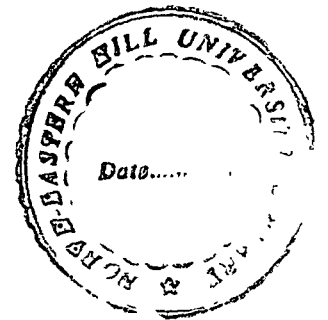


PHYSIOGRAPHY AND LANDUSE: A CASE STUDY OF THREE
WATERSHEDS ON THE NORTHERN SLOPES OF MEGHALAYA

Submitted by
Mark Julian Ford



Dissertation submitted in partial fulfillment of Degree of Master of Philosophy in
Geography of North-Eastern Hill University, Shillong

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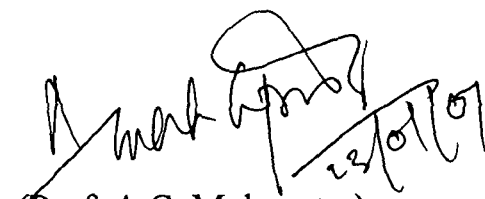
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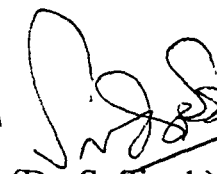
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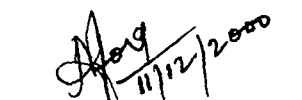
This is being submitted to North-Eastern Hill University for the degree of Master of Philosophy in Geography.



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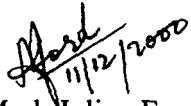
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Dated: 11.12.2000
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CHAPTER-I

1.0 Introduction:

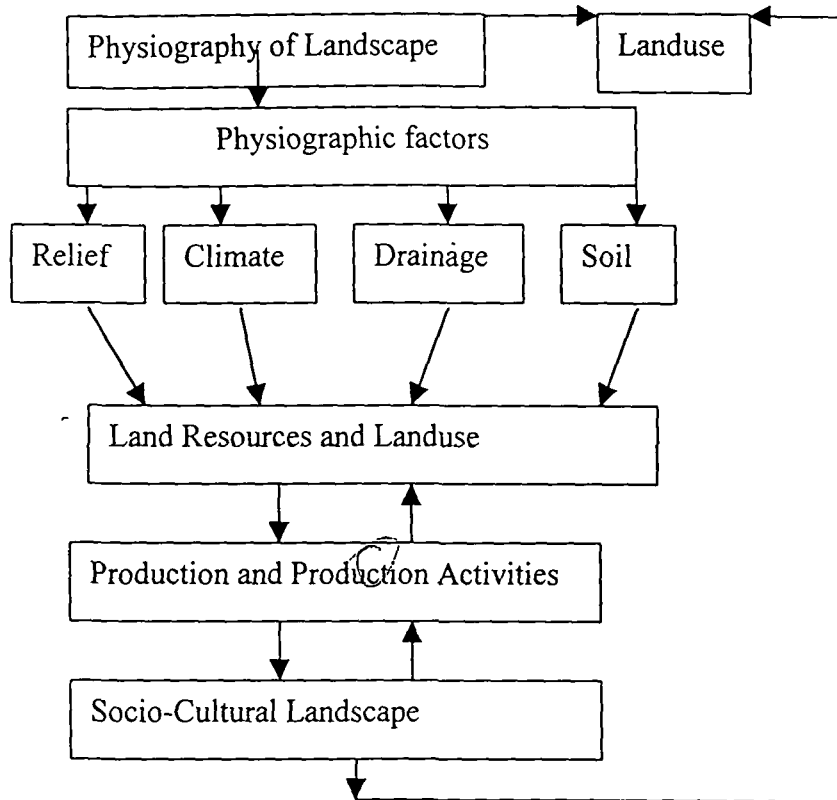
Man encounters nature every day of his life. Man adopts and adjusts himself with the changing times and also manages to survive under the most difficult times. Geography with its 'holistic' concept have kept man at the centre. All activities are, therefore, related to activities of man. Though man has claimed to be superior over nature in many respect. He has never been able to tame the will of nature in guiding his primary activities. In an area where human population is largely involved in agro-production, one cannot deny the extent of rules set by nature. Nature dominates in almost all areas of human activities. Hence, under these constraints, man has to be content with what best he can derive. Thus, the use of land under these circumstances considered result from the best possible understanding of the physical conditions of land.

In more detail, it can be said that the relationship between man and nature can be studied under the following concepts of geography, that are based on (1) the 'determinism', which includes two sets of the attributes of landscape, namely, the sets of physical attributes and the sets of socio-cultural and economic activities of man as well. It is conceived that the second set of attributes is controlled by the physiographic factors. However, according to Taylor, there is a stage of 'adjustment' between these

two sets of attributes. The limit and level of adjustment is determined by the 'technology'. Therefore, in some areas, physiographic factors have its total control on human activities. Secondly, another concept of interaction is studied under the purview of 'possibilism' in which the human activities and technological enhancement are more important than the physiographic factors of landscape. However, in the hilly areas of the world where population density is less, the need of food is also low, the deterministic view of changing socio-economic activities of landscape can be seen under the control of physiographic factors.

Landuse is an integrated view of landscape in which socio-economic activities of man are perceived and influenced by the physiographic factors. In hilly areas where there are a direct control of the physiographic factors and less interference in nature, the study of 'land cover' is more important than landuse, because land cover shows picture of the total effect of the physiographic factors on landscape in an area. While landuse pattern are the result of both sets of attributes that are related to the activities of man and nature. Therefore, landuse is influenced by availability of land resources and man utilised these resources through science and technology (Fig.-1.1).

Fig. – 1.1: Landuse and its Confluencing Factors.



2.0 Statement of the Problem:

The study of landuse has a wide and complex meaning. It is the function of land, water and air; and man has been utilising it since time immemorial to fulfill changing demand with the passage of time. Land as a resource has a wide range of variation depending much on the different factors. These factors are slope, climatic variation, soil, field pattern and the numerous living organism thriving in it. A proper utilisation of the land according to its suitability would help to fulfil and sustain the

human needs. This study thus addressed to condition prevailing in hilly terrain where physical factors of land exerts influence of landuse pattern.

Landuse in the modern connotation refers to the relationship between population and land. The growing population and the increasing its pressure on land are the present dimension of this relationship. 'Landuse is the function of four variables, i.e., land, water, air and man. Each has its own role to compose its life history, land constitutes its body, water runs through its veins like blood, air gives its life and man acts as the dynamic factor to reflect its type, pattern and distribution' (Singh, 1981). Hence, at present land is a scare resources, which needs careful planning for proper utilisation.

Land is man's very important resources and all human activities centre around this base. To Darwin man's activities were moulded and shaped by the physical forces that surrounded him. Man, therefore, has to adjust to the environment. Under the present dimension of land-man relationship, land management is the utmost importance for sustenance of a community or society.

The physical factors have been observed to play a major role in the variation of landuse especially in the hilly areas of the North Eastern part of India. This is very much reflected in the types of landuses. The main reason for this is the occurrence of a large variety of terrain that induces change in many respect within a short distances. Under these conditions, the human response through adjustment and adaptation has clearly given a positive attitude towards these hurdles. Most of these negative factors have not been used profitably for advancement. Slopes is never a hurdles, it attempts

at modifying landuse. In fact, land use of any area is the result of physical factors (relief, climate, soil) as well as human responses (social customs, economic conditions, technological changes and politico-administrative factors). In mountain and hill areas, physical factors are more influential and even control the landuse pattern rather than human responses. Therefore, the impact of physiographic factors on landuse is tried to discuss in the present piece of research.

In fact, this relationship between men and nature which can be seen through the study of landuse pattern is a realisation that it is spatially and temporarily vary in hilly and mountain areas of the world. Within the mountainous area, it also varies because of the changes of variability of any attributes of physiographic factors as well as the alteration of socio-cultural responses of man. However, it is found in various studies that the set of physiographic attributes has significant dominance on the landuse of the landscape. Therefore, the changes in the geomorphic characteristics, relief features, drainage patterns, climatic conditions and soil characteristics alter the landuse system and their evolving pattern on the landscape. As a result landuse pattern of any hilly and mountain area may only be studied with respect to the study of these physiographic factors.

The validity of this fact can be examined in the present research to consider the Northern slopes of the Meghalaya plateau which ranges from 200m to 2000m of elevations with varieties of physiographic factors as well as the socio-economic activities of man also. The variation of landuse pattern may be examined to observe its established relationship with the physiographic factors.

3.0 Objectives:

Keeping these aspects of physiographic-landuse relationship in mind, the relationship would be examined considering the Northern slopes of Meghalaya plateau. The present research work focuses attention on the following main objectives as:

1. to examine the various landuse pattern under different environmental conditions prevailing on the Northern slopes of Meghalaya;
2. to assess the impact of physiographic factors on landuse pattern; and
3. to suggest the suitable ways for land management and its implementation.

4.0 Research Questions:

According to the objectives of the present study, the following research questions may be posed which are relevant to examine the landuse on the Northern slopes of Meghalaya.

1. what is the relationship among the physiographic attributes in various environmental conditions of landscape especially on the Northern slopes?
2. upto what extent are these physiographic factors responsible in determining the landuse pattern in various environmental conditions?
3. Can landuse change/modification be practicable under the present physiographic setup?

5.0 Methods and Data Collection:

The answers of these questions as mentioned above can only be given when the relationship of the various physiographic attributes can be established by considering the physiographic attributes of the different environmental conditions of the landscape of the Northern slopes. The first question is closely related to such relationships. For the same, the following attributes of the physiographic phenomena may be considered for testing the ground reality of such conditions.

1. *Relief Features:*

The relative height and slopes are two important attributes of the relief features. These attributes can be shown by preparing the contour map of the area which is the main thrust of comparing and correlating the attributes of the landscape. The contour maps are the important tools. Slope map will also be helpful for showing the relationship of these physiographic factors and for predicting the effects of relief features on landuse pattern.

2. *Drainage:*

The drainage pattern and drainage density which evolved the land features of landscape is equally important to study. The flow of water in the area is closely related to drainage pattern and drainage density. Drainage density may be considered as one of the important attributes of physiographic factors which may be able to explain the complex relationship of the landscape.

3. *Climate:*

Climatic conditions influence the pattern and density of the drainage system. It also determines the natural vegetation of the area. Therefore the climatic conditions should also be considered as physiographic factors for establishing the interrelationship of such variation of landscape. The data regarding climatic conditions have been collected from I.C.A.R., Barapani, Eri Seed Farm, Nongpoh and Horticulture Farm, Burnihat for showing the climatic factors and latter interpreted for establishing the interrelationship.

4. *Soils:*

Soil of an area are the results of the relief features, drainage pattern and climatic conditions. Therefore, the attributes related to geomorphic attributes as given above must be positively and highly correlated with the characteristics of soils. For such relationship, the attributes related to physical and chemical properties of soil have been considered.

Besides these factors, landuse may also be incorporated in the same sets of physiographic attributes. However, the landuse characteristics and the attributes related to landuse pattern are kept separately in the different sets of attributes for their detail study and comparing them with the first sets of attributes to explain or to give the answer to the second question.

The third research question is related to the suitability of landuse pattern and land management. For this purpose, the sets of physiographic conditions are put

together under one umbrella and compared with the landuse pattern to suggest the managerial aspects of land system.

So far as the methodological aspects of the present research are concern, the above explained attributes of the physiographic conditions and landuse patterns are generated for selecting three micro watersheds from the different elevation on the Northern slope of Meghalaya plateau. These watersheds are true representative of different environmental condition of the area (Fig.-1.2).

In fact, the detail information of physiographic factors of these micro watersheds that are approximately about 1000 ha (or nearly 10 sq. km) of its areal size, are not available in topographic sheet of R.F. 1:50,000. Therefore, the related attributes are generated by conducting physical survey of these watershed and preparing maps related to contours, average slopes, soils, landuse/land cover maps on R.F. 1:10,000 scale. The Umdohbyrthih which is located at the upper edge of the plateau, the mapping was done on R.F. 1:5000 because of its smaller size.

After conducting the physical survey and preparing concern maps, the data of these attributes are generated for examining the facts. However, the comparison was also done through the maps and results are interpreted by superimposing them accordingly. Therefore, the entire research work is based on primary survey. The uniform scales of relief and slope attributes are used for comparison (Table-1.1).

Table – 1.1: Uniform Classification of Elevation and Slope Categories.

Elevation Categories	Slopes Categories
Very High	Very Extremely Steep
High	Extremely Steep
Highly Moderate	Very Steep
Moderately Low	Highly Strong
Low	Very Strong
Very Low	Strong
Very Extremely Low	Moderately Strong
	Moderate
	Low

Cartography is the basic tool for geographers. Therefore, the mapping and generated data are shown by diagrams and results are also interpreted through the diagrammatic methods. On the other hand, the statistical techniques like mean, standard deviation and correlation are also applied for the purpose.

Collection of Soil Samples and their Analysis:

The second stage of the work is related to collection of soil samples from the field, according to different elevations and landuse pattern. The soil samples were collected from the watersheds and analyse in the soil Lab, Department of Geography, NEHU, Shillong as well as the Lab of Directorate of Agriculture, Government of Meghalaya, Shillong. Later on, the soil characteristics are compared and correlated with the attributes of slope, drainage and other physiographic attributes of watershed. In order to assess the impact of soil characteristics on landuse, these soil attributes are also correlated with landuse pattern in different watersheds.

The relationship of soil-physiography, geology is also tried by analysing soil samples from various soil profiles so that the visual appeal of the facts can be highlighted.

In addition, it can also be stated that some data of general landuse pattern are also collected from the secondary sources, especially from I.C.A.R., Barapani; Eri Seed Farm, Nongpoh and Horticulture Farm, Burnihat.

