incorporate analysis of the human population, its characteristics and the nature of its interaction with the environment by way of habitat formation and economic operations. The present chapter deals with the main characteristics of the population of the West Khasi Hills District, the settlement structure and pattern and the economy, which is overwhelmingly agricultural in character.

Today, the population growth is the most notable demographic process in the world. The rate of world population growth has increased tremendously in the recent decades. At the end of 1968 there were about 3500 million people on the earth, but during 1968 about 119 million babies were born and some other 49 million persons died. The total increased was 70 million in that particular year. Indeed, the 1968 total was 500 million more than 1960 total, nearly 1000 million more than in 1950, and twice as many as at the time of the First World War. It is also confidently expected that if present trend persists there will be more than 6000 million people living on the earth by 2000 A.D.[1]

In India, the first population count was carried out in 1872 when the total population was estimated to be 206.15 million. The Census of 1901 put India's population at 238.1 million. But, it can be seen a spectacular rise (Table 4.1) within a span of 8 decades, the total population has almost trebled, i.e. reaching the figure of 685.2 millions,[2] with average growth rate of 2.5 per cent per year in the last three decades.

Table - 4.1: Population of India, 1901-81

(Fig. in million)

Year	Total Population
1901	238.4
1911	252.1
1921	251.3
1931	279.0
1941	318.7
1951	361.1
1961	439.2
1971	548.2
1981	685.2

Source: Census of India (1981); General Population Tables, Series 1, Part II-A(1).

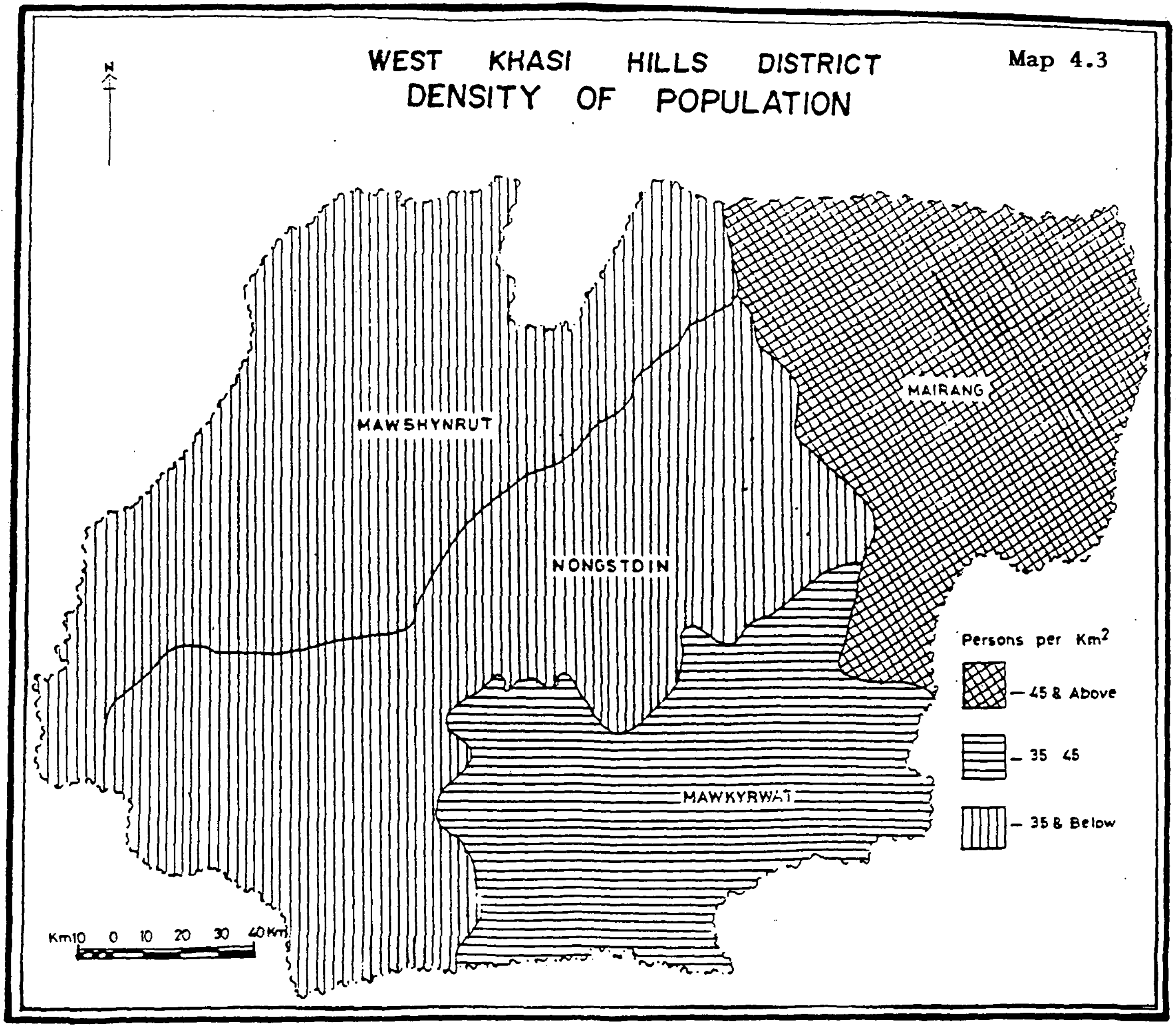
1 J.I. Clarke (1971); Population Geography and the Developing Countries, Pergamon Press, Oxford, pp. 1-2.

2 Census of India (1981); General Population Tables, Series 1, Part II-A(1).

Note: 1. Includes the projective figure of Assam where census could not be held.
2. The population figure excludes the population of area under unlawful occupation of Pakistan and China where census could not be taken.

4.1.2. West Khasi Hills district supports 12 per cent total population of Meghalaya. The district has total geographical area of 5,247 square kilometres with a density of population of 30 persons per square kilometre (Census 1981). This is far below that of the State, which accounts 59 per cent per square kilometre. Map 4.3 shows the density of population of West Khasi Hills district, C.D. Block wise for 1981. Among the C.D. Blocks, Mairang C.D. Block has got highest density of population with 46 persons per square kilometre, followed by Mawkyrwat 37 persons per square kilometre, Nongstoin 26 persons per square kilometre and Mawshynrut 20 persons per square kilometre. The total geographical area of the Mairang C.D. Block is 989 square kilometres which is the lowest area among the four C.D. Blocks with the second highest total population. Due to the rugged terrain, the distribution of population is uneven, which could be noticed from the Map.

West Khasi Hills became a separate district in 1976. Before this the district formed a part of the combined district of Khasi and Jaintia Hills. Therefore, before 1981, there is no separate Census enumeration of population of the district. However, estimates of data in connection with different population censuses are available from 1901 onwards. Table 4.2 and Fig. 4.2 provide the summary of total population of the district of West Khasi Hills and that of the State of Meghalaya and the percentage of population of the district in the popula-


WEST KHASI HILLS DISTRICT
DENSITY OF POPULATION
Map 4.3
N
MAWSHYNRUT
NONGSTOIN
MAIRANG
MAWKYRWAT
Persons per Km2
45 & Above
35 45
35 & Below
Km10 0 10 20 30 40Km

tion of the State from 190` to 1981. The salient features of this table is that while the population of the district increased from 39,000 in 1901 to 1,61,500 in 1981, a growth of nearly 4 times, the absolute population, its share in the total population of the State remained relatively unchanged, i.e. around 11.5 per cent.

Table - 4.2: Population of West Khasi Hills District, 1901-81

(Fig. in 000)

Year	Total Population West Khasi Hills District	Total Population Meghalaya	Percent
1901	39.6	340.5	11.47
1911	45.5	394.0	11.42
1921	47.1	422.4	11.13
1931	56.1	480.0	11.67
1941	64.3	555.8	11.53
1951	70.4	605.6	11.57
1961	89.5	769.3	11.57
1971	110.8	1011.6	10.88
1981	161.5	1335.8	12.06

Source: Census of India (1981); Meghalaya, Series 14, Part II (A and B).

A study of the decadal growth of population shows that prior to 1951 (Table 4.3), the growth in Meghalaya as well as the West Khasi Hills district was lower than the all India growth of population of 13.31 per cent (1941 to 1951). After 1951, the rate of growth of population in the district as well as in the State has been higher than the all India average. The rate of growth of population in West Khasi Hills district during the 1971-81 decade has been substantially higher than both the average for the State (32.05 per cent) and the nation (25.0 per cent). This large increase is due to immigration into the district resulting from upgradation of Nongstoin as a District Headquarters and Mairang as a Sub-Division Headquarters.[3]

Table - 4.3: Percentage Decadal Growth of Population of West Khasi Hills District

(Fig. in 000)

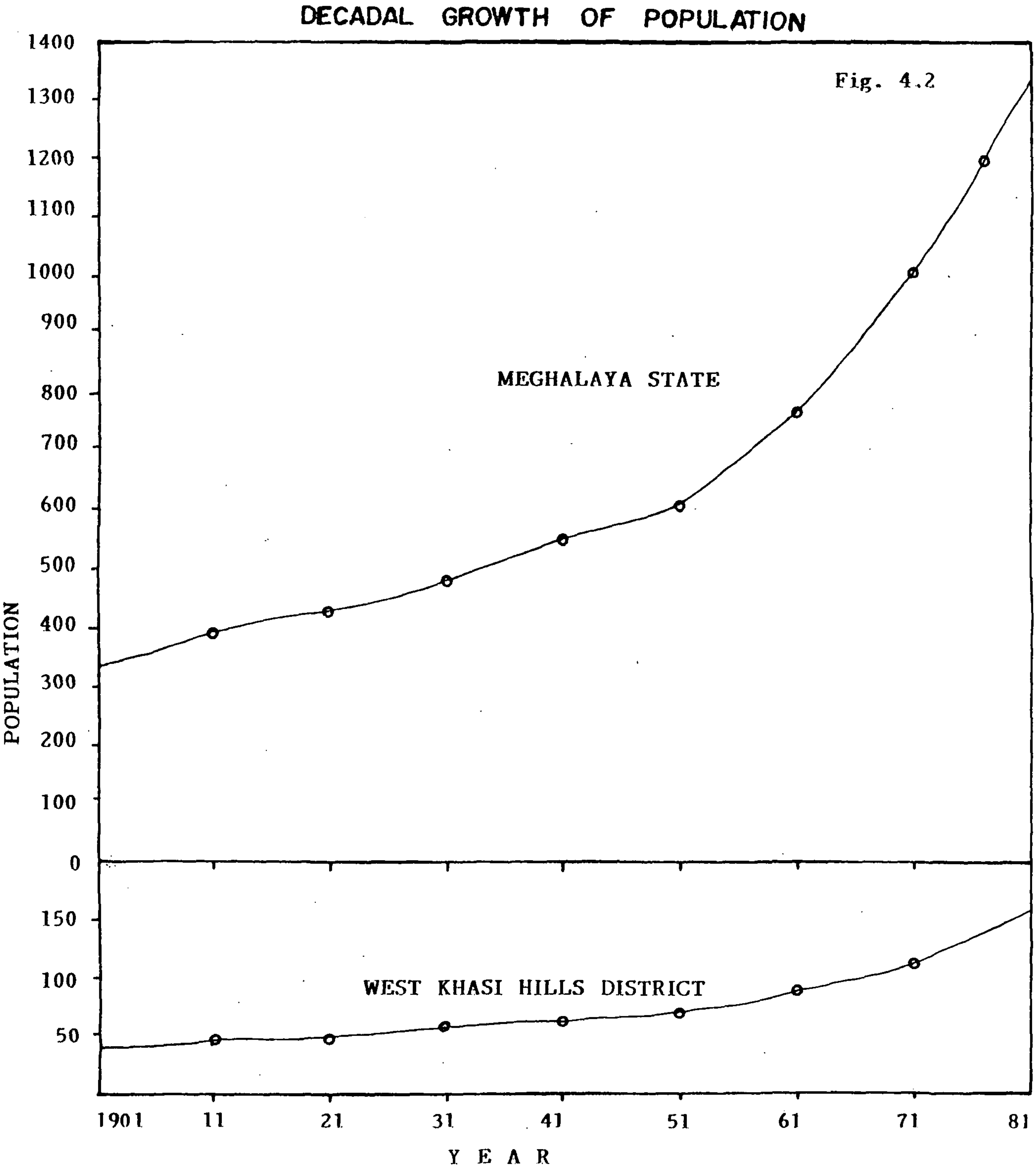
District/ State	1901-1911	1911-1921	1921-1931	1931-1941	1941-1951	1951-1961	1961-1971	1971-1981
West Khasi Hills District	16.37	3.52	19.11	14.62	9.49	27.13	23.80	45.76
Meghalaya State	15.71	7.21	13.83	15.60	8.96	27.03	31.50	32.05
India	5.75	-0.31	11.0	14.22	13.31	21.64	24.80	25.00

Source: Census of India (1981); Meghalaya, Series 14, Part II (A and B).

Table 4.4 indicates the Block wise and sex wise distribution of population of the West Khasi Hills district and the sex-ration.[4] Out of the four Community Development Blocks, Mawkyrwat has the highest total population of 46,200. However,

3 Census of India (1981); Government of India, District Census Handbook, West Khasi Hills District, Series 14, Meghalaya, Shillong, 1981, p. 29.

4 Sex-ratio is the ratio of female per thousand male population.


DECADAL GROWTH OF POPULATION
Fig. 4.2
MEGHALAYA STATE
WEST KHASI HILLS DISTRICT
POPULATION
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
150
100
50
1901
11
21
31
41
51
61
71
81
Y E A R

Nongstoin being the only urban centre, is also the only urban block of the district (8.0 per cent). The overall sex-ratio of the district is 949 which is marginally lower than the overall sex-ratio of the State (954). This is a special situation where the sex-ratio is higher than the national average of 935 (1981). This may be due to the matriarchal society existing in the State and the general social desirability as well as better upbringing of the female child.

Table - 4.4: <u>Population of West Khasi Hills District (Block-Wise) - 1981.</u>

(Fig. in 000)

Name of the block		Population			% of Male to total population	% of Female to total population	Sex Ratio
		T	M	F			
Mairang	T	45.0	23.0	21.9	51.19	48.81	953
	R	45.0	23.0	21.9	51.19	48.81	953
	U	-	-	-	-	-	-
Mawkyr-wat	T	46.2	23.4	22.7	50.82	49.18	968
	R	46.2	23.4	22.7	50.82	49.18	968
	U	-	-	-	-	-	-
Nong-stoin	T	42.1	22.7	20.4	51.54	48.46	940
	R	38.3	19.5	18.7	51.12	48.88	956
	U	3.8	2.1	1.7	55.70	44.30	795
Mawshyn-rut	T	28.1	14.6	13.5	51.96	48.04	925
	R	28.1	14.6	13.5	51.96	48.04	925
	U	-	-	-	-	-	-
West Hills Dist.	T	161.5	82.9	78.6	51.31	48.69	949
	R	157.6	80.7	76.9	51.20	48.80	953
	U	3.8	2.1	1.7	55.70	44.30	795
Megha-laya	T	1335.8	683.7	652.1	51.18	48.22	954
	R	1094.4	556.9	537.5	50.89	49.11	965
	U	241.3	126.7	114.5	52.52	47.48	904

Source: Census of India (1981); <u>Meghalaya</u>, Series 14, Part II (A and B) District Census Handbook, West Khasi Hills District, Parts XIII (A and B).

Table 4.5 shows the Block-wise composition of population of the West Khasi Hills district and the State (1981). The vast majority of the population of the district belongs to Scheduled Tribes with 97.16 per cent. Since, there is no Scheduled Caste population in the district and therefore, the percentages for all the C.D. Blocks indicate the share of Scheduled Tribes population over 90.0 per cent. Compared to the average for the State, the share of Scheduled Tribes population in the district is higher. This is largely because the district is remote and inaccessible has remained beyond any significant in migration of non-Scheduled Tribes population.

Table - 4.5: <u>Social Composition of Population: West Khasi Hills District, 1981 (Block-wise)</u>

(Fig. in 000)

Name of the Block		Scheduled Tribes		Scheduled Castes	
		Persons	% of total population	Persons	% of total population
1. Mairang C.D. Block	T	44.3	98.47	-	-
	R	44.3	98.47	-	-
	U	-	-	-	-
2. Mawkyrwat C.D. Block	T	45.5	98.66	-	-
	R	42.5	98.66	-	-
	U	-	-	-	-
3. Nongstoin C.D. Block	T	40.9	97.12	-	-
	R	37.6	98.36	-	-
	U	3.20	84.85	-	-
4. Mawshynrut C.D. Block	T	26.1	92.69	-	-
	R	26.1	92.69	-	-
	U	-	-	-	-
5. West Khasi Hills Dist	T	156.9	97.16	-	-
	R	153.7	97.47	-	-
	U	3.2	84.85	-	-

Source: Census of India (1981); <u>District Census Abstract</u>, West Khasi Hills District, Meghalaya.

Table 4.6 provides the decadal growth of population, Block-wise in West Khasi Hills district (1971-81). The percentage of growth is highest in the Nongstoin Block,[5] accounting for 61.50 per cent, followed by Mairang (58.09 per cent), Mawshynrut (34.76 per cent) and Mawkyrwat (30.63 per cent). For reasons of accessibility and the development of Nongstoin and Mairang as administrative centres have become the centres of attraction from neighbouring areas for both tribals as well as non-tribals from elsewhere in the State.

Table – 4.6: Growth of Population in West Khasi Hills District (1971-81)

(Fig. in 000)

Name of the Block	Total Population in 1971	Total Population in 1981	% of decadal variation
1. Mairang	28.4	45.0	58.09
2. Mawkyrwat	35.3	46.2	30.63
3. Nongstoin	26.1	42.1	61.50
4. Mawshynrut	20.8	28.1	34.76
West Khasi Hills District	110.8	161.5	45.73
Meghalaya State	1011.6	1335.8	32.04

Source: Census of India (1981); District Census Abstract, West Khasi Hills District, Meghalaya.

Table 4.7 indicates the level of literacy in the district of West Khasi Hills (1981). The overall level of literacy

5 Census of India (1981); Op.cit.

in Meghalaya is marginally below the national average of 36.0 per cent. But in the West Khasi Hills District the level of literacy is marginally lower than that of the average for the State. Between different blocks of the district there is no significant difference, though Mawkyrwat Block has a 34.27 per cent level of literacy which is the highest among all the Blocks. There is also only marginal difference in the level of literacy among the male and the female population.

Table - 4.7: Literacy of West Khasi Hills District (Block-wise) - 1981

(Fig. in 000)

Name of the Block		Literates					
		Persons	P.C.	Male	P.C.	Female	P.C.
1. Mairang	T	12.8	28.54	6.3	27.61	6.4	29.52
	R	12.8	28.54	6.3	27.61	6.4	29.52
	U	-	-	-	-	-	-
2. Mawkyrwat	T	15.8	34.27	8.6	36.83	7.1	31.62
	R	15.8	34.27	8.6	36.83	7.1	31.62
	U	-	-	-	-	-	-
3. Nongstoin	T	13.4	31.93	7.6	35.28	5.8	38.53
	R	11.4	29.86	6.4	32.76	5.0	26.83
	U	2.0	52.35	1.2	56.64	0.8	46.95
4. Mawshynrut	T	9.5	33.73	5.6	38.27	3.9	28.82
	R	9.5	33.73	5.6	38.27	3.9	28.82
	U	-	-	-	-	-	-
West Khasi Hills District	T	51.6	31.97	28.2	34.01	23.4	29.75
	R	49.6	31.47	27.0	34.01	22.5	29.36
	U	2.0	52.35	1.2	56.64	0.8	46.95
Meghalaya State	T	455.1	34.08	259.0	37.89	196.1	30.08
	R	300.4	27.45	171.6	30.83	128.1	23.96
	U	154.7	64.12	87.3	68.90	67.3	58.82

Source: Census of India (1981); District Census Abstract, West Khasi Hills District, Meghalaya.

Table 4.8 indicates the share of working population (workers) of broad categories, blockwise in the district in 1981. The total working population (workers) have been categorized into four groups viz. (i) Cultivators and Agricultural labourers, (ii) Workers in Household Industries (including manufacturing, processing etc.), (iii) Other workers, and (iv) Marginal workers. The percentages of the total workers to total population in the district and the State are 50.08 per cent and 43.44 per cent, respectively. Among the C.D. Blocks, Nongstoin registers the largest percentage of total workers with 52.86 per cent, out of which 54.02 per cent rural and 41.47 per cent urban workers. This may be due to the location of Nongstoin Town where non-agricultural activities are comparatively more than the other blocks of the district. The percentages of cultivators and agricultural labourers in the district and the State are 47.14 per cent and 31.51 per cent, respectively. Blockwise, Mairang C.D. Block has the highest percentage with 49.76 per cent followed by Nongstoin (48.39 per cent), Mawshynrut (46.39 per cent) and Mawkyrwat (43.91 per cent). The State percentage of marginal workers is 2.49 per cent, which is higher than the district (1.77 per cent). In the district and the State the household and other workers (Categories II and III) are insignificant.

Table – 4.8: Workers Composition of West Khasi Hills District, 1981

(Fig. in 000)

Name of the Block		Total Workers		Cultivators and Agril. Labourers		Household Industry Manufacturing, Processing etc.		Other Workers		Marginal Workers	
		Persons	P.C.	Persons	P.C.	Persons	P.C.	Persons	P.C.	Persons	P.C.
1. Mairang	T	23.3	51.77	22.4	49.76	0.025	0.06	0.879	1.95	0.547	1.21
	R	23.3	51.77	22.4	49.76	0.025	0.06	0.879	1.95	0.547	1.21
	U	–	–	–	–	–	–	–	–	–	–
2. Mawkyrwat	T	21.2	46.0	20.2	43.91	0.008	0.02	0.963	2.08	2.633	1.37
	R	21.2	46.0	20.2	43.91	0.008	0.02	0.963	2.08	2.633	1.37
	U	–	–	–	–	–	–	–	–	–	–
3. Nongstoin	T	22.3	52.86	20.4	48.39	0.061	0.14	1.8	4.33	0.238	0.56
	R	20.6	54.02	19.8	51.83	0.009	0.02	0.829	2.16	0.235	0.61
	U	1.6	41.47	0.561	14.46	0.052	1.34	0.996	25.67	0.003	0.08
4. Mawshynrut	T	14.0	49.87	13.0	46.39	0.028	0.10	0.952	3.38	0.467	1.66
	R	14.0	49.87	13.0	46.39	0.028	0.10	0.952	3.38	0.467	1.66
	U	–	–	–	–	–	–	–	–	–	–
West Khasi Hills District	T	80.9	50.08	76.1	47.14	0.122	0.08	4.6	2.86	1.8	1.17
	R	79.3	50.29	75.6	47.95	0.070	0.04	3.6	2.30	1.8	1.19
	U	1.6	41.46	0.561	14.46	0.052	1.34	0.996	25.67	0.003	0.08
Meghalaya State	T	580.2	43.44	420.9	31.51	4.8	0.36	154.4	11.56	33.2	2.49
	R	502.3	37.61	416.5	38.06	3.6	0.33	82.2	7.51	32.8	3.00
	U	77.8	5.83	4.3	1.82	1.2	0.52	72.2	29.93	0.873	0.36

Source: Census of India (1981); District Census Abstract, West Khasi Hills District, Meghalaya.

Table 4.9 shows the dependency ratio[6] in the West Khasi Hills District (1981). In the district, the total non-working population is marginally lower than the total working population, 78.7 thousand and 80.9 thousand, respectively having a dependency ratio of 974. But in the State the non-working population (722.3 thousand) is higher than the total

Table - 4.9: Dependency Ratio of Workers in West Khasi Hills District, 1981

(Fig. in 000)

Name of the Block		Total Workers	Total Non-Workers	Dependency Ratio
1. Mairang	T	23.3	21.1	908
	R	23.3	21.1	908
	U	-	-	-
2. Mawkyrwat	T	21.2	24.3	1144
	R	21.2	24.3	1144
	U	-	-	-
3. Nongstoin	T	22.3	19.6	881
	R	20.6	17.3	840
	U	1.6	2.2	1409
4. Mawshynrut	T	14.0	13.6	972
	R	14.0	13.6	972
	U	-	-	-
West Khasi Hills District	T	80.9	78.7	974
	R	79.3	76.5	965
	U	1.6	2.2	1409
Meghalaya State	T	580.2	722.3	1245
	R	502.3	559.7	1114
	U	77.8	162.5	2088

Source: Census of India (1981); Meghalaya, Series 14, Part II (A and B).

6 The dependency ratio is the ratio of non-workers to workers per thousand. It indicates the general nature of work participation of the population in a given situation and the apparent and economic burden on the working population. In tribal areas, the nature of work participation (particularly, the female work participation is better) is better which is a healthy potential.

working population (580.2 thousand), having a dependency ratio of 1245. Among the Blocks, Mawkyrwat Block is having more non-working population (24.3 thousand) than the total working population (21.2 thousand) with a dependency ratio of 1144, which is the highest ratio among all the Blocks.

4.2. Settlement Pattern

4.2.1. Introduction

Each culture organizes and uses space in its own way, guided by its values, history, and self-perception. The basic resources of any society are the living space and productive land. Culture guides human control and organization of the land. Settlement[7] patterns may reflect physical environmental conditions or may appear to ignore them; culture - not terrain, soil, climate, or vegetation - is the significant factor.

All inhabited space is organized into usage areas according to function. Settlement is the organization and distribution of dwelling space as one such functional type. Compact and generally tightly organized, urban settlements require little space. For example, in the United States with its sprawling suburbs, the amount of space devoted to urban settlement is only 2 or 3 per cent of the total. Rural dwellings obviously encompass even less space, as rural dwellers

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7 C.E. Zimolzak and C.A. Standfield (1979); The Human Landscape Geography and Culture, Merrill Publishing Company, Columbus, London, p. 227.

comprise less than 25 per cent of the U.S. population. But in India, where more than 70 per cent population lives in rural areas, so obviously the percentage of rural dwellers would be higher than the developed countries like U.S.A. The nature of rural dwellings are either agglomerated, that is collected into villages or dispersed, scattered across the countryside. All rural dwellers are not farmers. Some are engaged in service or other occupations, small mining or factory villages. Farm villages dominate most of the world, forming an agglomerated settlement pattern. There is some correlation between settlement type and farm size. Huge farms, especially those in difficult physical environments tend to create dispersed settlement.

4.2.2. Evolution of Settlements in Meghalaya

Before going to discuss the various types of settlement patterns in the district, it is important to look back the evolution of settlement in this regard. There is scanty historical accounts of the region, since it is occupied by different tribal groups who had no written traditions living in physical isolation. However, there is some reference about them in Buranjis of the Ahoms[8] and the historical records of last century based on Ahom Chronicles supplimented by inscriptions, coins, copper plates and structures particularly

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8 R.L. Singh (ed. 1971); India: A Regional Geography, National Geographical Society of India, pp. 666-667.

on the Khasis, Jaintias, Mikirs and Cacharis which provide some evidence of occupation of its northern fringe even before the Christian era. There is no evidence of pre-historic settlements of the region. Recently, some scholars claim that the Rongram Valley of the Garo Hills was inhabited in the Palaeolithic times, based on their finding in the Daojalihading excavation site of the Rongram valley.[9]

There were waves of migrations into North-East India through the north eastern routes. Mostly, the migrants were invaders. They belonged to the 'Indo-Chinese Linguistic family'. The most important sub-families are the Mon-Khmer and Tibeto-Burman. The Mon-Khmer which constitutes the Khasis and the Jaintias. The other sub-families were grouped into three sub-groups - namely, Naga, Kuki-Chin and Bodo. The Khasis and Jaintia groups settled in the Khasi Hills and the Naga and the Kuki were driven to the Hills in the North East and the Bodo dominated the plains, the Garo Hills and the North Cachar Hills.

From the early part of 16th Century only, the history of the Khasis and the Jaintias may be traced. Prior to this, there were no records. The most well known in the 16th and 18th centuries are only the Jaintias Rajas (Kings) and to some extent, the Syiem (Raja or Chief) of Khyrim in the Khasi Hills.

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9 R.L. Singh (ed. 1971); Op.cit.

During the British period, the region underwent considerable changes through development of settlements and communication lines, particularly, after the formation of the Khasi and Jaintia Hills district in 1835 and the Garo Hill's in 1866. In 1827, the Cherrapunjee village was selected as the capital of the Province. But, owing to heavy rainfall (1300 cm), the capital was shifted to Yeddo (later name as Shillong) in the Khasi Hills in 1864. Since then, the Shillong has developed into a good administrative headquarters. British had constructed roads for administrative convenience in 1877, about 107 km long joining Shillong with Gauhati via Barapani, Umsning, Nongpoh. Earlier, a road running from Gauhati across the hills via Nongkhlaw, Mairang, Mawphlang, Cherrapunji, Mawsmai, Mawblang and Theriaghat to Bholaganj in Sylhet for a distance of 208 km was constructed.

There has been rapid development of educational institutions of various grades, medical services, roads and communication since Independence. In the mining areas, new settlement have come up in the Khasi Hills. Linear patterns of settlements have evolved along the arterial roads and national highways.

4.2.3. Distribution of Rural Settlement

Physiographically, the West Khasi Hills district has a highly dissected, plateau terrain, thin soil cover and limited arable land. The distribution of settlements are characterised mainly by the terrain of this district. As a matter of fact dispersed and hamleted settlements are common in the district.

Table 4.10 provides information on the inhabitated and uninhabitated villages of West Khasi Hills district (1981). The total number of villages of the State is 5,044, of which 4,880 are inhabitated villages and 164 uninhabitated. There are 743 villages in the West Khasi Hills district, of which 710 and 33 villages are inhabitated and uninhabitated, respectively. Besides the Nongstoin town, the settlements of the district fall under the rural category which accounts for more than 99.0 per cent of the total settlements.

Table - 4.10: Settlements in West Khasi Hills District, 1981

Name of the Block	Total No. of Villages	Total Inhabited in Villages			Uninhabita- Villages
		T	R	U	
1. Mairang	124	122	122	-	2
2. Mawkyrwat	183	181	181	-	2
3. Nongstoin	243	226	225	1	17
4. Mawshynrut	193	181	181	-	12
West Khasi Hills District	743	710	709	1	33
Meghalaya State	5,044	4,880	4,868	12	164

Source: Census of India (1981); Op.cit.

From the Table 4.11 (size classes of settlements), it is clear that most of the settlements are of very small size (population less than 200), which accounts for 65.26 per cent and 63.87 per cent in the State and the district, respectively. At the block level, Nongstoin and Mawshynrut contain more than 70.0 per cent settlements which fall under population size of less than 200, followed by Mawkyrwat (55.25 per cent) and Mairang (44.26 per cent). The size class (200-499) comprises of above 26.0 per cent of the total settlements of the district. But at the block level, Mairang and Mawkyrwat have more than 30.0 per cent settlements in this class. In the size class of (2000-4999) Mairang has got 1.64 per cent settlements which is the highest percentage of not only among the C.D. Blocks but also in the State (0.49 per cent) and the district (0.43 per cent). The type of dispersal and size of settlements depends on the nature and location of resources in a given region. The small size of settlements and the wide pattern of dispersal in the district indicates the limited nature of the land resource at the disposal of the people.

Table 4.12 provides the different amenities which are available in the district as well as each of the C.D. Blocks.

The crying need of the Hills district is communication and without communications and roads no development can be

Table – 4.11: Size Classes of Settlements (Rural)

Name of the Block	Total Villages	200		200-499		500-1999		2000-4999		> 5000	
		Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%
1. Mairang	122	54	44.26	40	37.79	26	21.31	2	1.64	-	-
2. Mawkyrwat	181	100	55.25	57	31.49	24	13.26	-	-	-	-
3. Nongstoin	226	157	69.47	51	22.57	10	4.42	1	0.44	-	-
4. Mawshynrut	181	138	76.24	40	22.10	3	1.66	-	-	-	-
West Khasi Hills District	710	449	63.87	188	26.74	63	8.96	3	0.43	-	-
Meghalaya State	4902	3199	65.26	1290	26.32	589	12.02	24	0.49	-	-

Source: Census of India (1981); Op.cit.

Table - 4.12: Social Amenities in West Khasi Hills District, 1981

Social Amenities	Mairang C.D.Block		Mawkyrwat C.D.Block		Nongstoin C.D.Block		Mawshynrut C.D.Block		West Khasi Hills District		Meghalaya
	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Total
1. Road											
a) Pucca Road	5	10.42	29	60.42	12	25.00	2	4.17	48	-	NA
b) Kutcha	64	23.27	76	27.64	52	18.91	83	30.18	275	-	NA
c) Footpath	53	19.41	66	24.18	56	20.52	98	35.90	273	-	NA
2. Post Office/ Tele. Office	6	16.67	20	55.56	7	19.44	3	8.33	36	8.35	431
3. Primary School	123	18.95	195	30.05	202	31.12	129	19.88	649	16.56	3918
4. Middle School	17	22.67	23	30.67	19	25.33	16	21.33	75	15.86	473
5. High School	2	15.38	6	46.15	4	30.77	1	7.69	13	6.37	204
6. PHC/Dispensary	2	22.22	4	44.44	2	22.22	1	11.11	9	11.11	81
7. Market (Weekly / Biweekly)	9	15.52	12	20.69	9	15.52	28	48.28	58	-	NA
8. Drinking water	122	17.40	174	24.82	220	31.38	185	26.39	701	-	NA
9. Power	17	56.67	7	23.33	6	20.00	-	-	30	4.29	700

Source: Census of India (1981); Op.cit.

made. In the West Khasi Hills district, there are 48 pucca roads, out of which 60.42 per cent belongs to Mawkyrwat C.D. Block, followed by Nongstoin (25.0 per cent), Mairang (10.42 percent) and Mawshynrut (4.17 per cent). Besides these pucca roads, there are Kutcha roads and footpath which are the main routes of communication, especially those in the interior areas. The district has been connected with Shillong (the State Capital) and some other areas through surfaced and gravel roads. Few important roads may be mentioned here, viz. the Shillong-Nongstoin surfaced road with a distance of 93 km has been extended for another 40 km upto Sonapahar. This road is one of the important roads connecting many villages. Another important road is the Shillong-Nongstoin-Tura Road via. Sonapahar connecting Shillong with Tura.

The total number of Post and Telegraph Offices in the district is only 36, which account for 8.35 per cent of all the Post and Telegraph Offices in the State of Meghalaya. Among the C.D. Blocks, Mawkyrwat (55-56 per cent) has the highest number of Post and Telegraph Offices. The postal and telegraphic communication in the district as a whole is very unsatisfactory. This may be due to the inaccessible nature of the terrain.

In the district, the number of villages with educational facilities are as high as 78.0 per cent. This is due to the fact that the number of primary schools are more, and Middle English and High Schools are very few in number. Only recently a college has been opened in Nongstoin Town, the Headquarters of the district. Nongstoin C.D. Block enjoys the highest number of educational facilities within the district, followed by Mairang C.D. Block.

Inadequate Medical facility is another problem faced by the people of the district. There is only one Government Hospital and very few dispensaries and PHS/PHC with only 30 beds in 1979-80. People mostly have to rush to Shillong, the State Capital, where private and Government Hospitals are available.

As regards to the drinking water facilities, though almost all the villagers have some sources of drinking water, very few of them enjoy the facilities of the tap water. Wells and rivers constitute the major source of drinking water. Inadequacy of safe water suplly to all the villages have led to an increase of diseases like gastro-entritis, typhoid and other water borne diseases.

In West Khasi Hills district, the number of villages electrified, so far, are 30 only. Mairang C.D. Block having the least number of villages in the district enjoys the highest number of electrified villages in the district with 23.33 per cent of the villages electrified.

4.2.4. Types of Settlement Location and Pattern

The complexity of structure, terrain and drainage has caused relatively uneven distribution of settlements in the district. Map 4.4 shows the distribution of settlements in West Khasi Hills district. The rugged areas of the plateau possess more uneven or irregular distribution of settlements, while relatively flat areas (the central part of the district) show more or less even distribution of settlements.

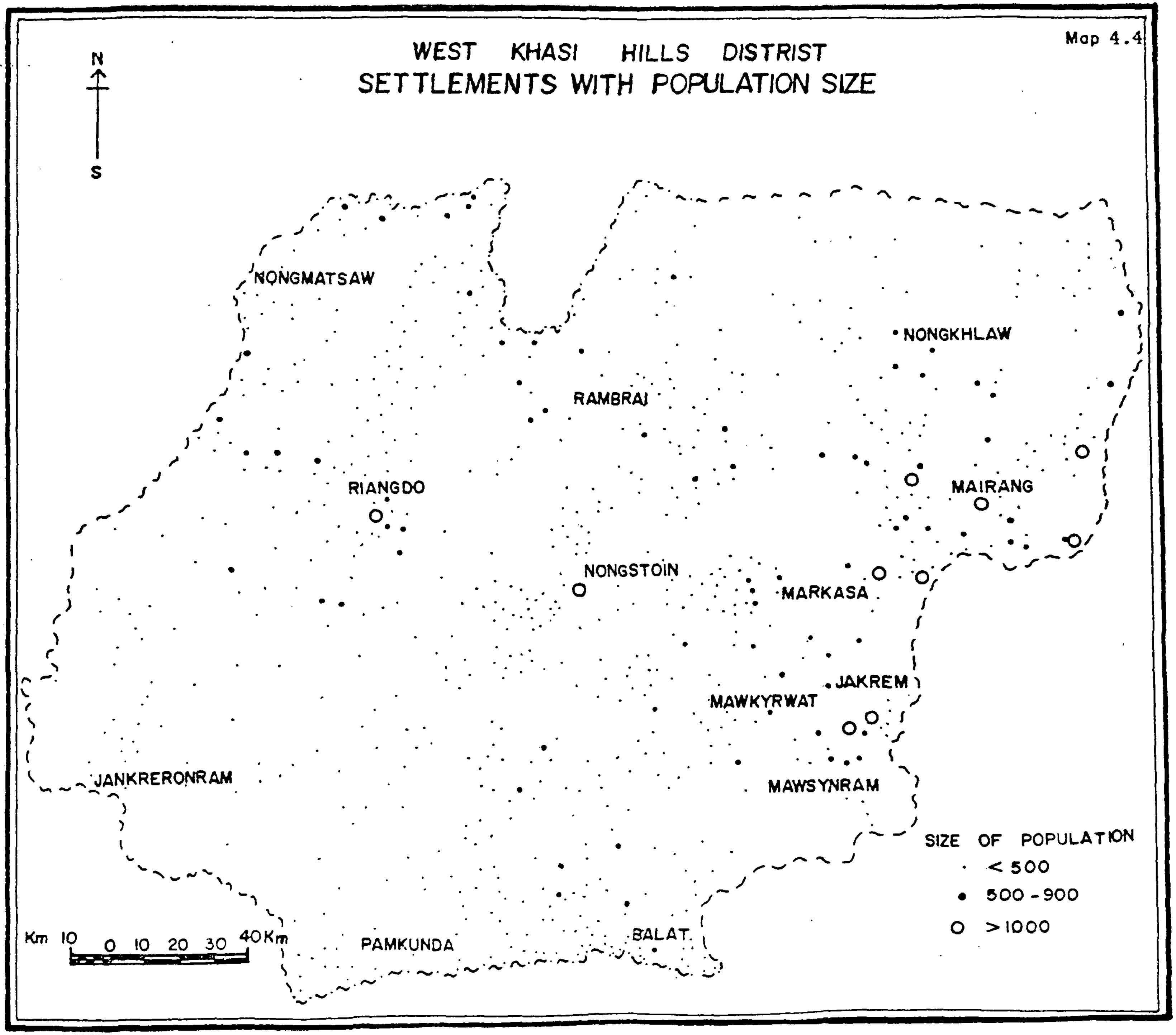
There is a correlation between settlement location and settlement pattern of the district. Most of the cases the characteristics of sites of settlements decide the pattern of settlements in the district. From the topographical sheets and the field survey, the researcher has identified the settlement locations and patterns for the district:

(a) Linear Settlement Pattern Along the River Valley/ Roadside

The linear settlement pattern is the most common along the river valley or the roadside of the district. The researcher came across such settlement patterns which are located along the valley of river Kynshi. Fig. 4.3 shows the location of settlements along river valleys and roads.

(b) Dispersed Settlements with Isolated Households Near Springs

Besides the riverine settlements, other water seeking settlements are available or close to natural or artificial source of water such as springs, wells, tanks or lake etc.

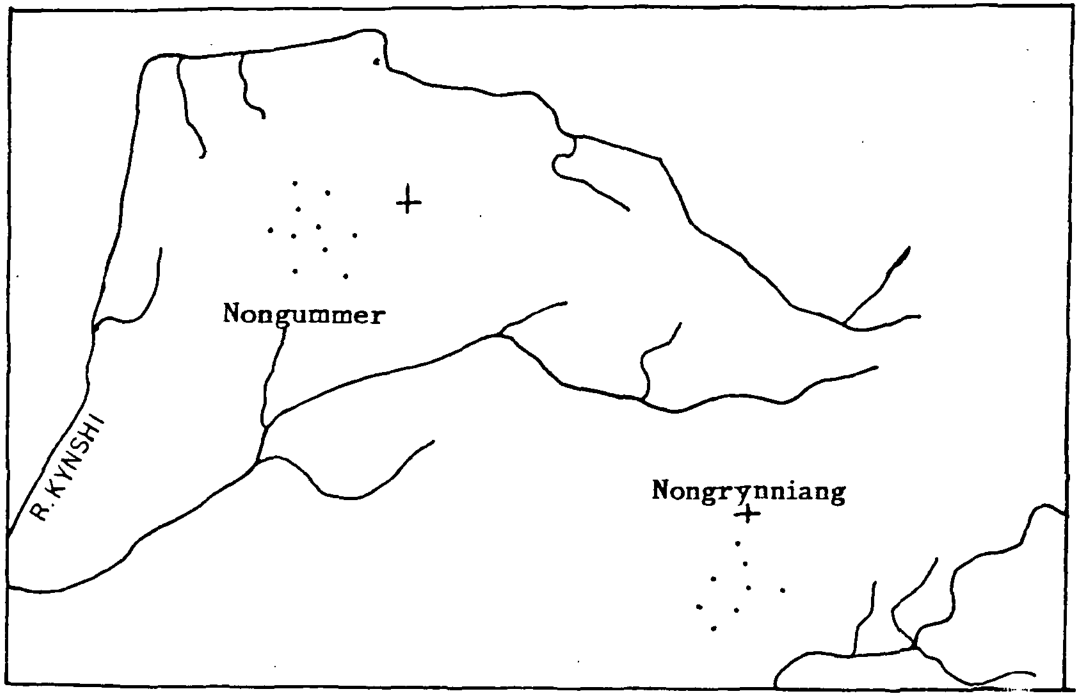

Map 4.4
WEST KHASI HILLS DISTRIST
SETTLEMENTS WITH POPULATION SIZE
N
S
NONGMATSAW
RAMBRAI
NONGKHLAW
RIANGDO
MAIRANG
NONGSTOIN
MARKASA
JAKREM
MAWKYRWAT
MAWSYNRAM
JANKRERONRAM
SIZE OF POPULATION
< 500
500 - 900
> 1000
Km 10 0 10 20 30 40Km
PAMKUNDA
BALAT

SETTLEMENTS NEAR NATURAL SPRINGS

Fig. 4.4

Toposheet

No. 78 $\frac{0}{3}$

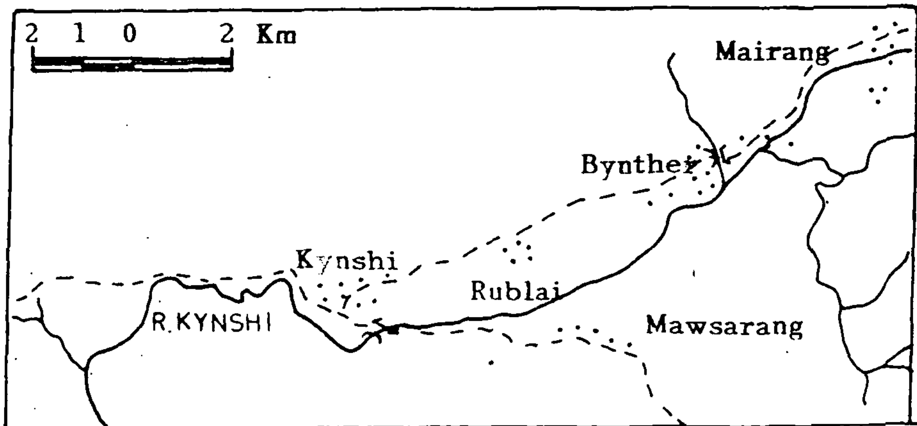


LINEAR SETTLEMENT ALONG THE KYNSHI RIVER VALLEY

Fig. 4.3

Toposheet

No. 78 $\frac{0}{10}$



Most of the cases, the settlements around springs are dispersed with isolated households. Fig. 4.4 shows this type of settlement pattern near Jakrem hot spring.

(c) Settlements Along the Watershed Zones

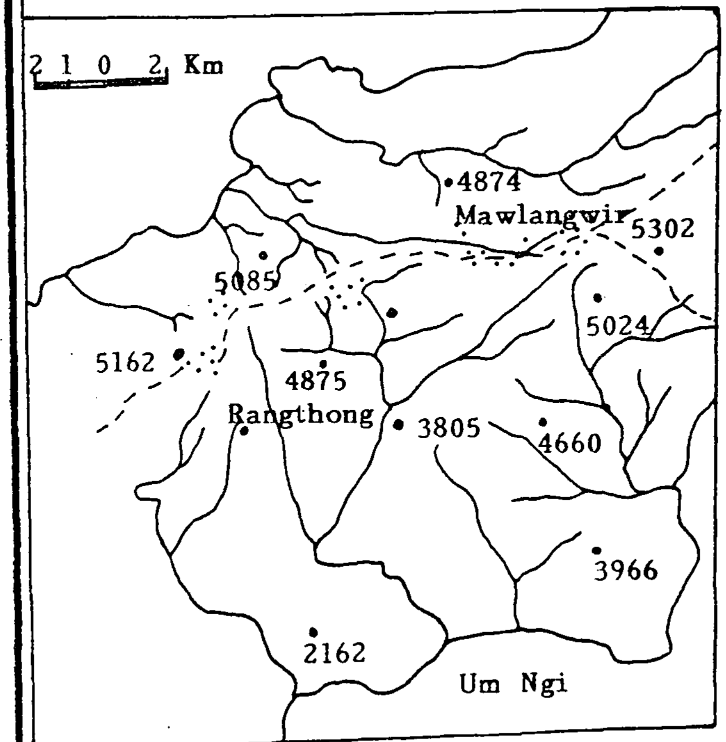
Sometimes settlements are not located near the valleys. They are located along the watershed zones. The flat plateau tops or hill ranges are divided the water. The villages are seen located in the central portion of the divide. This location has the advantage to easily accessible from both side-streams. The central part of the district is a plateau top area, where this type of settlements are available. Fig. 4.5 shows the settlements along the watershed zones near Marshillong.

(d) Settlements on the Slopes

The scarcity of plain land in this region is obvious. Therefore, the villagers have to construct their houses on the slopes and spurs, so that the valley or plain areas could be kept for agricultural purposes. The location of settlements on low hills, hill slopes as spurs or other types of elevated terrain is the marked characteristic features of the plateau. A number of large and small size settlements are located along the hill slopes of this district (Fig. 4.6). The northern, south-western and south-eastern part of the West Khasi Hills show a number of small villages, which are located on the hill slopes.

SETTLEMENTS ALONG THE WATERSHED ZONE NEAR MARSHILLONG

Fig.4.5



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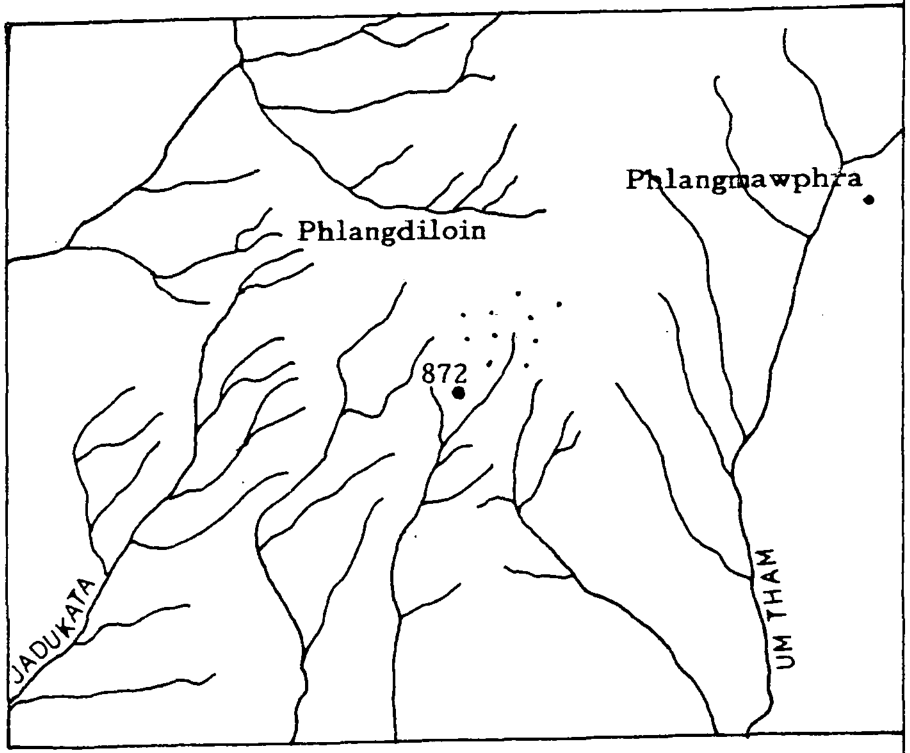
HILL-TOP SETTLEMENT

Fig.4.6



Toposheet No. $78\frac{0}{3}$

4.2.5. Factors Contributing Different Types of Rural Settlements

From the above discussion, the regional types of rural settlements, reveal that the evolution of a particular type of rural settlement is not only the result of single geographic feature such as relief but the assemblage of several environmental features as well as cultural and economic features also.

(a) Physical Factors

In the valley areas, the dispersed settlements with isolated households types of settlements are found in more in numbers since valley areas are more fertile than the hill slopes and crests. The isolated types of settlements are governed by certain physical factors and the important factors operating in West Khasi Hills are regional slopes and streams and upto some extent the natural springs. The terrain is also other important physical factor which controls the types of rural settlements. In the West Khasi Hills, the south-western part is characterised by undulating terrain and steep to moderate slopes and that is why in this part of the settlements are of isolated type.

(b) Socio-Economic Factors

Among the socio-economic factors responsible for different types of rural settlements are the Khasi Law of inheritance and the pattern of cultivation i.e. Jhumming. As a result of these two factors the dispersed and isolated households are most common in the district. The isolated households are the result of the excess population growth in the main village which could not support a large population because of the practice of jhum cultivation. The villagers have to go for looking new patches of jhum land.

4.3. The Economy

4.3.1. Introduction

The West Khasi Hills district and the State Meghalaya, have a predominantly traditional economy dominated by primary activities. Nearly, 82.0 per cent of the total population of Meghalaya are engaged in agricultural activities as their main occupation. The figure is far higher, about 89.0 per cent for the West Khasi Hills district where virtually life begins and ends with working on the fields. The State is deficient in production of foodstuffs and has to depend considerably on import of food items from the neighbouring valley regions. A very small section of the people is engaged in non-primary activities. The State is rich in minerals and water resources but measures taken so far for their exploitation are meagre and unsatisfactory.

There are vast tracts of land which are practically unsuitable for agricultural use. This is due to the rocky and rugged terrain or inaccessibility, as a result, these tracts lie as mere waste and fallow lands. The existence of current fallow tracts is a common phenomenon due to the prevalent shifting (locally known as jhumming, Shyrti in Khasi) cultivation which reduced the total forest cover in the district substantially.

4.3.2. Land Tenure System

It is important to discuss the land tenure system[10] in this region. In the district (and perhaps in the State as a whole), the land largely belongs to the people and not to the State. The land tenure systems are of different categories which are basically the same, though variations may occur here and there between one district and another. However, all types of land tenure systems cannot be covered here. A few important types of tenurial practices related to this district are presented here.

The broad categories of land use pattern in the district are as follows:

(a) Ri Kynti or Private Land is the land which belongs exclusively to a person or persons (irrespective of how he and they got exclusively under his or their possession), and which has as its boundaries of permanent stones, or boundary

10 Census of India (1981); Government of India, District Census Handbook, West Khasi Hills District, Series 14, Meghalaya, Shillong, 1981, pp. 9-11.

stones or stones making the division of the land, or of trees or bamboos or rivers or small streams or of plants or other definite marks.

(b) Raid Land (Ri Raid) is the land belonging to the community of the people of the Raid. Raid in the Khasi State is

(i) the administration of the Raid Durbar by the persons known as Bakhraw or Basan or the Elders or Headmen appointed within the State;

(ii) a section within a State which is under the Administration of the Bakhraw or Basans. This Raid is called in Maharam State as Phra Kynbat in Shella and in Mawdon State as U Sande.

(c) Ancestral Land (Ri Nongtymmen) means the land inherited from the mothers or grand-mothers from uncles or elder brothers or from the father or grand-father which is owned by those families who have descended from the first owners.

In some Khasi States such land is called Land of Relatives (Ri Kur), in other villages, this is named as land of the same bone (Ri Shyieng) or Land of the Family (Ri Rai Iing) and in other places this called Ri Phriang.

(d) Lyngdoh Land (Ri Lyngdoh) is a private land of the Lyngdoh clan or of a certain group of relatives where there is a forest dedicated to religious purposes called Law Lyngdoh (Priest's Forest).

(e) **The Syiem Land (Ri Syiem)** has three kinds:

(i) The private land of the Syiem family.

(ii) The private land which the Syiem family and some Basan and Myntri (Ministers) use for their maintenance as in Maharam State and elsewhere.

(iii) Land which all the members or citizens of the State can utilize as in Maharam State and this is almost the same as the Raid Land or Ri Raid.

The land system as was originally laid down by the forefathers to ensure both private and collective rights over the land and to provide land for every citizen according to his needs.

The State of Meghalaya is not cadastrally surveyed. This is due to the fact that any radical change in the customary land tenure system may invoke adverse public reactions.

4.3.3. Agriculture

Agriculture is considered as one of the vital means of livelihood of the people of this district. Out of the total of 82,797 workers, there are 71,947 cultivators constituting 88.92 per cent of working population in 1981. Most of the people practice 'jhumming' but a section of the people follow wet cultivation in the low lying areas of intermontane valleys and also some form of terraced cultivation including contour and strip-cropping on the hill slopes. The people in the district have a system of agriculture and take great care to adjust their agriculture to the productive capacity of the soil. They grow rice, mainly in the wet lands of the level valley plots and on slopes and ridges. By indigenous system of irrigation, the channels are fed by water from a long distances on contours. The use of plough is uncommon in the district except in northern and southern parts adjacent to plain areas.

In the central part of the district, maize, potato, vegetables, chillies, sweet potato, millets, etc., are grown in gardens and in the neighbourhood of the villages, particularly on the higher slopes as subsidiary food crops. A considerable area is also devoted highland paddy. Besides, the husbandry of various kinds of fruits, such as plum, orange, pineapple, lemon, lichi etc., are successfully grown in the uplands of the district and, particularly in the border areas adjoining Bangladesh. Areca-nut and Pan (betel leaves) are also grown abundantly which at one time, before partition, provided the people with a flourishing trade in the border areas. The crop-pattern in the district is determined more by the altitude and rainfall than by any other factor.

Table 4.13 and Pie diagram (Fig. 4.7) show the land utilization statistics of West Khasi Hills district as well as the State of Meghalaya for the period of 1980-81 and 1983-84. The net area sown has decreased from 4.03 per cent to 3.81 per cent in the district but it has increased from 8.58 per cent to 12.73 per cent for the State in 1980-81 and 1983-84. There was no significant increase or decrease in rest of the figures of land utilization.

From the Table 4.14 provides the information on the agriculturally active population in the district (1981), shows 47.12 per cent of the total population are agriculturally active whereas the States' figure shows only 31.51 per cent in 1981. In the district, the percentages of males and females in agriculture are 53.22 and 46.78 per cent, respectively. But in the State the male percentage is higher which accounts for 58.02 per cent and females 41.96 per cent.

Table 4.15 shows the distribution of area, production and yield of various crops in West Khasi Hills district and as well as the State for two years i.e., 1984-85 and 1986-87. In these two years, there is no major changes in the areal extension of the six major crops in the district. But, it is clear from the table that the production and yield of all the crops have decreased. The production and yield of rice in 1984-85 were 8535 metric tons and 966 Kg/ha, but in 1986-87

Table - 4.13: Land Utilisation in West Khasi Hills District (1980-81 and 1983-84)

(Area in Hectare)

Sl. No.	Type of Land Use	1980-81				1983-84			
		West Khasi Hills District		Meghalaya State		West Khasi Hills District		Meghalaya State	
		Area	P.C.	Area	P.C.	Area	P.C.	Area	P.C.
1.	Geographical Area	524700	-	2248900	-	524700	-	2242900	-
2.	Forest	179597	34.23	812121	36.11	179594	34.23	670214	29.88
3.	Barren & Uncultivable land	69263	13.20	230574	10.25	69486	13.24	225964	10.07
4.	Land put to Non-agricultural use	8933	1.70	85066	3.78	8998	1.71	99207	4.42
5.	Cultivable waste	191803	36.55	454542	20.21	193212	36.82	527480	23.53
6.	Permanent Pastures & Other grazing land	5250	1.00	17119	0.76	4541	0.87	40977	1.83
7.	Land Under Misc. trees, crops & groves	35855	6.83	144835	6.44	35851	6.83	134962	6.02
8.	Current fallows	5115	0.97	51345	2.88	5323	1.01	69234	3.09
9.	Old fallows	7741	1.48	260353	11.58	7729	1.47	187968	8.38
10.	Net Area Sown	21143	4.03	192945	8.58	19966	3.81	285534	12.73

Source: Directorate of Economics, Statistics and Evaluation Government of Meghalaya, 1987.

Table - 4.14: Agriculturally Active Population in West Khasi Hills District, 1981

(Fig. in 000)

District/ State		Total Population	%	Agril. Active Population (Agril Lab. & Cultivators)	
				Total	%
1. West Khasi Hills District	T	161.5	12.09	76.1	47.12
	M	82.9	51.33	40.5	53.22
	F	78.6	48.67	35.6	46.78
2. Meghalaya	T	1335.8	-	420.9	31.51
	M	683.7	51.18	244.2	58.02
	F	652.1	48.82	176.6	41.96

source: District Census Handbook, West Khasi Hills District, Part XIII - A and B, 1981.

Table - 4.15: Area, Production and Yield in West Khasi Hills District (1984-85 and 1986-87)

Area in hectares, Production in Metric tons, Yield in Kg/Ha

WEST KHASI HILLS DISTRICT

Crops	Ha	%	P	Y	Ha	%	P	Y
1. Rice	8838	38.0	8535	966	9640	39.0	7711	800
2. Maize	4773	21.0	6693	1402	5099	20.0	3656	717
3. Banana	428	2.0	5514	12883	604	2.4	6655	11018
4. Potato	6744	29.0	60603	8986	7370	29.0	58960	8000
5. Sweet Potato	1115	5.0	3345	3000	1108	4.0	3317	2994
6. Tapioca	680	3.0	4027	5922	781	3.1	4259	5453

MEGHALAYA

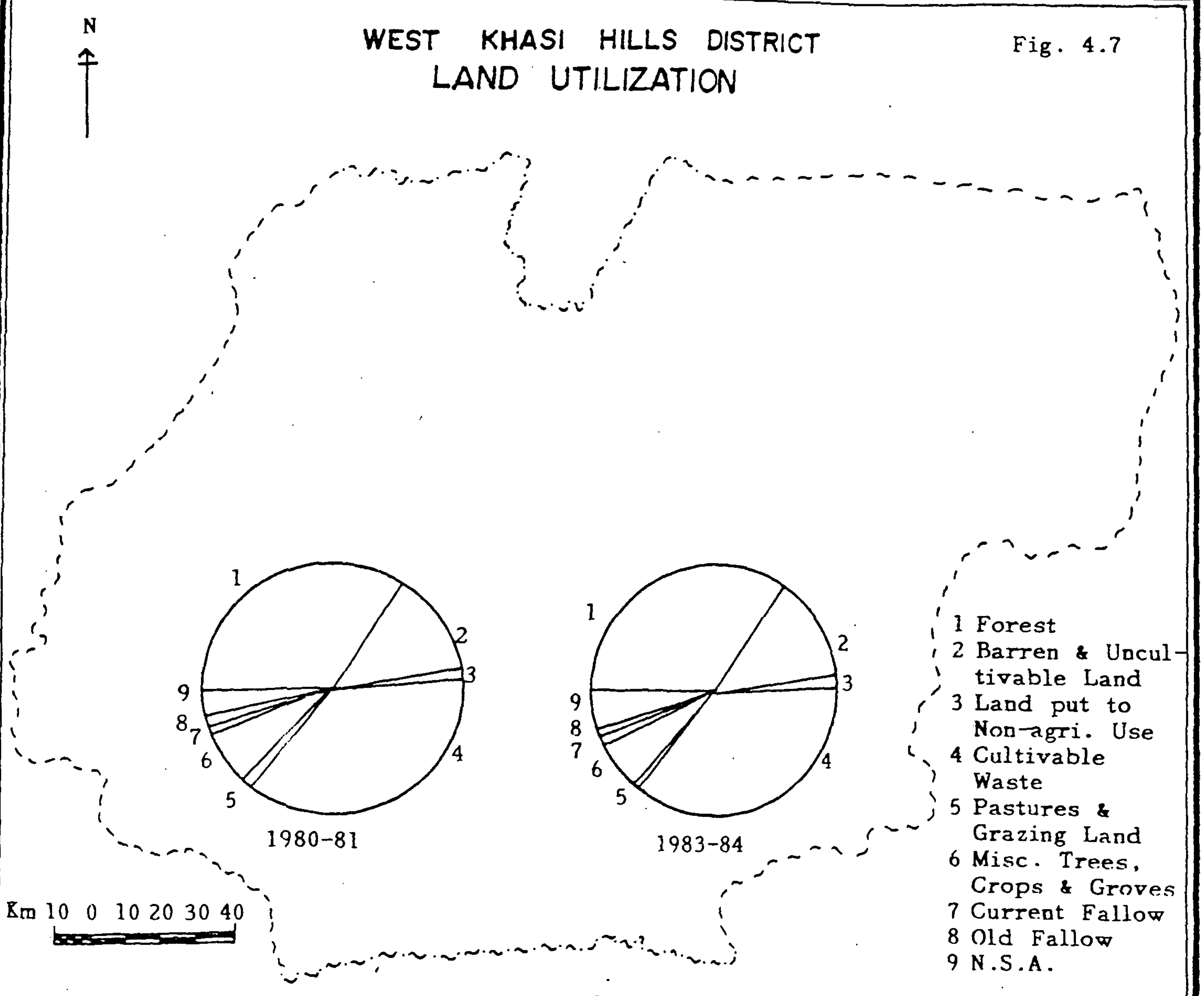
1. Rice	111355	69.0	124198	1115	108540	68.0	98771	909
2. Maize	17626	11.0	24106	1368	19153	12.0	20095	1049
3. Banana	3829	2.4	47655	12446	4057	3.0	48591	11977
4. Potato	18960	12.0	149424	7881	18876	12.0	154626	8192
5. Sweet Potato	3774	2.3	12299	3259	3834	2.4	12716	3317
6. Tapioca	3836	2.4	21482	5600	4032	3.0	23304	5780

Source: Government of Meghalaya, Directorate of Economics, Statistics and Evaluation, 1988.

WEST KHASI HILLS DISTRICT

LAND UTILIZATION

Fig. 4.7



the production and yeild reduced to 7711 metric tons and 800 kg/ha, respectively. During this period i.e. 1984-85 and 1986-87, the production and yield of the State have been declined for the first three crops i.e. rice, maize and banana. This, may be due to less favourable rainfall.

In the Table 4.16 shows the data on jhumming in West Khasi Hills district in 1983 (Map 4.5). Total villages of the district is 743 (both inhabitated and uninhabitated) of which 185 villages practised jhum cultivation. Out of the total households 29,167, only 12.44 per cent households are engaged in jhumming. Among the C.D. Blocks, Mawshynrut Block has got the highest number of villages and households under jhumming, which account 50.26 per cent and 24.42 per cent followed by Nongstoin C.D. Block (27.57 per cent and 14.96 per cent), Mairang (9.68 per cent and 2.21 per cent) and Maw-kyrwat (4.92 per cent and 5.72 per cent). There are many factors responsible for the prevalence of shifting cultivation in this region. The climatic conditions, the hilly terrain, the dietary habits of the people, and their customs are a few of these factors. The shifting cultivation is the natural way of life of the tribal people. But it is detrimental to a forest economy, and, therefore, to the national economy as it leads to wanton destruction of forests.

Map 4.5

WEST KHASI HILLS DISTRICT
AREA UNDER SHIFTING AGRICULTURE

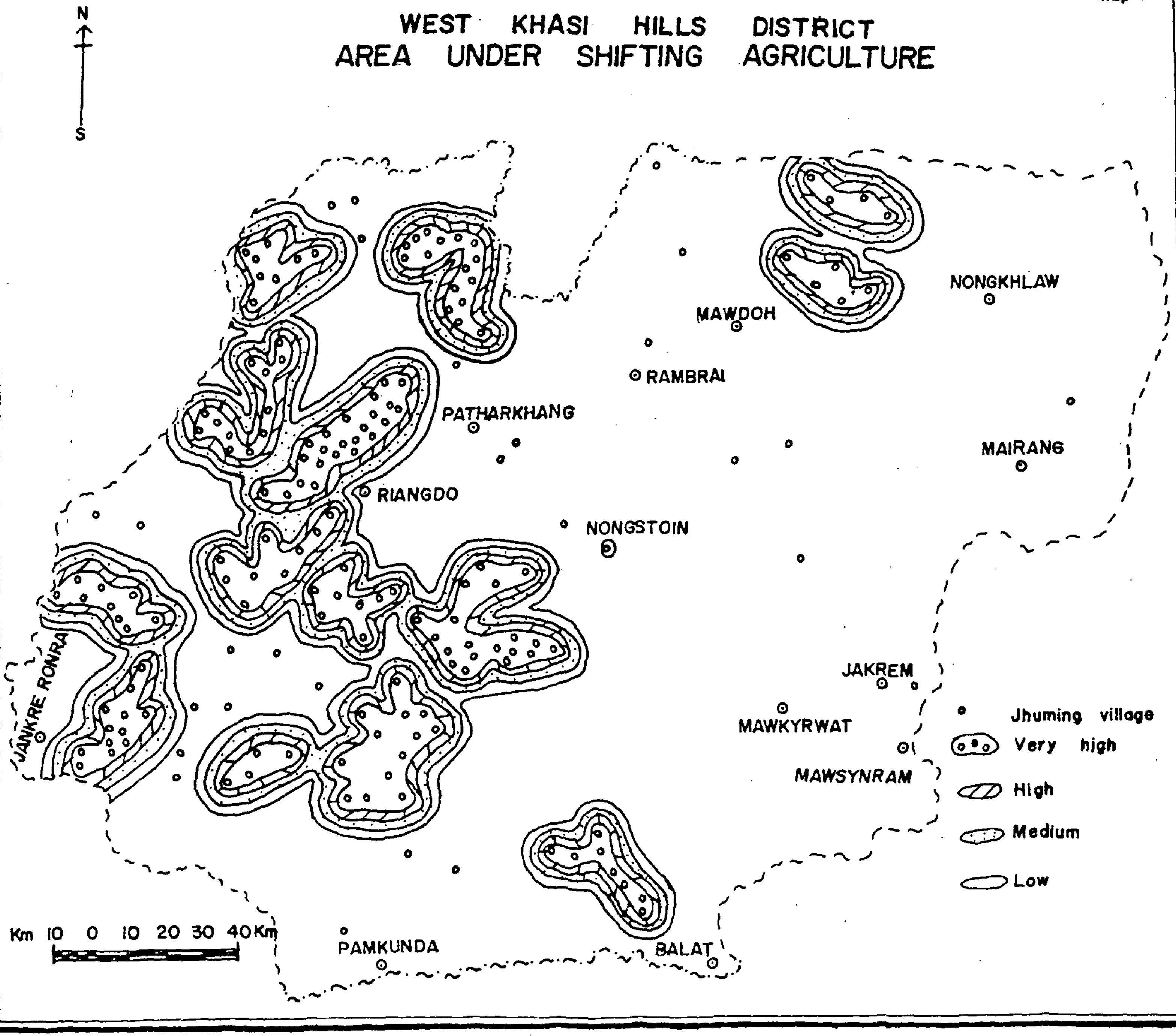


Table - 4.16: Jhumming in West Khasi Hills District, 1983

Block/District	Total Village	Total village under jhuming	%	No. of house-holds	Jhuming house-holds	%
1. Mairang	124	12	9.68	7923	175	2.21
2. Mawkyrwat	183	9	4.92	8634	494	5.72
3. Nongstoin	243	67	27.57	7598	1137	14.96
4. Mawshynrut	193	97	50.26	5012	1725	34.42
West Khasi Hills District	743	185	24.90	29167	3629	12.44

Source: Special Report on Jhum, Census of India, 1981, Series 14, Part - I of 1983, Meghalaya.

Commercial forest plantations which are being experimented in the district is Wattle (acacia species) which produces the valuable bark for leather tanning. It grows well over 900 metres of elevation, along with potato cultivation. The principal crop, as well as the staple food in the district is rice. The only areas where the wet paddy are cultivated are at foothills alongside the border of Kamrup district of Assam and Bangladesh.

4.3.4. Mineral Resources

Meghalaya is very rich in mineral resources. But so far only coal, limestone, and sillimanite have to some extent been commercially exploited. Some other minerals are under investigation of the department concerned. In the West Khasi

Hills district, most of the minerals are being investigated. The district is rich in sillimanite, coal and limestone which are being exploited already.

(a) Sillimanite

Sillimanite is an important mineral which is used for making refractory bricks and certain types of ceramic wares. The sillimanite corundum deposits of Sonapahar (Mawshynrut) in the West Khasi Hills district are well known and are reputed to be the best quality sillimanite in the world. It is estimated that Sonapahar contains an approximate reserve of 2,55,000 tonnes of high grade sillimanite spread over a belt of 20 by 10 km. It is an interesting fact that Sonapahar accounts for nearly 90 per cent of the country's production of Sillimanite.

(b) Coal

Meghalaya is rich in low grade coal with an annual production of about 40,000 tonnes which is raised mainly from a few small collieries. Most of the coalfields fall under the East Khasi Hills District. West Khasi Hills district produces very less quantity of coal, with the continuation of large scale investigation in and around an old mine block of Borsora and Langrin fields, it is expected that the production of coal in this district will increase. Coal deposits in the Nongshyrlem areas, West of Nongstoin is under preliminary investigation. Coal produced from this State is known for its volatility, high sulphur and low ash content.

(c) Iron

Iron is found in the form of fine sand, consisting of minute crystal of titaniferous magnetic oxides which are irregularly distributed in the mass of the softer portions of the granite rocks and occasionally in some of the gneissic beds. The upper portion of the granite is partially decomposed and when the ore is extracted, the iron bearing strata are raked into a stream of water which is carried along the foot of the escarpment using the gravity principle for separation. The ore is gradually washed out of the sand and other matter, and is smelted in a primitive furnace. It is either sold in balls or is worked into dao, hoes and other agricultural implements. The process is described in a note recorded in 1885, which was published in a book called 'Notes in Some Industries of Assam'[11] at the Shillong Secretariat Press in 1896. The principal places at which iron ore was smelted in former days were Nongspoung of West Khasi Hills District and Mylliem in East Khasi Hills. The iron industry has however, practically disappeared now because locally produced iron cannot compete in price with manufactured iron. The investigation by drilling

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11 Census of India (1980); District Census Handbook, West Khasi Hills District, p. 14.

for iron ore occurrences around Aradunga and Rangsapara (Near Hahim) is being taken up.

(d) Limestone

In all districts of the State large reserves of limestone are found. Many limestone quarries are interbedded with coal bearing sandstones.

Limestone is one of the geological products which are of economic value and which have been exploited to a great extent right from early days. But most of the exploited areas of limestone falls under East Khasi Hills district. In the West Khasi Hills district the exploited areas are Borsora, Ranikor etc. It is believed that there are millions of tons of limestones in these hills which have remained unexploited. Khasis have got their own methods of producing lime, by burning it in kilns.

(e) Copper

Excavation of copper was important and was exploited in the early days at Nongstoin. Khasis, in the past, have used their own method of smelting copper and was largely used for the manufacture of pots, cups and vessels.

Recently, promising areas of uranium have been located in some areas of the southern slopes of the district. Intensive exploitation is at present being conducted by AEC. The development of minerals will hasten the process of industrialization in the State. The huge reserves of limestone may be utilized for the purpose of setting up cement or clinker plants. Coal may be utilized for setting up coal-based industries. The availability of sillimanite and various types of clay may aid in setting up of a few refractory, pottery and ceramic industries. Minerals are exhaustible resources. Therefore, the use and exploitation of minerals should proceed on a scientific and sustainable basis.

4.3.5. Forest Resources

The district is rich in vegetation which ranges from tropical to temperate. Dense jungles clothe the higher summits which abound with wild life. Forest areas constitute quite a large part of the geographical area of the State. There is a constant danger of denudation and deforestation due to the rising population resulting in growing demand for more land for cultivation, grazing and fuel, age old practice of shifting cultivation and heavy encroachments of the people living on the outskirts of the reserved forests. However, steps have been taken by the departments concerned to prevent and check deforestation.

There are quite a large number of species of timber in the district which are being supplied outside the State. Besides the valuable timber trees, medicinal plants, hard and soft wood of various types are found. Sal and Teak are the most important produce. The 'Khasi Pine' (Pinus insulars of Pinus Kasiya) grows abundantly and is an important forest produce which is reported to be of the best quality, yielding a high grade oil or turpentine. Pine grows well in the elevation of 900 to 1500 m and it usually does not grow below 700 m or above 1800 m. Chestnut trees, oaks and firs are also found especially in the low lying areas of the district where the elevation goes down to less than 600 m or so. Rich grasslands appear where the jungles have been cleared and felled. With the setting up of the bamboo chip factory at Nongdaju, large jungles of bamboos growing in this district can be utilized. Cane products, turpentine and rasin are few other items of the forest resources. The photopgraphs show the various types of forest in the West Khasi Hills district.

In the hill areas, forests hold the life line of the people. The system of farming, the type of life the community lives, the social and cultural superstructures are all built on the forest base. The decline and destruction of forests in such a canvas inevitably will cause the gradual disintegration and ruin of the societies of the hill people. Hence, the State can utilize its sovereign power in respect of administration, regulatory and developmental functions, for the management of forest resources.

Some Patches of Mixed
Forests Near Jakrem

Pine Forests Near Rambrai

Pine Forests Near Markasa

Slash and Burn for Jhuming
Near Riangdo

CHAPTER - 5

LAND CLASSIFICATION: GENETIC AND LANDSCAPE APPROACHES

LAND CLASSIFICATION: GENETIC AND LANDSCAPE APPROACHES

5.1. The purpose and methods of land classification on the basis of genetic and landscape approaches have already been discussed in the earlier chapters. In the present chapter, an attempt has been made to classify West Khasi Hills district in relation to the genetic and landscape approaches i.e. dealing at macro (ecological zone) and micro (land facet) land classification, respectively.

5.2. Identification of Macro-Regions (Ecological Zones): The Genetic Approach

As mentioned earlier, in the nineteenth century under the influence of botanists and geologists, the geographers had grouped the natural phenomena and the environmental controls of their associations by dividing the earth into natural regions. The primary aim of the geographer, namely - the recognition of unity in diversity as shown in the distinctive character of portions of the earth's surface. This has led to the concept of genetically based 'natural regions'. These natural regions[1] are based on climatic (Herbertson, 1905) factors like -temperature and amount and distribution of rainfall. These climatic factors may cause the changes of the natural vegetation and the morphology of the earth's surface.

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1 A.J. Herbertson (1905); "The Major Natural Regions: An Essay in Systematic Geography", Geogrl Jour. 20, pp.300-12.

In the Herbertson's types of natural regions, a study indicates that the morphology is the overriding criterion used in the actual delimitation of regions and that climatic boundaries have been adjusted wherever necessary to avoid conflict. Though, after all, no realistic land units can be deliminated on criteria, which are invisible or hypothetical (as 'natural vegetation' is for an increasingly large part of the earth). Therefore, the 'natural regions' forwarded by Herbertson have faced certain limitations:

(i) That the regions are large having an area of occurrence between 10^4 and 10^6 sq. miles.

(ii) Despite the genetic bond, they are internally complex, and

(iii) Their boundaries are vague; for instance, Herbertson described his as 'the approximate central lines of transitional areas'.

Keeping in view the above, an attempt has been made to identify the broad ecological zones as macro-regions in the West Khasi Hills district by repeated subdivision on the basis of causal environmental factors. There are six causal environmental factors, namely - geology, relief, slope, drainage, climate and vegetation which have been chosen as the basis of land classification with a genetic approach. The effect of the land environment mostly depends on the interaction of these environmental factors. Under the natural conditions at the same time, the characteristics of land is affected by variations in environmental factors. All the factors are interrelated. For instance, increase in deforestation would result in soil erosion and land degradation, a specific type of humus formation, which in turn is guided by specific climate etc.

At the first level of the genetic division of the district, first the individual criteria are studied and then combined by superimposing the relevant maps of the district to arrive at delimitation of macro-regions (ecological zones).

5.3. Description of the Criteria and Their Regional Dimensions

The description of various criteria used for demarcation of macro-regions in the district, could be stated as in the following manner.

(a) Geology

The Meghalaya Plateau has indeed a chequered evolutionary history of emergence, submergence and peneplanation with several phases of erosion, sedimentation, diastrophism, intrusion, movements of land and sea emission.[2] It is a fragment of the super-continent of Gondwana and contains within its bare face the marks of peneplanation which ranges from

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2 R.P. Singh (1968); "Geomorphology of Shillong Plateau of Assam", Proc. Pre-Cong. Sym. on Meghalaya II (I.G.U., Gauhati, 1968), p.1.

Pre-Cambrian to Recent and sub-recent periods. The higher parts of the plateau preserve marks of Gondwana surface, while later cycles are traced below them. The emergence of the Pre-Cambrian Gondwana Block is attested in this plateau. Later, it was submerged partially by the encroaching sea during the Mesozoic and early Tertiary times and was uplifted slowly from the bed of the sea at the time the Himalaya rose from the floor of Tethys. The orogenic movement was so slow and free from buckling that the sedimentary beds retained their horizontal character and gave rise to structural platforms well developed in the Cherrapunji area.[3]

The soils of the North Eastern Hill Region have developed under the influence of many types of bed-rock conditions. The major areas of Khasi Hills have been formed of gneissic rocks.[4] The rocks comprise mainly of biotite-gneiss, biotite granulite, tourmaline schist etc.

The rocks in Meghalaya belongs to five geological formations. These five formations[5] are:

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3 S.P. Chatterjee (1968); India - A Physical Geography, Publications Division, New Delhi, p.40 (Chapter on 'Physiography' in the Gazetteer of India, I).