6.0 Chapter Scheme:

The whole material is arranged into five chapters as: Chapter-I includes the introduction including the background of the problem, objectives, research questions, methodology and data collection. Chapter-II incorporates the environmental conditions of the entire Meghalaya plateau and its regional personality to justify the watershed samples which are representative areas of such environmental conditions. In Chapter-III, the detail physiographic characteristics of the watersheds and their interrelationship are interpreted. While Chapter-IV includes the details of landuse pattern and land characteristics in the watershed. Lastly, Chapter-V has the synthesis of fact of all the three watersheds and generalise their result in the form of main findings.

CHAPTER – II

ENVIRONMENTAL CONDITIONS OF MEGHALAYA PLATEAU

1.0 Introduction:

It is highlighted in the preceding chapter especially in the design of the present study that the attributes related to physiographic conditions and variations of environmental conditions are to be included in the present study to give the insight of environment of landscape. The detail study of the environmental conditions may be done by considering the physical as well as human aspects of environment of an area. In the present chapter, only the physiographic attributes are considered in detail because the main theme of our research is to correlate the physiographic factors with landuse pattern. As a result physiographic parameters of Meghalaya plateau are considered and its regional variations are highlighted here. In fact, the study of physiographic attributes of the environment may be done in various ways. However, the geological structure, relief features, climatic conditions, drainage system, soils and vegetation are studied in detail because these aspects are closely related to the physical attributes of the environment.

2.0 Geology:

Meghalaya plateau is a result of Tectonic movement, basically formed due to faults and thrusts. The larger part of it, i.e., the main Shillong massif, is formed by gneissic complex in which non propyritic migmatic granitoids (dome formation of the Shillong groups and Khasi green stone formation) of the upper protozoic eras are available (Agarwal 1994). There are some patches of the Shillong group which belong to the lower protozoic as well. The Disang thrust separates the massif from the sediments of Bengal – Assam massif (Anon 1974). Therefore, most of the Garo & Jaintia Hills are dominated by the Disang series of cretaceous – Tertiary sequence. Whereas, in the foothills of the Southern slopes of the Shillong massif after the Dawki fault, there are Dihing and Dipitila series of pleistocene and then there are quaternary and recent deposits found on the terraces and in the valleys of the Southward of the Surma river system.

The strike in the foliation of the gneiss of Meghalaya Plateau is more or less similar to that Chotanagpur Plateau. Further resemblance is seen in the marine transgression which affected the southern shores of the plateau in the cretaceous deposits which lie undisturbed upon the older rocks (Spate 1967). The Stratigraphy of Meghalaya shows the following rocks of different geologic periods:

1. Archean Gneissic complex,
2. Shillong Group of Rocks,
3. Lower Gondwana Rocks,

4. Sylhet Traps,
5. Cretaceous – Tertiary Sediments, and
6. Quaternary & Recent Deposit.

2.1 Archean Gneissic Complex:

The central part of the plateau is the ancient mass of Gneiss much intruded by a coarse granite. These Archean rocks are much exposed in the central & northern parts of the plateau. The rocks are believed to be the North-Eastern extension of the Indian penninsular block separated by the Garo-Rajmahal trough fault. The rocks are composed predominantly of Para & ortho-gneissis, Magmatites & Meta – Sedimentary Band.

2.2 Shillong Group of Rocks:

The Shillong group occupies a moderately larger area especially to the Eastern and the Southern parts of Shillong. The composition of this group has a considerable thickness of well-bedded quartzites, locally conglomeritic and frequently micaceous and of unknown thickness of highly crumpled and foliated mica schist, hornblende schist, chlorite schist, granulates and amphibolites with occasional band of shale and slate. In the Khasi Hills, the strike of the beds is running in an East – West direction with general Southerly dip along the Northern portion and the Northerly dip in the Southern portion. Along the Southern boundary of the Shillong bed, there is a steep plane of contact between the highly altered sedimentaries and the accumulated bedded

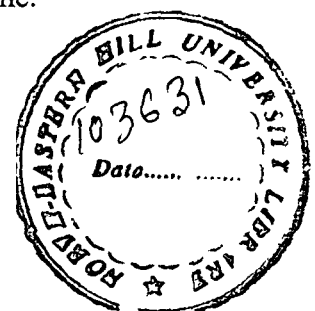
igneous rocks, known as the Sylhet Trap, which is suppose to correspond to the Trap of the Rajmahal Hills.

2.3. *Sylhet Trap:*

In the Sylhet Trap, the nature of the plateau is basalts, exposed in a narrow East – West strip covering an area of about 80 kms long and 40 kms wide, along the border of the Shillong plateau. They apparently overlie the eroded Pre Cambrian basement which themselves are overlain unconformably by the Upper Cretaceous – Eocene sediments. The sediments and the lava form a monocline becoming a flexure towards the south. The sediment at the crest of the flexure in the Terrighat – Shella sector with its East – West axis, changes along its trace westward to a high angle reverse fault to normal & vertical fault (Dawki fault) and marks the extreme limit of the Sylhet trap to the south.

2.4. *Lower Gondwana:*

The Lower Gondwana rocks is recognized at Singrimari in Garo Hills. It consists of Pebbles bed, sandstone and carboneaceous shale with streak and lenses of coal. The sandstone dips westwards and is intruded by dykes of dolerites. The lowest beds of the Calcareous facies of the Eocene sediments. This has been termed by Fox as the Tura Stage of rock. It includes sandstone and shale and a thin seam of coal. This stage is now believed to have been included to the Cherra sandstone.



2.5 Cretaceous Tertiary Sediments:

The oldest fossiliferous sediments of Meghalaya belongs to the Cretaceous system predominantly seen in the Plateau region. These sediments occupy the Southern slopes of Meghalaya. It is considered to be the continuous series of the Cretaceous – Tertiary sediments of the Bengal Basin. Here the sediments are divided into two groups; (a) Khasi Group, (b) Jaintia Group.

(a) *The Khasi Group*: The Khasi group is the distinct of Arenaceous facies consisting of the oldest rocks of Jadukuta formation followed by Mahadek formation.

(b) *The Jaintia Group* The Jaintia group is a calcareous facies and is divided into three formation, viz., the Langpar formation, the Shella formation and the Kupli formation.

2.6 Quaternary and Recent Deposits:

The Tertiary rocks occur along the southern and western border of the Garo Hills in the isolated areas and along the Southern fringe of Khasi Hills, overlain by isolated patches of older Alluvium. Along the Northern fringe of the Garo Hills districts one such patches can be found. These deposits consist of beds of assorted Pebbles with coarse, loose sand and brownish clay. The pebbles beds at places occur in irregular repetition. These rocks usually form exceptionally flat top, low hillocks and mounds with red soil cover. Recent alluvium is found in river valleys on the northern foot hills region of the Garo and Khasi hills along the Western border of Garo

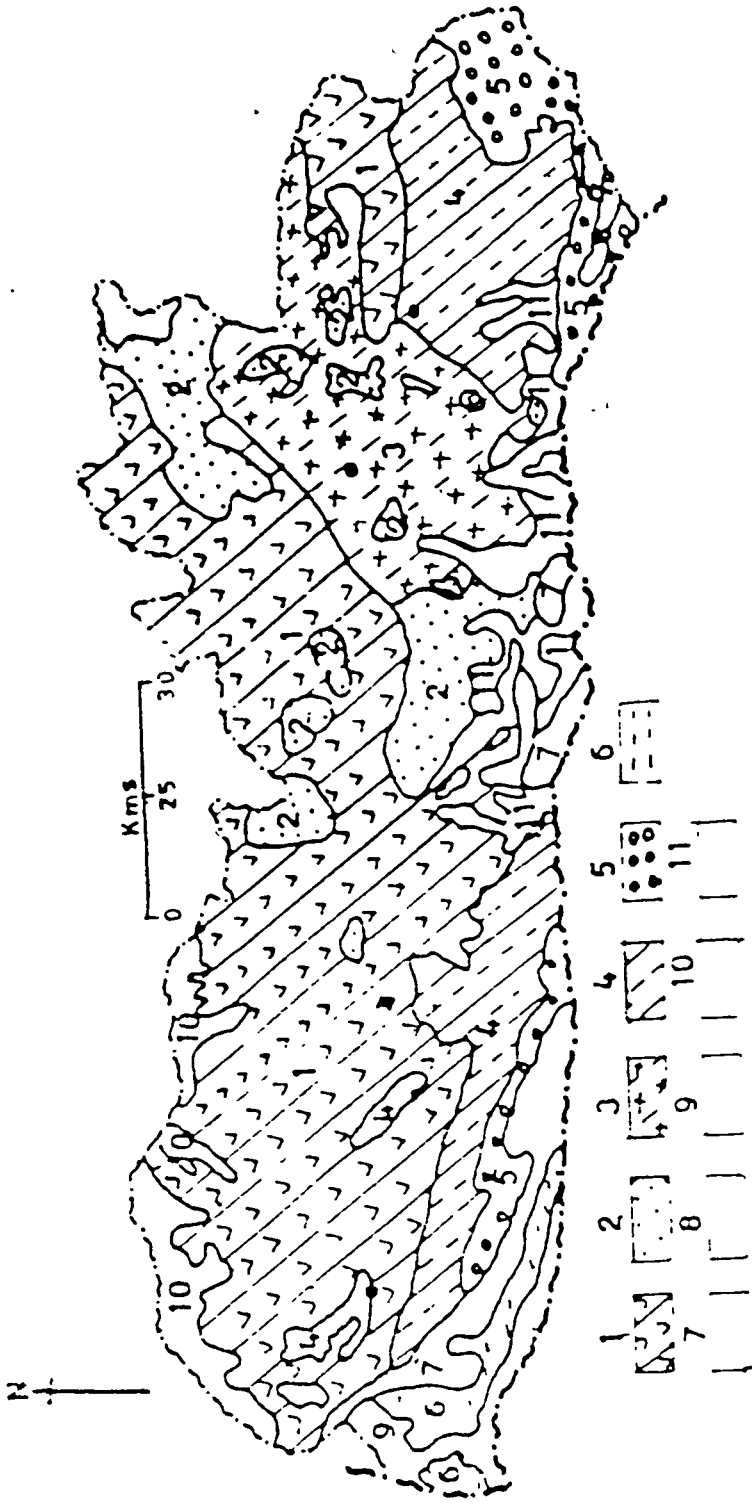


Fig.2.1: Geological Structure

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

3.0 Relief Features:

In general, the slopes and the relief features are parts of the land system. They are directly controlled by the geological structure as interpreted above and have the direct bearing on hydrological attributes, micro climatic conditions and the land use / land cover patterns of the area (Vink 1975). In light of geological structure of Meghalaya plateau, its terrain features may be characterized as follows :

The central part of Meghalaya, i.e. the Shillong massif, has a 'horst' like with flat top appearance with elevation ranging from 1500 – 2000m occupying most of the uplifted tracts of the Khasi Hills. The region exhibits a varieties of relief features with uplifted flat lands. Scarpments and eroded land features are noticeable. There are two major scarpments:

- (1) The Myllem – Mawphlang scarp which is about 30kms with the highest point of 1961m (Shillong Peak) exhibiting steep slopes running towards the North to the Umniam lake.

The Mawthadrishan Scarp of the West – Central part covering a longitudinal distance of about 45kms from Nongshillong to Mawlieh Villages. These Scarps demarcate the boundaries of the Water divide of the area and separate the Drainage system of Meghalaya into two parts as: (1) The Brahmaputra System; those rivers which flows to the North and joined the Brahmaputra river, and (2) The Surma System; those rivers flowing to the South and joined the Surma river at the lower coarse (Singh 1996).

Another important fault line demarcates the major relief features of the central parts of Shillong massif from that of the sloppy areas of the southern slopes and Jaintia Hills. This fault line runs along the Dawki fault where scarp edges ridges, rapids, gorges exhibit in the region. In addition to these, some micro features like deep gorges, canyon, sharp hill ridges and funnel like features of river valley can also be observed.

The Northern slopes of the Shillong massif, the region is characterized by the relief features such as quartzites domes, crest of sandstones and inter-ridge valleys with flat valleys and the ridges exhibiting heights ranging between 170 – 820m. Two peneplane surfaces can also be identified. These are: (1) Khanapara – Jorabat region, and (2) Burnihat – Nongpoh region.

The fault line of the ridges from Nongholi – Burnihat are running in the North-West to South-East direction with most hillock exhibiting flat tops.