4 G.S.I. (1974). Misc. Publication No. 30, Part IV, pp.70-75.

5 T. Oldham (1960); "Notes on the Geological Structures of the part of the Khasi Hills", Memo, G.S.I. Vol. I, No.2.

(i) The Archean Gneissic Complex,

(ii) The Lower Gondwana Rocks,

(iii) The Sylhet Traps,

(iv) The Shillong Group of Rocks, and

(v) The Cretaceous Tertiary Sediments.

Map 5.6 shows the distribution of different types of rocks in the West Khasi Hills District.

(i) Archaean Gneissic Complex

Archaean Gneissic complex occupies the major portion of the district. The rocks in this complex are biotite, gneiss, quartzite, schist, sillimaniate etc. They are composed of mainly gneisses, magnatites and meta-sedimentary beds.

(ii) The Lower Gondwana Rocks

The lower Gondwana rocks are found in south-west corner of this district, where coal is available. In this Lower Gondwana coalfield with thick coal seams, underlying the dolomites and phyllites.[6]

(iii) The Sylhet Traps

This type of formation is available in the southern part of the district. The direction of the formation is east

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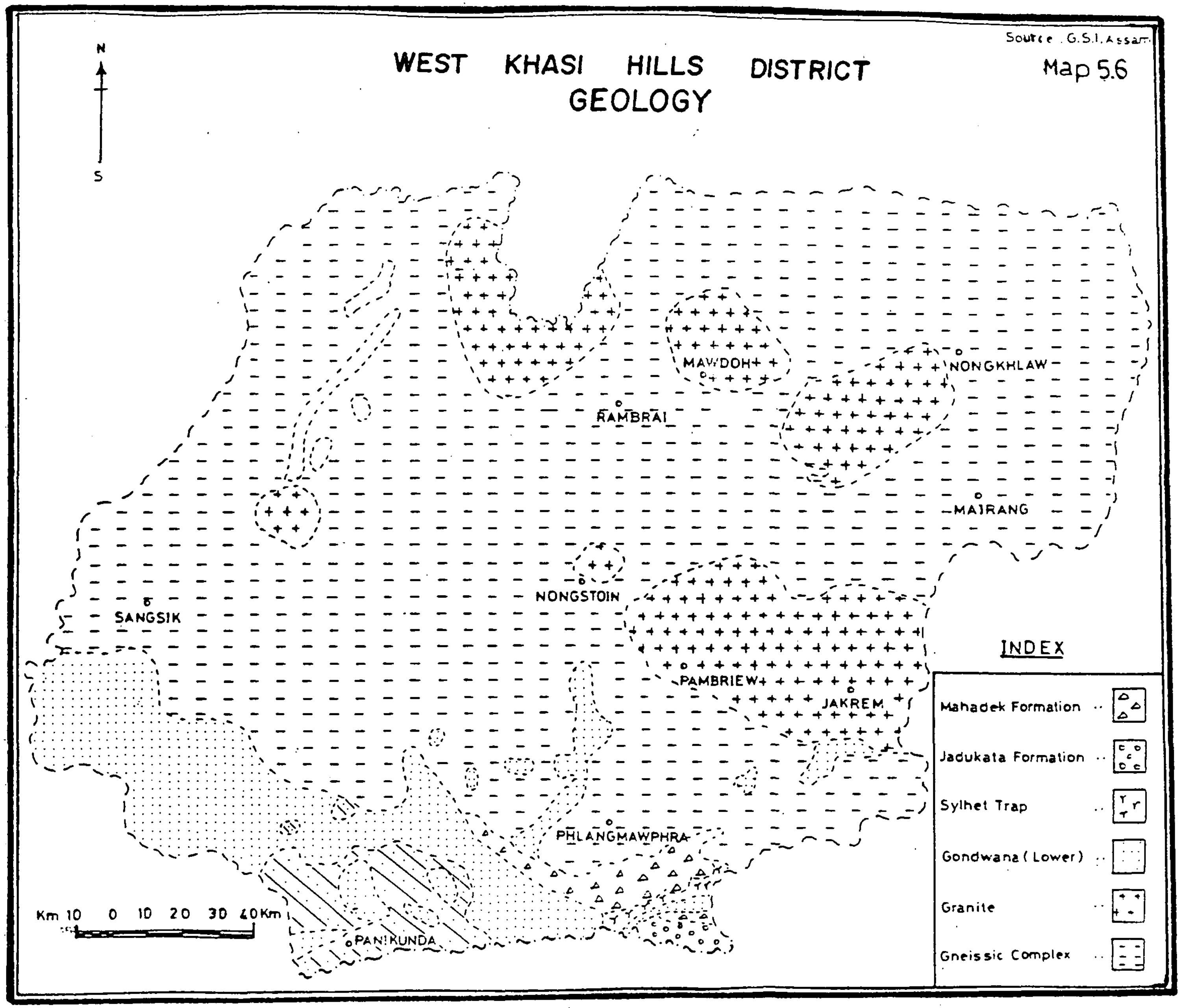
6 D.N. Wadia (1975); Geology of India, 4th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, pp.172-180.



WEST KHASI HILLS DISTRICT
GEOLOGY
Map 5.6
Source . G.S.I. Assam
N
S
NONGKHLAW
MAIRANG
MAWDOH
RAMBRAI
NONGSTOIN
SANGSIK
PAMBRIEW
JAKREM
PHLANGMAWPHRA
PANIKUNDA
Km 10 0 10 20 30 40Km
INDEX
Mahadek Formation
Jadukata Formation
Sylhet Trap
Gondwana (Lower)
Granite
Gneissic Complex

Table - 5: Geological Formation and Rock Types in Meghalaya

Geological Age	Group	Formation	Rock Type
Recent	New Alluvium (Thickness not known)	Unclassified	Sand, Silt, Clays
----------	----------	Unconformity	----------
Pleistocene	Older Alluvium (Thickness not known)	Unclassified	Sand, Clay, Pebble, Gravel, and Boulder deposits.
----------	----------	Unconformity	----------
Mio-pliocene	Dupi Tila Group (1050 m)	Unclassified	Mottled Clays, Feldspathic, Sandstone, Conglomerate.
----------	----------	Unconformity	----------
Oligo-Miocene	Garo Group	Chengapara Formation (700 m)	Sand, Siltstone, Clay, Marl.
		Baghmara Formation (530 m)	Pebble, Conglomerate, Clay.
		Simsang Formation (1150 m)	Siltstone, Sandstone, alternations sand.
Eocene	Jaintia Group	Kopili Formation (500 m)	shale, Sandstone, Marl.
		Shella Formation (600 m)	Alternation of Sandstone, Limestone.
		Langpar Formation (100 m)	Calcareons Shale, Sandstone, Limestone

Table 5.1 (Contd.)

Geological Age	Group	Formation	Rock Type
Upper Cretaceous	Khasi Group	Mahadek Formation (150 m)	Arkose (Glauconitic)
		Bottom Conglomerate Formation	Conglomerate, Arkose
		Jadukata Formation (140 m)	Sandstone, Conglomerate, alternations.
----------	----------	Unconformity	----------
Jurassic	Sylhet Group (600 m)		Basalt, Rhyolite, Acid Tuff.
----------	----------	Unconformity	----------
Pre-Cambrian		Intrusives (Acid & Basic)	Poprhyritic & Coarse Granites, Pegmatite, Aplite, Quartz-Vein, Epidiorite, Dolerite, Basalt.
		Shillong Group	Quartzite, Phylite, Conglomerate.
----------	----------	Unconformity	----------
Archaean		Gneissic Complex	Biotite, Gneiss-Biotite-Hornblende, Gneiss, Granitic Gneiss, Migmatite, Mica Schist, Sillimanite-Quartz, Schist, Biotite Granulite, Amphibiotite, Pyroxene Granulite, etc.

Source: G.S.I., Misc. Publication No. 30(1974), Part - IV, p.73.

to west bounded in a narrow strip. Balat area of the district is composed of this type of formation. Sylhet trap includes predominantly basalt, rhyolites and acid tuffs. Sylhet trap and the adjoining Archaean rocks to the north are characterised by several basalt dykes.

(iv) The Shillong Group

In the eastern part of the district, Shillong Group of rocks are available. They are composed of quartzite, phylites, schists, conglomerates etc.

(v) The Cretaceous-Tertiary Sediments

This formation occupies the southern parts of the district. The rocks are mainly sandstone, shale, and limestone.

This formation is divided into three groups:

(a) The Khasi Group,

(b) The Jaintia Group, and

(c) The Garo Group.

(a) The Khasi Group

The Khasi Group is again sub-divided into two formations:

(i) The Mahadek, and

(ii) The Jadukata formation.

The Jadukata formation consists of alternation of conglomerate and limestone. It overlies non-conformably the Sylhet Trap and occurs to the north of the Riba Fault. The Mahadek formation consists of coarse arkose rocks.

(b) Relief

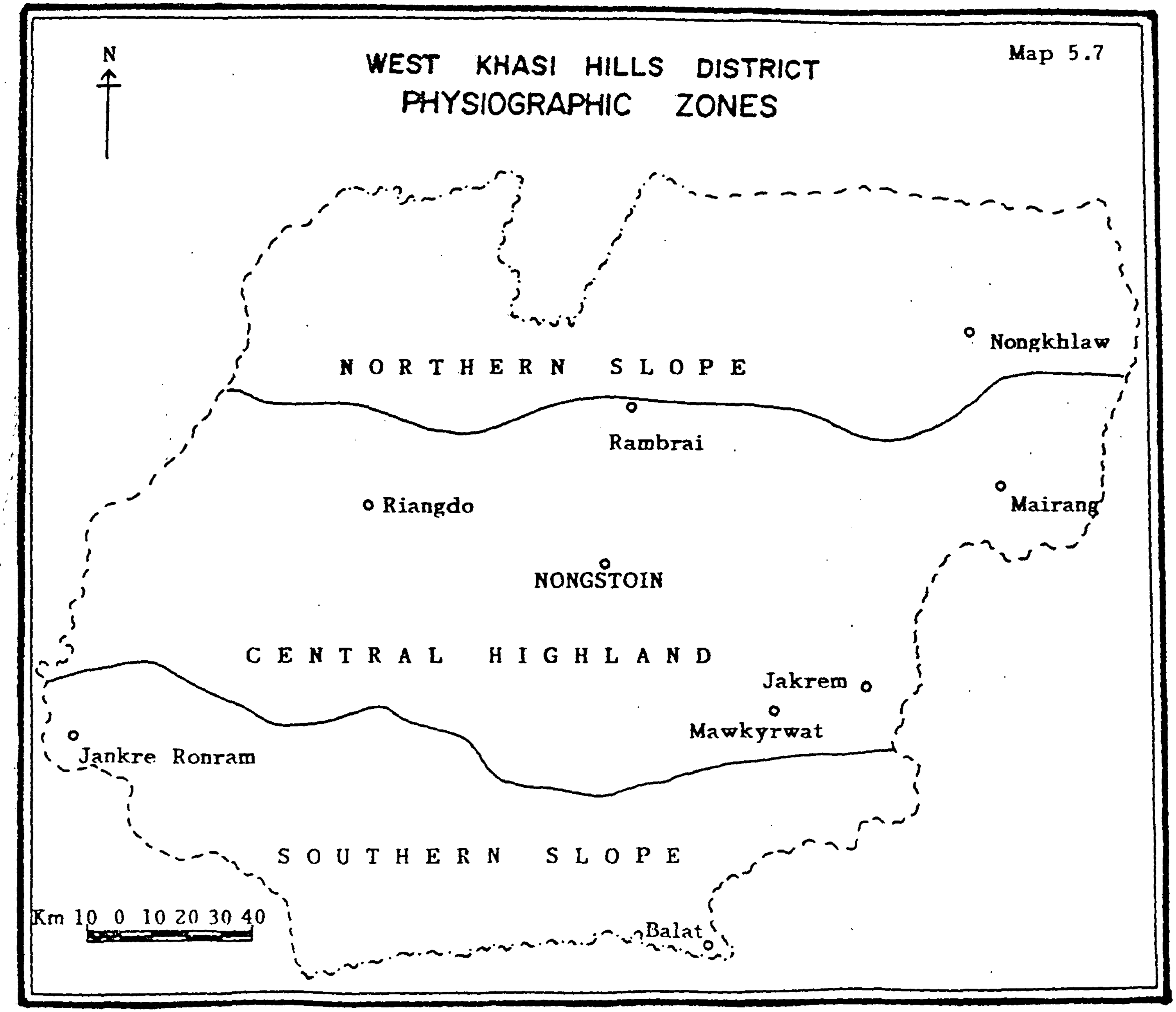
The physiographic characteristic of the region is remarkable due to the highly dissected and irregular terrain in the West Khasi Hills district. It is full of hills, valleys, plateaus and rivers. In the north, small hillocks are found which merge with the plains of Assam. In the south, the slopes are very steep and there are deep gorges and spurs. The middle portion of Meghalaya i.e. plateau proper, looks like an imposing table-land with steep escarpments and deep valleys bordering the Sylhet plains of Bangladesh.

The district has been divided into three relief regions (Map 5.7) on the basis of the general physiographic characteristics of the district:

(i) The Central Highland,
(ii) The Southern Slopes, and
(iii) The Northern Slopes.

(i) The Central Highland

The Central Highland of the district forms the western part of the Ri Khasi (Shillong) plateau of Meghalaya. This


WEST KHASI HILLS DISTRICT
PHYSIOGRAPHIC ZONES
Map 5.7
N
Nongkhlaw
NORTHERN SLOPE
Rambrai
Riangdo
Mairang
NONGSTOIN
CENTRAL HIGHLAND
Jakrem
Mawkyrwat
Jankre Ronram
SOUTHERN SLOPE
Km 10 0 10 20 30 40
Balat

region occupies the cent al portion of the district. Mairang, Markasa, Nongstoin etc. lie within this region. The second highest peak of Meghalaya Thadraishan (1893 metres) is located in this region, lying between Mairang and Nongstoin. The Central Highland region climbs down gradually to meet the hills of Garo Hills (East and West Garo Hills) at the elevation ranging from 1200 metres to 600 metres at various places. A number of rivers originate in this high region and drain both to the north and the south.

(ii) The Southern Slopes

The southern slopes comprise of a belt of lower hills and valleys. Mawkyrwat, Ranikor, Borsora are included in this region. The hills in this region are in north-south alignment. In many places, the slopes are very steep starting and ending abruptly, Cliffs and precipies overlook gorgeous valleys at many places. The region touches the plains of Bangladesh in the south and elevations of 200-300 metres above the mean sea level (MSL). The Rongkhai, the Kynshiang and Um Ngi are the principal rivers flowing southward through the western, the central and eastern parts, respectively. There are many small rivers and streams such as the Wah Bulit, Wah Iaw, Um Wosar, Um Blei, Um Waisar, Um Than and Rilang, which join the Kynshiang after criss-crossing the central part of this region.

(iii) The Northern Slopes

The northern slopes is a belt of low hills. The elevation gradually decreases northward to meet the plains of Assam at an elevation of 150 metres above mean sea level. Khri, Um Synthi, Um Siri, Um Kamran, Tursung and part of the Umtrew are the rivers in the area.

(e) Slope

The assessment of the average slope plays a vital role for demarcation of physiographic regions in an area. Due to the rugged terrain, the variation of average slopes in the hill ranges and plateaus are very significant. Map 5.8 shows the average slope[7] regions of West Khasi Hills district. The district has been divided into five categories of average slope regions. They are:

(i) Valley (Flat) land - < 2° slope
(ii) Gentle slopes - 2° - 10° slope
(iii) Medium slopes - 10° - 20° slope
(iv) Steep slopes - 20° - 30° slope
(v) Crest land: Generally mildly undulating > 30°

In the Northern slopes of the district, slopes vary from 10° to 20°, covering around 70.0 per cent of the area.

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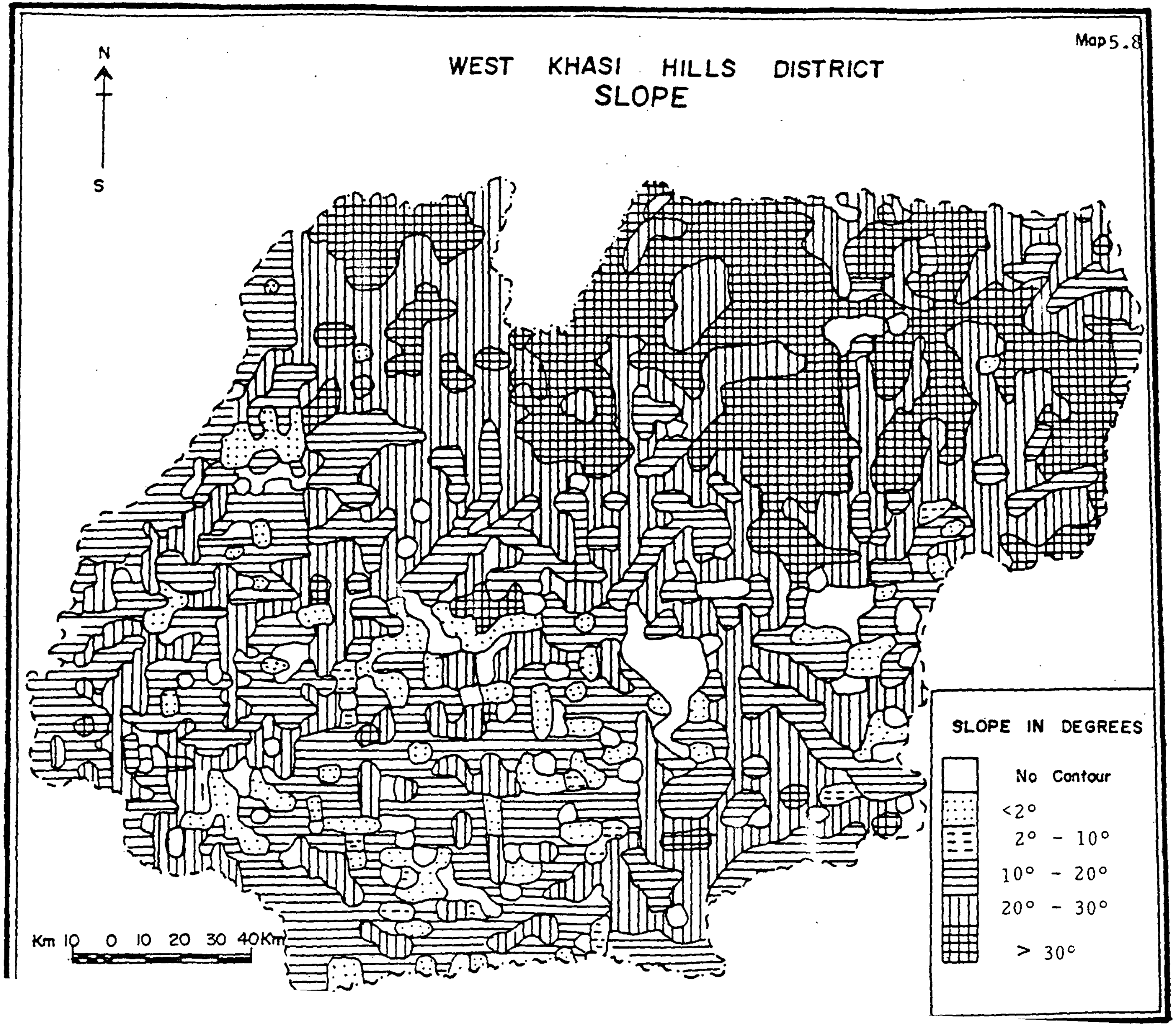
7 For details, see in the Methodology.


Map 5.8
WEST KHASI HILLS DISTRICT
SLOPE
N
S
SLOPE IN DEGREES
No Contour
<2°
2° - 10°
10° - 20°
20° - 30°
> 30°
Km 10 0 10 20 30 40Km

In the southern parts, there are steep slopes ranging from 10° to 20° slope. The steepness is very high due to the Dawki fault-line, which dissects the district from the plains of Bangladesh. It is estimated that more than 35.0 per cent area of the district has 20° - 30° slope.[8] Table 5.2 provides classification of slope regions by areal extension. As a result of the preponderance of steep slope regions, there is a dearth of valley and flat lands.

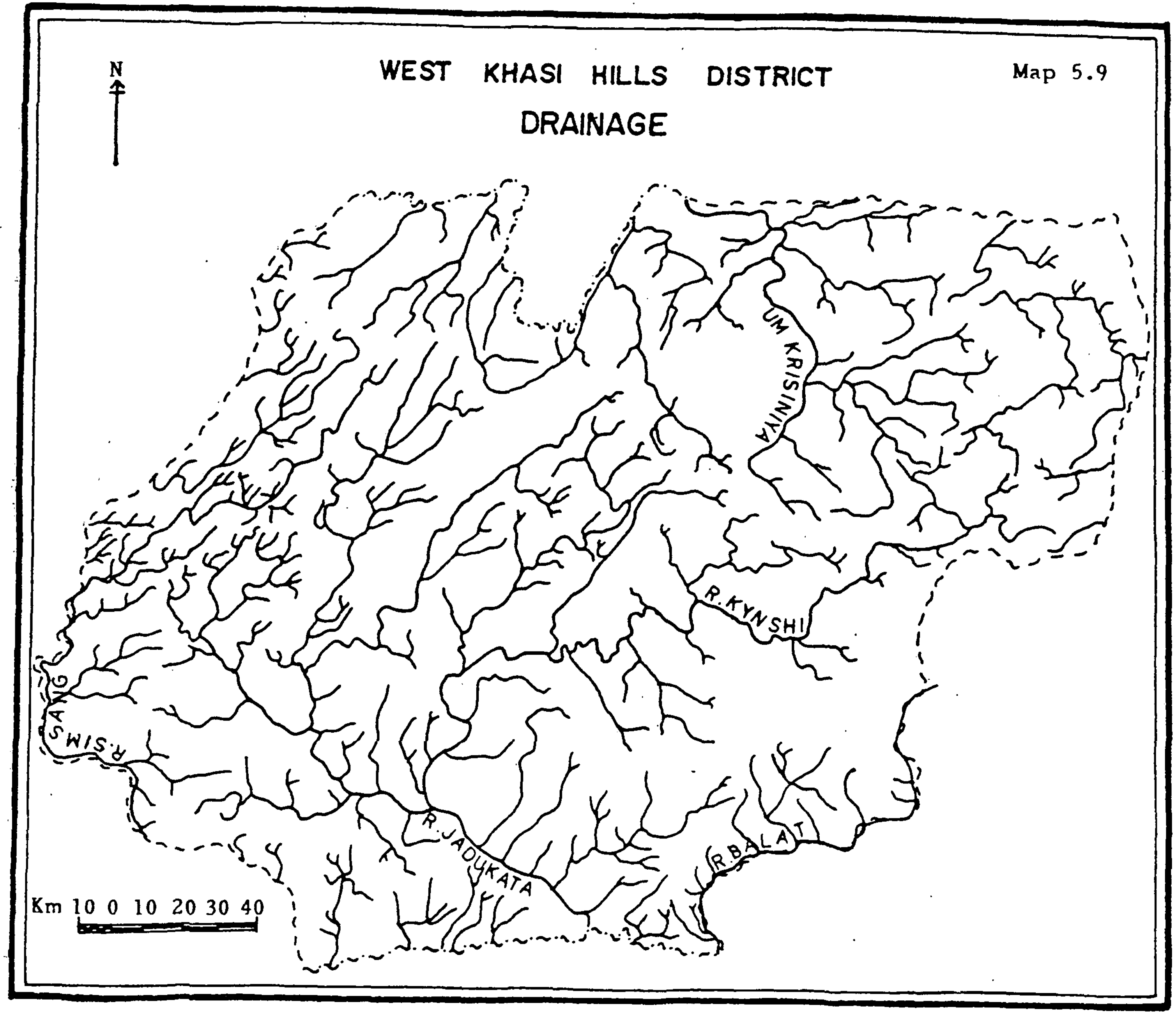
Table - 5.2: Percentage of Area Under Different Slope Regions

Sl. No.	Slopes in degrees	Area in sq.km.	Percentage
1.	< 2°	590	11.24
2.	2° - 10°	67	1.28
3.	10° - 20°	1620	30.87
4.	20° - 30°	1850	35.26
5.	Crestland > 30°	1120	21.35
	West Khasi Hills	5247	100.00

(d) Drainage

A few rivers are flowing in the district. Map 5.9 shows the distribution of rivers in the district. The Central Highland Plateau acts as the watershed and the rivers are flowing towards north and south of this highland. Of the southern groups of rivers, the important ones are the Kynshiang,

8 The area of the slope regions have been measured by Planimeter and graphical methods.


WEST KHASI HILLS DISTRICT
DRAINAGE
Map 5.9
N
UM KRISINIYA
R. KYNSHI
R. SIMSANG
R. JADUKATA
R. BALAT
Km 10 0 10 20 30 40

the Balat and the Simsang etc., those of the northern system are the Um Krisiniya and the Umtrew etc. The main characteristic feature of the northern rivers is that most of them have formed plain embankments at their entrance into the plains, thereby making the northern boundary of the plateau fairly irregular. Conversely, the southern rivers debouch onto the plains in deep ravines in the faulted face of the southern boundary.

It has been noticed that these rivers carry the soil nutrients from the hill slopes and deposit in the valley areas, which are suitable for wet paddy cultivation. Moreover, the river is the main source of drinking water for the hill people.

(e) Climate (Temperature and Rainfall)

Temperature Conditions

The climate of the district is tropical to subtropical. It differs from that of the Brahmaputra valley mainly due to its high relief which, in general, makes the climate very salubrious while that of Brahmaputra plains is comparatively warmer in summer. Therefore, in the Northern Slopes and in the Southern Slopes, the experiences in summer is hot and the winter is mild. In the Central Highland, the climate is tempered by the altitude with maximum summer temperature generally not exceeding 27°C and minimum winter temperature not dropping below 1°C. Table 5.8 shows the average annual maximum and minimum temperature at important centres of the West Khasi Hills district.

Table - 5.3: Average Annual Maximum and Minimum Temperature West Khasi Hills District (Temperature in °C)

Year	Nongstoin		Riangdo	
	Maximum	Minimum	Maximum	Minimum
1979-80	24.70	16.74	22.58	15.27
1980-81	24.30	18.55	22.11	13.67
1981-82	24.33	18.16	23.25	15.83
1982-83	23.75	16.97	24.41	15.08

Source: District Statistical Abstract, West Khasi Hills, 1983.

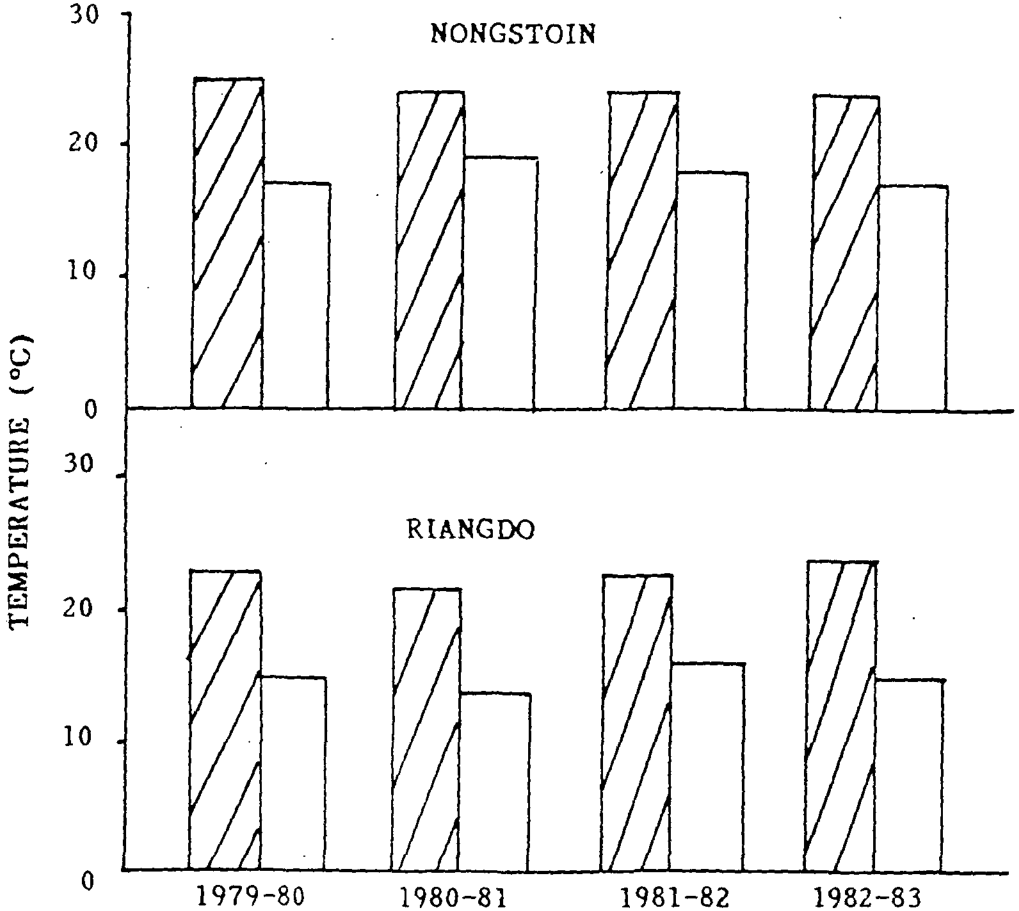
The variation of temperature in four years at the selected centres is very little. In Nongstoin, the maximum temperature was 24.70° in 1979-80 and in Riangdo, it was 24.41°C in 1982-83. The minimum temperature is 16.74°C in 1979-80 at Nongstoin and 13.67°C at Riangdo station in 1980-81. Diagram 5.8 shows the four maximum and minimum temperature in the West Khasi Hills District.

Rainfall

Rainfall is generally assured during the summer, but it varies greatly in intensity and duration from region to region within the district. The south-west monsoon accounts for most of the rainfall. The southern slopes which face the

Fig. 5.8

WEST KHASI HILLS DISTRICT
AVERAGE ANNUAL MAXIMUM & MINIMUM TEMPERATURE
(in °C)



incoming rain bearing winds, receive the maximum of rainfall, recording an annual average of upto 12,000 mm[9] in the eastern border near Mawsynram. In the Central Highland, the annual rainfall averages 2,500 mm to 3,000 mm, whereas in the northern zone, which lies in the rain shadow area and the precipitation is less, recording as low as 1,250 mm per annum. There is no accurate data of the relative humidity available, but it is learnt that during December to April, the dry months, relative humidity is as low as per 50 per cent. The rest of the year is humid recording over 90 per cent, especially during June to August. Table 5.4 shows the average annual rainfall at important centres of West Khasi Hills.

Table - 5.4: Annual Rainfall in West Khasi Hills

(Rainfall in mm)

Year	Nongstoin	Riangdo
1979-80	3789.9	2915.0
1980-81	3169.7	3301.9
1981-82	3643.3	3218.0
1982-83	4136.6	3223.2

Source: District Statistical Abstract, West Khasi Hills, 1983.

9 Rainfall figures have been collected from the District Statistical Abstract for West Khasi Hills, 1983, Government of Meghalaya, Department of Economics, Statistics and Evaluation.

(f) Vegetation

Although the vegetation of the Meghalaya plateau is extremely varied from the botanical point of view, yet the area under forest is considerably less in comparison to the surrounding regions. In spite of the heavy downpour in the southern face of the Central Meghalaya, where one usually would expect a dense evergreen rain forest, the entire area is relatively bare and the landscape is covered intermittently with grass and shrubs with the underlying rocks projecting out and the soil highly leached and denuded. This may be mainly due to the effect of the terrain with steep slopes and to the structural character of the limestone rock beds which lead to a quick draining off the rain water of the area. The western part of the plateau is characterised by vegetational cover almost similar to the lower Brahmaputra valley with distinct absence of grass vegetation. In the northern and southern low-hills have mostly dense tropical mixed vegetation with predominance of sal forests and dense thickets of bamboo.

A variety of natural vegetation, ranging from sub-tropical to temperate vegetation can be found in the district, according to difference in micro-climatic conditions. Tropical vegetation is seen generally upto an elevation of 600 metres, beyond which subtropical to temperate vegetations and grass-lands are found.

The natural vegetation has enriched the district with forests of valuable timber like pine, teak, sal, etc. especially in Nongstoin, Mawshynrut (Sonapahar) and Mairang. Commercially important cane and bamboo are also found in abundance. Map 5.10 shows the distribution of natural vegetation in West Khasi Hills district.

The area under forest as estimated for the four constituent Development Blocks of the district is about 35 per cent,[10] of the total geographical area of the district. Nearly, 90 per cent of the total forested area is under control of the District Council and the rest under the State Government. While most of the forest under the control of the Government are managed under regular working plans and schemes, those under the District Council had no such plans.

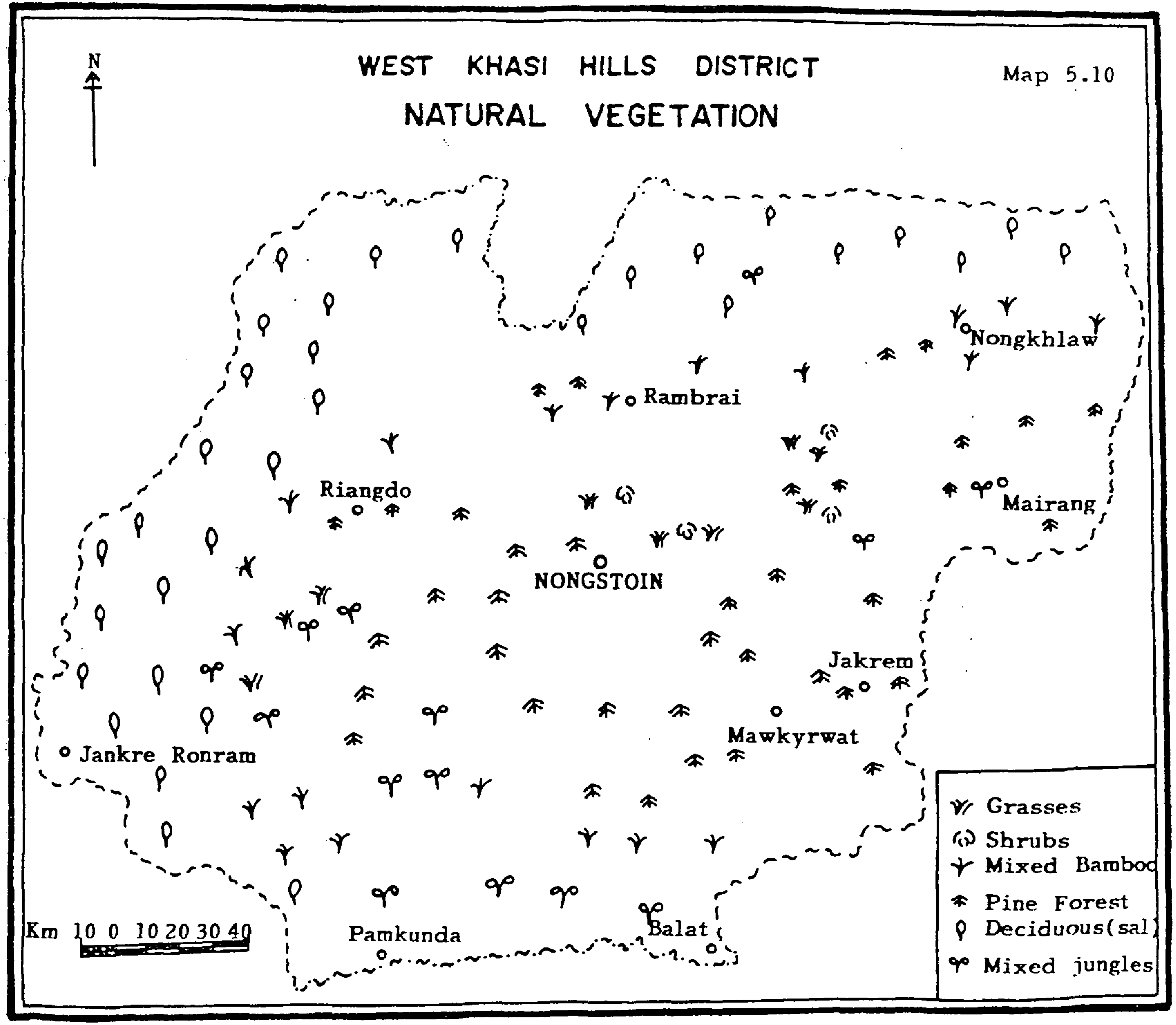
Table 5.5 shows the area under reserved, protected, unclassified and leased forests in the West Khasi Hills (1982-84).

Table - 5.5: Area Under Forests, West Khasi Hills (1982-84)

Year	Reserved forest	Protected forest	Unclassified forest	Private forest of leased	Village forest of other	Total area under forest
1982	NR*	NR	1640	NR	NR	1640
1983	NR	NR	1640	NR	NR	1640
1984	NR	NR	1640	NR	NR	1640

*NR - No Record
Source: District Statistical Abstract, West Khasi Hills, 1983.