The Western parts of the Plateau (Garo Hills) exhibits of about 1000m having numerous series of ridges and scarpments The Tura scarpment runs about 60 kms stretching between Somaswari and Ganoi river with elevation of 1200m in height. The

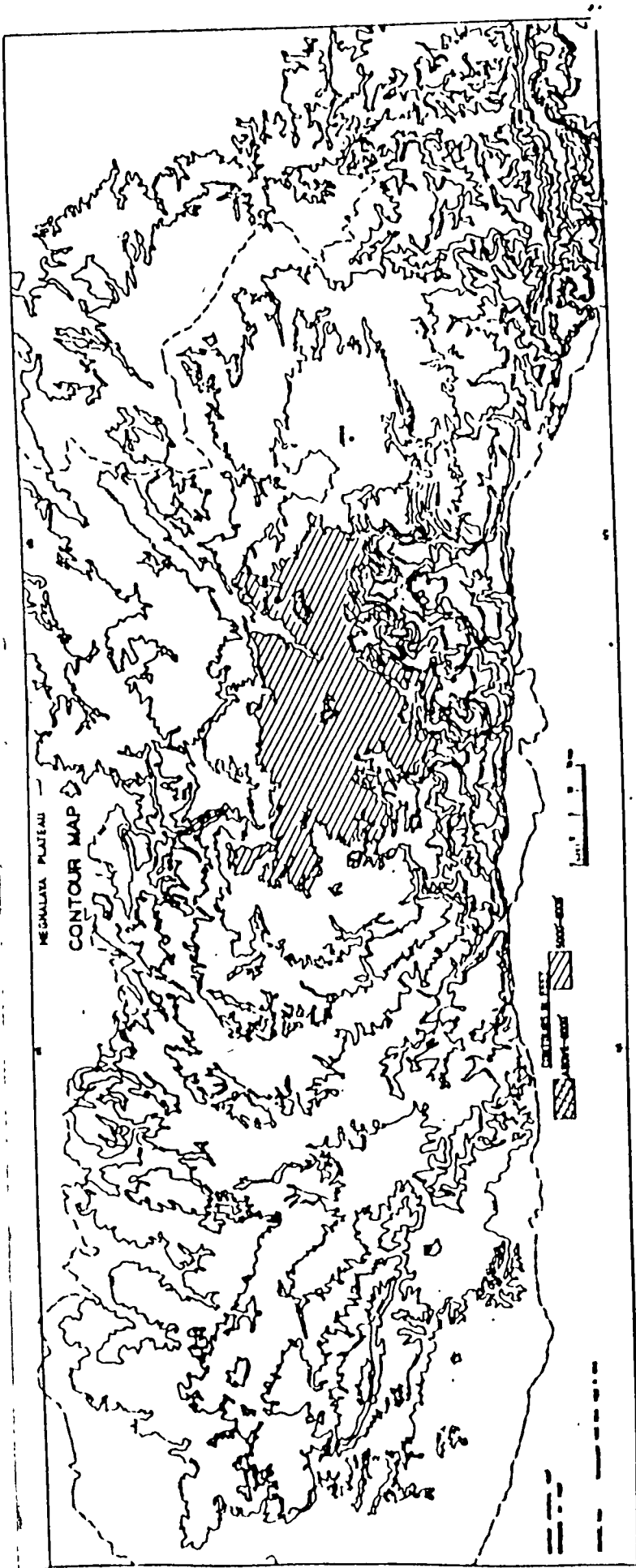


Fig.2.2: Meghalaya Plateau-Relief Features (Contour Map).

Source D

whole region exhibits relief features of marshes and meandering streams. The foot of these dissected tracts lie the Surma valley. Another range which demarcates the central and Western Plateau is the Moheshkhola – Adaguri range.

4.0 Climatic Conditions:

In general, the entire Meghalaya region comes under the influence of the *Humid Tropical climatic conditions with nearly 3000mm annual monsoonal rain*, but with significant areal variation from 12,033mm occurs in Cherrapunji and Mawsynram areas which is in the South-Central slopes to only 2,296mm to the North-Eastern parts of the plateau. A significant monthly variation of rainfall and temperature has been recorded in some of the selected area of Meghalaya. The graph shows the rainfall and temperature of the selected centres (Fig.-2.3).

From the above representation, it is clearly shown that the areas of the Central and Northern parts are receiving lesser rainfall as compare to that of the Southern slopes. One such factors is that the alignment in the central and Northern parts are running in an East – West direction. As a result, the areas in the Central and Northern slopes renders as a rain shadow effect as is the case, the leeward side of any hills received less rainfall then the windward side. The Cherrapunji and Mawsynram areas which are located on the Southern slopes, which are in the windward side, are influenced with the South – West Monsoon which laden great amount of moisture from the Bay of Bengal brings more rain to the areas to the Southern slopes. But to the Northern slopes, the moisture bearing winds has almost exhausted all its moisture and,

by the time, monsoon reaches the Northern slopes, it has not enough power as it is in the Southern slopes. So, the variations in climatic conditions are guided by the relief features and direction of monsoon movement. The temperature and rainfall pattern in the area are as follows:

4.1 Temperature:

The temperature regime in the Meghalaya plateau changes with altitudes. Comparatively, the Western and the Southern parts which are very close to the Bangladesh plain where the relief is lower, they are much warmer. On the other hand, the higher reaches of the central parts of plateau, the temperature is much conducive, but as one moves down further to the Brahmaputra valley, the temperature rises again. With this, it can be said that the temperature at the lower relief is of tropical type with typical monsoon climate (i.e., Hot and Humid). Whereas the higher reaches the temperature is cool and humid; this is the characteristic of a temperate type of climate.

In the relatively low elevation of Western part of Meghalaya, temperature for most parts of the year is fairly high. The month of April is recorded the warmest, having the mean maximum of 34.9°C and the mean minimum of 22.1°C. By December the temperature cools down and is recorded the mean maximum of 24.9°C and a mean minimum of 11.6°C. On the other hand, the elevated region of the Shillong massif as well as the elevated region of the Northern slopes, the temperature is much more conducive, except August when the temperature is recorded the highest 30.6°C. Otherwise, the rest of the year, the temperature always remain below 30°C. The mean

maximum of the warmest month in the elevated region is 30.6°C and the mean minimum is 20.9°C and the temperature of the coldest months is having a maximum mean of 16.3°C and a mean minimum of 9.1°C. But areas at the Shillong massif, the temperature sometimes touches 0°C.

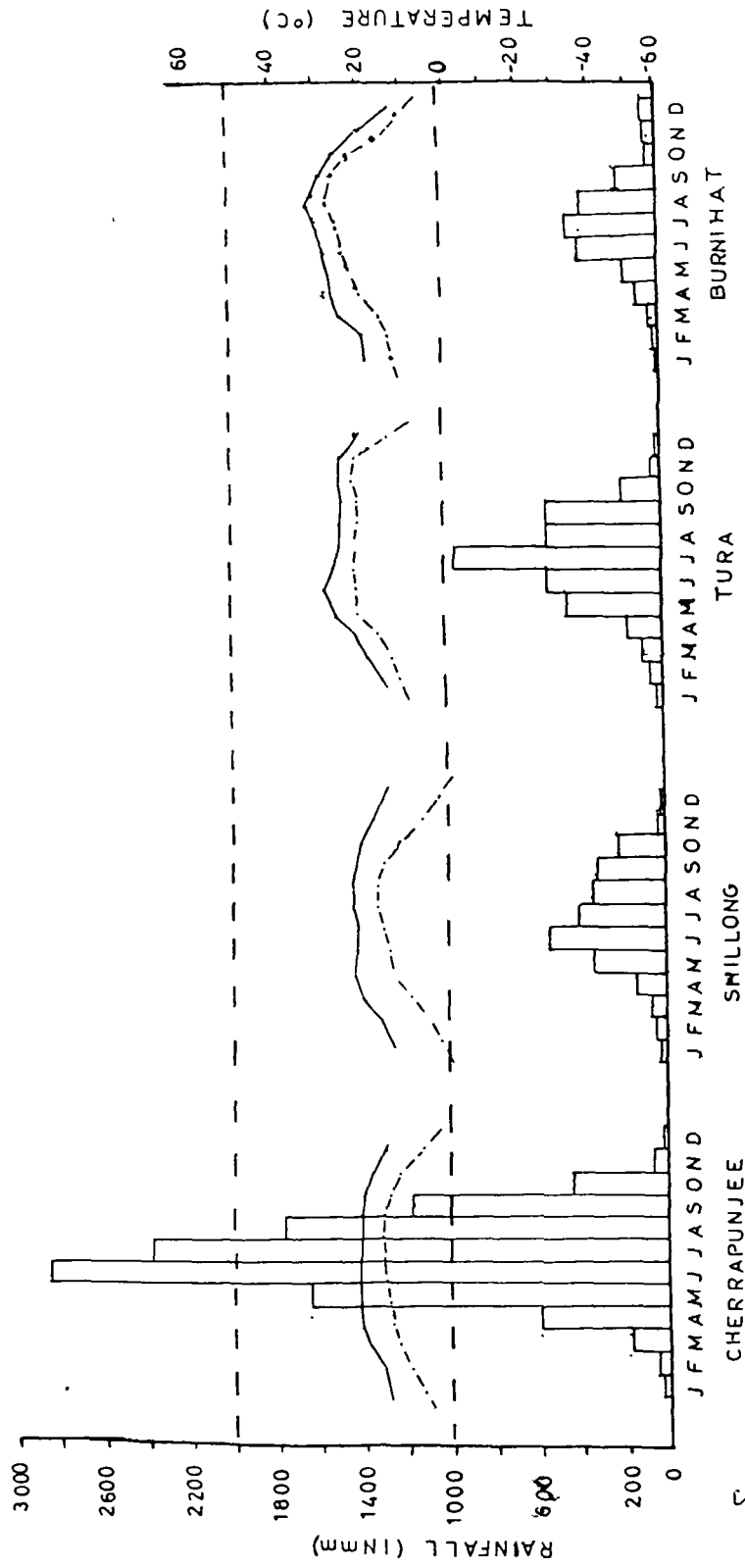
Though the Northern Slopes is in the rain shadow of the Shillong Peak. Yet the whole region is having enough humidity and moisture more or less as that of the Southern slopes which is in the windward side of the Bay of Bengal. This can be clearly seen from the rainfall, temperature and humidity graph of the different selected station situated on the Central Southern, Western and Northern parts of Meghalaya plateau (Fig.-2.3).

4.2 *Rainfall:*

The overall, rainfall distribution of Meghalaya, which is prepared from selected centres Cherrapunji (situated on the South Central slopes) Shillong (representing the central part of the table land), Tura (representing the western most parts of Meghalaya) and Burnihat (representing the Northern most part of the plateau region) shows that summer season has the maximum amount of rainfall (May to October). In areas of the Southern slopes, the amount of rainfall recorded the highest compare to the other stations because Cherrapunji in the windward side whereas the other region are in the rain shadow. Another factor is the influence of the topographic features.

On account of receipt of large amount of rainfall, the Southern slope of the Shillong massif recorded a rainfall intensity of about 77.68 mm/ day in Cherrapunjee .

Fig-23.: Monthly Variation of Rainfall and Temperature in Meghalaya



Source 9

This is comparatively higher than the Western parts of the plateau where rainfall intensity is about 30.36 mm/day. On the central part of the massif, it is recorded 19.70 mm/day specially in Shillong, and the Northern massif of about 18 mm/day in Burnihat (Singh 1996). During winter seasons (November to March) rainfall occurs very less. Consequently, it is the period of stagnancy of rainfall and also moisture deficiency in the atmosphere (Fig.-2.3).

5.0 Drainage System:

The evolution and development of drainage and the main characteristics of drainage are the result of the geological history of rocks formation and the tendency of residing confluences (Strahler 1963). The cases of river capture drainage system which are seen in Meghalaya, change the complete structure, geological formation and its resultant topography of the region. These have given rise to a varieties of drainage pattern of the plateau. The most commonly developed types of drainage pattern are Dendritic, Trellis, and Radial. Dendritic types are situated mostly in the dissected plateau, particularly in the Southern slopes of the Shillong Massif, Umiew Umngot and Umlieghan developed into a Dendritic pattern. In the Western parts of Meghalaya, Dendritic patterns are common except in few places in Tura, where the Dendritic patterns take the shape of a Radial pattern. On the Northern slopes, the tributaries of Umniam and Umtrew develop into a Trellis type of patterns. This may be the result of the Granitic complex of the geological structure of the region. So rivers are following the regional slopes and the direction of the dip.

The profiles of main rivers of the Meghalaya plateau would give us an idea on the slopes and the general relief features. The rivers have to traverse till it reaches the Surma and the Brahmaputra rivers.

The Drainage system of Meghalaya plateau have to traverse through different geological setup. The South flowing rivers exhibit the steepness of the slopes that they have to flow. Particularly river Umiew where the slopes suddenly drops and then have to pass through steep slopes and latter joined the Surma river (Fig.-2.4). Whereas those rivers flowing North ward travel through a gentler slopes and all throughout its course they are having more or less a uniform dip till they join the Brahmaputra river. But one notable point is that, though the slopes are gentler, the drainage pattern of the region do not behave with that of the slopes. This could be from the different factors that acts on the land, such as: The geological setup of the Northern slopes composes of granitic, gneiss and schist which are harder rocks. This unable the streams to erode very easily. As a result, the topography of the region still exhibits a youthful topography. On the other hand, the river profiles of the Western parts of Meghalaya exhibits a completely different type of topography. Here the lower courses of the streams have almost reached a maturity stage with numerous river terraces can be observed and even the rivers are wider than those flowing in the upper reaches (Fig.-2.4).