10 Government of Meghalaya (1983); Op.cit., p. 21.


WEST KHASI HILLS DISTRICT
NATURAL VEGETATION
Map 5.10
N
Nongkhlaw
Rambrai
Riangdo
Mairang
NONGSTOIN
Jakrem
Mawkyrwat
Jankre Ronram
Pamkunda
Balat
Km 10 0 10 20 30 40
Grasses
Shrubs
Mixed Bamboo
Pine Forest
Deciduous(sal)
Mixed jungles

The type of the forest for the district could be classified into four types on the basis of altitudinal and climatic variations. These four types of forests are:

(a) Subtropical pine forests,

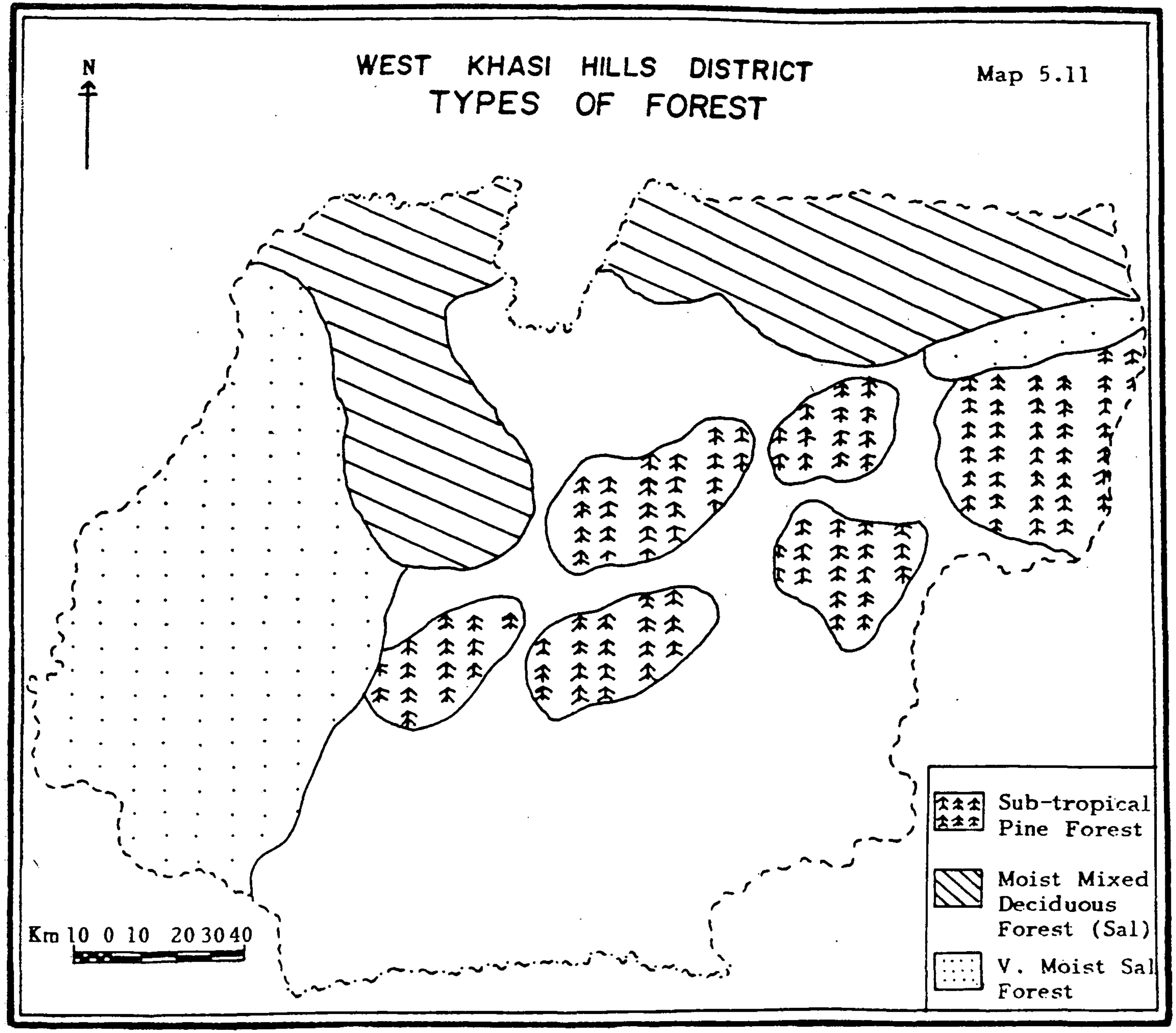
(b) Moist mixed deciduous forest (with sal),

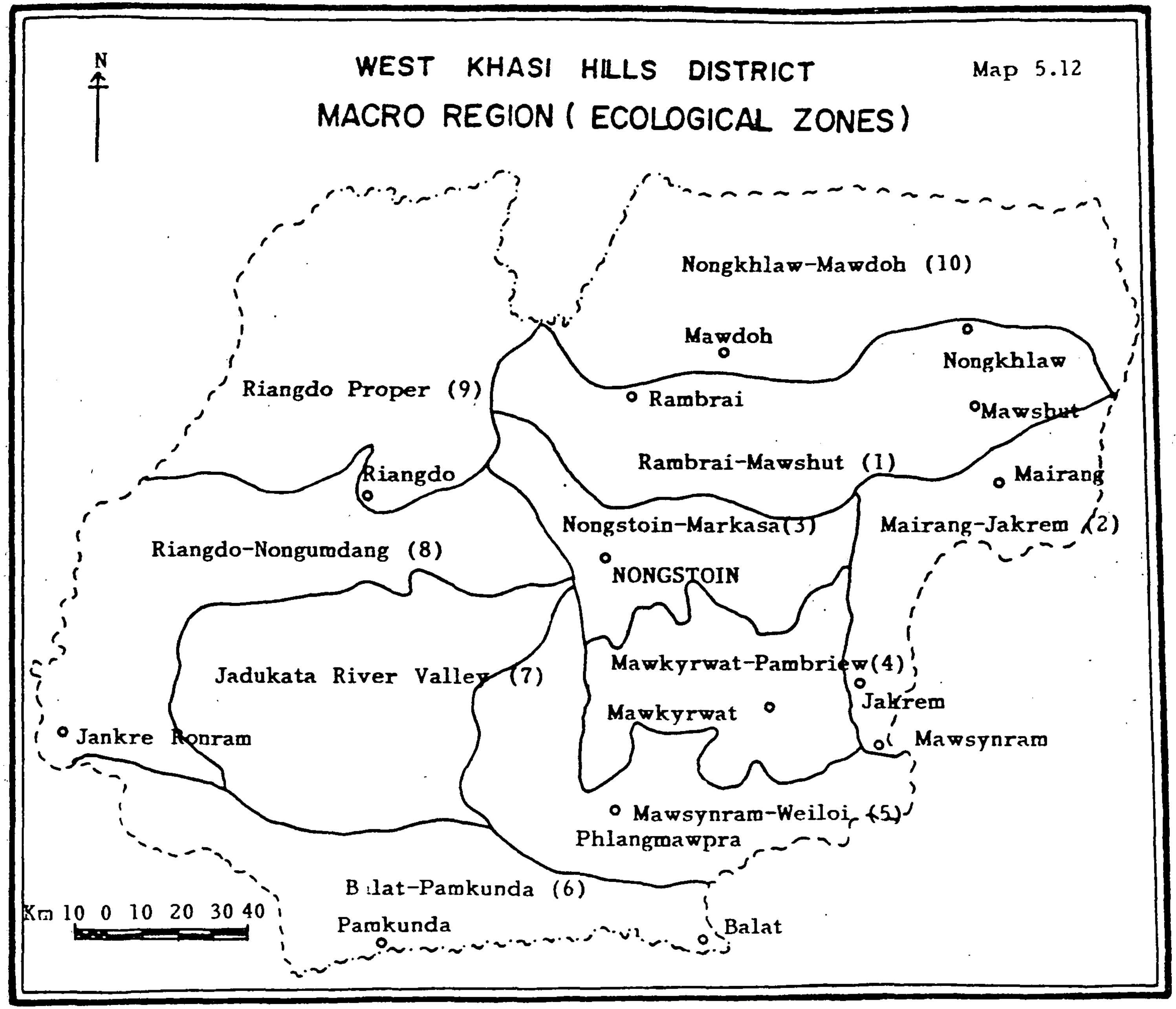
(c) Very moist sal bearing forests, and

(d) Reserved forests.

Map 5.11 shows the distribution of forest types in the West Khasi Hills district. As observed, the extent of degenerate and unproductive forests is very large, about 90.0 per cent of Government managed forests are still inaccessible. All these lead to very little earning from the forest and a paradox for an otherwise forested district.

Physiographically, the district is highly dissected and of irregular terrain and therefore, it is not easy to make a field survey in each and every corner of the district. However, the district has been divided into ten macro-regions (ecological zones) (Map 5.12) for which the different environmental criteria have been superimposed to form a composite mosaic of different macro-regions. It may be mentioned here that each of the criterion is not equally significant in the demarcation of the macro-region but some or one of the criteria becomes the main cause of characterisation of each of the region providing distinct regional characteristics to the


WEST KHASI HILLS DISTRICT
TYPES OF FOREST
Map 5.11
N
Km 10 0 10 20 30 40
Sub-tropical Pine Forest
Moist Mixed Deciduous Forest (Sal)
V. Moist Sal Forest


WEST KHASI HILLS DISTRICT
MACRO REGION (ECOLOGICAL ZONES)
Map 5.12
N
Nongkhlaw-Mawdoh (10)
Mawdoh
Nongkhlaw
Rambrai
Mawshut
Riangdo Proper (9)
Riangdo
Rambrai-Mawshut (1)
Mairang
Nongstoin-Markasa(3)
Mairang-Jakrem (2)
Riangdo-Nongumdang (8)
NONGSTOIN
Mawkyrwat-Pambriew(4)
Jadukata River Valley (7)
Jakrem
Mawkyrwat
Jankre Ronram
Mawsynram
Mawsynram-Weiloi (5)
Phlangmawpra
Balat-Pamkunda (6)
Km 10 0 10 20 30 40
Pamkunda
Balat

regions. In such an exercise it is obvious that each of the region has shown greater internal homogeneity and significant differences with an adjoining region.

5.4. Characteristics of Macro-Regions (Ecological Zones)

Map 5.12 shows the distribution and demaracation of the macro-regions (ecological zones) of the West Khasi Hills district.

5.4.1. Rambrai and Mawshut (1)

This is a flat plateau top area with a few small well defined plateau and valleys. The total area of this macro-region is 557 square km. accounting for 10.62 per cent of the total geographical area of the district. This region includes Rambrai and Mawshut areas.

The composition of rocks in this region is mainly of the gneissic complex. A few granitic rock formations are available in the easternmost part of this region. The average altitude ranges from 1600 metres to 1900 metres above MSL. Vegetation is mainly subtropical pine forests and some patches of evergreen forests which are observed in certain pockets of this region. The average slope is very steep, about 20° and above. The rainfall is less because the area falls under the rain shadow zone of the central highland. Table 5.6 provides the areal distribution of the macro-regions and the percentage coverage of the district.

Table - 5.6: Percentage area under different macro-regions (Ecological Zones) in West Khasi Hills District

Macro-Regions (Ecological Zones)	Total Area in sq.km.	Percentage of area to total geographical area of the district
1. Rambrai and Mawshut	557	10.62
2. Mairang and Jakrem	370	7.05
3. Nongstoin and Markasa	360	6.86
4. Mawkyrwat and Pambriew	380	7.24
5. Mawsynram and Weiloi	470	8.96
6. Balat and Pamkurda	450	8.58
7. Jadukata River Valley	660	12.58
8. Riangdo and Nongumdang	550	10.48
9. Riangdo proper	650	12.39
10. Nongkhlaw and Mawdoh	800	15.25
Total: West Khasi Hills	5247	100.00

5.4.2. Mairang and Jakrem (2)

This region is a dissected area with a number of small hillocks and plateaus, occupying an area of 370 sq.km., which accounts for 7.05 per cent of the total area of the district. The greater parts of Mairang subdivision, Sohiong valley and Jakrem are under this region. The valleys, i.e. the flat lands are fully utilised for agriculture in this region.

The gneissic complex of rocks are common in Mairang and Sohiong valleys but in case of Jakrem, the composition of rocks is of gneissic formation. The average altitude varies from 1200 metres to 1700 metres and average slopes vary fro 10° to 15°. The subtropical pine vegetation are only available in the region.

5.4.3. Nongstoin and Markasa (3)

This region is a part of the central highland of the plateau. It has a total area of 360 sq. km., which accounts for 6.86 per cent of the total area of the district. The district headquarters, Nongstoin and some parts of Markasa Subdivision are under this region.

The rock composition is of the gneissic complex. In the northern part, granitic rock formations are found. The average altitude is 1400 metres to 1600 metres. The vegetation is subtropical pine forests. The average slopes vary from 10° to 20°. The annual average rainfall[11] at Nongstoin was recorded as 4200 mm in 1983.

5.4.4. Mawkyrwat and Pambriew (4)

This region includes the extension of southern part of the Central Highlands, especially the Mawkyrwat and Pambriew areas. The total area of this region is 380 sq. km., accounting for 7.24 per cent of the total area of the district.

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11 Government of Meghalaya (1983); Op.cit., p. 7.

The composition of rocks in this region is mainly granite. The average altitude varies from 1000 metres to 1300 metres above MSL, where pine and dense bamboo forests are found. Most of the hill ranges and plateau tops are exposed of bed rocks. In the northern part, some tributaries of the river Kynshi and Balat are draining downward through this region. In summer, rainfall is high, since, this zone is adjacent to Mawsynram where world's highest rainfall is recorded (recently).

5.4.5. Mawsynram and Weiloi (5)

This region includes Mawsynram, the place where world's highest rainfall[12] (12,163 mm) was recorded in 1983. Some areas of Weiloi are under this region, with 470 sq. km. accounting for 8.96 per cent of the total area of the district.

The rock formation is of the gneissic complex. This region is separated from the southern part by the Dawki fault-line. The average altitude varies from 500 metres to 900 metres. Vegetation is mainly of bamboo forests with some patches of mixed forests. The average slope is very steep, ranging from 20° and above.

5.4.6. Balat and Pamkunda (6)

This region is separated from the main land by Dawki fault line stretching from east to west. The total area of

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12 Government of Meghalaya (1983); Op.cit., p. 7.

this region is 450 sq. km. accounting for 8.58 per cent of the total area of the district. Balat, Pamkunda and Ranikor belong to this region.

The entire region is composed of the Khasi Groups of rocks having three formations, namely - Mahadek, Jadukata and Sylhet Trap. The vegetation is mixed deciduous forests with Sal and Teak forests. The average altitude is less than 500 metres. The only major river in the region is the river Balat.

5.4.7. Jadukata River Valley (7)

This region is almost a valley with extensive flat lands. The total area of this region is 660 sq. km., which accounts for 12.58 per cent of the total area of the district.

The composition of rock formation of this region is of the gneissic complex. The average altitude ranges from 400 metres to 700 metres. Vegetation is mainly Bamboo forests with some patches of mixed deciduous forests. The average slope varies from 6° to 15°. The summer incidence of rainfall is medium to high.

5.4.8. Riangdo and Nongumdang (8)

The southern part of Riangdo, Nongumdang, Nongjonthiang and Jankre are under this region having an area of 550 sq.km. which accounts for 10.42 per cent of the total area of the district. The topography is almost regular with small hillocks.

The main rock formation is of the gneissic complex with varying depth and composition. The average altitude varies from 400 metres to 600 metres. Vegetation is mainly dense mixed jungles with Sal forests.

5.4.9. Riangdo Proper (9)

The world's largest deposits of Sillimanite is found in this region. It includes the areas of Riangdo (Sonapahar) and it acts as a watershed zone lowering to the plains of Kamrup district of Assam. It occupies an area of 650 sq.km. accounting for 12.39 per cent of the total area of the district.

The bedrock formation of the entire region is of the Gneissic complex. In Riangdo proper, the formation of rock is sillimanite and granitic rocks. The available forest cover in this region is mostly composed of moist deciduous forests with Sal and Teak forests. The average altitude varies from 800 metres to 1400 metres.

5.4.10. Nongkhlaw and Mawdoh (10)

This region falls in the northern slopes of the district which meets the plain areas of Assam. With a total area of 800 sq.km., it includes the areas of Nongkhlaw and Mawdoh, which accounts for 15.25 per cent of the total area of the district.

The rock formation in this region is mainly of the Gneissic Complex. In some parts, the granitic formations are also found. The average altitude varies from 500 metres to 1200 metres with a few hills and plateaus. The average slopes vary from 20° and above. Sub-tropical Pine forests, moist mixed deciduous forests with Sal trees are common vegetation types in this region. Rainfall is medium to high during the summer season.

5.5. Identification of Landfacets (Micro-Region): The Landscape Approach

A detailed discussion on the genetically derived macro-regions of the West Khasi Hills district have been done in the first part of this chapter. These macro-regions are not of the division and subdivision of areas but of combination of the smaller regions in order to arrive at the larger ones. These smaller regions within the macro-region can be called as 'micro-region'. These micro-regions have been identified from the similar conditions as to climate, physiography, geology, soil and edaphic factors in general. As mentioned earlier that land classification based on landscape approach involves the recognisation in the landscape of distinctive components with only a limited range of variation of the criteria. This degree of variation was measured by 'landfacet', as being made up of simpler 'land elements'.

'Land facet' is a nomenclature given to small land units with homogeneous environmental (or geographical) characteristics. Such characteristics may be the geology, the predominant soil type, the slope or vegetation cover. In the present situation of a plateau area the major control characteristics in determining the land facets is found to be the slope. Of course the other parameters are assessed too. But, slope is the dominating factor. As stated earlier, five types of land facets have been identified in the district. They are:

(i) Flat and valley land ($<2°$ slope)

(ii) Gentle slopes ($2° - 10°$ slope)

(iii) Medium slopes ($10° - 20°$ slope)

(iv) Steep slopes ($20° +$), and

(v) The crest land (Generally undulating or domal, but is not essentially determined by slope alone. It may have some features of the flat land but its ecology is distinctly different due to outward draining compared to the inward draining character of the valleys).

In the methodology, it was mentioned that the uses of satellite imageries and topographic sheets pertaining to the West Khasi Hills district. Since the approach involves analysis of visible features, a topographical map can provide a picture of land forms but will probably be deficient in respect of the surface cover. The anatomy of the landscape could be distinctly interpreted from the aerial photographs. But, due to the non-availability of air photos for the whole district, researcher had to use the available satellite imageries. It is enough to state that the stereoscopic image combine to offer to the interpreter an expression of land units, both individually and in their groups, on a scale which is particularly appropriate to this approach.

The land complex as a whole is the object of study, even when a particular criterion may be of prime interest to a land classifier. Such an integrative approach has to apply for identifying a land facets of a region. In this integrated approach, no land attribute can really be understood in isolation, in a degree it must express the interaction of all criteria, on ecosystematic lines.[13] This integrated view of the land complex is particularly appropriate to the assessment of overall land potential.

By using the above mentioned principles, the entire district has been identified into detailed land facets. Map 5.13 shows the distribution of various types of land facets in West Khasi Hills district. There are altogether 189 land facets outlined in the relevant tables and maps. Table 5.7 indicates the total and percentage of area of macro-regions and land facets (micro-regions) in West Khasi Hills district.

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13 J.A. Mabbutt (1968); "Review of Concepts of Land Classification" in Stewart, G.A. (ed) 1968, Papers of a CSIRO Symposium, Organised in cooperation with UNESCO, 26-31 August 1968, Macmillan, Victoria, p. 16.

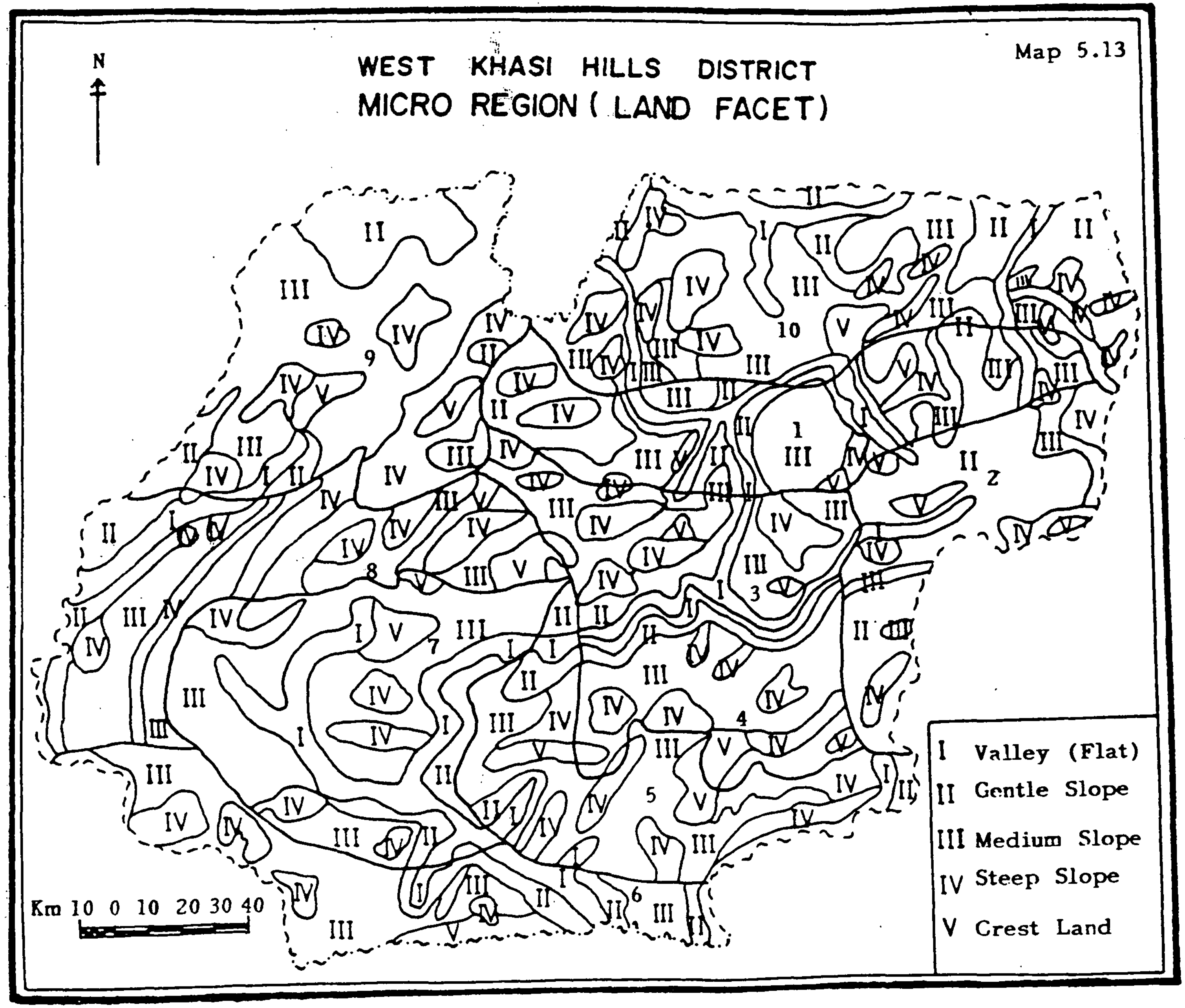
Map 5.13
WEST KHASI HILLS DISTRICT
MICRO REGION (LAND FACET)
N
I Valley (Flat)
II Gentle Slope
III Medium Slope
IV Steep Slope
V Crest Land
Km 10 0 10 20 30 40

Table - 5.7: Area of Macro-Regions (Ecological Zones) and Micro-Regions (Landfacets) in West Khasi Hills District

(Area in Sq.Km.)

Macro-Regions (Ecol. Zones)	Total Area	P.C.	Valley Area	P.C.	Gentle Slopes	P.C.	Medium Slope	P.C.	Steep Slope	P.C.	Crest Land	P.C.
1. Rambrai & Mawshut	557	10.62	100	17.95	150	26.93	210	37.70	70	12.57	30	5.39
2. Mairang & Jakrem	370	7.05	40	10.81	210	56.76	50	13.51	50	13.51	20	5.41
3. Nongstoin & Markasa	360	6.86	90	25.00	50	13.89	120	33.33	80	22.22	20	5.56
4. Mawkyrwat & Pambriew	380	7.24	60	15.79	60	15.79	150	39.47	80	21.05	30	7.89
5. Mawsynram & Weiloi	470	8.96	80	17.02	40	8.51	180	38.30	130	27.66	40	8.51
6. Balat & Pamkunda	450	8.58	90	20.00	70	15.56	200	44.44	60	13.33	30	6.67
7. Jadukata River Valley	660	12.58	210	31.82	80	12.12	290	43.94	60	9.09	20	3.03
8. Riangdo & Nongumdang	550	10.48	70	12.73	110	20.00	190	34.55	140	25.45	40	7.27
9. Riangdo Proper	650	12.39	20	3.08	100	15.38	350	53.85	150	23.08	30	4.62
10. Nongkhlaw & Mawdoh	800	15.25	110	13.75	160	20.00	320	40.00	170	21.52	40	5.00
West Khasi Hills	5247	100.00	870	16.58	1030	19.63	2060	39.26	990	18.87	300	5.72

It has been noticed that the topographical characteristics of valley bottoms (flat land) differ from one place to another. These differences occur within the same macro-regions also. Some valley (flat) lands are located at higher elevations and some are at low altitudes. The vegetation cover obviously differs because of altitudes, accessibility and the nature of human intervention.

The table indicates that, overall, valley land accounts for 16.58 per cent of the total geographical area of the district and gentle slopes another 19.63 per cent. About 59.0 per cent of the area is under medium and steep slope (above 10° slope) and hence, not suitable for extensive cropping practice. Nearly, 22.0 per cent of the area constitutes of the crest ecology.

Jadukata river valley (7) has the largest valley area i.e. 210 sq.km. and 31.82 per cent area of the region. The other important valley (flat) regions are Nongstoin-Markasa (3) and Balat-Pamkunda (6).

Land facets help in going deeper into the parametric approach of land classification, i.e. the evaluation of land potentials at the micro-level which is dealt with in Chapter 6 of the thesis.

5.6. In the first part of this chapter, an attempt was made to identify the macro-regions (ecological zones) in the

West Khasi Hills district. There are ten macro-regions (ecological zones) were identified on the basis of genetic approach using the environmental factors like - geology, relief, slope, drainage, climate and vegetation. It has been observed that the components and pattern of the land in the district are the logical expression of the environmental factors which were in due course of time have been shaped to the existing land forms. A discussion has been made for the environmental factors used for the demarcation of macro-regions. At the same time the characteristics of each and every macro-regions has also been discussed in brief.

In the second part of this Chapter, a discussion has been done on landscape approach to identify the 'land facets' (micro-regions) in the district. Seeing the unity of the components in its physiographic origin and the bond of the pattern as morphogenetic, the whole district has been divided into 189 land facets or micro-regions. This recognition of different land facets in the district has got significance from the geomorphological point of view. It has provided a rationale in extrapolative mapping, for decision as to grouping into components and an understanding of why changes of landscape are occurring and also the causal inter-relationships within the land complex. Further, where genetic controls are understood and seen to be similar in the district, widely separated components and patterns could usefully be compared and experience gained in one area can benefit another. This level of study helps in understanding the complexity of land classes as have emerged over long natural processes and helps in evaluative studies as to their potentials and problems for effective human use.

CHAPTER - 6

SOIL RATING INDICES AND EVALULATION OF LAND POTENTIAL: A PARAMETRIC APPROACH

SOIL RATING INDICES AND EVALUATION OF LAND POTENTIAL: A PARAMETRIC APPROACH

6.1. In the process of evaluating the potentiality of land for its current human use or for future use, the necessity of evaluating the soil quality becomes one of the most crucial factors. Soil constitutes of only a very thin layer on the earth's crust, evolving over thousands of years and as a result of a complex processes interplayed by numerous abiotic and biotic elements and itself is made of a complex ecosystem of site, moisture, nutrients and a variety of living beings interwoven into a delicate fabric of inter-relations. Although, evaluation of soil or sub-soil conditions may be important for selective urban, industrial and other uses, it is the most pivotal to an agricultural economy and more so to a predominantly agricultural society. That is why, as mentioned in 5.5, this chapter will dwell on the analysis of evaluation of land potential by use of a soil rating index covering the whole of the district of West Khasi Hills.

6.2. There are two systems of land evaluation available (i) the Storie Index[1] or the Storie Multiplication System (Storie, R.E. 1954) and (ii) the Clarke Index[2] (Clarke, G.R.

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1 R.E. Storie (1954); "Land Classification as used in California for the appraisal of land and taxation purposes", Trans. 5th Int. Cong. Soil Sci. 3, pp. 407-12.

2 G.R. Clarke (1951); "The evaluation of soils and the definition of quality classes from studies of physical properties of the soil profiles in the field", Jour. Soil Sc.2, pp.50-60.

1951). The Storie index is a numerical product of three important factors determining the soil quality; they are; (a) the character of soil profile as reflected in texture, structure and inherent fertility, (b) topography, and (c) the modifying factors like climate, salinity/alkalinity, degree of stoniness and susceptibility to erosion etc. However, although useful the method suffers from the over emphasis on the profile factor which is of indirect importance only, the conversion of subjective judgement to score values and the relative weighting system in the process of combining all the varied elements into a single index value.

The Clarke index is largely based on the profile and the physical characteristics of soil. It may be suitable for field assessment only due to the simplicity and lack of need for laboratory testing of samples. But, it rarely covers all the important factors contributing a certain quality to soil.[3]

In the present study, in light of the apparent limitations of the above two methods, a new parametric approach to land potential evaluation has been attempted. It involves the surface samples[4] and the characteristics of the sample

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3 K. Atkinson and R.T. Smith (1975); Techniques in Pedology, Paul Elek Sc., London, pp. 37-53.

4 The surface sampling is a common field technique of obtaining samples by obtaining an average sample of 3/5 bore holes of depths of 6" - 9".

sites (as the moderating factor as well as factors responsible for pedogenesis[5]). Thus, the major soil characteristics have been divided into three groups; i.e.

(i) Physical characteristics,

(ii) Chemical characteristics, and

(iii) Site chracteristics.

A total of twelve variables have been constructed on the basis of numerical scores derived from the original data. The variables are listed groupwise in the following manner:

Group A: Physical characteristics

X_1 : Texture

X_2 : Structure

X_3 : Colour

Group B : Chemical characteristics

X_4 : pH

X_5 : Nitrogen

X_6 : Phosphorus

X_7 : Potassium

X_8 : Organic Carbon

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5 Profile has been purposefully excluded from the analysis at this stage, since it is mcre related to pedogenesis and the vertical material distribution of soil. The profile analysis is included in the Appendix 6 B.

Group C : Site characteristics

X_9 : Altitude

X_{10}: Degree of Slope

X_{11}: Vegetation, and

X_{12}: Topography

Since the variables represent a wide variety of attributes of a given soil sample, often on subjective basis, composite characteristics etc., there is the need of conversion of the primary pedological attributes into ratio scale or ordinal scale, so that it becomes easier for manipulation of data. The detailed basis of conversion is provided in Chapter 3. Once, all the variables are available they have been composited into soil rating indices at two levels, at the group level and then, a combination of the group level indices into a final composite score[6] (index).

The factor analysis (in this case the principal component analysis) is given briefly as the following (for detail see Appendix - 6).

$$['I - \lambda R] = 0 \quad \text{........} \quad (1)$$

Whereas, R is the correlation matrix of the given set of variables, λ is the eigen vector, I the relevant identity matrix and the equation, the characteristics equation.

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6 M.G. Kendall (1957); A Course in Multivariate Analysis, Griffin, London.

$$[I - \lambda_i R][W] = 0 \quad \ldots\ldots\ldots \quad (2)$$

Whereas λ_i is a given eigen value and W is the corresponding factor loadings (or weight vector);

Subject to the condition that

$$\Sigma W_1^2 + W_2^2 + \ldots\ldots\ldots + W_n^2 = 1 \quad \ldots\ldots\ldots \quad (3)$$

The Index I is given by the following equation:

$$I = \sum_{i=1}^{n} \frac{X_j}{\bar{X}_j} \times W_i \quad \ldots\ldots\ldots \quad (4)$$

Whereas, X_j is the given variable, X_j the arithmetic mean and W_i is the corresponding factor loading.

In the present study, there are a total of 382 soil samples and a total of 12 variables divided into three groups. The adoptation of the principal component technique to make the composite indices of soil rating has obvious advantages, like the index such arrived at shall explain 'maximum sum of squared correlations' and the weighting system on variables shall be dependent on 'factor independence' of the variables.[7] The advantages of this technique are well known.

The analysis of the samples has been done in four stages. First, the intercorrelations of the variables have been studied to help in understanding the nature of relationship between

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7 M.G. Kendall (1939); "The Geographic Distribution of Crop Productivity in England", Jour. Ro. Stat. Soc.

the variables and their level of statistical significance. At the second stage, the variables have been combined into composite indices using the first two principal components and the weight vectors derived from the respective characteristic roots. At the third level the three group indices representing the physical, chemical and site characteristics of the samples have been combined into a single composite score representing all the 12 soil variables.

6.3. Analysis of Correlation Matrices

Any study dealing with a large number of variables needs the analysis of interrelationship of the variables. This helps in understanding the nature of relationship between different factors. In the present case, there are twelve variables indicating various attributes of soils and land of the West Khasi Hills district, which have been broadly grouped into three groups of variables, as stated earlier. They have been combined into a single index indicating the status of the soil and land potential using the Principal Component Technique. One of the conditions in the above technique is removal of the problem of multi-colinearity, i.e. the variables which have high correlations get a lower weightage and vice versa. In that light, the analysis of the correlations become more important, since low correlations between the variables indicate factor independence. Therefore, the correlation matrices at the group level have been studied independently.

Table 6.1 shows the correlation matrix of the group of variables indicating the physical characteristics of the soil samples. The correlation between variables X_1 (Texture) and X_2 (Structure) is positive but insignificant. Correlation between texture and colour (X_3) is negative but insignificant; the correlation between structure and colour is positive but insignificant. They indicate a general independence of the factors.

Table - 6.1: Correlation Matrix of Group of Physical Characteristics

	X_1	X_2	X_3
X_1	1.00		
X_2	0.10	1.00	
X_3	0.05	0.01	1.00

Table 6.2 shows the correlation matrix of the chemical group of variables. The correlation between pH (X_4) and nitrogen (X_5), potassium (X_7) and organic carbon (X_8) are all positive and significant at 95.0 per cent level of confidence or above. The correlation between pH and phosphorus (X_6) is negative and significant at 95.0 per cent level. The correlations between nitrogen and phosphorus is negative and insignificant; between nitrogen and potassium and organic carbon are positive and significant. It may be noted that the occurrence of nitrogen in soil is generally in ammonia form due

to the decomposition of organic matters and therefore, the high positive correlation between X_5 and X_8 is but natural. The correlations between phosphorus and potassium is positive but insignificant and between X_5 and X_8, negative and insignificant. Between potassium and organic carbon, there is a positive and significant correlation. Generally, the pattern of correlations indicate some amount of multi-colinearity which at the level of the composite index are removed by low weightages on those variables.

Table - 6.2: Correlation Matrix of Group of Chemical Variables

	X_4	X_5	X_6	X_7	X_8
X_4	1.00				
X_5	0.12	1.00			
X_6	-0.16	-0.08	1.00		
X_7	0.13	0.17	0.05	1.00	
X_8	0.24	0.60	-0.17	0.23	1.00

Table 6.3 indicates the correlations of the variables of site characteristics, like altitudes (X_9), slope (X_{10}), vegetation (X_{11}) and topography (X_{12}). The correlation between altitude and vegetation is negative and highly significant due to the fact that the higher altitude areas are covered by vegetation with low score values (Pines). The correlation

between X_9 and X_{12} (topography) is negative but not significant. The correlations between slope and topography and slope and vegetation are positive and highly significant due to the low score factor for high slope areas which have also low score from the point of view of topography and vegetation. For similar reasons the correlation between X_{11} and X_{12} is positive and significant.

Table - 6.3: Correlation Matrix of Group of Site Characteristics

	X_9	X_{10}	X_{11}	X_{12}
X_9	1.00			
X_{10}	-0.01	1.00		
X_{11}	-0.27	0.54	1.00	
X_{12}	-0.50	0.48	0.40	1.00

Table 6.4 indicates the correlations between the three composite group indices I_A, I_B and I_C, which show though positive but no significant correlations due to non-multicolinear relations and factor independence. From analytical point of view, (a la Kendall) this is a desirable attribute.

Table - 6.4: Correlation Matrix of the Group of Final Indices (A, B, C)

	A	B	C
A	1.000		
B	0.088	1.000	
C	0.002	0.021	1.000

6.4. Characteristic Roots

Table 6.5 provides the values of the characteristic roots (First and Second principal components), which are derived out of the corresponding correlation matrices. In the present study, the first eigen value (which has also the highest value) is taken to derive the weight vector which then is used as the factor loadings in a multiplicative weight system on the variables. The given eigen values also indicate a significant characteristics of the relationship between the composite index and the individual variables. The relationship is given by the ratio of the eigen value to the number of variables in the system which indicates the percentage of variation explained by the composite index of the given set of variables used in the analysis. Therefore, this becomes a very significant indicator of how adequate or otherwise has been the use of a particular eigen value in the preparation of the composite index.

Table - 6.5: Eigen Values and the Percentage Variations Explained

Group	Principal Components		No. of Variables	% Variations Explained	
	First	Second		First	Second
A	1.11	1.00	3	37.0	33.3
B	1.86	1.07	5	37.2	21.4
C	1.98	1.04	4	49.5	26.0
I	1.09	1.00	3	36.3	33.3

In case of the group of physical variables (Group A), the highest eigen value (First principal component) has a value of 1.11, which explains 37.0 per cent of variations in the group of variables. In variables of group B, the highest eigen value has a value of 1.87, which accounts for 37.2 per cent of variations and in the group C (Site characteristics) the eigen value has a very high value of 1.98, which explains 49.5 per cent variations. In the final index I_D (Composited groups of I_A, I_B and I_C), the eigen value has a value of 1.09, which accounts for 36.33 per cent variations. In case of all the three groups of variables, the first principal component accounts for more than 1/3 of the variations, which is considered adequate in such analysis. However, since the eigen values are derived out of the correlation matrix, a high consistency in the correlation matrix is usually reflected in high value of first principal component. This is shown in case of group C variables.

The set of second eigen values are 1.005 for A, 1.074 for B, 1.040 for C and 0.499 for D group of variables. They are significant in the way they explain 33.50 per cent, 21.48 per cent, 26.0 per cent and 33.3 per cent of variations in the data, respectively. However, they indicate totally a different, second most dominant characteristic of the data.

6.5. Factor Loadings

Table 6.6 outlines the factor loadings of the corresponding eigen values (first and second). The first principal component of A has high positive factor loadings in favour of X_1 (texture) and X_2 (structure) and negative (low) weightage for colour of the soil. Therefore, the dominant factors are the texture and structure of the soils which together account for the particulate behaviour of the soil, while colour generally arises out of the conditions of pedogenesis (and parent materials) and nature of the organic content of the soil. Therefore, this factor may be called the Particulate Factor dominance of the soil. The second principal component of A shows a negative loading for a X_1, moderate weightage for X_2 and very high weightage on X_3 (soil colour). This indicates the second most dominant physical factor as the soil colour which is largely an independent factor. Therefore, this eigen value can be called the Colour Factor dominance of the soils.

The first principal component of group B variables has the highest factor loadings on X_5 (nitrogen) and X_8 (Organic carbon), moderate loadings on X_4 (pH) and X_7 (Potassium) while has a negative loading on X_6 (Phosphorus). This principal component clearly emphasises the highest dominance of nitrogen and organic carbon in the chosen group of chemical variables of the soil samples. Therefore, this principal component can be called the Humus-Nitrogen Complex Factor of the samples.

Table - 6.6: Factor Loadings of First and Second Principal Components

Group of Variables		Principal Components	Factor Loading				
			1	2	3	4	5
A	1:	1.112	0.753	0.677	-0.293		
	2:	1.005	-0.035	0.430	0.405		
B	1:	1.859	0.477	0.783	-0.304	0.432	0.860
	2:	1.074	-0.344	0.174	0.804	0.526	0.053
C	1:	1.983	-0.270	0.820	0.826	0.746	
	2:	1.040	0.932	0.269	-0.190	0.252	
D	1:	1.091	0.717	0.736	0.185		
	2:	0.000	-0.229	-0.021	0.973		

N.B.: Group A includes: X_1 (Texture), X_2 (Structure) and X_3 (Colour);

Group B includes: X_4 (pH), X_5 (Nitrogen), X_6 (Phosphorus), X_7 (Potassium) and X_8 (Organic carbon);

Group C includes: X_9 (Altitude), X_{10} (Slope), X_{11} (Vegetation) and X_{12} (Topography);

Group D includes: I_A (Index of Physical characteristics), I_B (Index of Chemical characteristics), and I_C (Index of Site characteristics).

The second principal component indicates a very high (positive) weightage for X_6 (Phosphorus) and moderate weightage for X_7 (Potassium) and X_5 (Nitrogen), low weightage for X_8 (Organic carbon) and X_4 (pH) (negative). This component emphasises the dominance of the NPK complex within the chemical variables and therefore, can be called the NPK Factor dominance of the soils.

Within the variable group C, the first principal component has a factor loading dominance on X_{10} (Slope) and X_{11} (Vegetation) and X_{12} (Topography), whereas altitude (X_9) has a negative low weightage. Slope and vegetational attributes dominate this group of variables. Therefore, this factor can be called the Slope-Vegetation-Topography Complex (Factor) of the soil variables.

The second principal component has a very high positive factor loading on X_9 (Altitude), low loadings on X_{10} and X_{12} and low (negative) loading on vegetational factor. The dominance clearly is of the altitude factor. Therefore, this component can be called the Altitude Factor in the variable group.

In the group D variables which has the three composited factors, I_A, I_B and I_C (only the first principal components), the first component has high (positive) loadings on I_A and I_B and low (positive) loading on site characteristics group of variables, I_C. This component, therefore, can be named as the Physico-Chemical (Complex) Factor of the soils. Conversely, the second principal component, shows a very high factor loading (0.973) on I_C and low (negative) loadings on I_A and I_B. Therefore, the loading dominance is clearly in favour of the site characteristics; which can be named as the Site Factor, which becomes the second most important factor in the soil rating analysis.

6.6. Analysis of Soil Rating Status Indices

6.6.1. At first, all the samples and therefore, the 382 observations of the Index of group A variables (I_A) have been classified into five groups on the basis of the characteristics of the landfacets, i.e. into samples in the valley bottoms (flat land), gentle slopes, medium slopes, steep slopes and crest lands. An analysis of Table 6.7 indicating the classification of the composite index of physical characteristics shows that the samples of valley bottom (80) landfacets are of consistently high positive values with an average of 1.13. The highest values are indicated in the gentle slopes (79) with an average of 1.16. The medium slopes (77), steep slopes (74) and crest land (73) indicate an average score values of 1.11, 1.06 and 1.05, respectively. Therefore, there seems a consistent gradation of index values from high, in case of valley lands and gentle slopes to low values in case of steep slopes and crest land samples. It may indicate that overall physical characteristics of soils of valley bottom facets are marginally less favourable than the gentle slopes, but have generally higher scores than the medium, steep slopes and crests.

Table - 6.7: Land Facet-Wise Distribution of Average Composite Indices of Physical Characteristics of Soil, Group A

	Valley Land	Gentle Slopes	Medium Slopes	Steep Slopes	Crest Land
Average	1.13	1.16	1.11	1.06	1.05

6.6.2. An analysis of Table 6.8 indicating the classification of the composite index of chemical characteristics of soils shows that the samples under valley bottom landfacets are of high positive values with an average of 2.42, which is the highest. The gentle slopes indicate an average scores value of 2.23, followed by crest land (2.17), medium slopes (2.13) and steep slopes (1.96). The average score value of crest land samples is higher than the average score value of medium slopes and steep slopes. This may be due to the nature of pedogenesis (in situ), and the overall vegetational cover and humus formation, which is relatively of poorer quality in medium and steep slopes. It has also been noticed that there is a gradation of index values from high value in case of valley bottom to low in case of steep slope samples. Therefore, it may indicate that the chemical characteristics of soil in the valley bottom facets are most favourable. This may be due to the flat land, where deposition characteristic of finer particles wasted down from slopes. On the other hand, in the medium slope and the steep slope samples, the composition of chemical characteristics of soil are poor with low score values.

Table - 6.8: **Land Facet-Wise Distribution of Average Composite Indices of Chemical Characteristics of Soil, Group B**

	Valley Land	Gentle Slopes	Medium Slopes	Steep Slopes	Crest Land
Average	2.42	2.23	2.13	1.96	2.17

6.6.3. An analysis of Table 6.9 indicating the classification of the composite index (I_C) of site characteristics shows that the samples under valley bottom landfacets are of consistently high values with a highest average value of 4.08, followed by gentle slopes (2.89), and medium slopes (1.60). The average (low) score values of steep slope and crest land samples are 0.97 and 0.72, respectively. These values are very low in comparison to the valley bottom, gentle slope and medium slope samples. Therefore, there seems a consistent gradation of index values from very high in case of valley bottom to very low in case of steep slopes and crest land samples (which is three times lower than the valley bottom samples). It may indicate that the site characteristics of soils of valley bottom facets are most favourable. This may be due to the fact that the availability of (soil) major nutrients for plant growth are favourable. It is also favourable in case of topography in the valley bottom, since the land surface is almost flat or plain. But, in case of the gentle slopes and the medium slopes, topography which is somewhat undulating get lower scores. The ruggedness is more prominent in cases of steep slopes and crest lands, where practically no favourable site characteristics of soils can be observed.

Table - 6.9: Land Facet-Wise Distribution of Average Composite Indices of Site Characteristics of Soil, Group C

	Valley land	Gentle slopes	Medium slopes	Steep slopes	Crest land
Average	4.08	2.89	1.60	0.97	0.72

6.6.4. An analysis of Table 6.10 indicating the classification of the composited Index I_D, shows that the samples under valley bottom landfacets are of consistently high value with a highest average score of 1.67, followed by gentle slopes (1.61), medium slopes (1.57), crest land (1.56) and steep slopes (1.47). The average score value of crest land samples is higher than the steep slope samples; this may be due to the high average score value of crest land samples in case of chemical characteristics of soil. Otherwise, there seems to be a consistent gradation of the values of the Composite Index from high in case of valley bottom to low in case of steep slope samples. It may indicate that there are high values in cases of physical, chemical, and site characteristics of soil in the valley bottom facets, followed by gentle slopes, medium slopes and crest land samples. It has been noticed that the valley bottom land has got the highest score value, which could be considered the most favourable compared to the other categories of land facets. The parameters of all the three characteristics of soil have been found unfavourable towards highlands and steep slope ecologies.

Table - 6.10: Land Facet-Wise Distribution on the Average Final Index of Soil Ratings (Index I_D)

	Valley land	Gentle slopes	Medium slopes	Steep slopes	Crest land
Average	1.67	1.61	1.57	1.47	1.56

6.7. An analysis of the composite indices of all the ten ecological zones would provide comparison of the soil status and soil suitability between different ecological zones of the West Khasi Hills district. The index of physical characteristics has been shown in Table 6.11, which indicates that the average value of the composite scores of physical parameters are relatively favourable in ecological zone 1, 4, 7, 2, 5, and 8, the average values being 1.26, 1.20, 1.18, 1.15, 1.14 and 1.11, respectively. One may point out, as seen in earlier part of this chapter that physical parameters are relatively favourable towards the gentle slopes, valley bottom (flat land) and medium slope ecologies. It can be seen that ecological zones 1, 4, 7, 2, 5 and 8 are largely plateau top and low slope areas. The highest average value occurs in the Rambrai zone, which has many hill ranges and plateau tops. The average values occur in zone 6, 9 and 10, which are essentially low slope areas and low altitudes areas. The lowest average value occurring in the Nongstoin Zone (1.03), which has many hill ranges and high altitudes ranging from 1400 metres to 1600 metres high.

Table - 6.11: Ecological Zone-Wise Distribution of Average Composite Indices of Physical Characteristics of Soils, Group A

	Ecological Zones									
	1	2	3	4	5	6	7	8	9	10
Average	1.26	1.15	1.03	1.20	1.14	1.09	1.18	1.11	1.08	1.06

6.7.1. An analysis of Table 6.12 indicating the chemical parameters of soil, shows that the highest average score of 3.31, occurs in the ecological Zone 8, followed by Zone 9 (2.83), Zone 2 (2.62), Zone 3 (2.56), Zone 10 (2.29), Zone 6 (1.89), Zone 1 (1.85), Zone 5 (1.71), Zone 4 (1.69) and Zone 7 (1.48).

The chemical parameters of soils are relatively better in the ecological zones, where vegetation cover is mixed deciduous forests and low altitude areas. The ecological zone 8, i.e., Riangdo-Nongumdang and the adjoining areas has the highest average scores of 3.31 indicating low altitude ranging from 400 metres to 600 metres above MSL and mixed deciduous forests. Moreover, this zone is also favourable in physical parameters of soils. The lowest value has occurred in the Zone 7, i.e. Jadukata-River Basin. This may be due to the soil erosion and deposition of the transported materials carried by the tributaries of the River Jadukata.

Table - 6.12: Ecological Zone-Wise Distribution of Average Composite Indices of Chemical Characteristics of Soils, Group B

	Ecological Zones									
	1	2	3	4	5	6	7	8	9	10
Average	1.85	2.62	2.56	1.69	1.71	1.89	1.48	3.31	2.83	2.29

6.7.2. An analysis of the composite index of site parameters (characteristics) has been shown in Table 6.13, which indicates that the ecological zone 6, i.e. Balat-Pamkunda zone has the highest average score of 3.36, followed by Zone 4 (2.40), Zone 9 (2.40), Zone 8 (1.99), Zone 3 (1.97), Zone 2 (1.96), Zone 5 (1.88), Zone 10 (1.77), Zone 7 (1.75), and Zone 1 (1.73). This indicates that the Zone 6 is the most favourable by site parameters. This may be due to the availability of low altitude areas and mixed deciduous forests, which gets high score values in the numerical conversion system from qualitative attributes. The lowest average score of 1.73 is found in the Zone 1, i.e., Rambrai Zone. The site parameters are not favourable in this zone because, this is a plateau top area, where average altitudes range from 1600 metres to 1900 metres with pine vegetation. The average slope is very high about 40° and above. Rainfall is very less because it falls under rain shadow zone.

Table - 6.13: Ecological Zone-Wise Distribution of Average Composite Indices of Site Characteristics of Soils, Group C

	Ecological Zones									
	1	2	3	4	5	6	7	8	9	10
Average	1.73	1.96	1.97	2.40	1.88	3.36	1.75	1.99	2.40	1.77

6.7.3. An analysis of the Composite Index I_D (final) has been shown in Table 6.14. Among the ten ecological zones, the average scores of Composite Index I_D is the highest in ecological Zone 8 (2.01), followed by Zone 2 and 9 (1.79 for both cases), Zone 3 (1.61), Zone 10 (1.60), Zone 1 (1.57), Zone 6 (1.56), Zone 4 (1.49), Zone 5 (1.46) and Zone 7 (1.40). The highest average scores of Composite Index occurs in the Riangdo-Nongumdang Zone, which has low altitude areas, gently undulating topography and thick jungles of evergreen forests. Therefore, the score values get high scores in case of site parameters (characteristics) of this zone. Moreover, this zone has got the highest average score of 3.31 in case of chemical parameters of the soils among the ten ecological zones of the district. The second highest average index occurs in Mairang and Riangdo proper zones, although both of them are not similar in all the parameters of the soils sampled. Mairang zone has extensively large valley/flat areas in between many hill ranges. The Riangdo proper zone is the extension of the Riangdo-Nongumdang zone, which falls in between the plain areas of Assam and Meghalaya. Although, the average composite index value is positive for all the ecological zones of the district, they are not favourable, except the first three ecological zones.

Table - 6.14: Ecological Zone-Wise Ditribution of Average Composite Indices of Final Index, I_D

	Ecological Zones									
	1	2	3	4	5	6	7	8	9	10
Average	1.57	1.79	1.61	1.49	1.46	1.56	1.40	2.01	1.79	1.60

6.8. Spatial Differentiation of Soil Quality Indices

The Composite Index I_D, i.e. of the three sub-groups A, B, and C for the all 382 soils samples have been arranged in ascending order and the samples have been classified into quartile classes Category I (< 1.36): Poor Soils; Category II (1.36-1.64): Medium Soils; Category III (1.60-1.91): Good Soils and Category IV (>1.91): Very Good Soils.

6.8.1. At first all the samples, therefore, all the 382 observations have been categorised into ecological zone-wise. An analysis of Table 6.15 shows the Soil Rating Status in the district that the ecological Zone 8, i.e. Riangdo-Nongumdang zone has the best quality of soil (among the ten ecological zones) indicating 54.1 per cent of very good soils (IV) class within its 37 samples. This may be due to low altitude and mixed deciduous forests which could conserve the soil nutrients from erosion, clay dominance of texture and higher humus availability. It has also a significant percentage of good soils (III), indicating about 30.0 per cent. The medium (II) and poor (I) categories of soils show only 8.1 per cent each in this zone. Soil rating status-wise the second best ecological zone is the Nongkhlaw-Mawdoh zone, i.e. Zone 10. It has got 41.2 per cent of samples under very good (IV) soils, with 26.5 per cent and 23.5 per cent as good (III) and medium (II) soil categories, respectively. This is due to the extensive valley bottom (flat) lands with small hills, which are fully utilized for cultivation. The third best zone, in terms of soil quality is the Zone 9, i.e. Riangdo proper, indicating 37.8 per cent of very good soils (IV), 35.1 per cent of good

Table - 6.15: Soil Rating Status (Ecological Zone-Wi·e)

Eco. Zone (Macro-Region)	Total Sample	Category I Poor Soil		Category II Medium Soil		Category III Good Soil		Category IV Very Good Soil	
		No.of sample	%	No.of sample	%	No.of sample	%	No.of sample	%
1.	39	11	28.2	11	28.2	12	30.8	5	12.8
2.	39	3	7.7	7	17.9	16	41.0	13	33.3
3.	38	8	21.1	10	26.3	7	18.4	13	34.2
4.	43	20	46.5	16	37.2	5	11.6	2	4.7
5.	36	10	27.8	12	33.3	10	27.8	4	11.1
6.	42	24	57.1	6	14.3	4	9.5	8	19.0
7.	37	13	35.1	12	32.4	8	21.6	4	10.8
8.	37	3	8.1	3	8.1	11	29.7	20	54.1
9.	37	0	0.0	10	27.0	13	35.1	14	37.8
10.	34	3	8.8	8	23.5	9	26.5	14	41.2
Total	382	96	100.0	95	100.0	96	100.0	95	100.0

soils (III) and 27.0 per cent under the medium (II) quality of soils. There are no samples belonging to the poor soils (I) category. It is because of the low altitude with gentle slopes, the deciduous forests and gently rolling hills. The Zone 3, i.e. Nongstoin Zone, has come next to Riangdo Zone, in terms of the soil quality status. This zone has got 34.2 per cent of very good soils (IV), 26.3 per cent of medium soils (II), 18.4 per cent of good soils (III), and 21.1 per cent of poor (I) quality soil^. The percentage of poor quality soil is significant in this zone, because Nongstoin is dominated by highlands and plateau top areas and sparsely distributed pine vegetation. The Zone 2, i.e. Mairang zone has got 41.0 per cent of good soils (III), 33.3 per cent of very good soils (IV), 17.9 per cent of medium (II) quality soils and 7.7 per cent of poor (I) quality soils. This is due to the extensive valley bottom (flat) lands with small hill ranges, which are fully utilized for agriculture. The next to Mairang zone is the Zone 1, i.e. Rambrai zone, indicating 30.8 per cent of good (III) quality soils, 28.2 per cent of medium (II) and poor (I) quality of soils (for both the cases) and 12.8 per cent of very good (IV) quality of soils.

The percentage of poor quality soils is high in this zone, because Rambrai is dominated by highlands, sparse Pine vegetation, soil degradation and low rainfall. The percentages of poor (I) quality soils are very significant in the zones 4, 5, 6 and 7 and therefore, the dominance of below average quality of soils. The zone 6, i.e. Balat zone has got 57.1 per cent of poor quality soils, which is the highest percentage among the ecological zones. The soil erosion is more in this zone because of southern most part of the district, which receives one of the highest quantum of rainfall in the world, resulting in severe soil erosion and leaching of the soils.

6.8.2. Land Facet-Wise Distribution of Soil Indices

An analysis of Table 6.16 indicating Soil Rating Status, shows 31.4 per cent of very good (IV) quality of soils under medium slope ecologies, followed by gentle slope ecologies (28.8 per cent), valley bottom (flat land) (26.2 per cent), crest lands (24.9 per cent) and steep slopes (14.4 per cent). In the good soils (III) category, valley bottom (flat) soils have got the highest percentage indicating 34.0 per cent, followed by crest land soils (26.2 per cent), medium slope soils (24.9 per cent), steep slope soils (20.9 per cent) and gentle slope soils (19.6 per cent). In case of medium (I) quality of soils, valley bottom (flat), gentle slope, medium slope, steep slope and crest land soils have got 24.9 per cent, 22.3 per cent, 17.0 per cent, 34.0 per cent and 26.2 per cent, respectively. The dominance of poor (I) quality soil is highest in the soils of gentle slopes, which shows 32.7 per cent, followed by steep slopes (24.9 per cent), valley bottom (flat land) (20.9) per cent and crest land samples (17.0) per cent.

Though the occurrence of very good (IV) quality of soils is marginally higher in the medium and gentle slope soils, than the valley bottom (flat land) soils, the overall soil qualities under the valley bottom (flat land) is found satisfactory. Since, in the valley bottom (flat land) soils, the percentages of good (III) and medium (II) qualities of

Table - 6.16: Soil Rating Status (Land Facet-Wise)

Landfacet	Total Nos	Category I Poor		Category II Medium		Category III Good		Category IV Very Good	
		No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.
1. Valley	81	16	20.9	19	24.9	26	34.0	20	26.2
2. Gentle Slopes	79	25	32.7	17	22.3	15	19.6	22	28.8
3. Medium Slopes	75	19	24.9	13	17.0	19	24.9	24.	31.4
4. Steep Slopes	75	22	28.8	26	34.0	16	20.9	11	14.4
5. Crest Land	72	13	17.0	20	26.2	20	26.2	19	24.9
Total	382	96	100.0	95	100.0	95	100.0	96	100.0

soils are higher than in the other categories of landfacets. Therefore, there seems to be a very positive relationship between soil quality and the landfacets. The quality of soil becomes poorer with the increase in slope and altitude.

6.9. In the present Chapter an attempt was made on the analysis of evaluation of land potential by use of a rating index covering the whole of the district of West Khasi Hills. The main findings of the present chapter could be summarised as follows:

(1) The analysis of correlation matrices of the group of physical variables indicate a general independence of the

factors. The pattern of correlations among the chemical group of variables indicate some amount of multi-colinearity which at the level of the composite index are removed by low weigh-tages on those variables. In case of the group C variables, i.e. site characteristics, the correlation between altitude (X_9) and vegetation (X_{11}) is negative and highly significant due to the fact that the higher altitude areas are covered by vegetation with low score values (Pines).

(2) The correlations between the three composite groups indices, I_A, I_B and I_C, which show though positive but no significant correlations due to non-multicolinear relations and factor independence.

(3) In the three groups of variables, the first principal component accounts for more than 1/3 of the variations, which is considered adequate in this analysis. The second eigen values indicate totally a different, second most dominant characteristic of the data.

(4) Factor Loadings in First and Second Principal Components

The First Principal component of A, the dominant factors are the texture (X_1) and structure (X_2). In the second Principal component of A, the most dominant factor is soil colour (X_3). In case of the first principal component of B, the dominant factors are nitrogen (X_5) and Organic Carbon (X_8). But in the second principal component of B, the dominance of NPK complex with the chemical variables is found. Within the variable C, the first principal component has the dominance on slope (X_{10}) and vegetational (X_{11}) attributes while in the second principal component of C, the most dominant factor is the altitude (X_4).

(5) In the group I_D, variables which has the three composited factors, I_A, I_B and I_C (only the first principal components), the first component has high (positive) loadings on I_A and I_B and low (positive) loading on site characteristics of group of variable I_C. In the second principal component, a very high factor loading (0.973) and I_C and low (negative) loadings on I_A and I_B is shown.

(6) Analysis of Soil Rating Status Indices (Land Facets-Wise)

The composited Index I_D, shows that the samples under valley land facets are of consistently high value with a highest average score of 1.67, followed by gentle slopes (1.61), medium slopes (1.57), crest land (1.56) and steep slopes (1.47).

(7) Analysis of Soil Rating Status (Macro-Region Wise)

Among the ten macro-regions (ecological zones), the average scores of composited Index I_D is the highest in macro-region 8 i.e., the Riangdo-Nongumdang, which has low altitude areas, gently undulating topography and thick jungles of evergreen forests. Therefore, the score values get high scores in case of site parameters (characteristics) of the region.

Moreover, this zone has got the hi,hest average score of 3.31 in case of chemical parameters of the soil among the ten macro-regions of the district. Although, the average composite index value is positive for all the macro-regions of the district, they are not favourable, except the Riangdo-Nongumdang, Mairang and Riangdo proper macro-regions.

(8) Spatial Differentiation of Soil Quality Indices

The Composited Index I_D, i.e. of the three sub-groups A, B and C for all the 382 soil samples have been arranged in ascending order and the samples classified into quartile classes:

Category I (<1.36): Poor soils,

Category II (1.36-1.64): Medium soils,

Category III (1.60-1.91): Good soils, and

Category IV (>1.91): Very good soils.

(a) Macro-Region Wise

The macro-region Riangdo-Nongumdang (8) has the best quality of soil (among the ten macro-regions), followed by Nongkhlaw-Mawdoh (10), Riangdo proper (9), Nongstoin (3), Mairang (2), Rambrai (1), Balat (6), Mawsynram and Weiloi (5), Jadukata River Valley (7), and Mawkyrwat and Pambriew (4).

(b) Land Facets-Wise

The occurrence of very good (IV) quality of soils is marginally higher in the medium and gentle slope soils than the valley bottom (flat land) soils, the overall soil qualities under the valley bottom (flat land) is found satisfactory. Since, in the valley bottom (flat land) soils, the percentages of good (III), the medium (II) quality soils are higher than in the other categories of land facets, there seems to be a very positive relationship between soil quality and the land facets. The quality of soil becomes poorer with the increase in slope and altitude.

CHAPTER - 7

LAND CLASSIFICATION FROM THE POINT OF VIEW OF ENVIRONMENTAL MANAGEMENT: A NORMATIVE APPROACH

LAND CLASSIFICATION FROM THE POINT OF VIEW OF ENVIRONMENTAL MANAGEMENT: A NORMATIVE APPROACH

7.1. The Environmental Dimension of Land Classification

'Environment' is a very complex system. It can only be adequately studies using multidisciplinary, or interdisciplinary approach. This involves the systematic cooperation of several sciences on an integrated basis. The meaning of environment differs from man to man. Though it is a complex system it can only be partially understood. A particular approach has to be chosen in order to arrive even at a limited understanding of the situation. An environment is related to a given organism or group of organisms. These organisms may be primary plants, animals or man depending on the viewpoints. Environments have different sizes and regional demarcation according to the size and complexity of the organisms. The grouping of complexes of environmental factors in land units and landscapes or physiographic regions lead to landscape ecology. The geographical or landscape approach to environment is indeed an excellent way to give full value and extensive treatment to the various attributes of environments.[1] This is done by producing different kinds of maps (for example, maps of vegetation, soils, water, physiography etc.) at different scales. Environment can be defined in the following way:

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1 D.A. Davidson (ed. 1983); Landscape Ecology and Land Use, Longman, London and New York, p. 8.

> "Environment: this can only be defined in relation to an organism or a group of organisms. It is the collection or complex of external factors to which the organism(s) is (are) directly or indirectly related. The result is that there are many different environments. Each organism has its own environment which is more or less influenced by other organisms. In any environment, abiotic, biotic and psychological environmental factors may be distinguished. From a biological standpoint, man is just one of these organisms. Man can, however, exert a disproportionate influence on the environments of other organisms, sometimes favourable (agricultural crops), but often injurious."[2]

Land classification results in aerial differentiation and this becomes increasingly important in environmental management. The following reasons may be given for this.[3]

1. The regional and local differences between different environmental factors in various kinds of land mean that the same human activities have different impacts on different land units.
2. The various kinds and intensities of human activities in different regions and localities enhance the effects.
3. Environmental criteria differ for the various communities of men, animals and plants and this again enhances the differentiating effect.
4. In particular human criteria for environmental management differ considerably, as can be demonstrated by the differences in requirement with regard to.

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2 D.A. Davidson (ed. 1983); Op.cit., p. 13.

3 Ibid., p. 232.

5. The various differentiating factors mentioned above have very complex interactions and this makes the ultimate local and regional differentiation of environmental management an absolute necessity.

Land classification for various applications of modern technology to rural and urban areas should also be executed with a view to indirect and often unforeseen environmental impacts. Good land use planning implies the avoidance, and where necessary improvement of land degradation in its many different forms. This has to be considered in various phases of land evaluation such as:[4]

1. Identification and judgement of land qualities and limitations with regard to land degradation.
2. The formulating of relevant and foreseeable land utilization types which often has to include various land conservation practices.
3. The indication of land suitability classes for these land utilization types.
4. The identification and judgement of the needs for land improvement on the different land units, including constructions or other permanent improvements for land conservation.

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4 D.A. Davidson (ed. 1983); Op.cit., p. 233.

In this respect it must be understood that many land quality, or land limitations are not static data, but instead give an indication of variables of natural and cultural ecosystems, which should preferably be studied as processes. These processes include various kinds of degradations. In addition, the various variables of ecosystems are not independent in their effects; their interactions and the interactions of the processes which they are connected often induce the gravest danger. This is perhaps best exemplified by the processes leading to desertification. Destruction of vegetation in one part of the continent may have impact on the climate and land degradation of adjoining parts of the continent.

Land degradation is a worldwide phenomenon affecting all the continents of the earth and gradually decreasing the natural resources of land. This expresses as soil erosion which is a well-known phenomenon, against which at least the farmers of some countries have taken the appropriate measures over many centuries. For instance, the Former Netherlands East Indies (now Indonesia), laws were established during the nineteenth century in order to prevent deforestation and thus, to combat erosion in hilly and mountainous areas. The sense of soil erosion and conservation were brought to the attention of the USA and of the world particularly by the activities of the late Huge Hammond Bennett, the first Administration of the U.S. Soil Conservation Service, who started his work in the early 1930's.[5] To-day, a large library is necessary to hold the ever increasing literature on soil erosion and soil conservation. Examples are found in the publications and bulletins of many national soil conservation services as well as in those of FAO and UNESCO and in many books by individual authors.

To-day, land degradation has become a much more comprehensive subject which is seen as a part of the environmental crisis of the modern world.[6] Land degradation has the most serious impact in the poorest countries and on the poorest peoples. This means, primarily, lack of food for the growing population of most countries and this is a major and ever increasing global problem.

Deforestation is one of the primary causes of land degradation. It is not possible, however, to conserve all forests; people have to have food as well as other agricultural and forestry products such as clothes, houses, etc. Uncontrolled and unwarranted deforestation is perhaps the greatest of all ecological dangers. It must be remembered that deforestation is also taking place in more developed countries, such as, Australia, China, USSR and USA. But, it is accelerating

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5 D.A. Davidson (ed. 1983); Op.cit., p. 168.

6 E.P. Eckholm (1976); Losing Ground Environmental Stress and World Food Prospects, Norton and Co., New York, p.223.

most rapidly in the developing world. Currently, as mentioned earlier, about 35.0 per cent of the world's land surface is at risk, and about the 850 million people who live there are directly threatened.[7]

In the foregoing chapters, discussion have been done on soil erosion and land degradation in India. However, soil erosion and land degradation are age-old problems in India. In the past few decades, due to rapid industrialisation and urbanisation, there has been a large scale denudation and deforestation resulting in the acceleration of the process of soil erosion and land degradation. Out of 328 million hectares of the geographical area of the country, it is estimated that 175 million hectares representing 53.0 per cent of land are subjected to some form of soil erosion and land degradation. Therefore, there is a need for land classification from environmental point of view to protect this large land from degradation and to increase the production from our land resources.

Of all the environmental problems facing the country, the problems of deforestation has received the maximum importance from the point of view of soil erosion and land degradation. The latest satellite data confirm that India is losing

7 D.A. Davidson (ed. 1983); Op.cit., p. 169.

1.3 million hectares of fores' a year, nearly eight times the annual rate put out by forest departments. The Delhi-based Society for Promotion of wastelands Development (SPWD)[8] estimates degraded non-forest land ought to be added to the area of degraded forest lands. The Forest Research Institute argues that degraded forest area is limited to the 17.6 million hectares of unclassed forests. The Department of Environment claims that less than half of the 75 million hectares classed as forest lands is actually under adequate tree cover. Thus, estimates of degraded forest lands vary from 17.6 million hectates to 37.5 million hectares, and the total extent of wastelands in India ranges from at least 111 million hectares to 131 million hectares. Moreover, India's wasteland areas have been affected seriously by salinity, alkalinity and wind and water erosion.

As it is mentioned earlier, the main casuality of the process of desertification is occurring in the hill areas of North East Region of India, where land is being degraded quickly by its faulty use pattern, with the increase in population and without any significant availability of other avenues of employment, there is a consistent pressure on land, particularly, in the West Khasi Hills district of Meghalaya. This

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8 The Second Citizen's Report (1984-85); The State of India's Environment, Centre for Science and Environment, New Delhi.

has resulted in complete occupation of valley lands permanently and the slopes and crest lands have been occupied under shifting cultivation, resulting in severe soil erosion and land degradation. Therefore, there is a need for land classification from environmental point of view, so that the concerned authorities can implement the plans to check the soil erosion and land degradation in the district.

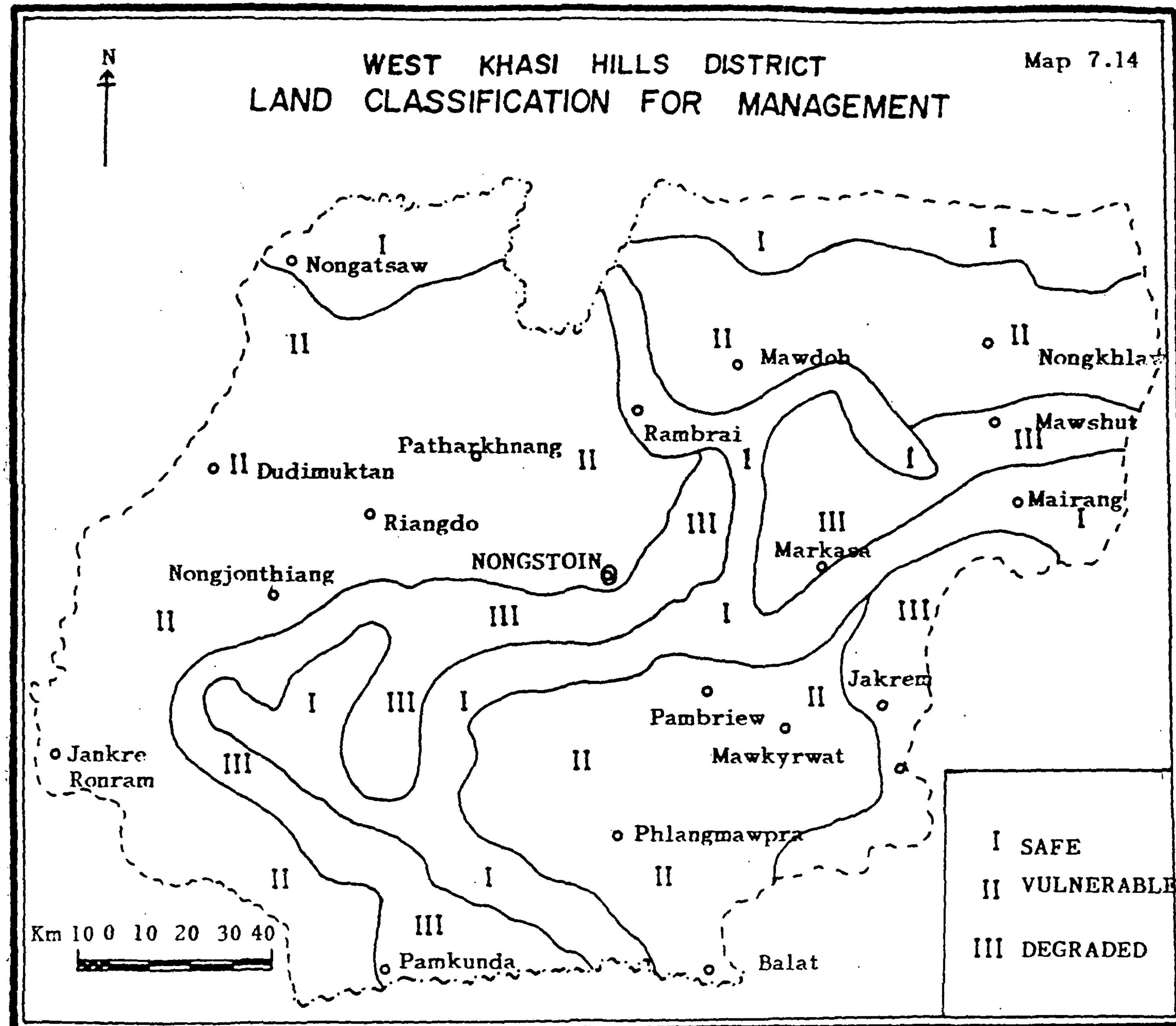
7.2. Keeping in view the above, broadly, three types of normative classes of land have been identified in the West Khasi Hills district (Map 7.14). These classes are:

(a) The relatively 'safe',

(b) The 'vulnerable', and

(c) The 'degraded' land.

(a) The Relatively 'Safe' Area: The environmentally 'safe' areas are mostly the plains and valley areas where the rate of soil erosion and land degradation are less. It is also found that the plain or valley areas of the West Khasi Hills district are the best with an average soil status index of 1.67 compared to 1.47 of the steep slopes. These areas also have been fully under permanent occupation, whether for settlement purposes or for permanent agriculture. The valleys of West Khasi Hills are put to production of either wet paddy or potato cultivation. A variety of subsidiary crops are also grown. Since, valleys receive silts eroded from


Map 7.14
WEST KHASI HILLS DISTRICT
LAND CLASSIFICATION FOR MANAGEMENT
N
Nongatsaw
Mawdoh
Nongkhlaw
Rambrai
Mawshut
Patharkhnang
Dudimuktan
Riangdo
NONGSTOIN
Mairang
Markasa
Nongjonthiang
Jakrem
Pambriew
Mawkyrwat
Jankre
Ronram
Phlangmawpra
Pamkunda
Balat
Km 10 0 10 20 30 40
I SAFE
II VULNERABLE
III DEGRADED

the slopes, the annual washing away of top soils are to some extent replenished by addition of silts. Due to high humidity and wet conditions in these areas soil desiccation is not a common phenomenon. Moreover, the cropping practices, particularly high bunding of field boundaries prevent erosion from the valley lands.

(b) The 'Vulnerable' Areas: 'Vulnerability' is, however, a more general concept. It embraces all the various kinds of ecological degradation and land degradation which may result from human action. Vulnerability may refer to the biotic as well as to the abiotic components of natural and cultural ecosystems. In the present study, the vulnerability of the different kinds of land have been identified by studying the following factors:

(i) Vulnerability causes by present landuse pattern in the district, particularly intensification of cropping practices on slopes surrounding the valleys;

(ii) Vulnerability arising out of continuum of shifting cultivation (jhumming) with a shortened cycle i.e., less than 5 years;

(iii) Vulnerability also arises due to natural phenomena like landslides in areas of unstable rock structures, heavy rainfall coupled with deforestation; and

(iv) Areas not directly under human occupance but subjected to large scale deforestation for lumbering purposes also creates vulnerability of these areas to quick land degradation.

(c) The 'Degraded' Lands: The impression must be avoided that land improvement is only relevant after some kind of land degradation has occurred. This is certainly not true. It is always possible and useful to initiate land conservation or land improvement or both when no land degradation has occurred. The aims are to ensure that land will not be degraded and to improve an area for a specific land use purpose. Land degradation may be due to human action as well as land improvement, which may be termed as 'Land transformation'. As a result of various human activities on land, the lands of the world are undergoing increasingly rapid and extensive transformation. These activities include urban and industrial as well as various kinds of agricultural land uses. For the present category i.e., 'degraded land' in the West Khasi Hills, the following criteria have been chosen for its demarcation:

(i) Degraded land includes the eroded rock slopes of hills and spurs, degraded forests and the grasslands; and

(ii) Degraded land arises with the acceleration in deforestation (for jhumming) and intensification of activities on slopes (over 15° - 20°) which lead to quick soil erosion and land degradation.

7.3. As mentioned earlier, the study aims at evaluation at two levels; (a) land classification on the basis of the genertic and landscape characteristics dealt within Chapter 5, and (b) land classification on the basis of land potential with a parametric approach in Chapter 6. This leads us to arrive at a normative division of land of the West Khasi Hills from the environmental and agricultural management point of view. At a very broad level, such normative classes have already been stated to be of three types; (a) the relatively 'safe', (b) 'vulnerable', and (c) the 'degraded' land.

The classification of macro-regions (ecological zones) and micro-regions (land facets) provide us with information on one broad pattern of environmental endowment of land in the West Khasi Hills district. For instance, valley land occupies 870 sq.km. and 16.58 per cent of the total land area, while gentle slopes occupy 1030 sq.km. or 19.63 per cent of the geographical area of the district (Table 5.7). Similarly, steep slopes (> 20°) occupy 990 sq.km. or 18.87 per cent and the crest lands 300 sq.km. or 5.72 per cent of the total geographical area of the district.

The study of land classification on the basis of soil rating of the district (Chapter 6) provides us with information about the potentialities of the soils under different ecological conditions (the land facets). The valley (flat) and gentle slopes are found to be the most suitable soil from the point of view of potentials, while the steep slopes and crest lands are at the bottom of the 'potential' scale.

On these basis Map 7.13 and Table 7.1 provide the broad aerial extension of land under the stated three normative classes.

Table - 7.1: Land Classification for Land Management

Classes		Area in sq.km.	Percentage
I	Safe	792	15.10
II	Vulnerable	3767	71.80
III	Degraded Land	688	13.10
	Total	5247	100.00

The valley and gentle rolling lands which constitutes the major parts of the 'safe' lands for the current practices do not worry us. However, judicious management, further intensification technology upgradation of the practices suitable to the local conditions will help in meeting local self-sufficiency in foodstuffs.

The degraded land which now constitutes more than 13.0 per cent of the land area, includes the eroded rock slopes and spurs, degraded forests and grasslands. Moreover, continuously over the years, 1-2 per cent areas are added to the degraded list. With acceleration in deforestation and intensification of activities on slopes (over 15° - 20°) this process of land degradation also will accelerate to 3-4 per cent per year. This would mean that within the next 20-25 years a major part of the district will constitute of degraded land, quite common sight in the Western Ghats, Andhra Pradesh and Tamil Nadu (Eastern Ghats). Therefore, special management techniques are to be adopted to check as well as regenerate the degraded lands.

The 'Vulnerable' tracts of land constitute the majority of the balance sheet of the district. Areas classified as vulnerable are those, though productive (both agriculture and forests) in the short run (within 5 years or so) have the potentiality of getting degraded within next 5 to 10 years. These areas constitute of the medium, steep slopes and crest lands which are now put to (a) permanent occupance for agriculture, (b) land clear cut of forests (on slopes) for timber or shifting cultivation, and (c) areas, put to consistent 'slash and burn' agriculture, particularly under shortened shifting cycles of less than 10 years (for example Mawshynrut area). Therefore, the strategy of land management would be of conservation and protection.

7.4. Policies and Its Implementation

In the present chapter, a normative land classification of the district has been suggested (Map 7.14). The district has been divided into three types of land classes from the point of view of land management policy. The classes are, (A) land classified as relatively 'safe', (B) land classified as 'vulnerable', and (C) land classified as 'degraded'. Each of these classes requires different strategies of land management and policies to effectuate such strategies.

(A) Safe Land

The areas marked as 'safe' are mostly of valley and gentle slopes, where soils are the most favourable and they are the least prone to severe erosion; (i) Intensification of agriculture is possible in these areas, (ii) Moreover, there are large number of smaller valleys which are not yet under occupation due to inaccessibility. Some relocations of settlements are possible in these areas, (iii) On the gentle slopes and medium slopes ($< 20°$) rolling hills the emphasis must be on terracing, on a much more larger and sustained scale. Agroforestry and orchards on the edges, interspersed with crop lands will hold the soils and also save the valley lands from constant rock flows from the higher slopes.

(B) Vulnerable Lands

More than 70.0 per cent of the land area of the district is classified under this category. It contains two different types of areas; (i) the southern and south-eastern fringes of the district which recieves one of the heaviest quantum of rainfall of the world; therefore, the natural process of the landslides and erosion required (a) afforestation of areas now thinned of vegetation, and (b) constant civil works of bunding (contours) to check landslides. (ii) The second type of vulnerable areas occur to the north (on hills and slopes) and to north-west where shifting cultivation is very common. Strategies here should include (a) increase in the shifting cyle to more than 10 years and a gradual reduction in the area under 'slash and burn'. Of course, this is only possible with the cooperation of the farmers, who are to be educated and taken into confidence, (b) Afforestation programmes are to be taken up (on agro-forestry basis) in the already cleared land. (c) The medium, steep slopes and the crest lands are to be protected, particularly the latter two.