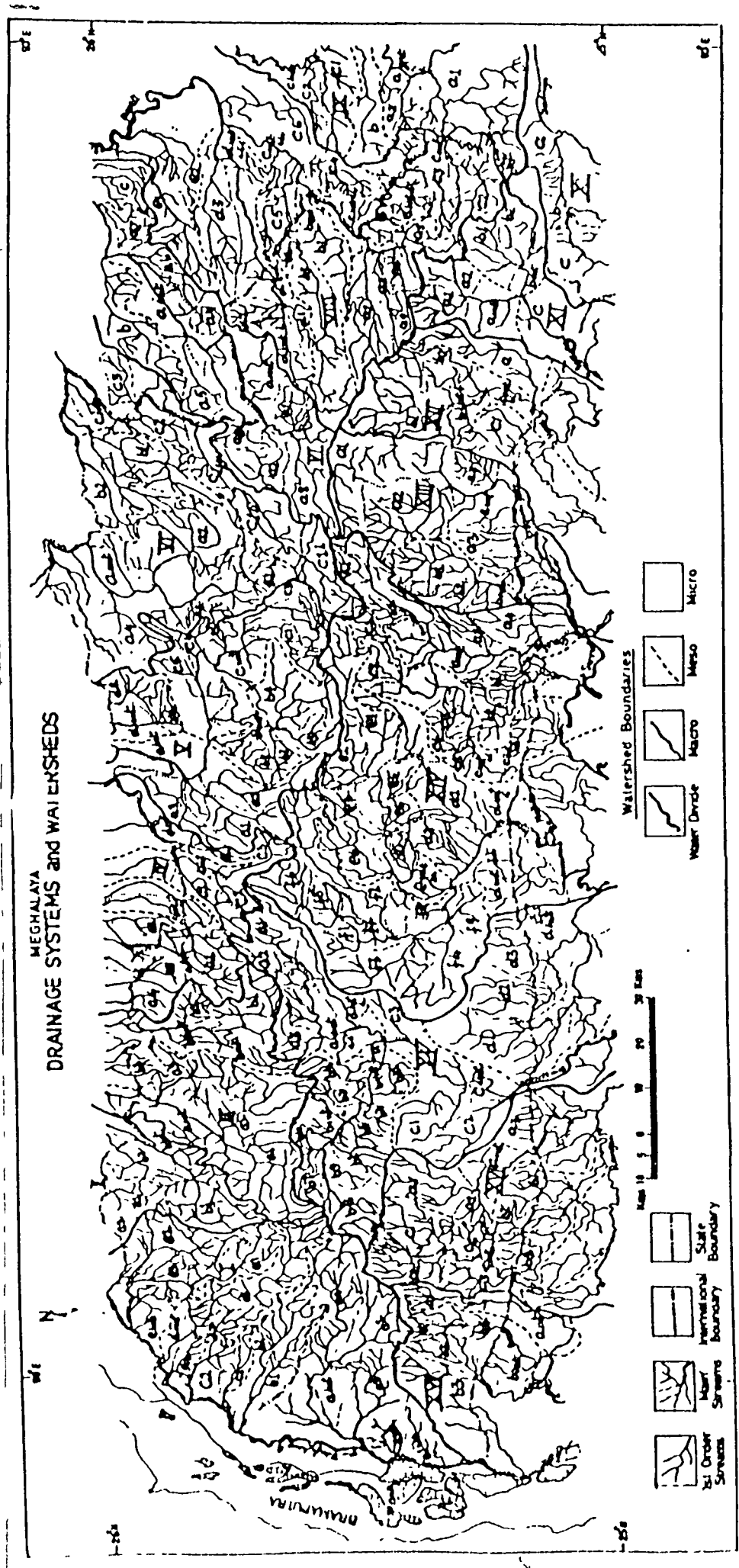


Fig. -24: Drainage Systems and Watersheds

Source 9

6.0 Soils:

Soil is the thin surface layer of the earth restricted to land with the fertility characterised by the organic and mineral composition and a profile type of structure that it alone possesses. The emergence of soil is the result of combined activity upon the rocks by water, air, solar energy, plant and animal organism, hence the properties of soil reflect the local characteristic features of the environment and managing the activity of man (Yakusushova 1983). The above definition of soil clearly states about the interaction of all the factors like climate, geology and relief on one hand and the interdependence of soil formation on inputs of matters and energy together with organism interaction on the other. The propagation of soil and their composition also depend on the bio-climatic conditions and characteristics of the pre-vental sub-strata of rocks and the aspect of relief. In this regards, the environmental zones have a humid climate and such the development of soil would correspond very much to other humid areas. However, as the case may be the temperatures of these environmental zones are much lower than what the humid tropical areas experience. Therefore, weathering process will be retarded substantially, though at the same time allowing weathering and soil formation process to continues (Zoan 1986).

The type and structure of rocks also play a vital role in the evolution of soil. Soils also have distinctive characteristics due to the action and interactions of climate, vegetation, animals and relief of the whole region over a long period of time. Thus, the soil structure will indicate the air and water holding capacity of soil. It also reflects the mineral and organic content of soil, it will determine the susceptibility and soil erosion

and the capacity of soil for plant growth (Singh 1995). All the sample watersheds are dominated by gneisses and granules. These in turn are transformed mainly to Kiolinite but due to the ferruginous concretions give such soil a reddish colour (Ram & Singh 1993). However, much cannot be commented on the formation of soils in these areas. They need a closer look and require exhaustive research before any conclusion can be made.

As in the case of the areal variations of the soils, soils in Meghalaya Plateau vary from place to place in their physical characteristics. According to Haridasan and Rao (1985), soils in Meghalaya Plateau are mostly lateritic in origin and vary from sand loam, red loam to clay loam. Thus based on the above classification, the broad types of soil are as follows:

(a) *Lateritic Soils:*

This type of soil is derived directly from the residuary basic and intermediate igneous rocks produced by weathering, particularly in hot climates. These soils are deficient in potash, phosphoric acid and lime. These soils are extent from West to East in the Northern border of the plateau.

(b) *Ferruginous Red Soil (Old or Alluvium):*

As the name indicates these soils are red in colour, they are poor in lime, potash, iron oxide and also uniformly poor in phosphorous content. In general, these soils are poorer in nitrogen, phosphorous and humus. They are found in the highland

areas bordering the plains and also found all along the Northern fringe in the region. In texture, they vary from sandy loam to clayey loam with varying degree of nitrogen content (i.e., from high to low).

(c) *Mountain or Hill Soils:*

This is the most predominant type of soil found in the Meghalaya Plateau. These soils are generally loamy in character varying from clayey to sandy loam and red in colour. They are rich in organic matter and nitrogen, but usually acidic but are deficient in phosphate and potash. These soils occupy almost the entire region except a limited tract in the foothills and submontane fringes of the region.

7.0 Natural Vegetation:

The vegetation of Meghalaya Plateau is extremely varied and interesting from the botanical point of view. The South-Central part of plateau under forest is considerably insignificant, compare to the surrounding areas. It is interesting to note that, in spite of the heavy down pour in its Southern and Central parts, one would expect a dense evergreen rainforest. Yet the entire area is bleak and dreary with only grasses covering the hillock and landscape which the underlying rocks project out from the very badly leached soil surfaces.

In the Western part of the plateau, the vegetation is characterised as those very similar to that of the Brahmaputra valley where there is a distinct absence of grass

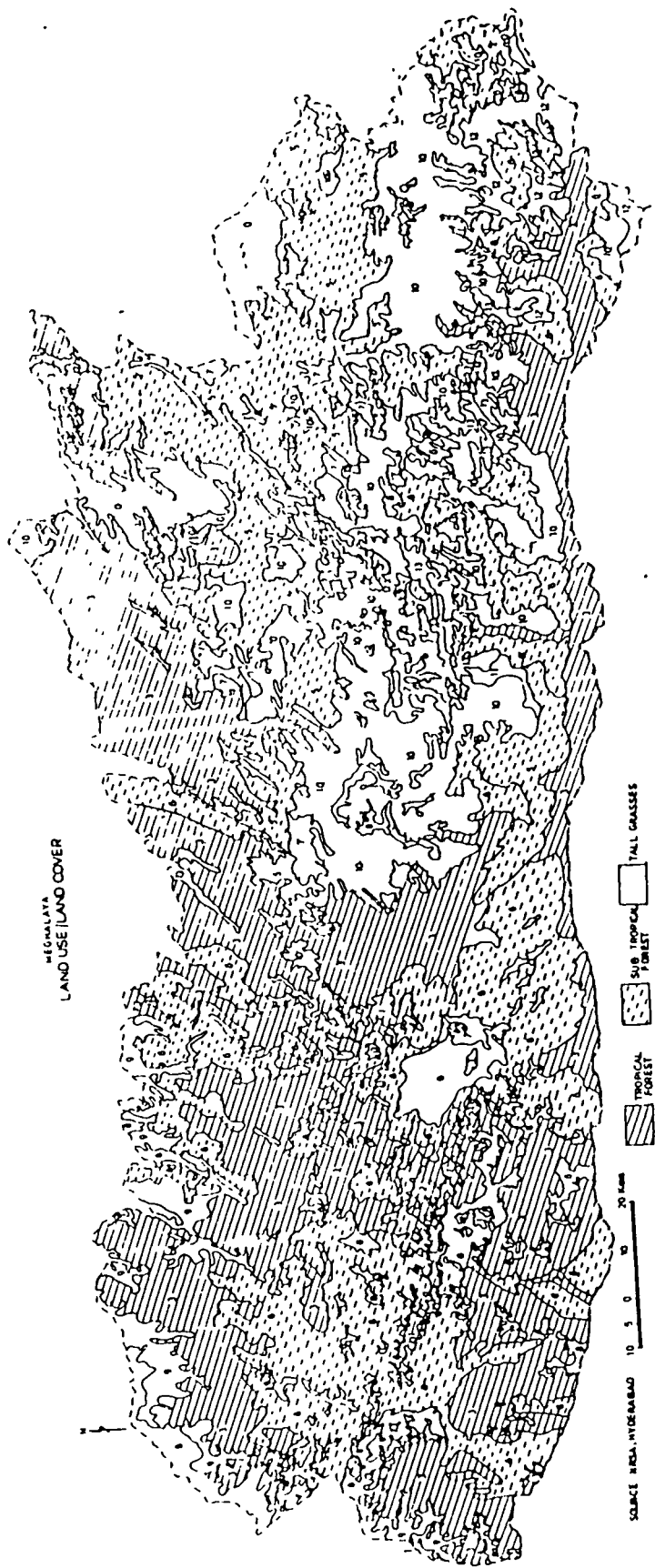
vegetation. This region mostly have a dense tropical mixed forests with predominance of *sal* and dense thickets of bamboo.

The vegetation of the Eastern and Central part of Meghalaya is of a mixed tropical evergreen hardwood forest upto elevation of 300m both on the Northern and southern parts. Along side there are thickets of bamboo, cane, wild banana trees especially on the slopes of the narrow valley. Within the elevation of 300-750m, the region have a grass level vegetation where trees and scrubs are insignificant although scattered of pine trees can be seen in the rolling grass lands. About the elevation of 750m of the Central and Eastern Meghalaya, pine forests are prominent particularly in the Shillong hills. Along with pine, willow, birch, mokrisal, oak, magnolia, beech and the other miscellaneous trees, besides the rhododendron upto the elevation of 1200m are the main species of the region (Fig.-2.5).

8.0 The Regional Personality:

There are various methods and techniques to show the regional personality or areal differentiation of the environmental conditions of any area. In the preceding section of the chapter, the environmental conditions are described in general. The areal characteristics and the synthesis of the fact of these environmental conditions are equally important. It would justify the location of the sample watershed as well as would be able to highlight a composite view of environment of Meghalaya plateau.

There are various geomorphological methods for delineating the geomorphological areas of the landscape in which the geomorphological parameters



Legend : 1= Tropical Evergreen Forests, 2= Tropical Semi-Evergreen Forests, 3= Tropical Moist Deciduous Forests, 4= Sub-Tropical Evergreen Forests, 5= Sub-Tropical Pine Forests, 6= Sal Forests, 7= Agriculture/Follow Lands, 8= Shifting Cultivation/Jhum, 9= Abandoned/Regrom/Jhum, 10= Grassland/Waste land/Denuded areas, 11= Water Bodies, 12= March land, 13= Hill/CloudShadow/Unclassified, 14= Clouds/Sand

Fig.-25: Distributional Pattern of Land Cover/Landuse in Meghalaya

and the nomenclatures of the environmental conditions are based (Amedeo 1967). The soil scientist emphasised the soil parameters for studying the areal differentiation of the environmental conditions. Landuse mapping was done by emphasising the environmental conditions of land which is related to the environmental management (Vink 1975; NBSS & LUP 1989). In the present research, the main aim is to delineate the zones based on the environmental conditions especially the physiographic features of Meghalaya plateau. The regional personality is highlighted here by dividing the plateau into 4 broad regions of macro areal levels (Singh 1996). This classification is based on the basis of similarities of 13 parameters related to geomorphological, hydrological, soils & landuse characteristics of 102 watershed (the areal units for classification). The correlation matrix was prepared and highly correlated parameters are grouped to form these regions (Singh 1996). The main environmental conditions of these region are as follows:

- (a) The areas of 'horst' type of topography which is centrally located, having an elevation of more than 1000m, with varieties of undulating hills escarpment, inter piedmont valley for paddy cultivation and tall grass. The gradual slope with thick pine forest with minimal erosion.
- (b) The transitional zone of steep slopes which are contiguous to the 'horst'. The steep slopes of Southern sides (Dawki-Mawsynram and South Garo Hills) have severe erosion rate, thin cover of soils (gravelly) undulating slopes with rapids, waterfall, deep valleys, gorges where barren land is dominating on the landscape with

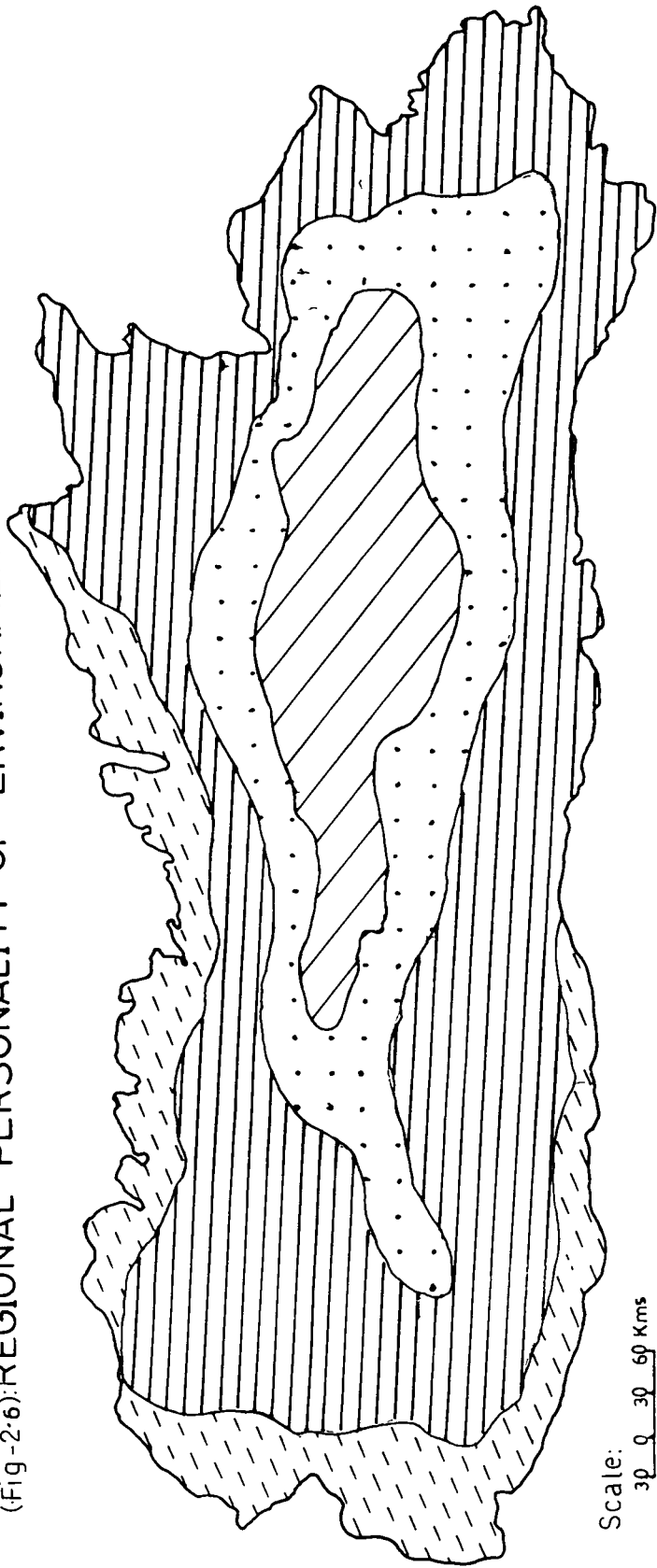
tropical sub-tropical trees especially in the valley slopes. The transitional zones of the Northern slopes has significantly have different environmental conditions. The slopes are steep but soil profiles are quite deep with less rain and moderate climate. Bamboo dominated forest can be seen on these forests. There are significantly high interactions of human activities. As a result, the landuse are different and intensive.

- (c) The third zones are piedmont valleys of most diversified landuse conditions. The zone covers the entire foothill areas of about 100-500m bordering the Northern slopes of Garo Hills with fertile laterite soils. Agricultural practices in the valley are some of the dominating features.
- (d) The flat lands of extreme Northern sides of Garo and Khasi Hills, the climate is tropical with moderate rain and landscape is dominated by agricultural practices in the open valley.

On the basis of the areal variations in the environmental conditions especially on the Northern slopes of Meghalaya plateau, three representative watersheds are selected for understanding the parametric relationship and the impact of physiography on landuses in these areas (Fig.-2.6).

Based on geology and physiographic attributes (like relief, drainage, climate, soil) and to some extent the vegetation of the Meghalaya Plateau, their interrelationships have been taken into account. Before reaching to the conclusion, there are many and varied parameters at micro hierarchic orders in their environmental

(Fig-2.6): REGIONAL PERSONALITY OF ENVIRONMENTAL CONDITIONS



Scale: 30 0 30 60 Kms

- Zones of horst types topography
- Zones of steep slopes
- Zones of piedmont valley
- Zones of flat land

Fig. No. 9

CHAPTER - III

PHYSIOGRAPHIC CHARACTERISTICS OF THE SAMPLE WATERSHEAS

1.0 Introduction:

The synthesis of the environmental attributes in its regional form is given in the preceding chapter highlighting that Meghalaya plateau especially its Northern slopes have a variety of environmental conditions which are generalised to put them into four main zones. However, three are more important and the fourth one, i.e., the foothills and open valley are the parts of the plain of Brahmaputra. River valleys, slopes and elevations are the determining parameters which influence the other parameters of physiographic as well as economic conditions of landscape and influence the landuse pattern of the area. Considering these parameters and drainage pattern of the Northern slopes, from where three watersheds have been selected for detail study, the physiographic characteristic of these watershed are interpreted in the present chapter.

2.0 Location and Extent:

Location of an area may be interpreted in many ways. The location of these three watersheds is interpreted in the present context not only by giving the geographical location of latitudes and longitudes, but the altitudes (elevations) and the

river basins where they are located because elevation is an important attribute for the sample watershed. The latitudes and longitudes as well as the altitudinal extent are given in Table - 3.1.

Table-3.1: Location and Extent of Sample Watersheds.

Name of Watershed	Extent			Area (ha)	Scale of Mapping (R.F.)
	Latitudes	Longitudes	Elevation (metres)		
Umdohbyrthih Watershed	25°40'-25°45'N	91°55'-92°0'E	1271-900	427	1:5000
Upper Wah Umran Watershed	25°40'35"-25°51'48"N	91°57'15"-91°50'20"E	1000-650	1954	1:10,000
Narang-Kongripara Watershed	25°59'-26°0'54"N	91°40'20"-91°52'0"E	516-180	1165	1:10,000

The sample watersheds are located generally 25°40'-26°0'N latitudes, it means in the global position there is not much variation except only 20 minutes difference which may not have much variation in the location of watersheds on the globe. However, there is a significant variation of physiographic attributes among them, because of the elevation and drainage system at the micro areal level. The specific locational characteristics of sample watersheds are given below:

- (1) The sample watershed, i.e., Umdohbyrthih, is located on the 2nd order stream of the Umiam river which is located at the upper part of the Northern slope near the Barapani lake. It represents the high altitudinal environmental conditions of Meghalaya plateau (more than 1000m). The shape of the watershed is like a

tumbler and has many streams in the upper reaches of the Northern part of the basin. The river Umdohbyrthih flows from North-East to South-West with its curvilinear shape. Three perennial streams join the main river in the area.

(2) The Upper Wah Umran watershed locally called Mawrong, because Mawrong village is located in the watershed, is the representative of the transitional zone of the steep slopes at the elevation of nearly 800m. This watershed is 10 km far from the Block headquarters (Umsning Block) and connected with metalled road. It has a varieties of physiographic features like dome shaped topography, deep valleys, flat lands with swampy pockets. It covers an area of 2000 ha (approximately), but has the variety of land uses. A sub-tropical type of climate prevails in the area. Regular water flow can be seen in the channels, though the amount of water dwindles during the dry season. This watershed is located on the 1st order stream of Wah Umran at the confluence of three rivers, the upper coarse of Umran river, the Umsohmanong and the Umwang. It is separated from the Umkaduh basin by a narrow strip located on the Northern side. The upper ridges of the watershed is distinguish by undulating topography, eroded rocks and deep valleys with dense forest. The lower section has a flat land with the depositional features of low lying areas (sheds).

(3) Narang-Kongripara is also one of the sample watershed which is a representative of foothill zones on the Northern slopes. Though it is located on the slightly higher latitudes of 26°0', yet it has a peculiar characteristics of lower elevation with areal extent of 1200 ha (approximately). It is interesting to note that in such a small

watershed, there is a significant variation in the elevation which shows the steepness of slopes and variation of landuses. However, it is located at the lower elevation of the plateau. The name of the watershed was given on the basis of the famous village: Narang-Kongripara, located on the North-Eastern part of the watershed. The watershed land is covered by the 1st order streams, namely, the *Dongbah*, and the *Ir Pathar Ka This*, *Ir Sohpun*, *Umjri Pahar* and others are the tributaries of the Undu river. The shape of the watershed is almost oval, where the Northern part has slopes of more than 15 percent whereas the South-Central part has flat land and open valleys.

3.0 Physiographic Characteristics:

As mentioned in the earlier chapter that the physiography of any area or watershed can be described by studying the relief, drainage, soils, climate and natural vegetation. The related parameters like elevation (relative height), slope, drainage density and drainage ordering, chemical properties of soils and tree species are studied by preparing detail maps of these attributes of these watersheds. The physiographic characteristics of each watershed are given separately in the following paragraphs.

3.1 *Umdohbyrthih Watershed (Upper part of the Northern Slopes of Meghalaya):*

This watershed covers an area of about 427 ha which is drained by the main *Umdohbyrthih* river. This river is fed by two tributaries, namely, the *Umkhukru* and the *Umdohbyrthih*. The 1st order streams are seasonal and are flowing from the North

and North-East to South-West in the watershed. The areas of the Northern part of the basin are formed by a varieties of relief features such as flat land topography (plateau type) on the water divide on the Northern side, rugged topography. The deep valleys on the slopes are some of the main features. The physiographic parameters of the watershed may be described in the following manner.

(a) *Relief:*

The elevation at the mouth of the watershed is recorded 850m, with a variation upto 1271m within a distance of 1 km. This means that the watershed have very steep slopes; there is a vertical increase of 421m per km of horizontal distance. The upper ridges of the Northern parts of the watershed are steeper. Therefore, the eroded topography can be seen. The detail contour map show that there is an open valley in the Southern part at the mouth of Umdohnyrthih river with the valley width of nearly 400m in the South-Western side of the watershed (Fig.-3.1).

Area-elevation relationship (hypsothetic curve) shows that nearly 2/3rd of the area of the watershed (i.e., 356.27 ha) falls under the category of high and very high elevation (1000-1200m) which is generally situated in the Northern hill top and hill slopes of the crest and foothills areas of the dissected escarpment. Flat valley is recorded only 16 percent of the area and the areas under extremely high elevation amounts to only 17 percent (Table-3.2).

(Fig. 3.1) C ONTOUR MAP
 (Umdohbyrthih Watershed)

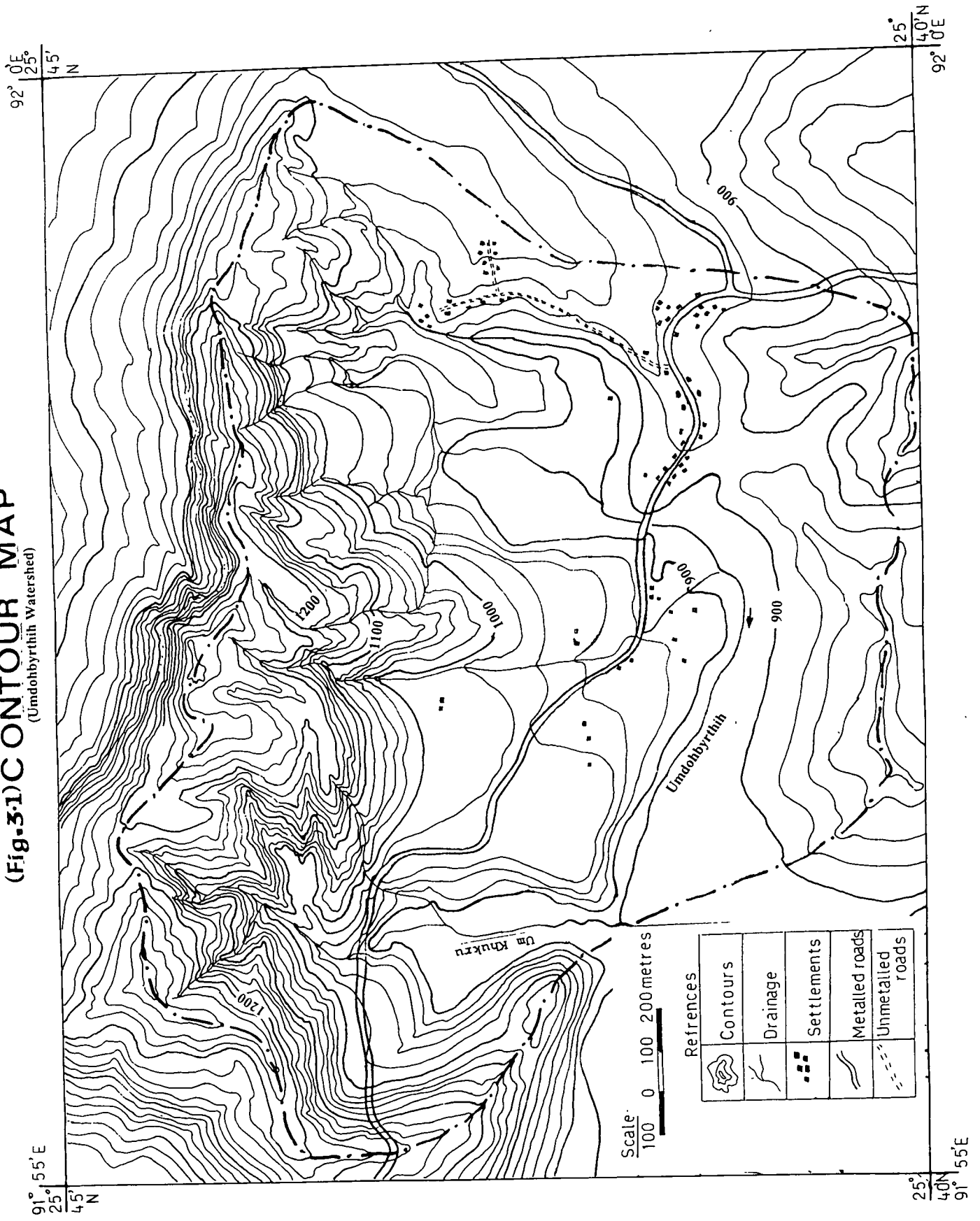


Table - 3.2: Elevation–Area Relationship.