(C) Degraded Lands

The degraded lands occur along the populated valley areas of the Central Highlands and the southern slopes facing Bangladesh. They require management techniques (1) Civil works for landslides, (2) Regeneration of forest, and (3) Protection.

To fulfil the requirements of such strategies mentioned above, there is need of active participation and cooperation of the local communities. Administrative intervention is important but not to be enshrined in some legislative acts. Village leadership and active action of the people is key to preservation and maintenance of this fragile land which is crucial to the life and prosperity of the people.

7.5. Summary

As mentioned earlier, in the present chapter an attempt has been made on normative approach to land classification from the point of view of environmental and agricultural management of land in the West Khasi Hills district. Broadly, three normative classes of land have been identified. These classes: (i) the relatively 'safe', (ii) 'vulnerable', and (iii) the 'degraded' land.

A detailed discussion have been made for each of the normative classes of land in the district. The 'vulnerable' tracts and degraded lands constitute more than 70.0 per cent and 13.0 per cent of the total geographical area of the district, respectively. At the same time, some suggestions and policies for 'safe', 'vulnerable' and 'degraded' lands of the district were also discussed. The district level of normative classes of land would lead to a macro-level study. Therefore, in the next chapter (Chapter 8) a detailed discussion has been made for normative division of land by taking case studies of two river basins of West Khasi Hills district.

CHAPTER - 8

MICRO-LEVEL LAND CLASSIFICATION: CASE STUDIES OF TWO RIVER BASINS OF WEST KHASI HILLS DISTRICT

MICRO-LEVEL LAND CLASSIFICATION: CASE STUDIES OF TWO RIVER BASINS OF WEST KHASI HILLS DISTRICT

8.1. An important objective of the study is to classify the land of the West Khasi Hills district, with the aim of providing a basis for environmental as well as the agricultural management of land. Land classification at the level of the district is too broad for detailed study and analysis. As mentioned earlier, 'land' is of a 'complex nature' for which there is a need for detailed micro-level study to understand the complexity. This can be achieved by taking a small or manageable area for detailed land classification. In the present Chapter, therefore, an attempt has been made to study the micro-level land classification of the combined catchment area of two small river basins of the district, Um Sohdkhiew and Umthied (both, tributaries of the river Kynshi).

8.2. The River Basin as a Micro-Region

The catchment area of a river is a very convenient area for detailed land classification. The river as a 'line within the area' integrates the physical and socio-cultural processes within the basin and provide a specific characteristics to a region. Excesses and deficiencies of water provoke crisis of a kind that stimulate the communities of the basin to various sorts of action.[1] If the crisis are sufficiently large and numerous, and the catchment area is sufficiently important in the national or state level, then these demands will become very strong at the planning level. The decision making process with regard to meeting the demands for action will be increasingly difficult unless the whole watershed is taken into account. The region needs to be studied as a unit so that it can be adequately understood and valid comparisons can be made with other regions. Moreover, the development plans involve considerations of the whole resource complex, and in a framework of land areas such as a river basin, various forces make land-forming agents.

Keeping in view the above, the combined catchment area of Um Sohdkhiew and Umthied have been chosen for the detailed land classification, for the purposes of environmental land management and potential agro-economic planning. As mentioned earlier, the study has been attempted on the basis of a 'landscape approach'. However, it is to be mentioned here that the classification of land has been done on the basis of aerial photographs available for the year 1964 and 1983. The following aspects have been studied in an integrated approach to study the various land classes of the river basin.

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1 C.C. Renwick (1968); "Land Assessment for Regional Planning: The Hunter Region of N.S.W. as a Case Study", in Stewart, J.A. (ed.) 1968, Op.cit., pp. 172-73.

(a) Population, settlement pattern and the general economy of the basin,

(b) Slope analysis,

(c) Forest types,

(d) Agricultural land use,

(e) Identification of 'land facets' based on the above criteria.

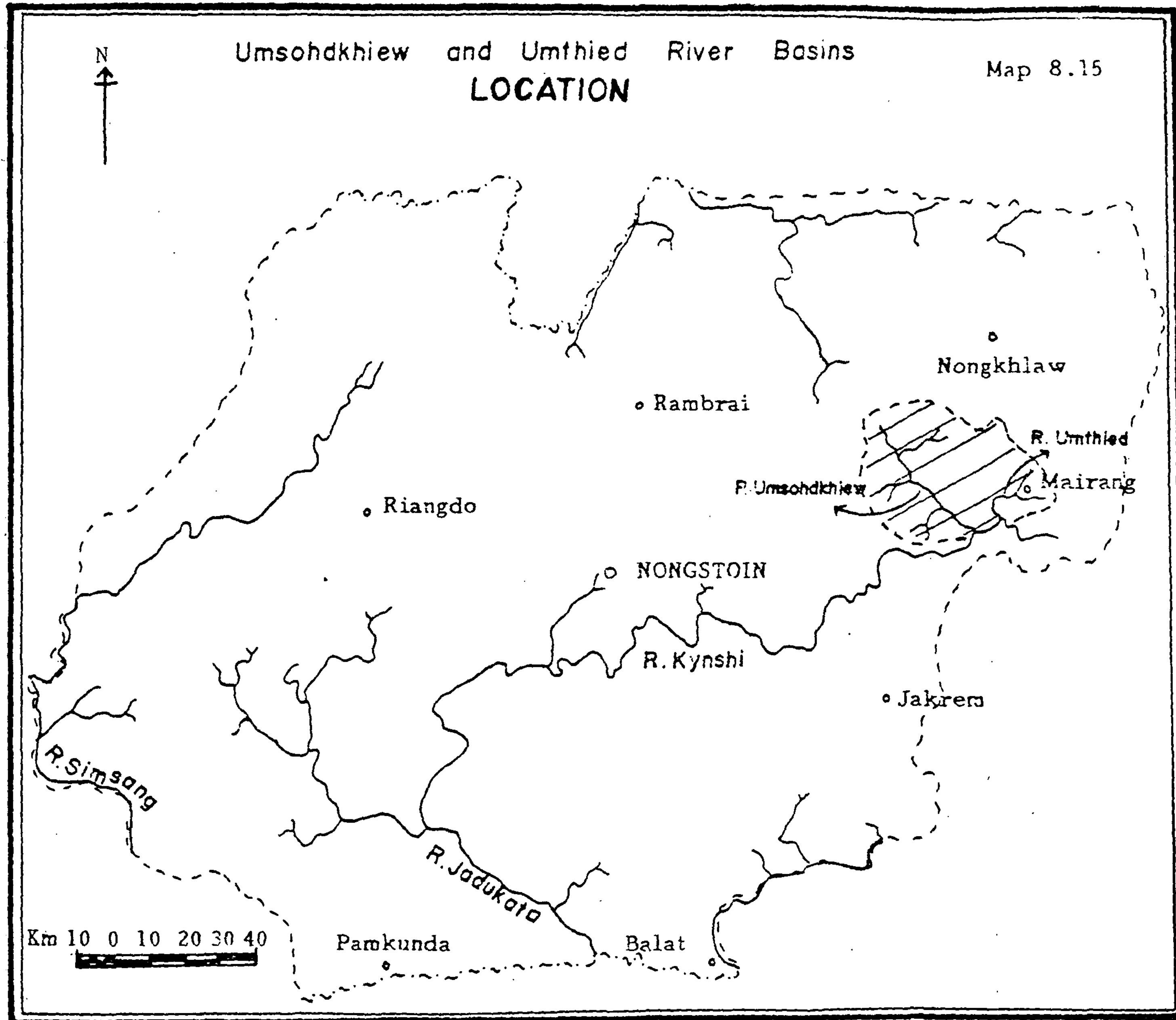
8.3. The Um Sohdkhiew and Umthied River Basins

The Um Sohdkhiew and Umthied river basins are located in the easternmost part of the West Khasi Hills district. The river basins lie between 25°35' North to 25°32'30" North Latitude and 91°34'40" East to 91°38'45" East Longitude covering an area of 52.0 sq.km. Map 8.15 shows the location of the river basin of Um Sohdkhiew and Umthied. Since, both the streams cover a small area and also originate from the same area, it can be considered as the 'combined basin' of the two streams.

Drainage Pattern and Their Significance

'Drainage pattern'[2] refers to the particular plan or design which the individual stream courses collectively form. A distinction can and in some instances should be made between the patterns of the individual streams and their spatial relationships to one another. It is generally recognized

2 William D. Thornbury (1986, 2nd edn.): Principles of Geomorphology, Wiley Eastern Limited, New Delhi, p. 117.



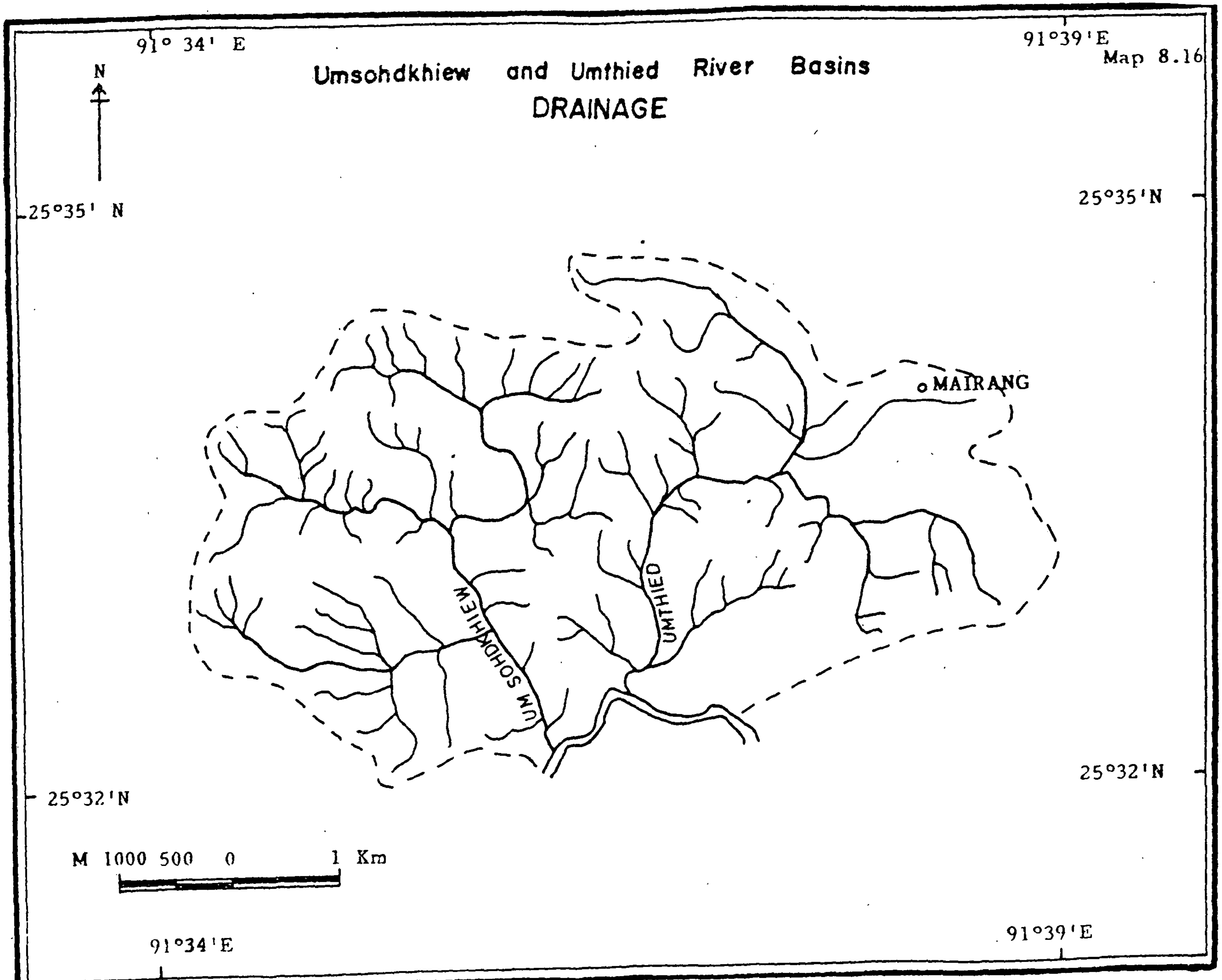
Umsohdkhiew and Umthied River Basins
LOCATION
Map 8.15
N
Nongkhlaw
Rambrai
R. Umthied
Mairang
R. Umsohdkhiew
Riangdo
NONGSTOIN
R. Kynshi
Jakrem
R. Simsang
R. Jadukata
Km 10 0 10 20 30 40
Pamkunda
Balat

that drainage patterns reflect the influence of factors like - slope, inequalities in rock hardness, structural controls, recent diastrophism, and the recent geologic and geomorphic history of the drainage basin. Because drainage patterns are influenced by so many factors, they are extremely helpful in the interpretation of geomorphic features. Their study represents one of the more practical approaches to an understanding of structural and lithological controls of land forms.

In the combined river basin of Um Sohdkhiew and Umthied, the dendritic drainage pattern is observed (Map 8.16). They are characterised by irregular branching of tributary streams in many directions and at almost any angle, although usually at less than a right angle. The stream Um Sohdkhiew flows from the north-eastern part of the combined basin. The other stream i.e. Umthied originates from the north-western part of the basin. Both the streams meet the Kynshi river in the southernmost part of the combined basin. The Kynshi river again meets the Jadukata river which is flowing in the southernmost part of the West Khasi Hills district.

8.4. Description of the Attributes and Their Regional Dimensions

The attributes, which have been used to identify the normative classes of land in the basin areas can be discussed in the following manner:


Map 8.16
Umsohdkhiew and Umthied River Basins
DRAINAGE
N
91° 34' E
91°39'E
25°35' N
25°35'N
25°32'N
25°32'N
91°34'E
91°39'E
MAIRANG
UM SOHDKHIEW
UMTHIED
M 1000 500 0 1 Km

(a) Population, Settlement Pattern and the General Economy of the Basin

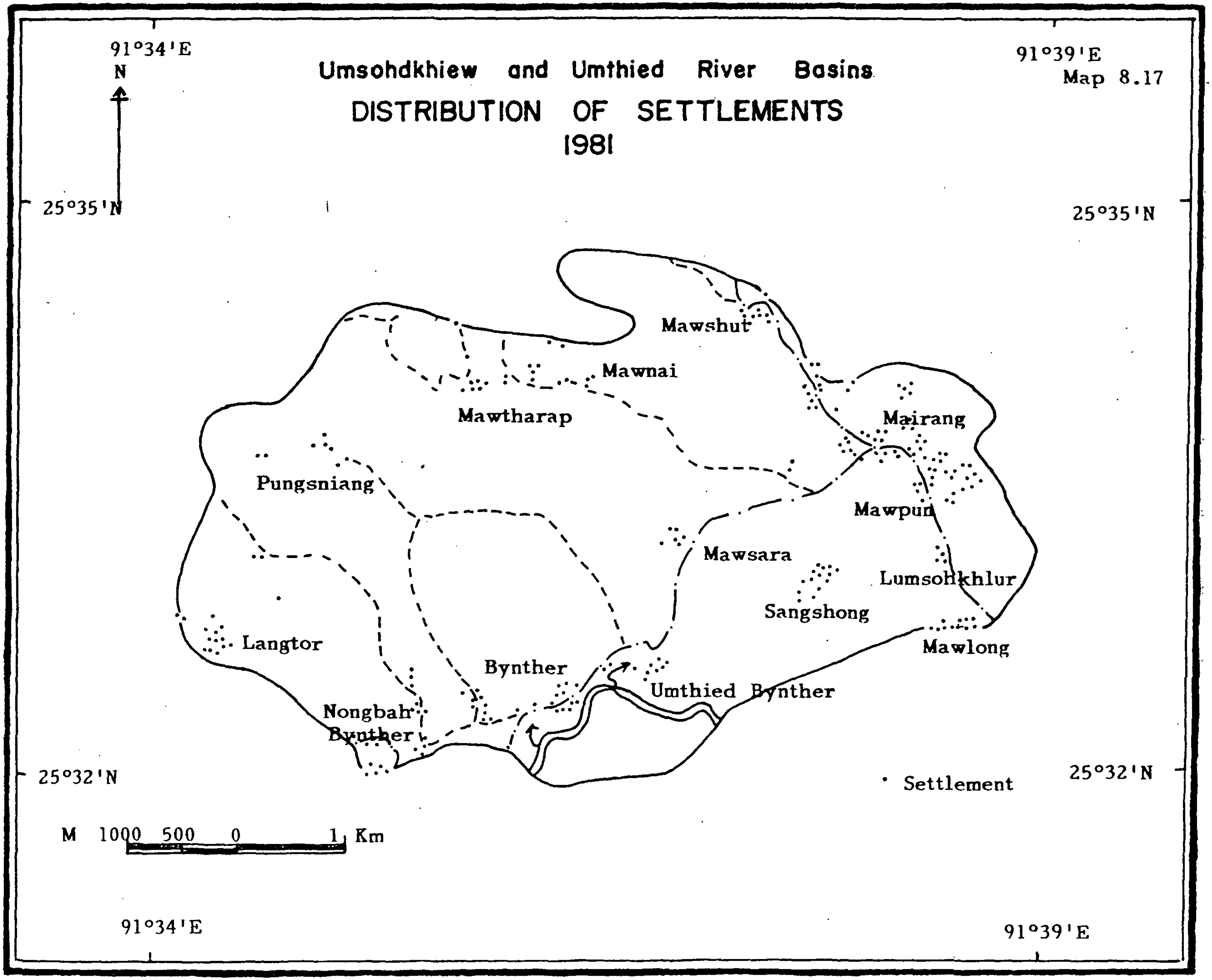
Physiographically, the basin area is highly dissected with small hills, spurs and valleys. As mentioned earlier that the distribution of settlements are characterised mainly by the terrain of the district so also the basin area. As a result clustered settlements are common in the hill slopes. Table 8.1 and Map 8.17 provide information on the distribution of population and the inhabited villages in the combined river basin for 1981. From the map it is clear that the concentration of settlement at Mairang village is the highest (872), which accounts for more than 65.0 per cent of the total population of the basin area. The total population of the basin area is 7,028 in 1981, which accounts for little more than 4.0 per cent of the total population of the district. The density of population is more than four times that of the district, which accounts for 135 persons per square kilometre. This is due to the fact that the area of the basin is small and intensively used. The concentration of the settlements, and population is the highest in the Mairang village due to the fact that Mairang is the headquarters of Mairang Sub-division of West Khasi Hills district. Moreover, Mairang is almost a valley (flat) area with intensive commercial cropping of potatoes and has good transport and communication with Shillong, the capital of Meghalaya.

Table - 8.1. Population and Households: Um Sohdkhiew and Umthied River Basins (1981)

Name of the Villages	Total population	P.C.	Total households
1. Mawshut	625	8.98	116
2. Mawnai	1062	15.11	211
3. Mawtharap	209	2.97	73
4. Pungsaniang	268	3.81	39
5. Mairang	4633	65.92	872
6. Mawsawa	231	3.29	34
Total	7028	100.00	1345

It can be noted that most of the settlements are located on the main roads which are connected with Shillong and Nongstoin. The distribution of settlements are, not only affected by the rugged terrain, but also the favourable climatic conditions for livelihood. The small plateau tops or the gentle slopes of the combined basin are thickly populated. This is due to the fact that these areas are easily accessible and are put to intensive agriculture.

The agriculture is the backbone of the economy of the district, where more than 97.0 per cent of the total population live in the rural areas. In the concerned river basin, almost all the population are engaged in primary activities.



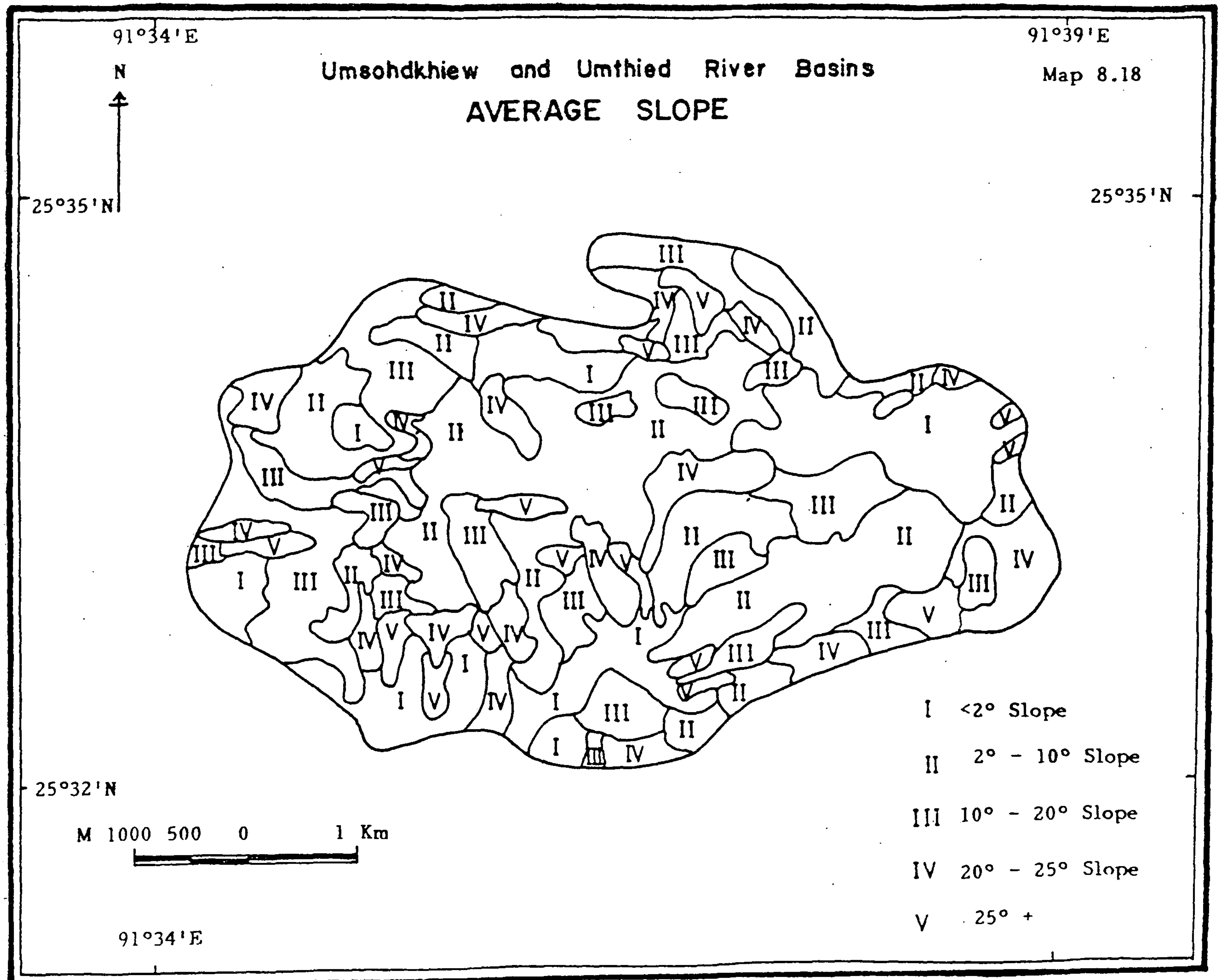
91°34'E
N
Umsohdkhiew and Umthied River Basins
DISTRIBUTION OF SETTLEMENTS
1981
91°39'E
Map 8.17
25°35'N
25°35'N
Mawshut
Mawnai
Mawtharap
Mairang
Pungsniang
Mawpun
Mawsara
Lumsohkhlur
Sangshong
Langtor
Mawlong
Bynther
Umthied Bynther
Nongbah Bynther
25°32'N
25°32'N
Settlement
M 1000 500 0 1 Km
91°34'E
91°39'E

The main agricultural crops are - paddy, maize, potato, ginger, turmeric etc. Most of the valley and flat lands are occupied by paddy and potato cultivation, although in the gentle slopes and medium slopes, the cultivation of potato is also noticeable. A variety of vegetable crops like, cabbage, cauliflower, beans, radishes, carrots, etc., are cultivated extensively in the area.

Forests, which are the main basis of the economy of many of the hill tribes is also true in case of the West Khasi Hills district. The avenues of industries whether mineral based or agro-based are rather limited except lumbering and allied activities in the basin area with a low level of cultivated land available and with a fast growing population (over 3 per cent per year), the people are left with no alternatives but to fall back on their traditional treasure house; the forests. This has led to a fast degradation of the forests and therefore, the resultant soil erosion and land degradation in the combined catchment area.

(b) Slope Analysis

The assessment of the average slope plays a vital role for identification of land facets in the river basin region. The variations in average slope in the combined basin area is very significant. Map 8.18 and Table 8.2 show the average slope categories of Um Sohdkhiew and Umthied river


Umsohdkhiew and Umthied River Basins
AVERAGE SLOPE
Map 8.18
N
91°34'E
91°39'E
25°35'N
25°35'N
25°32'N
91°34'E
M 1000 500 0 1 Km
I <2° Slope
II 2° - 10° Slope
III 10° - 20° Slope
IV 20° - 25° Slope
V 25° +

basins. The combined basin has been divided into five categories of average slope zones. The slope zones are:

(1) Valley (flat) land ... < 2° slope,

(2) Gentle slopes ... 2° - 10° slope,

(3) Medium slopes ... 10° - 20° slope,

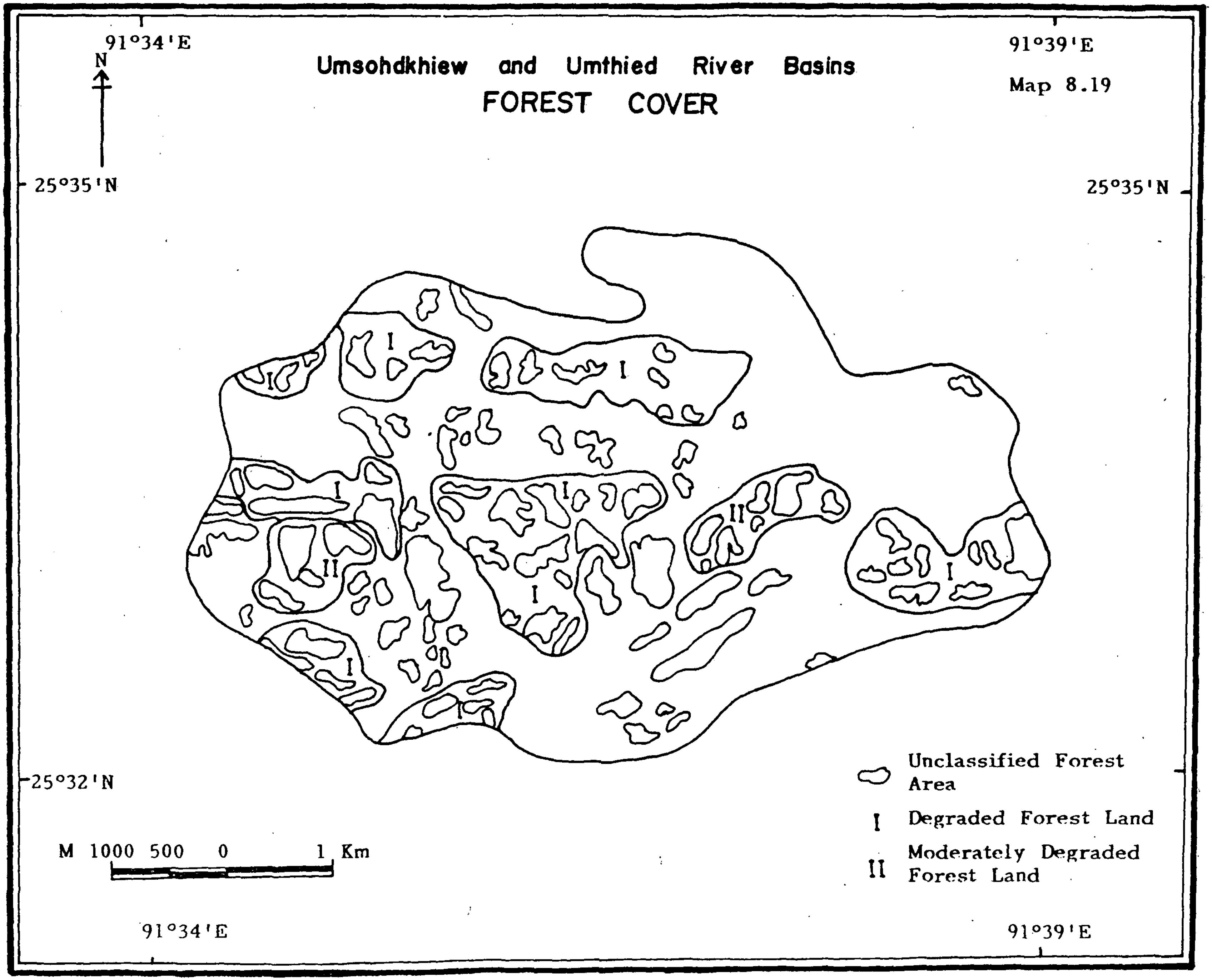
(4) Steep slopes ... 20° - 25° slope

(5) The crest land: Generally, mildly undulating. > 25°

In the northern and southern slopes of the combined basin, slopes vary from 10° to 20°, covering around 22.0 per cent area. In the north-western parts, there are steep slopes and it is estimated that around 16.0 per cent area of the combined basin has slopes more than 20°. More than 50.0 per cent area has slopes less than 10°. As a result of the preponderance of valley (flat) land and gentle slopes, a large part of the combined basin is utilized for permanent agriculture.

Table - 8.2. Area and Percentage of Average Slope Zones

Slope Category		Area in sq.km.	P.C.
I	(< 2° slope)	10.0	19.23
II	(2° - 10° slope)	17.5	33.65
III	(10° - 20° slope)	11.0	21.15
IV	(20° - 25° slope)	8.5	16.35
V	(> 25° slope)	5.0	9.62
	Total	52.0	100.00


Umsohdkhiew and Umthied River Basins
FOREST COVER
Map 8.19
N
91°34'E
91°39'E
25°35'N
25°35'N
25°32'N
I
II
M 1000 500 0 1 Km
Unclassified Forest Area
I Degraded Forest Land
II Moderately Degraded Forest Land
91°34'E
91°39'E

(c) Forest Types

The character of natural vegetation in the combined basin is the outcome of the environmental complex which exercises its influence, among other things, through soil and climate, particularly moisture supply. In a highland area, such as the river basin, variations in altitude and topography are of great significance and become determinants of distribution of natural vegetation. In the catchment area, the distribution of natural vegetation is very insignificant due to the small aerial extension of the region. A variety of natural vegetation, mostly sub-tropical pine forests and a few patches of mixed forests are found in the catchment area. Table 8.3 and Map 8.19 show the totally degraded and moderately degraded forest cover in the combined basin.

Table - 8.3: Area and Percentage of Forest Cover (1983)

Forest Classes	Area in sq.km.	P.C.
Degraded forests	9.5	82.60
Moderately degraded forests	2.0	17.40
Total	11.5	22.12

In 1964, the total forest cover in the catchment area was 20.0 sq.km.[3] accounting for 38.0 per cent area of the

3 The area of forest cover for the combined basin has been estimated from the aerial photographs of 1964 and 1983.

total geographical area of the combined basin. This forest cover has been reduced to 11.5 sq.km. in 1983, i.e. after a span of 19 years. The rate of deforestation is less than one kilometre per year. The degraded forest area occupies about 83.0 per cent of the total forest area of the combined basin. This may be due to the indiscriminate felling of trees and prevailing practices of shifting cultivation in the catchment area.

(d) Agricultural Land Use

Agriculture in the hill areas of North East Region of India is characterised by the predominance of shifting (jhuming) cultivation. Though the impact of jhum cultivation is much higher in the West Khasi Hills district, the jhum cultivation in the relevant river basin is, rather negligible. Table 8.4 and Map 8.20 show the area and percentage of land area under different agricultural uses. The total agricultural land of the catchment area is 21.0 sq.km. accounting for 41.0 per cent of the total geographical area, of which 23.0 per cent has been occupied by permanent agriculture, mostly wet paddy and potato cultivation. The terrace and hill (and crest) cultivation occupy 10.0 and 8.0 per cent of the area, respectively.

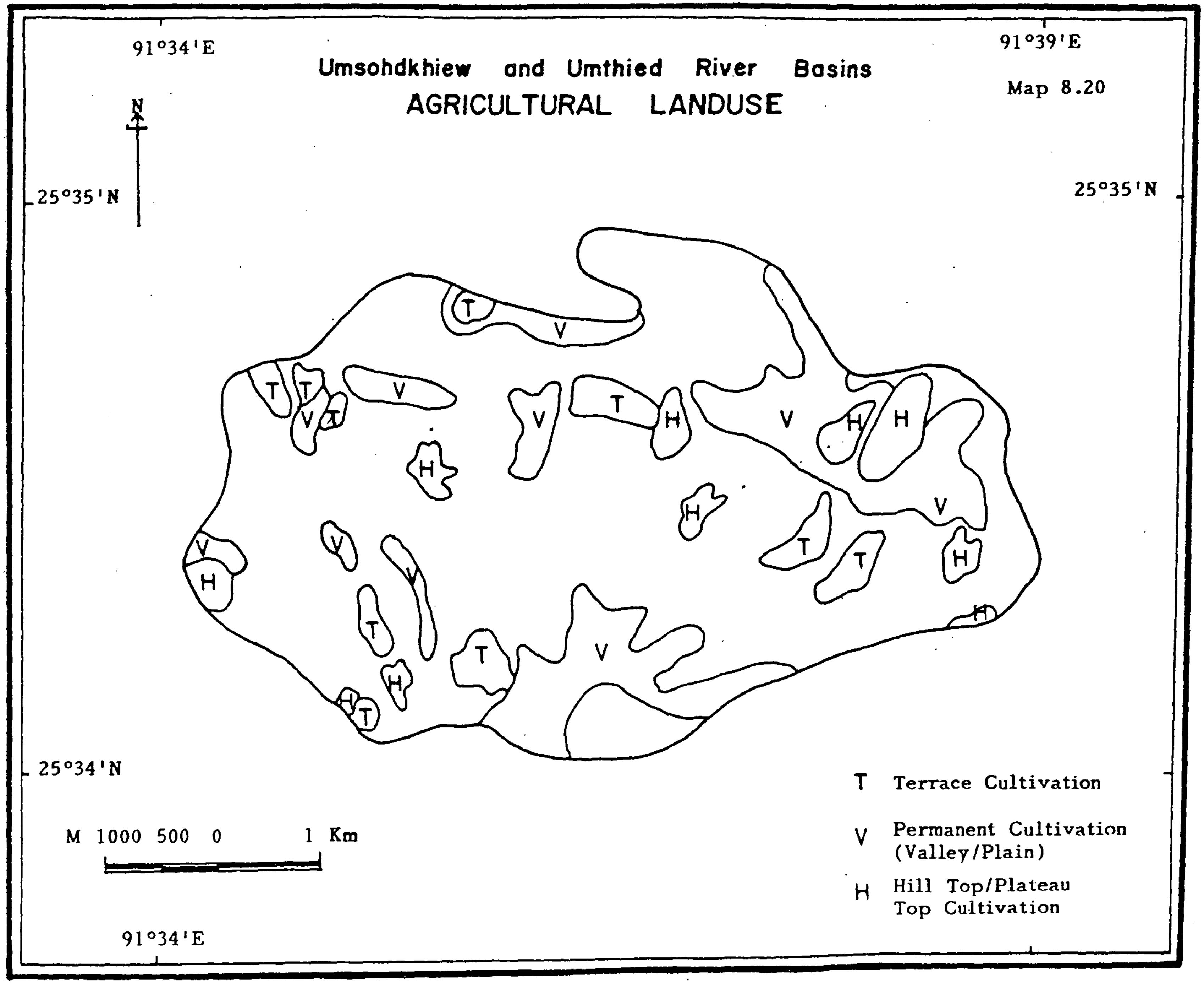
Table - 8.4: Agricultural Land Use

Agricultural Landuse Classes	Area in sq.km.	P.C.
Terrace cultivation (T)	5.00	10.00
Permanent cultivation (V)	12.00	23.00
Hill slope/Top cultivation (H)	4.00	8.00
Total	21.00	41.00

In the north-eastern and southern part of the basin, rice, maize, potatoes, vegetables, chillies, sweet potatoes, millets etc. are grown in gardens, particularly the higher slopes as subsidiary food crops. A considerable area is also devoted to highland paddy. The various kinds of fruits, such as plums, oranges, pineapples, etc. are successfully grown in the uplands of the basin area. The cropping pattern in the basin area is determined more by the topography and rainfall than by any other factor.

(e) Identification of 'Land Facets'

As mentioned earlier, 'land facet' is a nomenclature given to small and units with homgeneous environmental (or geographical) characteristics. This involves the recognition in landscape of distinctive with only a limited range of variation of attributes important to land use. The attributes, which have been considered to identify the 'land facets' are -



91°34'E
91°39'E
Umsohdkhiew and Umthied River Basins
AGRICULTURAL LANDUSE
Map 8.20
N
25°35'N
25°35'N
25°34'N
T
V
H
M 1000 500 0 1 Km
T Terrace Cultivation
V Permanent Cultivation (Valley/Plain)
H Hill Top/Plateau Top Cultivation
91°34'E

(i) Population and settlement pattern of the basin area,

(ii) Characteristics of different slope categories,

(iii) Forest types, and

(iv) Agricultural land uses in the basin area.

Out of these four parameters, the major control characteristics in determining the land facet in the prevailing conditions is the 'slope'. However, the other parameters were also assessed. But, slope is the dominating factor. Five types of land facets have been identified in the catchment area based on the slope characteristics. They are:

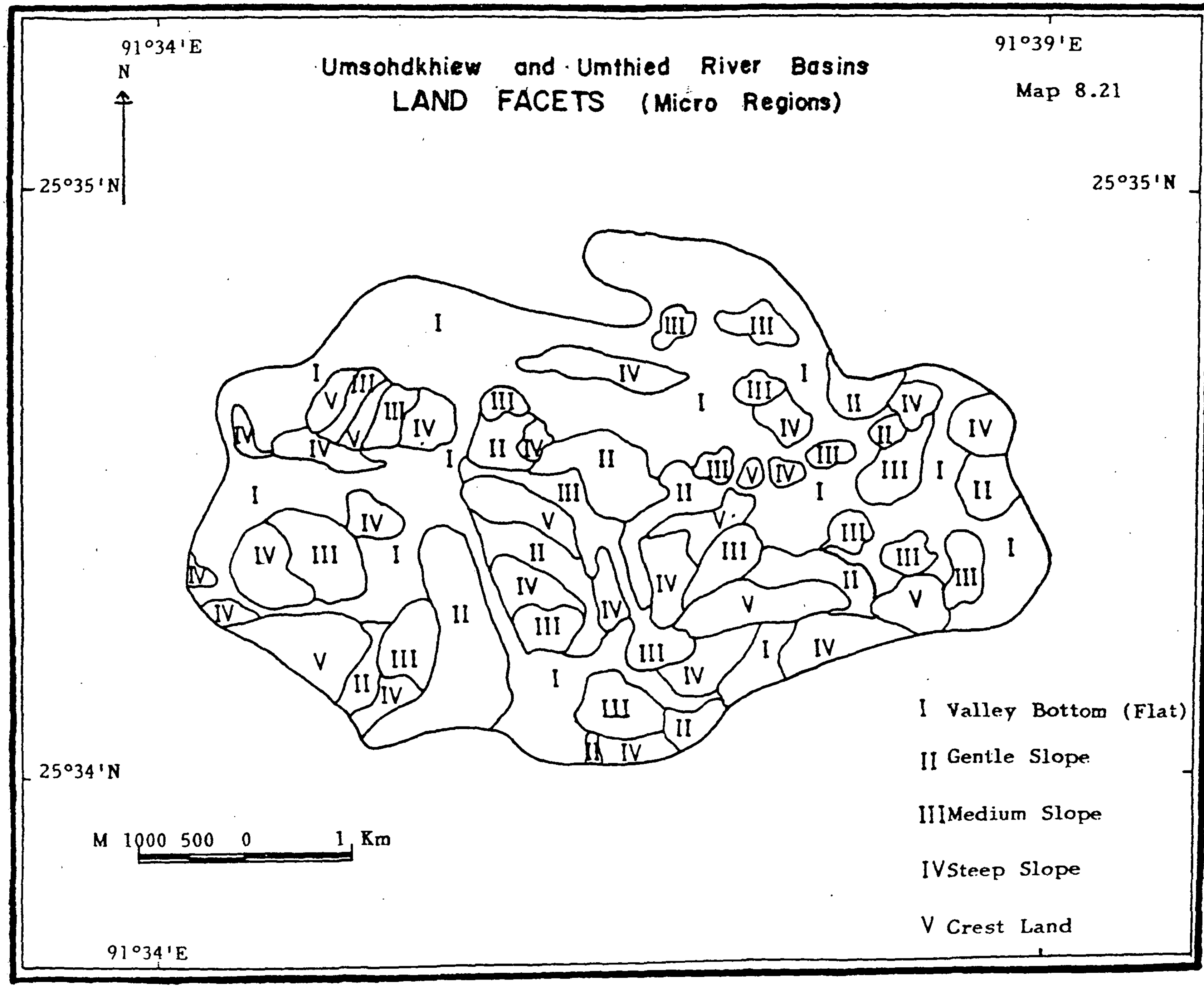
(i)	Flat and valley land	(< 2° slope)
(ii)	Gentle slopes	(2° - 10° slope)
(iii)	Medium slopes	(10° - 20° slope)
(iv)	Steep slopes	(20° +), and
(v)	The crest land: Generally, mildly undulating.	