Category	Elevation (m)	Area (ha)	Area (%)
Extremely high	Above – 1200	74.80	17.52
Very high	1200 – 1100	92.75	21.72
High	1100 – 1000	188.72	44.20
Moderately low	1000 – Below	70.70	16.56

(b) Slopes:

Though there are a variety of slopes if local relief features are taken into consideration. On the other hand, the average slope map shows that the slopes of the upper section where the 1st order stream are originating recorded more than 75 percent (very extremely steep slopes) in the pockets of the steep slopes of the flat ridges. A zone of very steep to extremely steep slope (50-75 %) is continuous on the Northern parts of the watershed (Fig.-3.2) which accounts for nearly half of the area of the basin (Table-3.3).

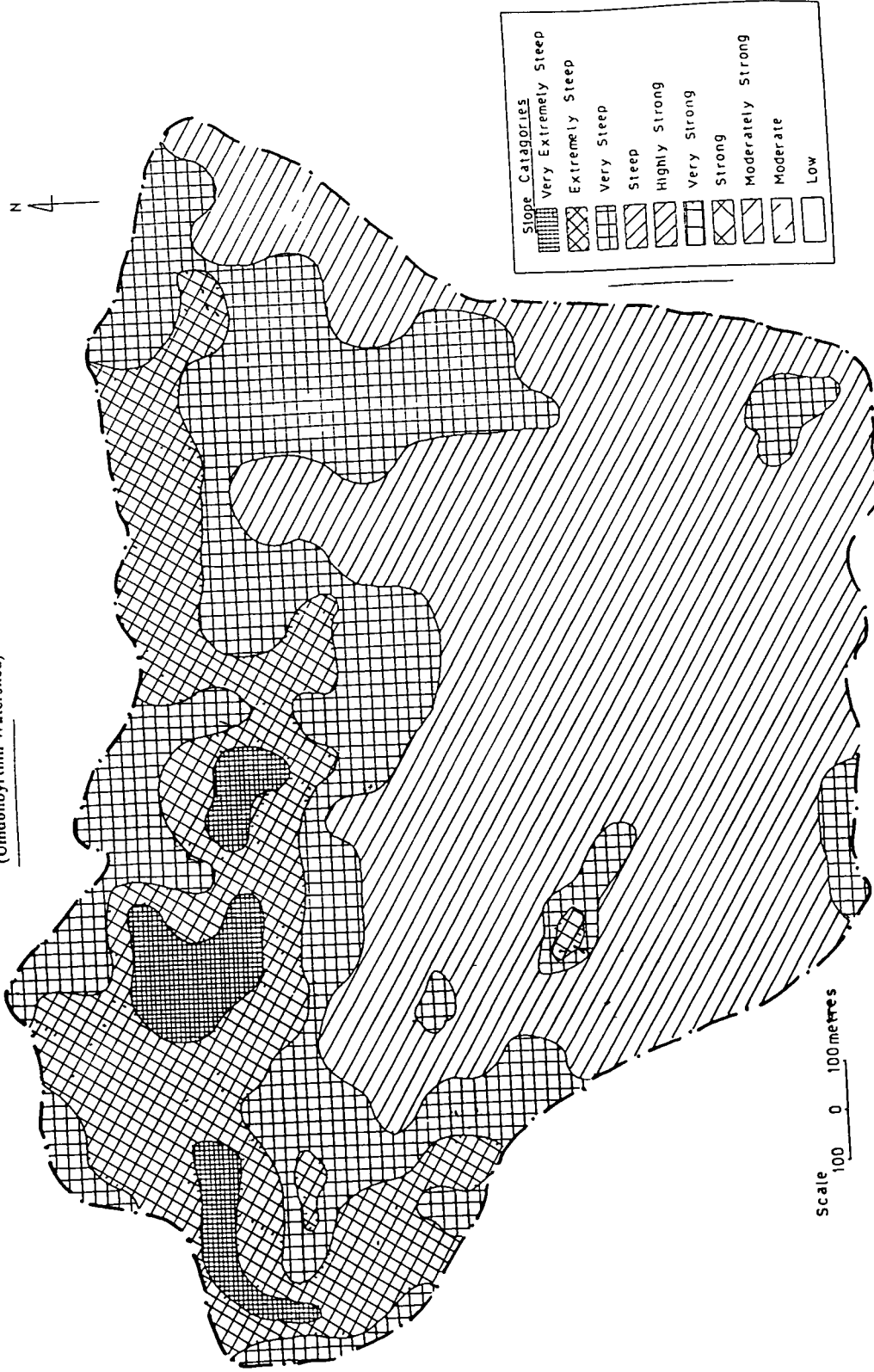
Table - 3.3: Area Under Various Category of Slope Gradient.

Category	Slope (%)	Area (ha)	Area (%)
Very extremely steep	Above – 75	94.80	22.20
Extremely steep	75 – 50	192.75	45.14
Very steep	50 – 25	48.91	11.45
Highly strong	25 – Below	90.54	21.20

(c) Drainage Systems:

Drainage system provides many parameters on quantitative study of basin characteristics. In fact, a trellis drainage pattern is evolving in the area. This shows the smoothness of the geological structure where the area is far from the fault time. However, there are many minor lineaments along the main channel through which the

(Fig-3.2)
SLOPE MAP
 (Umdohbyrthih Watershed)



Source 9

Umkhukru and the Umdohbyrthih streams are flowing. The area is drained by four orders of streams, but only the 3rd order are perennial. There is a spring in the North-Central part which divides the area into two main physiographic features, that is, (1) the flat topography of the South and (2) the steep hilly topography of the north (Fig.- 3.3).

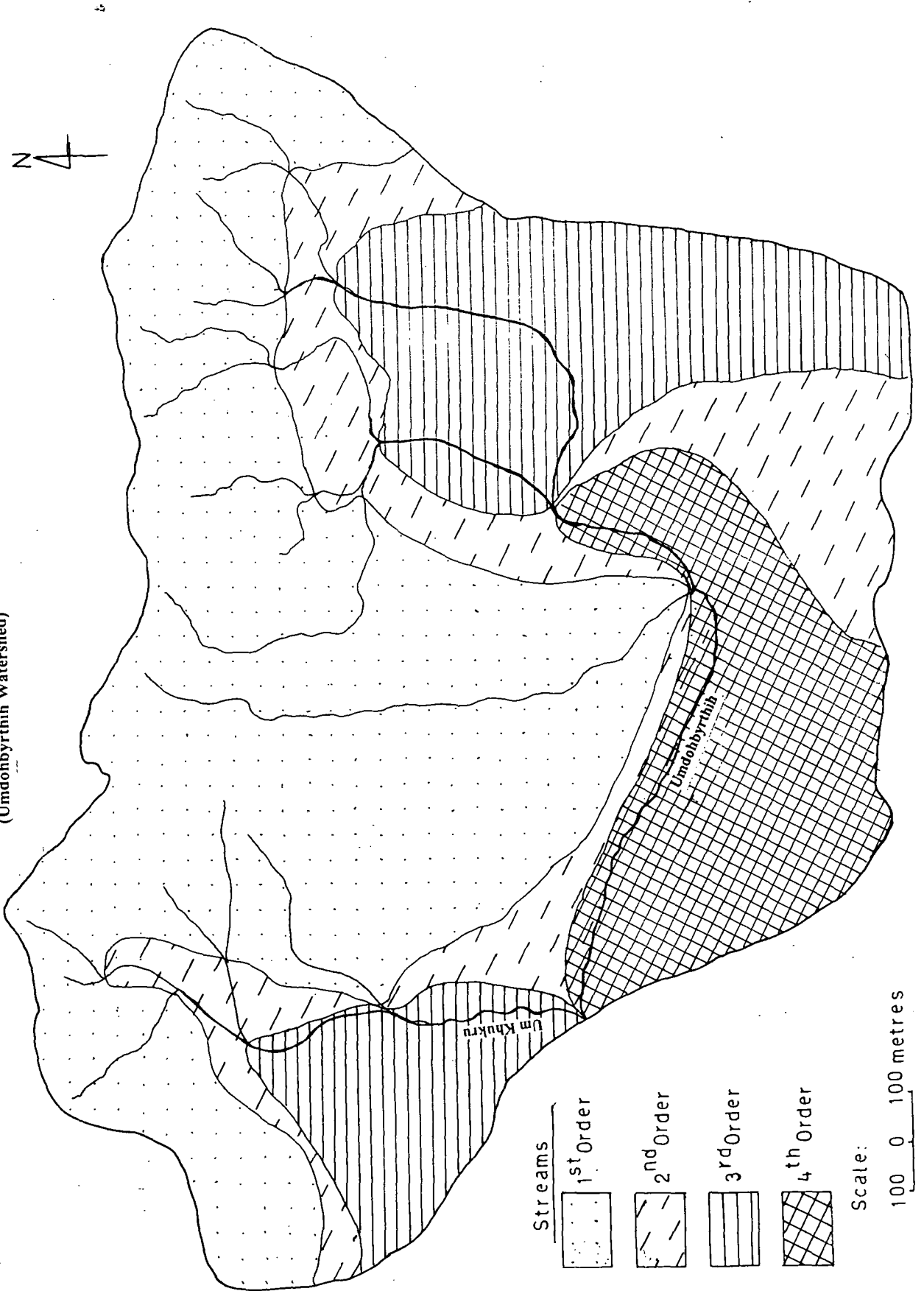
Bifurcation ratio is almost similar in all the stream orders, though the drainage density is higher in the areas of the 1st order and 2nd order streams. Above 27m length of drainage per hectare. The density gradually decreases when the streams order increases (Table-3.4).

Table - 3.4: Drainage Density and Bifurcation Ratio According to Stream Order in Umdohbyrthih Watershed.

Stream Segment	Total number of Streams	Total length of Streams (m)	Area (ha)	Drainage Density (m/ha)	Bifurcation Ratio
1 st Order	16	6400	177	36.16	-
2 nd Order	6	2000	83	24.10	2.66
3 rd Order	3	2100	93	22.58	2.00
4 th Order	1	1000	74	13.51	3.00

The Table shows that the area of about 177 ha is covered by the 1st order streams which covers almost half of the total area of the basin. However, areal size and streams length decreases proportionately, which in turn the watershed drained the water sufficiently and no flooding resulted in the area.

Fig-3.3: DRAINAGE MAP
(Umdohbyrthih Watershed)



- Streams
- 1st Order
 - 2nd Order
 - 3rd Order
 - 4th Order

Scale:
100 0 100 metres

(d) *Soil Fertility:*

The fertility status of the soils and the relationship of the fertility status is studied according to slope, soil depth, erosional rate and vegetal cover in the watershed. After analysing 25 samples of soils from the various slopes, vegetation and erosion, it is found that the soils are highly acidic (pH 4.0). This is due to heavy rainfall and leaching processes. However, Organic Carbon recorded medium in most of the cases, from the hill top to the valley bottom. Same is the case for Phosphate (Table-3.5).

Table – 3.5: Fertility Status of Soils in Umdohbyrthih.

Sl. No.	S (%)	d (cm)	e	V	C	pH	OC	P ₂ O ₅	K ₂ O
1	81.6	27	L	Pine	Yr	4.0	M	L	M
2	76.9	38	LH	Pine, Grass	Rb	4.5	M	L	L
3	31.1	>40	LH	Pine, Grass	Rb	4.5	M	L	H
4	75.5	20	LH	Pine, Grass	Drb	4.0	M	L	M
5	79.7	35	H	Pine, Brush,	Yr	4.0	M	M	L
6	78.3	>40	LH	Pine, Brush	Yr	4.0	M	M	M
7	55.5	36	L	Barren	Rb	4.0	M	L	L
8	54.1	>40	H	Upland Rice	Drb	4.0	M	L	L
9	52.7	>40	L	Thick Grass	B-Db	4.0	M	L	L
10	21.3	>40	L	Bamboo	Yr	4.5	M	L	VH
11	11.3	>40	L	Paddy	B	4.5	M	L	M
12	14.1	>16	L	Weeds	Db	4.5	L	L	L
13	21.3	>30	L	Bamboo	Yr	4.0	M	L	H
14	21.1	>40	VL	Grass	Yr	4.0	M	L	M
15	19.1	>40	VL	Paddy	Lbg	4.0	M	L	VH
16	15.5	>20	VL	Paddy	Lbg	4.0	M	L	M
17	19.7	>30	VL	Paddy	Lbg	4.0	M	M	H
18	19.7	>30	VL	Paddy	B-Db	4.0	M	M	M
19	19.7	>30	VL	Fallow	B-Db	4.0	M	M	M
20	19.7	>30	M	Barren	Yr	4.0	M	M	L
21	19.7	>30	L	Grass	Rb	4.0	M	L	M
22	19.7	30	M	Paddy	Lbg	4.5	L	L	VH
23	19.7	30	L	Fallow	Rb	4.5	L	L	VH
24	21.1	>40	H	Grass	Orb	4.0	L	M	VH
25	21.1	>40	H	Newly Prepared for Ginger	Yr	4.0	L	L	VH

Index: Character d = Depth in cm.; S = Slope in %; e = erosion as low/medium/high; V = Vegetation; C = Soil Colour (B=Brown, Drb=Dark reddish brown, B-Db=Brown to dark brown, Rb=Reddish brown, Yr=Yellowish red, Lbg=Light brown grey, Vdb=Very dark brown)

The classification of soil samples and their average values shows the general picture of the area. The steep slopes on the Northern parts (75-50 %) have a soil profile of about 30 cm deep. The erosion rate under such slope is high even when the area are under pine forest and tall grass. Such areas of the watershed have medium Organic Carbon and low Phosphate contents. While in the case of moderately low slope areas (below 20 %), the soil depth is more than 30 cm. On these slopes, permanent cultivation are carried out. The Organic Carbon contents are recorded medium and Phosphate continues to record low with less erosion rate. Therefore the soil on the valley are more fertile than the steep slopes.