It is clear that at one hand, the different slope categories are given and on the other in the given situation (of a plateau), the micro-use of land depends largely on the slope characteristics. Within the same slope zones, the types of vegetation, may differ and cropping pattern may vary in the valley area. The variation of cropping pattern is controlled by the slope categories in the basin. For instance, shifting cultivation in medium and steep slope zones has been found whereas the paddy and potatoes are practised in the valley (flat) and gentle slope zones.

Table 8.5 and Map 8.21 provide the distribution, area and percentage of different category of land facets in the catchment area. There are altogether 64 land facets outlined in the relevant tables and maps for the combined basin area. The flat and valley land accounts for 43.27 per cent area of the total geographical area of the combined basin and gentle slopes another 17.31 per cent. About 28.0 per cent of the area is under medium and steep slopes (above 10° slope). More than 60.0 per cent area of the combined basin is under valley land and gentle slopes (about 10° slope), hence, suitable for extensive cropping practice. The crest ecology constitutes about 11.0 per cent area of the total geographical area of the combined basin.

Table - 8.5: Land Facets: Area and Percentage in the Combined Basins

Land Facets		Area in sq.km.	P.C.
I	Flat and valley land	22.5	43.27
II	Gentle slopes	9.0	17.31
III	Medium slope	8.0	15.38
IV	Steep slopes	7.0	13.46
V	The crest land	5.5	10.58
	Total	52.00	100.00


Umsohdkhiew and Umthied River Basins
LAND FACETS (Micro Regions)
Map 8.21
91°34'E
91°39'E
N
25°35'N
25°35'N
25°34'N
91°34'E
M 1000 500 0 1 Km
I Valley Bottom (Flat)
II Gentle Slope
III Medium Slope
IV Steep Slope
V Crest Land

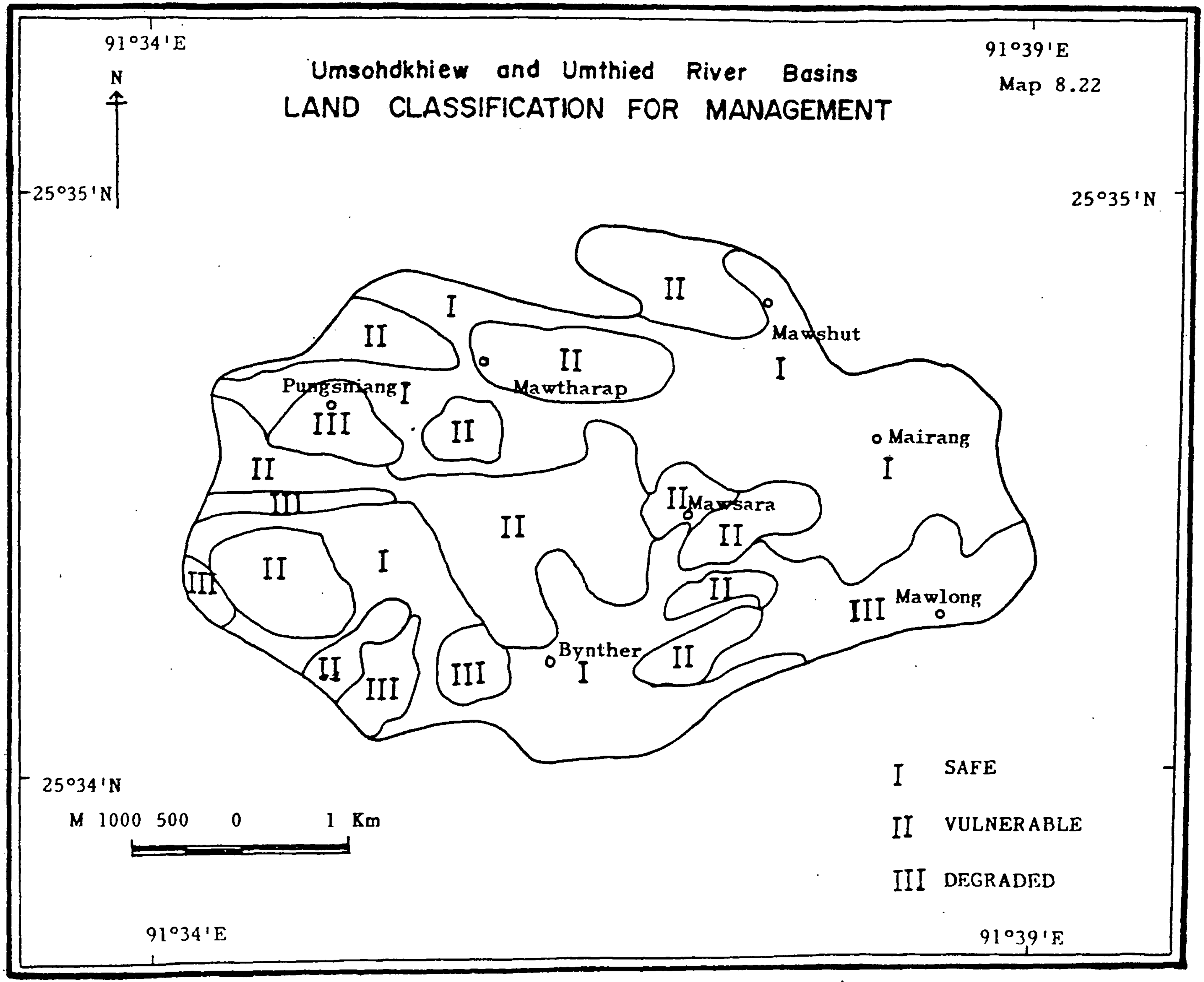
8.5. Land Classification on a Normative Basis

As mentioned earlier, the study aims at micro-level land classification to arrive at a normative division of land of the combined catchment area from the environmental management and agricultural planning point of view. At the micro-level, such normative classes have already been stated to be of three types: (a) the relatively 'safe', (b) the 'vulnerable', and (c) the 'degraded' areas of the combined basin which will help in actual conservation and management practices. On the basis of the attributes mentioned above the Table 8.6 and Map 8.22 provide the micro-level land classification under three different classes.

Table - 8.6: Area and Percentage of Normative Classes of Land in the Combined Basins

Category		Area in sq.km.	P.C.
I	Safe	23.0	44.23
II	Vulnerable	19.0	36.54
III	Degraded	10.0	19.23
	Total	52.00	100.00

The environmentally 'safe' areas are mostly the valleys and therefore, relatively plain areas where wet paddies and potatoes are grown. It has been estimated that about 44.0 per cent area of the combined basin is made up of 'safe' lands for the current types of land use practices. Since, the safe


Umsohdkhiew and Umthied River Basins
LAND CLASSIFICATION FOR MANAGEMENT
Map 8.22
N
91°34'E
91°39'E
25°35'N
25°34'N
Pungsmiang
Mawtharap
Mawshut
Mairang
Mawsara
Mawlong
Bynther
M 1000 500 0 1 Km
I SAFE
II VULNERABLE
III DEGRADED

land is relatively scarce in the combined basins and there is scope of great improvements in the rate of crop yield. It is possible to intensify the cultivation practices by which the farmer gets a better return and thus, taking off the pressure for bringing in additional land under cultivation. The potentiality of land under valley (flat) bottom and gentle slope lands are relatively higher than the steep slopes and crest lands in the West Khasi Hills district. The areas, which have been identified as safe land in the catchment, are also prone to flooding and soil erosion due to heavy rains. Therefore, appropriate management techniques including small irrigation works for the dry seasons can improve the quality of land and the yield.

The vulnerable areas are those which either occur near intensely cultivated valleys and populated areas, high slopes with weathered rocks with heavy rainfall, steep slope zones and areas under intensive shifting cultivation practice (Map 8.22). The vulnerable tracts of land constitute about 37.0 per cent area of the combined basin. Areas classified as vulnerable are those, though productive (both agricultural and forests) in the short run (within a period of 5 years) have the potentiality of getting degraded within the next 5-10 years. There are a few areas under this class, the major part occurring to the north-west and the central high land largely due to the human intervention and also the occurrence of steep slopes. In the vulnerable areas the strategy will have to be protection and conservation which entails a gradual reduction in areas under shifting cultivation with the possibility of providing alternative avenues of earning, terracing and improvements in the agricultural practices with the active cooperation and participation of the farmers. In areas of vulnerability arising out of the natural conditions, soil conservation measures including bunding and other civil works, afforestation on the slopes etc., might be necessary.

About 20.0 per cent area of the combined basin constitutes degraded land which includes the degraded forests and grasslands, the eroded rock slopes of the hills and plateaus and spurs. It has been mentioned in the foregoing chapter that continuously over the years, 1-2 per cent more areas are being added to the degraded land. Due to the rapid indiscriminate felling of forests (for jhumming) and intensive activities on slopes (over 10°-20° slopes), the process of land degradation also will accelerate to 3-4 per cent per year. This process, if continues for 15-20 years, the major part of the combined basin will constitute of degraded land only. As indicated in the map, these areas occur on the side of the valleys of Mairang and Nongban Bynther areas which are densely populated and intensely cultivated areas. These areas require specific land management techniques like, (i) regeneration of forests, (ii) civil works for areas prone to landslides and flood, and (iii) protection measures from the soil erosion and land degradation.

8.6. Summary

In the present chapter an attempt has been made to study the micro-level land classification of the combined area of two small river basins of the district, with the aim of providing basis for environmental as well as agricultural management of land. The main findings of the study are summarised below:

Physiographically, the combined basin area is highly dissected with small hills, spurs and valleys. The distribution of settlements are characterised mainly by the terrain of the region. The concentration of settlement at Mairang village is the highest (872), which accounts for more than 65.0 per cent of the total population of the combined basin. This may be due to the fact that Mairang is the headquarters of Mairang Sub-division of West Khasi Hills and the availability of valley (flat) area with intensive commercial cropping of potatoes. More than 60.0 per cent area of the combined basin has slopes less than 10°, hence, suitable for extensive cropping practices.

As stated earlier, at the micro-level, three types of normative classes have been classified for the combined basin. They are: (i) the relatively 'safe', (ii) the 'vulnerable', and (iii) the degraded land. The percentage of safe land in the combined basin is more than 44.0 per cent of the total geographical area of the basin followed by vulnerable (36.54 per cent) and degraded land (19.23 per cent). A detailed discussion have been attempted of each of the normative classes of land in the combined basin. Some suggestions and policies for 'safe', 'vulnerable' and 'degraded' lands of the combined basin were also discussed.

CHAPTER - 9

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

9.1. Summary

Despite the two hundred years of industrial civilization and its consequent prosperity (or even, poverty) land remains the single most important resource base for mankind. As an offshoot of the industrial phenomenon two philosophical outlooks of man affected the land resources significantly. The first outlook pertains to the supremacy of man over nature with the help of his greater understanding of the natural laws and its inevitable use in technological advancement. The second relates to the inexhaustibility of resource and specifically, the 'land' resource. As a result, with manifold increase in world population and the growing cleavage between the rich and the poor nations, the stress on increased exploitation of land either for food production or demand on housing and settlements and other built up structures and mining and industries has led to shrinkage of availability of land. Moreover, stricter control over international migration does not allow redistribution of population from the over populated to the under populated areas of the world. The single most reason for the alarming situation in land degradation has resulted from over exploitation and under management of crop lands in the developing nations and deforestation in the largest possible scale, although the problem to some extent remains in the developing world. The developing countries have resources and technology to manage reclaim and restore the degraded land if they desire. On the other hand, the developing nations neither have resources nor a large population allows them to neglect the meagre land resource which forms the basis of their sustenance. Therefore, management, preservation and regeneration of land resource remains one of the chief challenges before the developing countries if a sustainable and minimal standard of living is to be provided to their population.

In the present dissertation, an attempt has been made to study a backward, tribal district, West Khasi Hills of the State of Meghalaya in relation to land classification of the district keeping in mind the environmental processes and identifying various land units (facets) for management, preservation, conservation and regeneration of land both from the point of view of agriculture and forestry which happen to be the chief occupations of the people in the district. The study is primarily taxonomic with normative implications. The main approaches to land classification can be outlined in the following manner.

1. There are three bases of land classification which has been attempted here:

(a) Land classification on the basis of the genetic characteristics and landscape characteristics;

(b) Land Classification on the basis of the land potential with a parametric approach; and

(c) Land Classification on the basis of policy objectives, specifically the environmental management policy in view.

2. The other important approach is also the detailed land classification of the combined catchment area of Um Sohdkhiew and Umthied (two tributaries of the river Kynshi) which will provide indepth insight into the problem since, land classification at the level of the district can be considered as too broad a level.

The main findings of the study are summarised below:

In Chapter 1 of the dissertation, the problem and scope of the study, the hypotheses and the research issues have been outlined. The summary of the relevant literature available for the study and the details of methodology, data base and data analysis-methods and techniques have been discussed in the Chapter 2 and 3, respectively. Chapter 4 provides the general information on population (growth, density, work force etc.), settlement distribution, settlements under shifting cultivation and the economy, mainly agriculture and forestry.

In the first part of the Chapter 5, attempt has been made to identify the macro-regions (ecological zones) in the

West Khasi Hills district. There are ten macro-regions (ecological zones) which have been identified on the basis of genetic approach using the environmental factors like - geology, relief, slope, drainage, climate and vegetation. The regional variations among the environmental factors are significant in the district and they are responsible for the existing landforms. A detailed discussion has been made for these environmental factors which have been used for the demarcation of macro-regions and at the same time, the characteristics of each and every macro-region have been discussed.

In the second part, a discussion has been made to identify the 'land facets' (micro-regions) in the district on the basis of landscape approach. As stated earlier, 'land facet' is a nomenclature given to small land units with homogeneous environmental (or geographical) characteristics. Such characteristics may be the geology, the slope, the predominant soil type or vegetation cover. But, in the present situation of a plateau area, the major control characteristics in determining the facet is found to be the 'slope'. Of course, other characteristics have been assessed too. Considering slope as the main controlling characteristic in determining the land facet, five types of land facets have been identified in the district. They are:

(i) Valley (flat) land - $< 2°$ slope

(ii)	Gentle slope	- 2° - 10° slope
(iii)	Medium slope	- 10° - 20° slope
(iv)	Steep slope	- 20° + slope
(v)	Crest land	- Generally mildly undulating.

The entire district has been divided into detailed land facets. There are altogether 189 land facets in the district and they have been outlined in the relevant tables and maps. About 40.0 per cent geographical area of the district is classified as medium slopes (where slopes vary from 10° to 20° slope). The valley (flat) lands, gentle slopes, steep slopes and crest lands occupy 16.58 per cent, 19.63 per cent, 18.87 per cent and 5.72 per cent, respectively. Macro-region-wise, Jadukata river valley (7) has the largest valley (flat) lands, accounting for 31.82 per cent area of the rgion, followed by Nongstoin-Markasa (3) and Balat-Pamkunda (6) macro-regions.

An analysis of evaluation of land potential by use of rating index based on detailed sampling of soils (382) covering the entire district has been attempted in the Chapter 6 of the dissertation. It has been ascertained that out of the three groups of soil characteristics, namely - the physical, the chemical and the site characteristics, soils in the valley (1.67) and gentle slopes (1.61) (< 10° slope) are found to be most favourable in potential, while the crest lands (1.56) and steep slopes (1.47) (> 20° slope) are the least favourable soils. The physical characteristics, are not as favourable to the valley (1.13) than the gentle slopes (1.16) although the textures of finer (clay), the colours deeper (Deep Brown) and the structures strong. From the availability of chemical nutrients, valley soils are the best with high NPK status and availability of deeper formations of humus and therefore, the presence of organic carbon. However, the pH status of the entire district is highly acidic and therefore, it hampers the process of nutrients transfer (cations exchange) from soil to plants.

There is also a 'gradation' of soil properties from valley bottom facets to crest lands so far as site characteristics are concerned.

When interpreted macro-region-wise (the ten macro-regions), it is noticed that the soil rating status of six macro-regions namely, Riangdo and Nongumdang (8), Mairang (2), Nongstoin (3), Nongkhlaw and Mawdoh (10), Rambrai (1) and Balat and Pamkunda (6) are relatively good. It may be pointed out that these areas contain relatively more of valley and gentle slope areas. Moreover, the percentages of good and very good qualities of soils are relatively higher in these macro-regions. For example, Riangdo and Nongumdang (8) macro-region has got the highest percentage in very good quality soils, followed by Nongkhlaw and Mawdoh (10), Mairang (2) and Nongstoin (3).

Of all the environmental problems facing the country, the problems of deforestation has received the maximum importance from the point of view of soil erosion and land degradation. As it is mentioned earlier, one of the main casualities of the process of desertification is the hill areas of North East Region of India, where land is being degraded quickly by its faulty use pattern. With the increase in population (3 per cent per annum) and without any significant availability of other avenues of employment, there is a consistent pressure on land and land based resources, particularly, in the West Khasi Hills district of Meghalaya. This has resulted in complete occupation of valley lands permanently and the slopes and crest lands have been occupied by shifting cultivation, resulting in severe soil erosion and land degradation.

Keeping in view the above, a normative basis of land classification (Map 7.14) has been attempted for environmental and agricultural management of the district in three categories; land classified as environmentally 'safe', 'vulnerable' and 'degraded'. More than 70.0 per cent of the land area of the district is classified as vulnerable lands. The vulnerability of land arises out of intensification of landuse on slopes, deforestation and reduction in shifting cultivation cycle (< 5 years). It may be mentioned here that the north and north-western parts of the district are the most vulnerable due to shifting cultivation on hills and slopes. The safe and the degraded areas of the district are 15.10 per cent and 13.10 per cent, respectively. The environmentally safe areas are mostly the valley and therefore, relatively plain areas where wet paddies and potatoes are grown. Since, land is scarce in the district and there is a scope of great improvements in the rate of crop yield, it is possible to intensify the cultivation practices. The degraded land includes the areas of the eroded rock slopes of the hills and spurs, degraded forests and the grass lands. As mentioned earlier, that due to the acceleration in deforestation and intensification of activities on slopes (over 15-20 degrees and above), the process of land degradation also will accelerate to 3-4 per cent per year. This would mean that within the next 20-25 years a major part of the district will constitute of degraded land only. As indicated in the Map 7.14, degraded areas occur on the both sides of the valleys of the central highland which is densely populated and intensely cultivated. Therefore, these areas require special management techniques as stated earlier, like - (i) civil works for areas prone to landslides, (ii) regeneration of forests, and (iii) protection measures.

Lastly, an attempt has been made to study the micro-level land classification of the combined area of two small river basins of the district, with the aim of providing basis for environmental as well as agricultural management of land.

The study has been attempted on the basis of landscape approach to micro-level land classification by using aerial photographs pertaining to the combined basin. From the Map 8.17 it is clear that the concentration of settlements at Mairang village is the highest (872), which accounts for more than 65.0 per cent of the total population of the combined basin. Moreover, the density of population is 135 persons per sq.km. (Census 1981) which is more than four times that of the district. This may be due to the fact that the area of the combined basin is small and intensively used for agriculture. Mairang village has got the highest population due to the fact that Mairang is the headquarters of Mairang Sub-division. Moreover, Mairang is almost a valley (flat) area with intensive commercial cropping of potatoes and has good transport and communication with Shillong, the capital of Meghalaya. The classification of average slope zones in the combined basin shows that more than 50.0 per cent area has slopes less than 10°. About 22.0 per cent area has slopes of 10°-20° and another 16.0 per cent area has slopes more than 20° slopes in the combined basin. As a result of the availability of valley and gentle slopes, a large part of the combined basin has been put for permanent agriculture, like - wet paddy cultivation. The situation of forest cover in the combined basin is rather in a pathetic condition due to the indiscriminate felling of forests and the occupation of hill slopes. The total forest cover in the combined basin is 22.0 per cent which accounts for 11.5 sq.km. of the total area of the basin. Out of which 82.6 per cent and 17.40 per cent come under degraded and moderately degraded forests, respectively.

The agriculture is the main occupation in the combined basin. About 41.0 per cent area of the combined basin has been utilized for different types of agriculture of which permanent cultivation (mostly wet paddy) occupies 23.0 per cent, followed by terrace cultivation (10.0 per cent) and hill slope/top cultivation (8.0 per cent). Rice, maize, potatoes, vegetables, chillies etc. are grown in gardens, particularly the higher slopes as subsidiary food crops. A considerable area is also devoted to high land paddy. It could be mentioned that the cropping pattern in the combined basin is determined more by the topography and rainfall than by any other factor.

Keeping in view the above, an attempt has been made to identify the small land units (land facets) with homogeneous environmental (or geographical) characteristics in the combined basin. A total of 64 land facets have been identified of which

43.27 per cent area falls under flat and valley land facets, followed by gentle slopes (17.31 per cent), medium slopes (15.38 per cent), steep slopes (13.46 per cent) and crest lands (10.58 per cent). On the basis of the attributes mentioned above the Map 8.22 (Chapter 8) provides the micro-level land classification for the combined basin from the environmental and agricultural planning point of view. At the micro-level, such normative classes have already been stated to be of three types: (a) the relatively 'safe', (b) the 'vulnerable', and (c) the 'degraded' land. More than 44.0 per cent area of the combined basin has been identified as relatively 'safe' area and therefore, intensification of crop practices would help the farmers to get better return and thus, taking off the pressure for bringing in additional land under cultivation. The vulnerable tracts of land constitute about 37.0 per cent area of the combined basin. This vulnerability occurs due to the human intervention and also the occurrence of steep slopes. In the vulnerable areas the strategy will have to be protection and conservation. Measures like bunding, terracing, afforestation on the slopes etc. might be necessary. The degraded land constitutes about 19.0 per cent area of the combined basin which includes the degraded forests and grasslands, the eroded rock slopes of the hills and plateaus and spurs. As stated earlier, that continuously over the years, 1-2 per cent more areas are being added to the degraded land for the district but in case of the combined basin, the process of land degradation (due to population pressure, indiscriminate felling of trees and intensification of agriculture) will be much higher than the district. Therefore, in the degraded land strategy will have to be regeneration of forests and protection measures from soil erosion and land degradation.

9.2. Conclusion

On the basis of the aforesaid study, several implications of general and specific nature arise which require consideration from academicians, policy makers and administrators.

1. Land degradation and desertification which is assuming serious proportions in the developing nations specifically in high density, land dependent, agricultural countries like India, need earnest, immediate and appropriate management and conservation measures if a sustenable and tangible path to development is to be sought. In recent years, the concern of the Government of India on issues of environment, ecological balance, forest policies, and waste land management and regeneration through establishment of various bodies enactment of federal laws and large investments on these sectors like, social forestry, Ganga Action Plan, Waste Land Board, and Hill Area Plans are pioneering efforts compared to other similarly placed developing nations.

However, the question of land conservation, regeneration and management cannot be approached but from a holistic point of view. In the Indian situation, though land has always remained, historically, in short supply and intensively used for centuries academic efforts, specifically, from geographers have been at best patchy and segmented. Comprehensive classificatory studies on the potentials of land for potential agricultural or other uses have not been adequately studied. In this respect the current study is a first attempt to study various land classes, their potentials and problems from the point of view of management policies for the West Khasi Hills district of Meghalaya which is undoubtedly one of the most backward district of the country and is threatened with severe land degradation.

2. As discussed earlier, the genetic and landscape approaches to land classification are essentially taxonomic in character which for the geographer provides the essential base of understanding the manifest reality. In a situation, where land is neither cadastrally surveyed and therefore, no detailed maps being available, the two tier classification provides a basis for understanding the nature and characteristics of land units of various levels systematically. It also provides insight into the micro causal factors which differentiate one land unit from the other. It is significant that the micro-ecological controls like - slope, natural vegetation, moisture availability and the soil potentials determine the potentials for use of the land to which it can be brought

into. It is these micro variations rather than the commonality of their characteristics which are of interest to us.

3. The parametric approach based on a large number of field samples of soils, profiles and nature of the site characteristics provide insight into the positivist potential of land. Among the five classes of micro-land units (land facets) the valley lands and the gentler slopes which traditionally have been first to be occupied and intensely used are potentially the best for agricultural purposes. However, the medium slopes, the steep slopes and the crest lands have been also occupied whether under permanent slope fields, terraces or under shifting cultivation practices and are the least suitable and highly vulnerable to land degradation. In the district, the potential of the valley and the gentle slopes have not been fully exploited neither in coverage nor through improved crop culture nor in management. Out of the total geographical area of 5,247 sq.km. the valley and the gentle slopes cover nearly 37.0 per cent i.e., 1941 sq.km. or 194,100 hectares. However, the net sown area of the district is less than 4.0 per cent of the total geographical area. The potential land for agriculture i.e., 194,100 hectares provide a per capita availability of land in the district to the extent of 1.2 hectares which *prima facie* seems adequate from the point of view of food and other needs of the population. Therefore, there seems no justification for occupation of low potential

and highly vulnerable lands as stated for purpose of agriculture or associated usages. Moreover, the medium, steep slopes and crest lands can be put to forestry and horticulture which in long run not only yield higher returns but also help in stabilisation of slopes and therefore, conservation of soils. A number of other scientific studies as cited earlier (Chapter 2) corroborate similar findings and have a suggested appropriate policies for crop plant and management for the hill areas of the region.

4. The study based on an approach of land classification for environmental management of land identifies three broad normative classes of land such as the 'safe', the 'vulnerable' and the 'degraded' lands. This helps us in locating these classes of land in the district, their areal extension, the causal factors and, thus, the necessary policy implications appropriate to those classes of land. For example, the safe class of land can be put to further intensification under suitable crop plants or if not occupied to be brought under exploitation. The vulnerable class of lands are to be protected and conserved either through lessening of intensification of use, terracing, bunding, planting of horticulture plants, reduction in areas under shifting cultivations, reducing deforestation and programmes of afforestation. The degraded lands need specific measures of protection, conservation, and regeneration until their ecology becomes stabilized.

The micro-level study of the combined basin of two rivers such as Um Sohdkhiew and Umthied provide similar implicatons, but being located in a high population density area the nature of exploitation of land is at a higher degree and a large part of the agricultural land is put to commercial crop culture like - potato cultivation. This has resulted in making the entire basin area highly deforested and therefore, vulnerable to land degradation. Thus, in such micro-scale appropriate management measures require immediate attention.

The present study is essentially of taxonomic character and therefore, exploratory in nature. The principal aims, therefore, were to explore the pattern and nature of land classes in their horizontal and generic levels on the basis of existing situation of land. Therefore, no major hypothesis has been planned to be investigated. However, a number of secondary hypothesis have emerged during study (in Chapter 1).

The findings of the Chapter 6 of the dissertation provide that the soils of valley (flat) land and gentle slopes are relatively better in potential than the medium, steep slopes and crest lands. On the other hand, land potentiality declines with altitude and slope. Therefore, the results satisfy the first two hypotheses of the dissertation. Chapter 7 provides that the vulnerability of land arises out of intensification of land use on slopes, deforestation and reduction in the shifting cultivation cycle (< 5 years). The pressure of population of cultivable land has gone up tremendously which has been resulted in occupation of valley land permanently. The slopes and crest lands have been occupied by shifting cultivation, resulting in severe soil erosion and land degradation in the district. This supports the validity of the hypotheses third and fourth.

A micro-level land classification has been attempted in Chapter 8 of the dissertation which provides normative classes of land for environmental and agricultural management of land in a combined river basin. The study indicates that vulnerability and degradation of land arises out of improper or under utilization of existing valley land of the combined river basin. Moreover, the process of deforestation could be minimized if there is any occupational shift and management of land in the district.

9.3. The major limitations of the study are:

i) The present study deals with the land classification based on genetic, landscape and parametric approaches. No study has so far been attempted in this line in India and particularly, for North East Region. The available studies attempted in this line in India on land classification have been based on land use and land capability classification only. Due to the lack of comparable study for Indian situation, the present study is hampered in improving the methodology.

ii) The district lacks in reliable data and information i.e., secondary information on different aspects of land, existing land use pattern including the extent of shifting cultivation etc. This restrict the study to largely primary and map based data available.

iii) As in rest of the tribal and hill regions of North East, there has been no systematic surveying of land of West Khasi Hills. Since, land is not cadastrally measured, non-availability of detailed maps is a major limitations to which the study was to cope with.

9.4. Suggestions for Further Study

There is a necessity of further detailed studies on land use practices and land classification of the district. The main hurdles before any researcher in this area is the lack of measurement of land (cadastral surveys) which is now high time to be carried out. The greater utilization of aerial photographs at micro-level preferably scale lower than 1:25,000 should be available to the researchers. Moreover, efforts should be made by the concerned authorities to conduct extensive field survey in connection with land classification for the planning purpose. Moreover, in situations like the present one, greater field based approach is the need for the hour, which shall remain of immense challenge to researchers, if fruitful and relevant research is to be carried out on these remote and inaccessible regions of the country.

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APPENDICES

APPENDIX - 3.A

3.A.1. Relief Map (Methods of Representation)

The different methods employed to represent elevation and relief can be grouped under three heads:

i) Pictorial,

ii) Mathematical, and

iii) Combination of the previous two.

Among the three methods, 'Contour Method' of mathematical method is the standard method of representing relief.

Contour Method

Contouring is the standard method of representing relief. Contours are imaginary lines of the ground joining adjacent places at the same height above sea levels.

Construction of Relief Map

Contours of an interval of 150 metres have been traced from the topographical sheets of West Khasi Hills district of Meghalaya. Both 1:63,360 and 1:50,000 scales were used. But taking contour interval of 150 metres, the average relief map was prepared and reduced to a scale of 1 cm to 10 km.

3.A.2. Determination of Average Slope by Wentworth's Method

There are several methods of average slope determination of which Wentworth's method is a 'general and random' method and is easier to follow. The formula of Wentworth's method is given below:

$$\theta^\circ = \tan^{-1} \frac{N \times I}{3,361}$$

Where, 'N' is the average number of crossings of contours per mile,

'I' is the contour interval,

'θ' is the average angle of slope, and

3,361 is constant number.

Construction

Taking one inch equal to one mile, the topographic sheets were divided into a number of small squares. To determine the average angle of slopes for every square had to calculate their in degrees. The calculated angles were plotted in their respective squares and a choropleth map has drawn to depict the variations in the angles of slope over the different parts of the district.

3.B. Laboratory Methods of Mechanical Analysis of Soil

There are two methods for determining the mechanical analysis of soil. One is called Pipette Method and the other Hydrometer Method. But, for accurate work, the Pipette Method is employed. This method is based on the Stock's Law. For this study, the Pipette method has been used.

Stock's Law

Stock's (1851) suggested the relationship between the radius of a spherical particle and its rate of fall in a liquid.

He stated that resistance offered by the liquid to the fall of the particle varied with the radius of the sphere and not with the sphere. The formula is given below -

$$V = \frac{2gr^2(dp-d)}{9n}$$

Where, V = Velocity in Cm/Second

g = Acceleration due to gravity

dp = Density of the particle

d = Density of the liquid

n = Absolute viscosity of the liquid

APPENDIX - 3.B

Procedure (for Sand, Silt and Clay Separation)

20 gm of air-dry fine earth (<0.2 mm diameter) is transferred to a 1000 ml beaker, 60 ml of 6% (20 volume) H_2O_2 is added and mixed well and allowed to react for 15 minutes. After 15 minutes, the beaker is immersed into the Hot Water bath for 5 minutes. Stirring was continued to avoid frothing over. To remove, a further 35 ml of H_2O_2 is added and after a minute, the beaker is replaced on top of the Hot Water bath for 10 minutes and then immersed again for 5 minutes. The solution is diluted to about 150 ml and brought to boil on a burner.

Acid Treatment

1. After coding the beaker, 25 ml of 2 NHCL is added.
2. The sample is diluted to approximately 250 ml and allowed to react for an hour, rubbing at 15 minutes intervals.
3. After an hour, the solution is filtered through a Buchner funnel using hardened filter paper (11 cm Whatman No. 44).
4. After the washing was completed, the filter paper was spreaded out and transferred the material to the 1000 ml cylinder.

Dispersion (Silt and Clay Separation)

The volume was made up after rendering it alkaline to phenol-phthalein, with 10 ml of N/1 NaOH solution. After shaking (on a shaker), the suspension was allowed to stand for overnight.

Separation of Silt and Clay

The suspension had to shake by repeated inversions of the cylinder for about 1 minute and allowed to stand for requisite time taken from the silt column against the observed temperature in Table 3.B.1. 25 ml of the suspension has been withdrawn in a pipette fixed in a cork so that when the cork rests on the top of the bottle, the point of the pipette is at required distance below the surface of the suspension (10 cm in this case). The sample has been dried at 100°C, then ignited and weighed as silt plus clay.

Calculation

Weight of dish = W_1

Weight of dish + Silt + Clay = W_2
(in 25 ml suspension)

Weight of Silt + Clay = $W_2 - W_1$

Percentage of Silt + Clay in the soil

$$= \frac{(W_2 - W_1)\ 1000 \times 100}{25 \times 20}$$

Clay

The content of the cylinder has been shaked again for one minute and sampled in the same way at a depth of 10 cm after the settling time taken from the clay in the table.

Calculation

Weight of dish $= W_1$

Weight of dish + clay (in 25 ml suspension) $= W_2$

Weight of clay $= W_2 - W_1$

$$\text{Percentage of clay} = \frac{(W_2 - W_1)\,1000 \times 100}{25 \times 20}$$

Sand

Pouring away the bulk of the supernatant liquid and transferred the sediment to a 400 ml beaker, making up with water to a height of 10 cm above the base. After stirring well, the liquid had to allow to stand for the requisite period taken from the silt column in the table against the observed temperature. The turbid suspension had to pour away until the liquid was no longer turbid at the end of the process. The residue was the sand which was collected and dried at 100°C.

Calculation

Weight of dish $= W_1$

Weight of dish + sand $= W_2$

Weight of sand $= W_2 - W_1$

$$\text{Percentage of sand} = \frac{(W_2 - W_1)\,100}{20}$$

Table - 3.B.I: The Times of Sedimentation for the Clay and Silt Fractions (Depth of Sedimentation 10 cm)

Temperature °C	Clay Decantation Time Hrs.	Clay Decantation Time Mins.	Silt Decantation Time Mins.	Silt Decantation Time Seconds
8	11	-	6	40
9	10	40	6	30
10	10	25	6	20
11	10	10	6	10
12	9	60	6	-
13	9	35	5	50
14	9	20	5	40
15	9	5	5	30
16	8	50	5	20
17	8	35	5	10
18	8	25	5	-
19	8	10	5	0
20	8	0	4	48
21	7	50	4	40
22	7	40	4	30
23	7	25	4	30
24	7	15	4	20
25	7	5	4	15
26	6	55	4	10
27	6	45	4	5
28	6	30	4	0
29	6	20	3	55
30	6	15	3	50
31	6	5	3	45
32	6	55	3	40
33	5		3	35

Source: S.L. Chopra, Analytical Agricultural Chemistry, A Oxford and IBH Publications, p. 48.

APPENDIX - 3 C

LABORATORY METHODS OF CHEMICAL ANALYSIS OF SOIL

3.C.1. Determination of Available Nitrogen in Soil

Reagents

(1) 0.32% $KMnO_4$ solution,

(2) 2.5% NaOH,

(3) Liquid paraffin,

(4) 0.2 N H_2SO_4,

(5) 2% H_3BO_3, containing 20 ml of mixed indicator/ liquid,

(6) Mixed indicator: 0.66 gm methyl red plus 0.099 gm Bromo-cresol green dissolved in 100 ml of 95% ethyl alcohol.

Procedure

20 gm of sieved (< 0.2 mm) soil was taken in 100 ml Kjeldahl flask. 20 ml of water was added flowed by 100 ml each of 0.32% $KMnO_4$ and 2.5% NaOH.F during boiling was prevented by liquid paraffin (1 ml) and bumping by adding a few glass beads. The contents are distilled at a steady state and the liberated NH_3 is collected in the conical flask containing 20 ml of boric acid solution. About 100 ml of distillate is collected which is titrated with 0.2N H_2SO_4.

Calculation

$$\% \text{ of Nitrogen} = R \times \text{dilution factor} \times N \frac{1.4}{S}$$

Where, R = Volume of 0.2N H_2SO_4 used in titration

N = Normality of Standard Acid

S = Sample Weight, and

1.4 is a constant factor

3.C.2. Determination of Available Phosphorus in Soil Using Bray's Method No. 1 (For Acid Soil)

Apparatus

1. Photoelectric Calorimeter of Spectophotometer,
2. Pipette of various kinds & shaker.

Reagents

(a) Bray's Extractant No. 1

Dissolved 2.22 gm Ammonium Fluoride (NH_4F) in 20 ml of distilled water and added solution to 1.8 lits of water containing 4 ml of Cons. HCL. The solution had to volume to 2 lits.

(b) Molybdate Reagent

Adjectly 15 gm of AR reagent Ammonium molybdate ($(NH_4)_2$ MO_4) is taken and dissolved in about 300 ml of water. Warmed it to about 45°C. This molybdate is cooled and 350 ml of 10 N HCl is added slowly with rapid strain, when this solution cooled down again to room temperature, it is diluted with distilled water to adjectly 1 litre and mixed thoroughly.

(c) Stannous Chloride Stock Solution ($SnCl_2 2H_2O$)

Dissolved 10 gm $SnCl_2$ in 25 ml of Cons HCl (prepared only 5 ml each time and stored in coloured bottle).

(d) Working Solution of $SnCl_2 2H_2O$

Diluted 0.5 ml of stock solution (c) to 66 ml with distilled water just before use. It had to prepare fresh dilute solution every working day.

Procedure

4 g of Sieved (<0.2 mm) Soil is taken in 250 ml conical flask to which 14 ml of Bray's extraction solution is added and stirred for 15 minutes with the help of magnetic stirrer. The solution is filtered through Whatman No. 44 filter paper 2 ml of the filtrate was taken in a test tube diluted with 5 ml distilled water and 1 ml of ammonium molybdate and 1 ml of Stannous Chloride solution are added. The test tube is shaken for 10 minutes. After 20 minutes optical density is determined at 660 mm using Bray's extract from the control (without Soil) as the blank.

Calculation

$$\% \text{ Phosphorus} = \frac{C(\text{mg}) \times \text{Solution Volume (ml)}}{10 \times \text{Aliquot (ml)} \times \text{Sample Weight (g)}}$$

Where, C = mg phosphorus obtained from the standard curve.

To convert P to P_2O_5 the above figure was multiplied by 2.29.

Table 3.C.1 shows the Guide to Phosphate Status in Soil.

Table - 3.C.1: Guide to Phosphate Status in Soil

Phosphate Status	mg P_2O_5/100 gm Soil
Very low	0 - 1.4
Low	15 - 3.0
Medium	3.1 - 6.0
Medium High	6.1 - 10.0
High	10.1 - 20.0
Very High	> 20.1

Source: Figures from Gilchrist - Shirlaw (1967)

3.C.3. Determination of Exchangeable 'K' in Soil (Flame Photometer Method)

(1) Flame Photometer

(2) Pipettes of different types

(3) Shaking machine

Reagents

(a) Normal (N) Neutral Ammonium Acetate Solution (pH_7):

Dissolved 1540 gm Ammonium Acetate in 20 litres of water. After testing with pH meter, the solution is added ammonium hydroxide to bring it to pH 7.

(b) Standard Potassium Solution:

1.907 gm of KCl is dissolved in 1 litre distilled water.

(c) Working Solutions:

For preparation of working solution of 100 ppm K by taking 10 ml of standard K solution (by taking item (b) in a 100 ml Volumetric flask).

Procedure

5 g of air-dried soil (< 0.2 mm) is transferred to a 500 ml conical flask and 25 ml of ammonium acetate extraction solution (pH 7) is added stirred for 1 hour with the help of mechanical shaker. The solution is filtered through Whatman No. 44 filter paper. 2 ml of the filtrate is diluted with 10 ml of distilled water and read in Flame Photometer.

Calculation

$$\% \ K = \frac{C(mg/L) \times \text{Solution Volume (ml)}}{10 \times \text{sample weight (g)}}$$

Where, C = mg/L of 'K' obtained from Standard Curve.

To convert 'K' to 'K_2O' the above figure was multiplied by 1.20.

Table 3.C.2 shows the figures from Gilchrist - Shirlaw (1967) for Potass status.

Table - 3.C.2: The Figures from Gilchrist - Shirlaw (1967) for Potass Status

Potass Status	mg K_2O/100 gm Soil
Very Low	0 - 6
Low	6 - 10
Medium	10 - 18
Medium High	18 - 28
High	28 - 35
Very High	> 35

3.C.4. Determination of Organic Carbon by Walkly and Black's (1934) Method

Reagents

(i) Potassium Dichromate (N/1) Solution:

49.04 g of $K_2Cr_2O_7$ is dissolved in water and diluted to 1 litre.

(ii) Ferrous Ammonium Sulphate (N/2) Solution:

392 g of A.R. Grade $Fe(NH_4)_2\ (SO_4)_2\ 6H_2O$ in 800 ml water with 15 ml Conc. H_2SO_4 and diluting to 2 litres of water.

(iii) Diphenylamine Indicator:

0.5 g diphenylamine is dissolved in 20 ml of water and 100 ml Conc. H_2SO_4.

(iv) Phosphoric Acid (H_3PO_4, 85%).

(v) Conc. H_2SO_4 not less than 96%.

Procedure

1 g (<0.5 mm) air-dried soil is transferred to a 500 ml conical flask. 10 ml N/1 $K_2Cr_2O_7$ is added, followed by 20 ml 96% H_2SO_4. The flask is swirled gently for about a minute ensuring that no soil escapes contact with the reagents. The flask is then allowed to stand for 20-30 minutes on a heat proof surface. The solution is diluted with 200 ml distilled water and 10 ml 85% orthophosphoric acid (H_3PO_4). To this mixture is added 0.2 g solid NaF and 1 ml diphylamine indicator. This is then titrated against the standard ferrous solution (in burette). Intially, a dull green Chromous Colour is observed; this will turn blue, while the end point (quite sharp) is a bluish green. A blank titration is run using the same procedure but without adding soil. This standardises the ferrous solution against the Chromic acid.

Calculation

Weight of the soil taken = W gm

Volume of N/2 Ferrous Ammonium Sulphate required for reducing 10.5 ml $K_2Cr_2O_7$ solution (blank reading) = X ml

Volume of N/2 Ferrous Ammonium Sulphate required for reducing the excess of dichromate = Y ml (Experimental Reading)

$\therefore$ Difference = (X - Y) ml

1 ml of N/1 $K_2Cr_2O_7$ = 0.003 gm Carbon

$$\therefore \text{ Percentage of Carbon in Soil} = \frac{(X-Y) \times 0.003 \times 100}{2 \times W} = Z$$

$$\therefore \text{ Percentage of Organic matter in Soil} = \frac{Z \times 100}{58}$$

$$= Z \times 1.724$$

3.C.5. Determination of Soil pH by pH Meter Method

10 g of air-dried soil is taken in a 250 ml beaker and added 25 ml of distilled water. After shaking of 30 minutes reading is taken from pH meter. Before this, the pH meter is adjusted by using buffer of pH 4 and pH 9.2 (Tables to be dissolved for respective buffers). In the soil suspension, both the electrodes have been deepened and soil pH reading has been taken using 0 to 7 or 7 to 14 pH scale of the pH meter. Care has to be taken to keep the pH meter in Zero position while changing the soil samples.

Calculation

The average of three readings have been taken for pH value of soil.

APPENDIX - 6.A

6.A.1. Principal Component Analysis (After, M.G. Kendall)

Suppose that we have observations of p variables X on each n individuals. Now, an attempt has been made to simplify the situation, whether it is possible to find some new variables ξ_1, ξ_2 .... ξ_p which are linear functions of the X's but are themselves uncorrelated. In fact, we look for p^2 constants l_{ij} (i, j = 1, ..., p) such that

$$\xi_i = \sum_{j=1}^{p} l_{ij} X_j \qquad ..... \quad (1.1)$$

If the X's are measured from their means, the sum of any X_j over the n individuals is zero and hence, from (1.1), the same is true of any ξ_i. We now impose the condition that the ξ's be uncorrelated, i.e. that

$$E(\xi_i \ \xi_j) = E\left[\sum_{k=1}^{p} l_{ik} X_k \sum_{m=1}^{p} l_{jm} X_m\right] = 0, \quad i \neq j \quad .... \ (1.2)$$

This equivalent to,

$$\sum_{k,m=1}^{p} l_{ik} l_{jm} E(X_k X_m) = \sum_{k,m=1}^{p} l_{ik} l_{jm} C_{km} = 0, \ .... \ (1.3)$$

Where C_{km} is the covariance of X_k and X_m. We note from (1.2) that this imposes $\frac{1}{2}p(p-1)$ conditions on the l's. There are p^2 of them, so we can impose a futher $p^2 - \frac{1}{2}p(p-1)$ conditions and still find a solution. We have to impose the condition that the transformation is self-orthogonal, i.e. that,

$$\sum_{i=1}^{p} l_{ij} l_{ik} = 0, \quad j \neq k$$
$$= 1, \quad j = k \qquad \ldots. \ (1.4)$$

This thus absorbs the $\frac{1}{2}p(p+1)$ degrees of freedom in the transformation, so that under these conditions there will, in general, be only a finite set of solutions.

Geometrically, the orthogonality conditions (1.4) mean that in the first space we are looking for a rotation of the co-ordinate axes about the origin. The relations are most conveniently expressed in matrix form. Representing the X's by the column (p x 1) vector X and similarly for the ξ's, we have, corresponding to (1.1)

$$\S = lx \quad \ldots.. \ (1.5)$$

The orthogonality conditions (1.4) are equivalent to

$$ll' = I, \quad \ldots.. \ (1.6)$$

Where I is the identity matrix (i.e. ap x p matrix with units in the diagonals and zeros elsewhere). If we pre-multiply (1.6) by l' and post-multiply by the inverse of l', we have equivalently

$l'l = I$ ..... (1.7)

It will follow from (1.5) that

$X = l'\xi$ ...... (1.8)

For the covariances of the ξ's we have, corresponding to (1.3).

$E(\xi\xi') = E\,[lX(lX)'] = E(lXX'l') = lCl' = \lambda$, ... (1.9)

Where λ is a matrix with zero off-diagonal elements and with diagonal elements λ_1, λ_2, ... λ_p representing the variances of the ξ's. Premultiplying (1.9) by l', we find that,

$Cl' = l'\lambda$ ...... (1.10)

In full this is,

$$\begin{bmatrix} C_{11} & C_{12} & \cdots & C_{1p} \\ C_{21} & C_{22} & \cdots & C_{2p} \\ \cdots & \cdots & \cdots & \cdots \\ C_{p1} & C_{p2} & \cdots & C_{pp} \end{bmatrix} \begin{bmatrix} l_{11} & l_{21} & \cdots & l_{p1} \\ l_{12} & l_{22} & \cdots & l_{p2} \\ \cdots & \cdots & \cdots & \cdots \\ l_{1p} & l_{2p} & \cdots & l_{pp} \end{bmatrix}$$

$$= \begin{bmatrix} l_{11} & l_{21} & \cdots & l_{p1} \\ l_{12} & l_{22} & \cdots & l_{p2} \\ \cdots & \cdots & \cdots & \cdots \\ l_{1p} & l_{2p} & \cdots & l_{pp} \end{bmatrix} \begin{bmatrix} \lambda_1 & & & \\ & \lambda_2 & & \\ & & \cdots & \\ & & & \lambda_p \end{bmatrix} \quad ..(2.11)$$

Expanded in full this would give us p^2 equations. Consider the subset of p derived from the first column in the matrix product:

$$C_{11}l_{11} + C_{12}l_{12} + \dots + C_{1p}l_{1p} = l_{11}\lambda_1$$

$$C_{21}l_{11} + C_{22}l_{12} + \dots C_{2p}l_{1p} = l_{12}\lambda_1$$

$$\dots \quad \dots \quad \dots \quad \dots \quad \dots$$

$$C_{p1}l_{11} + C_{p2}l_{12} + \dots + C_{pp}l_{1p} = l_{1p}\lambda_1 \qquad \dots\dots(1.12)$$

Or,

$$(C_{11} - \lambda_1)l_{11} + C_{12}l_{12} + \dots + C_{1p}l_{1p} = 0$$

$$C_{21} + (C_{22} - \lambda_1)l_{12} + \dots + C_{2p}l_{1p} = 0$$

$$\dots \quad \dots \quad \dots \quad \dots \quad \dots$$

$$C_{p1}l_{11} + C_{p2}l_{12} + \dots + (C_{pp} - \lambda_1)l_{1p} = 0 \;\dots\dots\; (1.13)$$

Eliminating the l's, we have,

$$\begin{bmatrix} C_{11} - \lambda_1 & C_{12} & \dots & C_{1p} \\ C_{21} & C_{22} - \lambda_1 & \dots & C_{2p} \\ \dots & \dots & \dots & \dots \\ C_{p1} & C_{p2} & \dots & C_{pp} - \lambda_1 \end{bmatrix} = 0 \qquad \dots.(1.14)$$

Or, in matrix notation,

$$| \; C - \lambda_1 I \; | = 0 \;\dots.\; (1.15)$$

It will be found that the other equations in $\lambda_2, \ldots, \lambda_p$ are of exactly the same kind. Thus the required λ's (the variances of the ξ's) are the p roots of

$$| C - \lambda I | = 0 \quad \ldots\ldots (1.16)$$

The λ's are, in fact, the so called eigen values of the matrix C. The corresponding l's are the components of the eigen vector.

The new functions ξ are known as principal components. They are uncorrelated linear functions of the original variables. In particular, if the original variables were normally distributed, the new variables ξ are not only uncorrelated but independent. It is remarkable that they have another useful properties. Suppose that we had approached the subject from a different viewpoint and looked for the linear functions of the X's which have stationary values of their variance. If one of these is γ, expressed as

$$\gamma = \sum_{j=1}^{p} l_j X_j \quad \ldots\ldots (1.17)$$

its variance is given by

$$\mathrm{Var}\ \gamma = \sum_{j=1}^{p} \sum_{k=1}^{p} l_j l_k \ \mathrm{Cov}\ (X_j X_k) \quad \ldots\ldots (1.18)$$

We require to find the stationary value of this, subject to the condition

$$\sum_{j=1}^{p} l_j^2 = 1 \qquad \ldots\ldots \text{(1.19)}$$

This is equivalent to an unconditional stationary value of

$$\Sigma l_j l_k C_{jk} - \lambda \Sigma l_j^2 \qquad \ldots\ldots \text{(1.20)}$$

Where λ is an undetermined multiplier. Differentiation by l_j leads to

$$\sum_{k=1}^{p} l_k C_{jk} - \lambda l_j = 0 \qquad \ldots\ldots \text{(1.21)}$$

This leads to equation (1.16) with λ as one of the eigen values. In other words, the linear combinations with stationary values are the principal components. If we christen the components according to the magnitude of their eigen values (variances), we may say that the first component, ξ_1, has the largest possible variance of any linear function; the second, ξ_2, has the largest variance subject to being uncorrelated with the first; the third has the largest variance of linear functions which are uncorrelated with the first and second; and so on, down to the smallest eigen value, which corresponds to the linear combination with the smallest variance.

APPENDIX - 6.B

6.B.1. Description of Profiles

For the purposes of soil taxonomy, profile constitutes the very element since, it provides indication on a number of aspects of genesis of the peds and their horizon formation. In the FAO system, soil horizons of the profiles have been classified into 7 broad categories with capital Roman alphabets as nomenclature such as H, O, A, E, B, C and R. The H-horizon is the topmost layer constituting the organic materials deposited on the surface but largely, in partly decomposed form. The O-horizon is the layer just below H-horizon, developed on the horizon of material soil like, the raw-humus-mat covering certain acid soils. The A-horizon is the main topmost mineral horizon showing accumulation of humified organic matter intimately associated with the mineral fraction and has a morphology distinctly different from E and B horizons. The E-horizon is the alluvial horizon which underly the A-horizon and normally is differentiated by a lower content of organic matter and a lighter colour. B is the mineral horizon in which the rock structure is obliterated or is very faintly evident. This horizon contains an alluvial concentration of silicate clay, iron, aluminium and humus singly or in combination the residual sesquioxides and a prismatic structure. C is the mineral horizon of unconsolidated material from which the solum is presumed to have formed. This is also called the 'Parent Material'. R is the layer of the bed-rocks (Fitzpatrick, 1980).

In the present study, 16 profiles have been taken on a sample basis covering practically the entire district. The profiles were taken to a depth of 30 inch (75 cm) from plains as well as slopes of varying degrees. Section 6.B2 provides the distribution and broad characteristics of the profiles.

6.8.2. Soil Profiles Description

(i) Site Characteristics

(a) Location, (b) Geology, (c) Slope, (d) Drainage, (e) Vegetation, and (f) Land Use.

(ii) Profile Characteristics

(a) Master horizons (H, O, A, E, B, C and R), (b) Depth of horizons, (c) Colour, (d) Structure, (e) Texture, and (f) Root distribution.

Profile 1

(i) (a) Sonapahar (Riangdo), (b) Gneissic complex, (c) 18°, (d) Moderate, (e) Mixed evergreen deciduous forests, (f) Jhuming and wet paddy cultivation.

(ii) (a, b, c, d, e, and f)

H-O-A: 0 to 50 cm, Dark brown (10 YR 4/3), Medium-granular, Sandy clay.

E-B: 50 - 152 cm. Strong brown (76YR 5/8), Moderate-coarse-granular, clay loam.

C-R: > 152 cm, Brownish yellow (10 YR 6/6), Moderate-coarse-granular, Clay loam.

The root penetration upto the 140 cm.

Profile 2

(i) (a) Nongumdang, (b) Gneissic (c) 18°, (d) Moderate, (e) Mixed forest with bamboo, (f) Jhuming and wet paddy cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 60 cm, Reddish yellow (7.5 YR 6/6), Strong very coarse sub-angular blocky, sandy clay.

E-B: 60 - 110 cm, Yellowish red (5 YR 5/6), strong very coarse sub-angular blocky, sand.

C-R: > 110 cm, Yellowish red (5 YR 5/8), strong very coarse sub-angular blocky, Sandy clay.

The root distribution is upto the B-horizons.

Profile 3

(i)(a) Nongpyndeng (Nongstoin), (b) Gneissic(c) 16°, (d) Moderate, (e) Grass and pine, (f) Potato and vegetable crops.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 14 cm, strong brown (7.5 YR 5/6), very coarse sub-angular blocky, sandy loam.

E-B: 14 cm - 65 cm, strong brown (7.5 YR 5/8), strong very coarse sub-angular blocky, silty clay.

C-R: 65 cm - 170 cm, Reddish yellow (5 YR 7/8), strong very coarse sub-angular blocky, sand.

The root penetration is upto 13 cm.

Profile 4

(i) (a) Nongstoin, (b) Gneissic (c) 18°, (d) Moderate, (e) Pine forest, (f) Potato and Wet paddy cultivation.

(ii) (a, b, c, d, e, and f):

H-O-A: 0 - 11 cm, Brownish yellow (10 YR 6/6), Strong-coarse-sub-angular-blocky, Sandy loam.

E-B: 11 - 96 cm, Reddish yellow (7.5 YR 6/8), Strong very coarse sub-angular blocky, Silt loam.

C-R: 96 - 175 cm, Yellowish brown (10 YR 5/6), Strong very coarse-sub-angular blocky, Sandy loam.

The root distribution is upto the B-horizon.

Profile 5

(i) (a) Mawkyrwat, (b) Gneissic (c) 35°, (d) Moderate, (e) Wild grasses and exposed bed rock, (f) Potato and wet paddy cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 19 cm, Pale brown (10 YR 6/3), Moderate-very coarse-granular, Sandy clay.

E-B: 19 - 80 cm, Yellowish brown (10 YR 5/6), Weak-coarse-granular, Sandy clay.

C-R: 80 - 138 cm, Yellow (10 YR 7/6), Strong-very coarse - Sub-angular-blocky, Sand.

The root penetration is upto 25 cm.

Profile 6

(i) (a) Balat, (b) Jadukata (c) 0°, (d) Moderate, (e) Grasses and shrubs, (f) Paddy and potato cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 9 cm, Light yellowish brown (10 YR 6/4), Structure-less-fine-platy, clay.

E-B: 9 cm - 51 cm, Light yellowish brown (10 YR 6/4), Weak-coarse-Sub-angular-blocky, Sandy loam.

C-R: 51 cm - 75 cm, Reddish yellow (5 YR 7/6), Strong-Fine-Granular, Sand.

The root distribution is upto the C-horizon.

Profile 7

(i) (a) Balat, (b) Jadukata (c) 10°, (d) Moderate, (e) Mixed forests, (f) Paddy and potato cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 20 cm, Yellow (10 YR 7/6), Weak-coarse-granular, Sandy clay.

E-B: 20 cm - 36 cm, Greyish brown, Moderate-coarse-granular, Sandy clay.

C-R: 36 cm - 90 cm, Greyish brown, Strong-very coarse-sub-angular-blocky, Sandy clay.

The root penetration is upto 35 cm.

Profile 8

(i) (a) Rambrai, (b) Gneissic complex, (c) 0°, (d) Well-drained, (e) Pine with bamboo and wild grasses, (f) Paddy and potato cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 18 cm, Brown (10 YR 5/3) strong-coarse-granular, Sandy loam.

E-B: 18 cm - 34 cm, Brown (10 YR 5/3), Strong-very coarse-angular-blocky, Clay.

C-R: > 34 cm, Reddish yellow (7.5 YR 6/6), Strong-very coarse-angular-blocky, Sandy clay loam.

The root distribution is upto the E-horizon.

Profile 9

(i) (a) Nongkhlaw, (b) Granitic complex, (c) 0°, (d) Well-drained, (e) Mixed deciduous forest, (f) Jhuming and wet paddy cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 18 cm, Yellow (10 YR 7/6), Strong-coarse-sub-angular -blocky, loam sand.

E-B: 18 cm - 48 cm, Yellow (10 YR 7/6), Strong-very coarse-sub-angular-blocky, loam.

C-R: > 48 cm, Reddish yellow (7.5 YR 7/6), Strong-very coarse-sub-angular-blocky, Sandy clay.

The root penetration is upto the A-horizon.

Profile 10

(i) (a) Mawkyrwat-Jakrem, (b) Granitic complex, (c) 0°, (d) Well-drained, (e) Pine vegetation, (f) Potato and paddy cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 11 cm, Greyish brown (10 YR 5/2), Strong-very coarse-platy, Sandy loam.

E-B: 11 cm - 15 cm, Greyish brown (16 YR 5/2), Strong-coarse-platy, clay.

C-R: > 15 cm, Greyish brown (10 YR 5/2), Strong-very coarse-crumb, Clay.

The root distribution is upto the E-horizon.

Profile 11

(i) (a) Mawsynram, (b) Gneissic complex, (c) 0°, (d) Well-drained, (f) Potato and vegetable crops.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 13 cm, Grey (5 YR 6/1), Strong-very coarse-angular-blocky, Sandy loam.

E-B: 13 cm - 25 cm, Light brownish grey (2.5 Y 6/2), Strong-corase-platy, Sandy clay loam.

C-R: > 25 cm, Yellow (10 YR 8/6), Strong-very coarse-granular, Sandy clay loam.

The root distribution is upto the E-horizon.

Profile 12

(i) (a) Balat, (b) The Khasi Groups - Mohadecks Jadukata and Sylhet trap, (c) 0°, (d) Poor drainage, (e) Mixed deciduous forests, (f) Paddy cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 to 33 cm, Pale brown (10 YR 6/2), Weak-fine-granular, Clay loam.

E-B: 33 cm - 58 cm, Yellow (10 YR 8/6), Weak-fine-platy, Clay.

C-R: > 58 cm, Yellow (10 YR 8/6), Strong-coarse-granular, Silty loam.

The root penetration is upto the E-horizon.

Profile 13

(i) (a) Jadukata river valley, (b) Gneissic complex, (c) 0°, (d) Fair drainage, (e) Mixed forests - Shrubs, wild grasses and bamboo forests, (f) Paddy and potato cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 15 cm, Light brownish grey (10 YR 6/2), Weak-fine-granular, Silt.

E-B: 15 cm - 30 cm, Yellowish brown (10 YR 5/4), Moderate-very coarse-angular-blocky, loam.

C-R: Exposed bed rocks, Yellow (10 YR 7/6), Moderate-coarse-angular-blocky, Sandy clay loam.

The root distribution is upto the E-horizon.

Profile 14

(i) (a) Marbisu Village, (b) Gneissic (c) 15°, (d) Moderate, (e) Pine and grasse, (f) Potato and wet paddy cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 45 cm, Brownish yellow (10 YR 6/6), Moderate-coarse-granular, Sandy clay.

E-B: 45cm - 124 cm, Yellow (10 YR 7/6), Weak-fine-granular, Sandy clay.

C-R: 124 cm - 129 cm, Yellow (2.5 YR 7/6), Strong-coarse-granular, Sand.

The root distribution is upto the B-horizon.

Profile 15

(i) (a) Riangdo proper, (b) Gneissic complex, (c) 0°, (d) Well-drained, (e) Mixed deciduous forests, (f) Potato and Jhum cultivation.

(ii) (a, b, c, d, e and f):

H-O-A: 0 - 18 cm, Reddish Yellow (75. YR 6/8), Strong-very coarse-sub-angular-blocky, Sandy clay loam.

E-B: 18 cm - 36 cm, Reddish yellow (7.5 YR 6/8), Moderate-coarse-sub-angular-blocky, Clay.

C-R: > 36 cm, Yellowish red (5 YR 5/8), Strong-very coarse-granular, Sandy clay loam.

The root penetration is upto the E-horizon.

The profiles can be broadly classified into two categories:

(1) The in situ profiles formed on slopes on bed rocks largely of granite - Gneissic complex and Sand stones;

(2) The alluvial deposits occurring in the valleys composed largely of clay profiles, unconsolidated pebbles and rock fragments and a fair degree of humid layer under both aerobic and anaerobic conditions due to the extreme humid conditions prevalent and high base saturation.

(1) The slope soils have a depth generally not exceeding 75 cm but often the B and C Horizons may go to a depth of 3 to 4 metres due to excessive weathering of the bed-rock and the parent materials. The humus accumulations (layers H and O) are thin often dominated by the H-horizon (particularly under the Pine vegetation). There is a fair degree of

leaching of the top layers and the eluvial zones are discernable. The clay contents are less, usually below 20 per cent level. The dominance of oxides of iron and aluminium which provide the mottling structure to the soil.

(2) The depositional soils vary in depth, generally over 75 cm, sometimes going for many metres below. These soils have a higher clay content exceeding 40.0 per cent level. The soil horizons are not well defined except the H and A horizons. These soils generally remain under water for over eight months of the year. The layers are dark gleyey in colour. The water percolation is hindered by the gleyey clays (the photographs provide indication of some of the constitutions of the profiles).

Texture

The texture of the soils provides the nature of the particle size which controls the chemical reactions in the soils, water percolation, leaching and other characteristics. All the 382 samples have been texturally classified as per the percentage of particulate constitutes i.e., sand, silt and clay given by the system of textural classification by U.S. Department of Agriculture (USDA).

Table 6.B.1 provides the classification of the samples into twelve major textural classes and the number and percentage of samples under the given textural class. As it seems,

Table - 6.B.1: Soil Textural Classes

Sl. No.	Textural Name (Soil Class)	Textural Symbol	No. of of Samples	Per Cent
1.	Sand	S	4	1.05
2.	Loamy Sand	Ls	6	1.57
3.	Sandy Loam	sL	67	17.54
4.	Loam	L	16	4.19
5.	Silt Loam	Sl	27	7.07
6.	Silt	Si	5	1.31
7.	Sandy Clay Loam	sCL	94	24.61
8.	Clay Loam	CL	32	8.38
9.	Silty Clay Loam	Scl	10	2.62
10.	Sandy Clay	sC	31	8.12
11.	Silty Clay	Sc	6	1.57
12.	Clay	C	84	21.99

Table - 6.B.2: Land Facet-Wise Classification of Soil Texture

Texture Class	Valley		G. Slope		M. Slope		St. Slope		Crest Land	
	No.	%	No.	%	No.	%	No.	%	No.	%
1. Sand	1	1.3	2	2.5	0	0	0	0	1	1.4
2. Loamy sand	2	2.5	1	1.3	2	2.6	0	0	2	2.7
3. Sandy loam	14	17.5	12	15.2	17	22.4	10	13.5	18	24.7
4. Loam	9	11.3	0	0	4	5.3	4	5.4	0	0
5. Silt Loam	6	7.5	8	10.1	6	7.9	4	5.4	4	5.5
6. Silt	1	1.3	1	1.3	0	0	2	2.7	0	0
7. Sandy clay loam	15	18.8	26	32.9	19	25.0	17	23.0	15	20.5
8. Clay Loam	3	3.8	9	11.9	9	11.8	3	4.1	7	9.6
9. Silty Clay loam	0	0	2	2.5	0	0	3	4.1	2	2.7
10. Sandy clay	6	7.5	5	6.3	4	5.3	10	13.5	9	12.3
11. Silty clay	2	2.5	2	2.5	0	0	1	1.4	0	0
12. Clay	21	26.3	11	13.9	15	19.7	20	27.0	15	20.5
Total	80	100	79	100	76	100	74	100	73	100

there is dominance of three types of textures (a) clay, 22.0 % (84), (b) sandy clay loam 24.6% (94), and sandy loam 17.5% (67). The other important textural classes are silt loam (27), clay loam (32) and sandy clay (31).

Table 6.B.2 provides information on the classification of samples (texture) according to land facets. In the valley lands there is a dominance of clay and clay loam to the extent of about 50.0 per cent, of which the clay consists of 26.3 per cent. In the gentle slopes there is a dominance of loam soils particularly the sandy clay loam which accounts for 32.9% of the samples. Medium slopes are dominated by sandy clay loam and sandy loam types of soils. The crest lands are dominated by sandy loam followed by clay and sandy clay loams.

6.B.2. Colour

Soil colour provides an important attribute of the volume particularly of the top horizons. It indicates the type of bedrock from which soil has been formed, the type of organic matter content, the nature of weathering, climatic conditions, etc. e.g. high presence of organic matter of soil formation on Basaltic rocks or of Volcanic origin would provide a dark colour to the soil. Presence of oxides of iron gives the reddish colour and the yellow soils are characterised by hydrated ferrousoxides. The lighter colours like - grey and whitish are given by the presence of silica.

All the 382 surface samples have been classified into total of 24 colours (as per the Munsell Color Scheme). These colours range from yellow-red (7.5 Y R 6/6) to very Dark Grey (10 Y R 3/1). The dominant colour classes are light yellow brown (2.5 Y 6/4) 13.87 per cent (53), Yellowish brown (10 Y R 5/4) and brown (10 Y R 5/3) nearly 20.0 per cent, and brownish yellow (10 Y R 6/6) 12.0%. There is also a variety of grey colours available which constitute nearly, 15.0% of the total samples (Table 6.B.3).

Table 6.B.4 provides information on the soil colour classification according to land facets. In the valley soils there is a dominance of Yellow brown soils particularly, the light yellow brown (2.5 Y R 6/4) which accounts for 20.0 per cent of the samples. The gentle slopes are dominated by Yellow brown to Light brown soils. The medium slopes are dominated by light brown to brownish yellow soils (10 Y R 6/6). The steep slopes show no distinct difference in soil colour from the medium slopes. The crest lands are dominated by Light yellow brown, Yellow brown and brownish yellow soils.

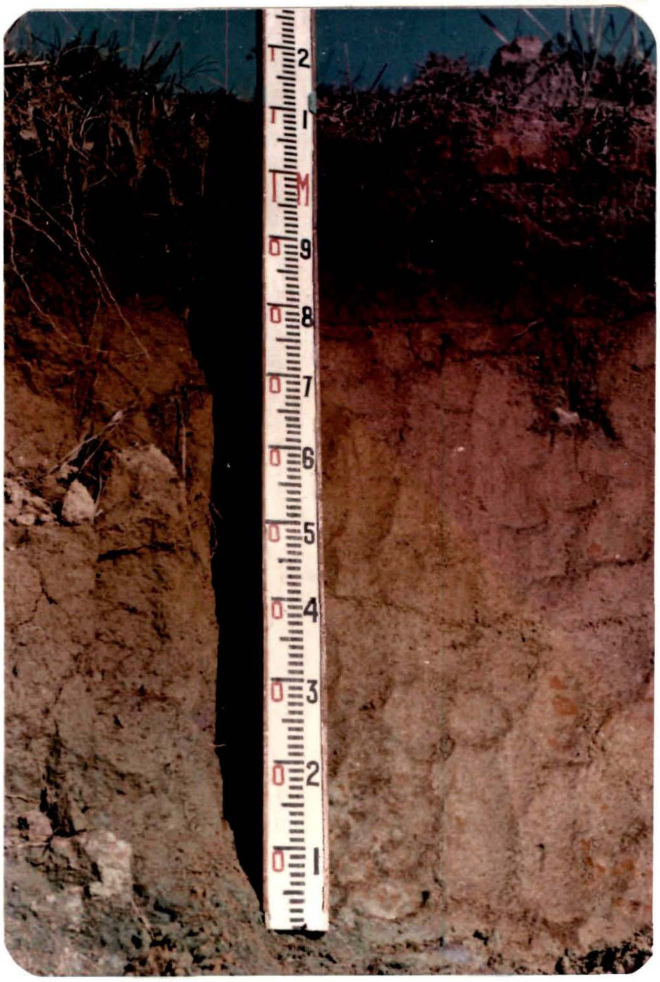
Table - 6.B.3: Soil Colour Classes

Sl. No.	Name of the soil Colour	Colour symbol	No. of samples	Per cent
1.	Yellowish Red (7.5 YR 5/6)	Yer	8	2.09
2.	Light Yellow Brown (2.5 Y 6/4)	Lyb	53	13.87
3.	Pale Brown (10 YR 6/3)	Pb	21	5.50
4.	Brown (10 YR 5/3)	B	27	7.07
5.	Yellowish Brown (10 YR 5/4)	Yeb	47	12.30
6.	Brownish yellow (10 YR 6/6)	By	46	12.04
7.	Light Brownish Grey (2.5 Y 6/2)	Lbg	17	4.45
8.	Pale Yellow (2.5 Y 7/4)	Py	12	3.14
9.	Strong Brown (7.5 YR 4/6)	Sb	19	4.97
10.	Yellow (10 YR 7/6)	Y	11	2.88
11.	Reddish Yellow (7.5 YR 6/6)	Ry	13	3.40
12.	Dark Yellow Brown (10 YR 4/4)	Dyb	15	3.93
13.	Very Pale Brown (10 YR 7/4)	Vpb	23	6.02
14.	Dark Brown (10 YR 4/3)	Db	16	4.19
15.	Greyish Brown (2.5 Y 5/2)	Gb	15	3.93
16.	Dark Greyish Brown (2.5 YR 4/2)	Dgb	9	2.36
17.	Very Dark Greyish Brown (10 YR 3/2)	Vdgb	10	2.62
18.	Grey (10 YR 5/1)	G	4	1.05
19.	Dark Grey (10 YR 4/1)	Dg	2	0.52
20.	Light Grey (2 YR 5/3)	Lg	7	1.83
21.	White (10 YR 8/2)	W	1	0.26
22.	Reddish Brown (5 YR 4/4)	Rb	1	0.26
23.	Light Grey Brown (10 YR 6/2)	Lgb	4	1.05
24.	Very Dark Grey (10 YR 3/1)	Vdg	1	0.26
	Total		382	100.00

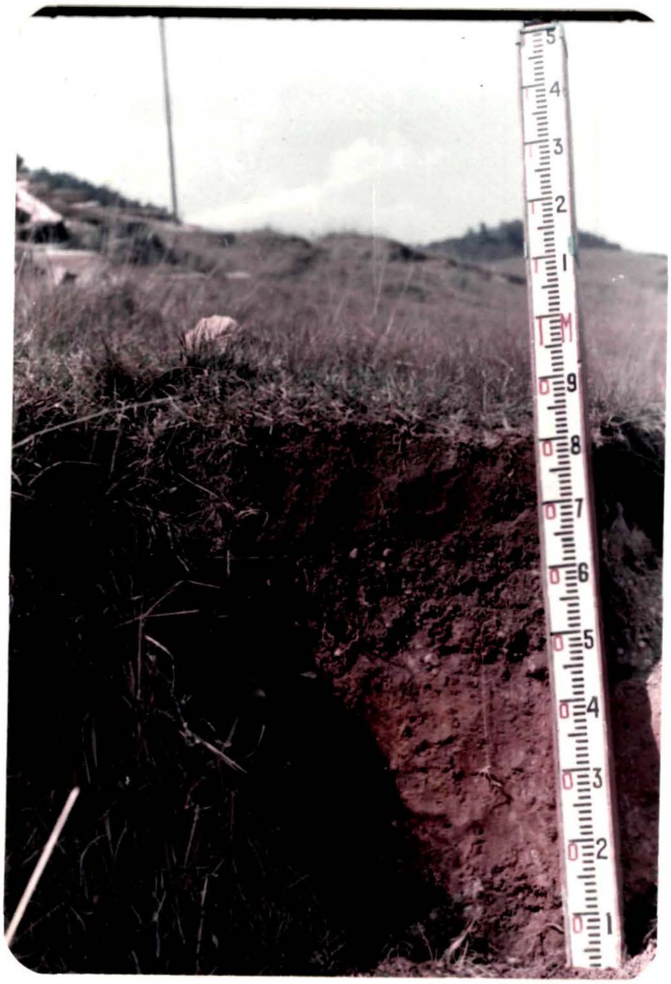
Table - 6.B.4: Land Facet-Wise Classification of Soil Colour

Soil Colour Classes	Valley		G. Slope		M. Slope		St. Slope		C. Land	
	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.
1. Yellowish Red	1	1.3	1	1.3	2	2.6	4	5.4	0	0.0
2. Light Yellowish Brown	16	20.0	7	8.9	8	10.5	8	10.8	11	15.1
3. Pale Brown	7	8.8	6	7.6	5	6.6	2	2.7	2	2.7
4. Brown	6	7.5	8	10.1	5	6.6	5	6.8	6	8.2
5. Yellowish Brown	8	10.0	12	15.2	10	13.2	7	9.5	8	11.0
6. Brownish Yellow	8	10.0	8	10.1	10	13.2	13	17.6	8	11.0
7. Light Brownish Grey	1	1.3	7	8.9	4	5.3	1	1.4	3	4.1
8. Pale Yellow	3	3.8	3	3.8	0	0.0	3	4.1	2	2.7
9. Strong Brown	4	5.0	2	2.5	1	1.3	5	6.8	7	9.6
10. Yellow	4	5.0	1	1.3	2	2.6	3	4.1	2	2.7
11. Reddish Yellow	0	0.0	1	1.3	3	3.9	3	4.1	5	6.8
12. Dark Yellow Brown	5	6.3	0	0.0	8	10.5	1	1.4	1	1.4
13. V. Pale Brown	4	5.0	5	6.3	6	7.9	4	5.4	3	4.1
14. Dark Brown	3	3.8	2	2.5	3	3.9	6	8.1	2	2.7
15. Greyish Brown	2	2.5	4	5.1	0	0.0	3	4.1	7	9.6
16. Dark Greyish Brown	2	2.5	4	5.1	1	1.3	1	1.4	1	1.4
17. V. Dark Greyish Brown	1	1.3	2	2.5	3	3.9	1	1.4	3	4.1
18. Grey	1	1.3	1	1.3	1	1.3	1	1.4	0	0.0
19. Dark Grey	1	1.3	0	0.0	0	0.0	1	1.4	0	0.0
20. Light Grey	2	2.5	3	3.8	1	1.3	0	0.0	1	1.4
21. White	0	0.0	0	0.0	1	1.3	0	0.0	1	1.4
22. Reddish Brown	0	0.0	0	0.0	0	0.0	0	0.0	1	1.4
23. Light Greyish Brown	0	0.0	2	2.5	2	2.6	1	1.4	0	0.0
24. V. Dark Grey	1	1.3	0	0.0	0	0.0	1	1.4	0	0.0
Total	80	100.0	79	100.0	76	100.0	74	100.0	75	100.0

Distribution of Soil Profiles



1. Near Mawsynram



2. Near Markasa

3. Near Nongstoin

4. Near Mawkyrwat

GLOSSARY OF ABBREVIATIONS

Journals

Annl. Assoc. Am. Geog.	- Annals of the Association of American Geographers.
Am. Geog. Soc. Publ.	- American Geographical Society Publication.
Geog. Rev. Ind.	- Geographical Review of India.
Geogrl. Jour.	- Geographical Journal.
Ind. Jour. Ag. Sc.	- Indian Journal of Agricultural Science.
Jour. Megh. Sc. Soc.	- Journal of Meghalaya Science Society.
Jour. Ro. Stat. Soc.	- Journal of Royal Statistical Society.
Jour. Soil Sc.	- Journal of Soil Science.
Jour. Ind. Soc. Photo Int.	- Journal of Indian Society of Photo Interpretation.

Others

CSIRO	- Council for Scientific Industrial Research Organisation.
edn.	- Edition.
ed.	- Edited.
et al.	- And others.
FAO	- Food and Agricultural Organisation.
IARI	- Indian Agricultural Research Organisation.
ICSSR	- Indian Council of Social Science Research.

Mem. GSI	- Memoris of the Geological Survey of India.
NBT	- National Book Trust.
Ox. For. Mem.	- Oxford Memoris.
Proc. Nat. Acad. Sc.	- Proceedings National Academy of Science.
Proc. Pre-Cong. Sym.	- Proceedings Pre-Congress Symposium.
UNESCO	- *United Nations Educational, Scientific and Cultural Organisation.*

BIO-DATA

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