(e) *Climate*

On account of the location of the watershed on higher elevation, the overall climate is temperate to sub-tropical in nature with moderately high rainfall (413 mm) and high humidity (more than 85%) during the wettest months. Monthly range of temperature varies from 5°C (in winter) to 28°C (in summer). Summer are mild and wet with more than 80 percent of rain is received during the months of May to September (Table-3.6).

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Table-3.6: Monthly Values of Temperature, Rainfall and Humidity in Umdohbyrthih Watershed.

Month	Temperature (°C)		Rainfall (mm)	Relative Humidity (%)
	Maximum	Minimum		
Jan	18.5	5.0	24.30	65.00
Feb	18.9	8.0	20.29	60.00
Mar	24.9	13.4	77.90	66.00
Apr	23.4	13.2	249.20	80.00
May	26.9	17.2	237.90	73.00
Jun	27.1	19.2	294.40	85.00
Jul	27.3	20.6	412.60	89.00
Aug	27.8	20.5	340.60	89.00
Sep	26.1	18.7	465.00	88.00
Oct	24.6	14.1	124.30	79.00
Nov	22.6	11.9	35.00	81.00
Dec	18.9	8.9	48.90	55.00

Source: ICAR, Barapani.

(f) *Natural Vegetation:*

Although the vegetation of Meghalaya plateau extremely varies and interesting from the so botanical point of view, yet the area under the forest is considerably in significant in comparison to the surrounding areas. Initially, the whole region is coursed by dense Tropical Mixed forests with predominance of bamboo, but most of these trees has been replaced by pine trees which is a secondary tree to the region. Yet some species still thrives in the gorges and in the stream sides. Identification has been made in the watershed and the following species has been found. These are *Elaeocarpus floribundus*, *Dillenia penlagyna*, *D. indica*, *Hovenia acerba*, *Lithocarpus fenestratus*, *Bambosa*, *Bambos*, *Khasyana*, *Pinus*, *Micromelum integerrinum*, *Symplocos paniculata* etc.

3.2 *Upper Wah Umran Watershed (Middle Part of the Northern Slope of Meghalaya):*

This watershed covers an area of 1954 ha drained by the upper course of the Umran river with its numerous tributaries namely *Umwang, Umsohmanong, Wah Pukri, Wah Mawyang, Wah Thungshriew, Wah Syrlihlyngdoh, Umsohynriew*. Most of the 1st order streams are seasonal in character feeding the bigger stream which flows to the Southerly direction. The watershed exhibits a variety of relief features like dome shaped topography at the water divide the North-Eastern and the North-Western side, rugged topography, deep valleys and the flat land with swampy pockets are the main features found in the watershed. The physiographic parameters of the watershed may be described as follows:

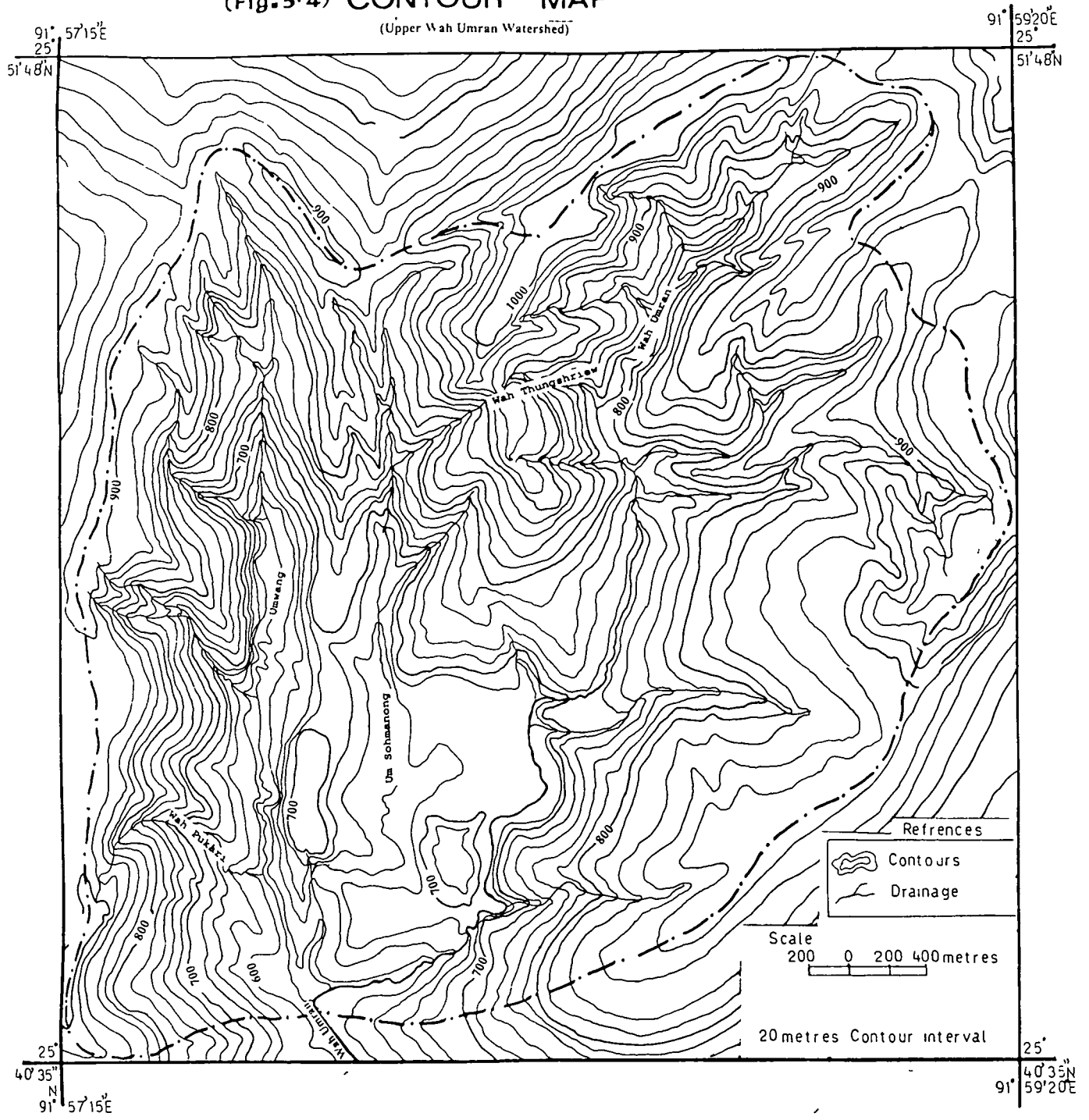
(a) *Relief:*

Its elevation at the mouth of the main river was recorded at 600m. The elevation varies from 600-1000m within a distance of 3.6 km, this means that the region has steep slopes that is there is an altitudinal difference of 111m per km. The upper ridges and hill tops in the North, North-East and North-Western parts exhibit eroded topography. The detail contour map further shows an open valley in the Southern parts. In the mouth of Umran river the valley opening has a width of about 200m. This means that flat lands are available in the southern side of the watershed (Fig.-3.4).

Area-elevation relationship (hypsometric curve) shows that nearly 84 percent of the area of the watershed (i.e., 1625.16 ha) fall under the category of low -

(Fig. 3.4) CONTOUR MAP

(Upper Wah Umran Watershed)



moderate to highly moderate elevations (700-1000m) which is mostly on the hilltops, hill slopes and to a greater extent the foothills. Flat valley are recorded to only about 11 percent (211.03 ha) whereas area of high elevation accounted to only about 6 percent (Table-3.7).

Table - 3.7: Elevation–Area Relationship.

Category	Elevation (m)	Area (ha)	Area (%)
High	A – 1000	117.81	6.03
Highly moderate	1000 – 900	442.70	22.66
Moderately low	900 – 800	750.42	38.40
Low moderate	800 – 700	432.04	22.11
Low	700 - B	211.03	10.80

(b) Slopes:

There are a varieties of slope if local relief features are considered, but the average slope map shows that the slopes at the area where the 1st order stream are flowing recorded to be more than 30 percent which fall under the category of steep to very steep slopes. This zone accounted for 50 percent of area (about 1033 ha) which is continuously observed on the North-Eastern, Northern and South-Western parts of the watershed (Fig.-3.5). There are pockets on the slopes and foothills with low to low - moderate slopes accommodated to 32.91 percent (861.50 ha) area of the watershed (Table-3.8).

(Fig-3 5)
SLOPE MAP
Upper Wah Umran Watershed

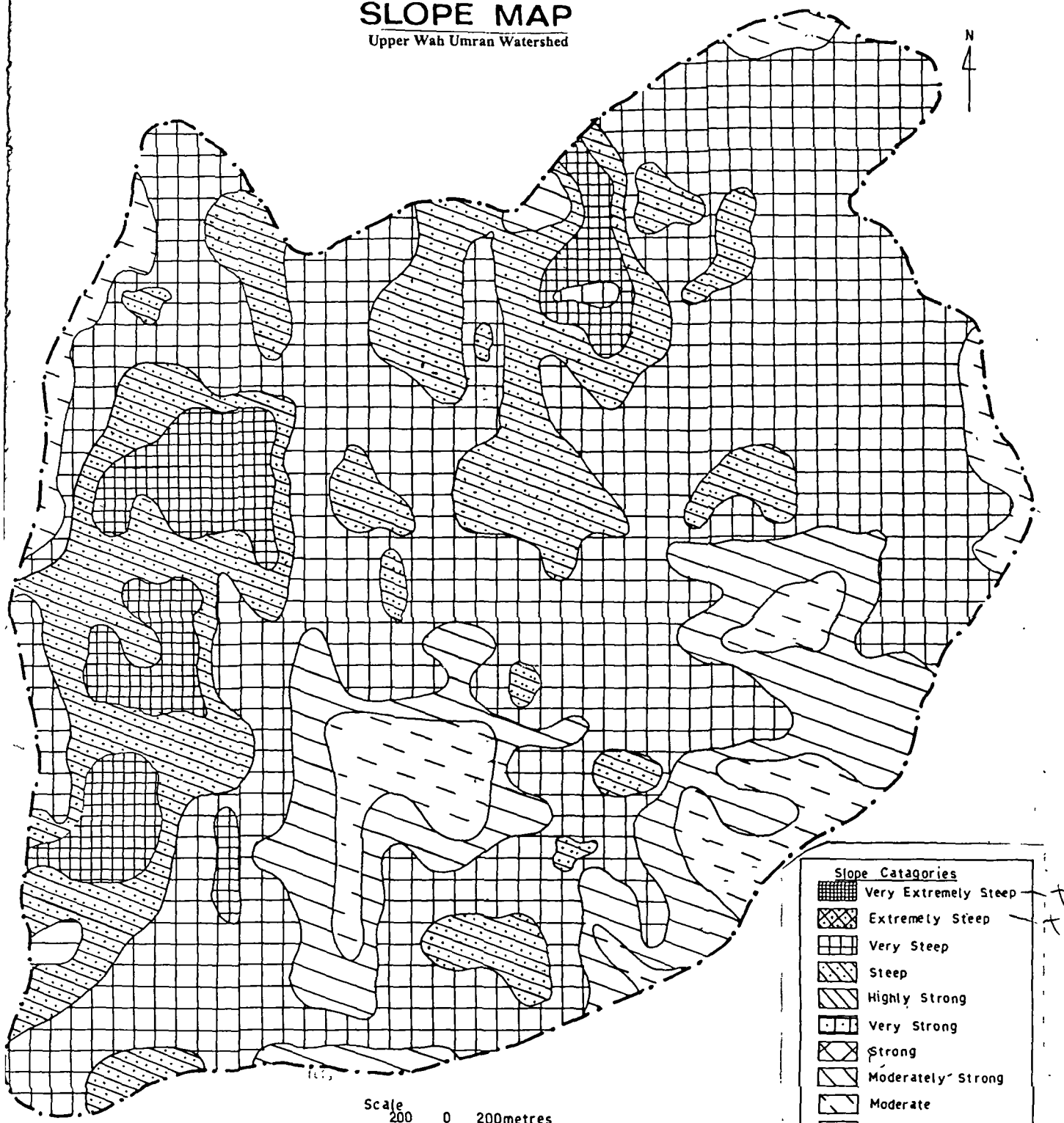


Table - 3.8: Area Under Various Category of Slope Gradient.

Category	Slope (%)	Area (ha)	Area (%)
Very steep	A – 40	339.00	17.38
Steep	40 – 30	396.00	20.27
Very strong	30 – 20	296.80	15.15
Moderately strong	20 – 10	196.50	10.03
Moderate	10 – B	665.00	34.03

(c) Drainage:

The drainage system of the area provides many parameters to study quantitatively the basin characteristics. In the watershed, a dendritic pattern is evolving which shows that the watershed is having a horizontal bedded archean sedimentary rocks as well as a massive igneous rocks like granite and schestose which are found in plenty. The area is drained by four order streams. Most of these streams are perennial, but dwindle to a greater extent during the dry season. The Umwang and upper coarse of Umran river divide the area into the different types of physiographic features as:

1. The flat topography in the South, and
2. The steep hilly topography of North-East, North-Western and Western section.

The bifurcation ratio is recorded lower in the 3rd order than in the 4th order. It means higher order has stronger drainage links. The density has also been found to be highest in the 4th and the 2nd order streams varying from 24 to 50m length of streams per hectare of area (Table - 3.9).

Table - 3.9: Drainage Density and Bifurcation Ratio According to Stream Order in Upper Wah Umran Watershed.

Stream Segment	Total number of Streams	Total length of Streams (m)	Area (ha)	Drainage Density (m/ha)	Bifurcation Ratio
1 st Order	26	20,900	1148	18.21	-
2 nd Order	6	10,200	424	24.06	4.33
3 rd Order	3	6,200	378	16.40	2.00
4 th Order	1	200	4	50.00	3.00

The Table shows that the area of about 1148 ha is covered by the 1st order streams which is more than half the total area of the basin. However, the number and length of the streams decrease proportionately. This shows that the watershed is drained by sufficient amount of water. Since the mouth of the watershed is wide no flooding is resulted during the rainy season (Fig.-3.6).

(d) Soil Fertility:

The soil fertility status and the relationship of the fertility status was studied according to slope, soil depth, vegetal cover and erosional rate within the watershed. After analysing 27 samples from various slopes, it is found that the soil is highly acidic (pH 4.0). This is due to heavy rainfall and leaching processes taking place. However, Organic Carbon ranges medium while Phosphate is recorded to be very low (Table - 3.10).

Fig-3.6 DRAINAGE MAP
(Upper Wah Umran Watershed)

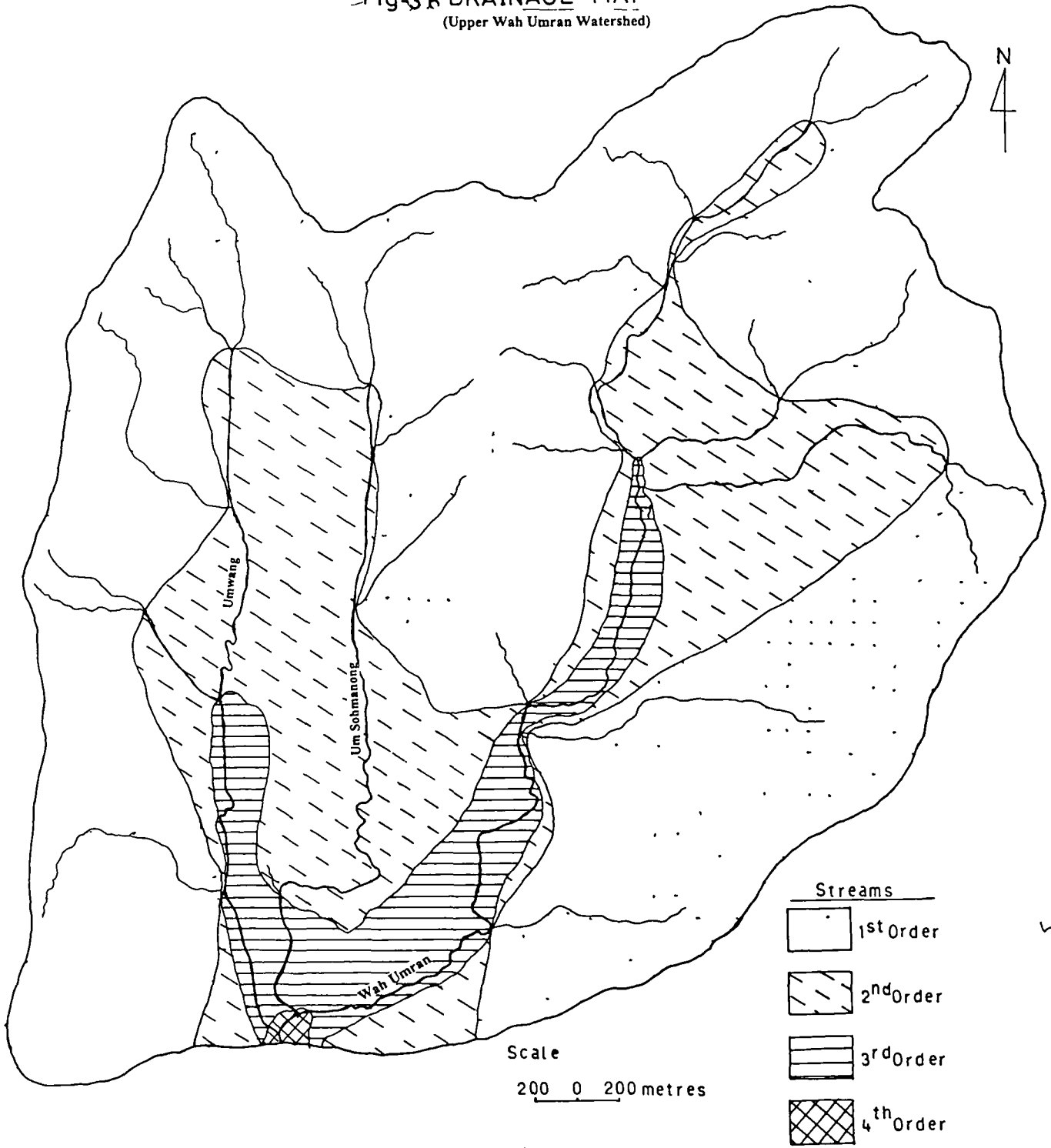


Table – 3.10: Soil Characteristics of Upper Wah Umran Watershed.

Sl. No.	S (%)	d (cm)	pH	OC	P ₂ O ₅	K ₂ O	V	e	C
1	12	20	4.0	M	H	L	Jhum	H	Drb
2	15	23	4.0	M	M	L	Broom	H	Yr
3	17	<40	4.5	M	L	L	Jhum	VH	Drb
4	14	<45	4.5	M	L	L	Barren	M	Yr
5	10	19	4.0	M	M	L	Bamboo	M	B
6	12	<25	6.5	L	L	L	Mixed Forest	VL	B-Db
7	13	30	4.5	M	L	L	Mixed Forest	VL	B-Db
8	10	<25	4.0	M	M	L	Mixed Forest	VL	B-Db
9	13	<20	4.5	M	VH	L	Mixed Forest	VL	B-Db
10	30	25	5.0	M	M	L	Pine, Grass	M	B
11	35	21	4.0	H	L	L	Dense Mixed Forest	VL	Dyb
12	32	25	4.0	L	L	L	Pine, Bush	M	B
13	34	30	5.5	H	VH	M	Sal	L	Rb
14	30	15	5.0	L	LVH	M	Grass	L	B
15	28	20	4.5	L	L	L	Pine, Bush	M	B
16	31	6	4.0	L	M	H	Waste, Weeds	VH	Yr
17	40	20	4.5	L	L	L	Settlement	M	Lbg
18	36	15	4.0	L	L	L	Thin Mixed Forest	M	
19	38	<25	5.0	L	L	L	Mixed Forest	M	B-Db
20	35	>20	5.0	H	L	L	Paddy	VL	Vdb
21	33	>23	5.0	L	L	L	Paddy	VL	Vdb
22	4	<25	5.5	L	L	L	Paddy	VL	B-Db
23	4	<30	5.0	L	L	L	Paddy	VL	B-Db
24	3	<30	6.5	H	H	L	Paddy	VL	B-Db
25	2	>30	6.0	L	H	L	Paddy	VL	B-Db
26	3	<20	5.5	M	M	L	Paddy	VL	Vdb
27	2	<30	5.0	M	L	L	Paddy	VL	B-Db

Index: Character

d = Depth in cm.; S = Slope in %; e = erosion as low/medium/high
V = Vegetation; C = Soil Colour (B=Brown, Drb=Dark reddish brown,
B-Db=Brown to dark brown, Rb=Reddish brown, Yr=Yellowish red,
Lbg=Light brown grey, Vdb=Very dark brown)

The classification of soil samples with the slope shows the general picture that the steep slopes (30 – 40%) have a soil profile of more than 25m deep and erosion rate ranges from low to medium under sub-tropical deciduous trees. Such areas in the watershed have high Organic Carbon contents. There are areas under the influence of broom and jhum cultivation and under pine forests. The erosional rate is recorded very

high and Organic Carbon content are very low. While in the case of moderate and moderately strong slopes (below 20%), the soil profile is almost 30m deep and are under permanent cultivation with very low rate of erosion. Organic Carbon contents were recorded between medium to high with low Phosphorous contents. Therefore, soils on the valley side are more fertile.

(e) *Climate:*

On account of the location of the watershed on the high elevation, the overall climate is temperate to sub-tropical in nature with moderately high rainfall (426 mm) and high humidity (90.2%). Monthly range of temperature varies from 10°C (in winter) to 28.2°C (in summer). Summer are mild and wet starting from May-September with more than 80 percent of rainfall is received during these months (Table-3.11).

Table-3.11: Monthly Values of Temperature, Rainfall, and Humidity of Upper Wah Umran Watershed.

Month	Temperature (°C)		Rainfall (mm)	Relative Humidity (%)
	Maximum	Minimum		
Jan	12.8	10.0	2.00	78.6
Feb	15.5	12.7	2.60	81.0
Mar	22.3	18.1	3.00	76.5
Apr	25.3	20.4	2.90	70.4
May	26.5	21.8	190.90	83.3
Jun	27.3	23.1	315.80	88.8
Jul	27.7	25.2	425.50	90.2
Aug	28.2	24.1	279.80	88.5
Sep	26.6	24.6	181.00	86.2
Oct	23.0	20.4	30.70	80.2
Nov	19.6	16.0	12.30	78.2
Dec	15.6	13.9	8.00	78.4

Source: Eri Seed Farm, Government of Meghalaya, Nongpoh, 1995.

(f) *Vegetation:*

The vegetation found in this watershed is of sub-tropical to tropical semi-evergreen forest. Here rainfall is still heavy and has a comparatively cooler winter. The species are of deciduous type. The types of species found in this region are *Elacocarpus floribundas*, *Dillenia pentagna*, *D. indica*, *Hovenia acerba*, *Ebretia acuminata*, *Careya arborea*, *Randia griffithii*, *Bochmeria*, *Sidaefolia*, *Eriobotrya angustissima* are some of the species found in the watershed.

3.3 Narang – Kongripara Watershed (Lower parts of the Northern Slopes of Meghalaya):

The watershed covers an area of 1165 ha and it is drained by the *Umdu* river with its numerous tributaries such as *Ir Lum Ladaw*, *Ir Kok pa ka Dai*, *Lunghun*, *Dongbah*, *Ir Pathei ka This*, *Ir Sohpun*, *Ir Syrlok*, *Um Bam Naingbari*, *Dongsiki Umjri Pahar* and others. Most of these streams are seasonal feeding the *Umdu* river which then flows to the South-Westerly direction. The watershed exhibits a variety of relief features with flat hill tops (plateau type) on the water divide very gentle undulating topography with wide piedmont plain are some of the main features. The physiographic parameters of the watershed can be described as follows:

(a) *Relief:*

The elevation at the mouth of the main river was recorded at 180m. The altitude varies from 180m to 516m at the highest point. Within a distance of 4 km., there is a general increase of altitude of about 84m per km. The upper ridges and

hilltop exhibit eroded topography. Furthermore, the detail contour map shows an opening valley at the Central part with its mouth situated at the South-Western part of the basin drained by the *Umdu* river with a width of about 500m. This shows that there are flat land at the South-Central parts of the watershed (Fig.-3.7).

The area-elevation relationship (hypsothetic curve) shows that about 54 percent of the area are under low to very low elevation (400-500m). This area accounts for about 624 ha of land situated mainly on the hill slopes and crest. The foothill and flat land (300-400m) accounts to about 28 percent and those of extremely low elevation (below 200m) includes about 18 percent (Table-3.12).

Table - 3.12: Elevation–Area Relationship.

Category	Elevation (m)	Area (ha)	Area (%)
Low	Above – 500	178.28	15.39
Very low	500 – 400	445.19	39.07
Extremely low	400 – 300	327.22	28.09
Very extremely low	300 – 200 200 – Below	203.30	17.45

(b) *Slopes:*

There are numerous varieties of slope category if local relief features are considered. But the average slope map, the slope gradient at the areas where the 1st order stream flowing on strong to moderately strong slopes (11-17%). This zone accounts for about 53 percent (611.66 ha) area which is observed on the Northern and Southern parts of the watershed (Fig.-3.8), whereas the Central parts have moderate to

(Fig-3.8)
SLOPE MAP
Narang-
Kongripara Watershed



Scale
200 0 200metres

- Slope Categories
- Very Extremely Steep
 - Extremely Steep
 - Very Steep
 - Steep
 - Highly Strong
 - Very Strong
 - Strong
 - Moderately
 - Moderate
 - Low

Source

low slopes (5-11%) and accommodated about 47 percent (533.34 ha) area (Table-3.13).

Table - 3.13: Area Under Various Category of Slope Gradient.

Category	Slope (%)	Area (ha)	Area (%)
Strong	Above – 17	102.43	8.79
Moderately strong	17 – 11	509.23	43.71
Moderate	11 – 5	337.11	28.93
Low	5 – Below	216.23	18.56

(c) *Drainage:*

The drainage system of the area provides many parameters to study the basin characteristics. In the watershed, a dendritic pattern is evolving. This shows that the watershed has a well set of geological setups of horizontal sedimentary and igneous rocks. The area is drained by four orders of streams, mostly perennial, but the amount of water dwindled in the dry season. The main *Umdu* river divides the region into the different types of physiographic features, namely,

1. The Northern and the Southern undulating topography, and
2. The Central piedmont plain in between the *Umdu* river and its tributaries.

The bifurcation ratio is recorded highest in the 3rd order streams. It shows that there are numerous streams of the 1st and 2nd orders that feed the 3rd order streams. The

drainage density of streams as also recorded the highest at the 3rd order, that is 120m/ha with stream length of 1500m (Table - 3.14).

Table-3.14: Drainage Density and Bifurcation Ratio According to Stream Ordering in Narang-Kongripara Watershed.

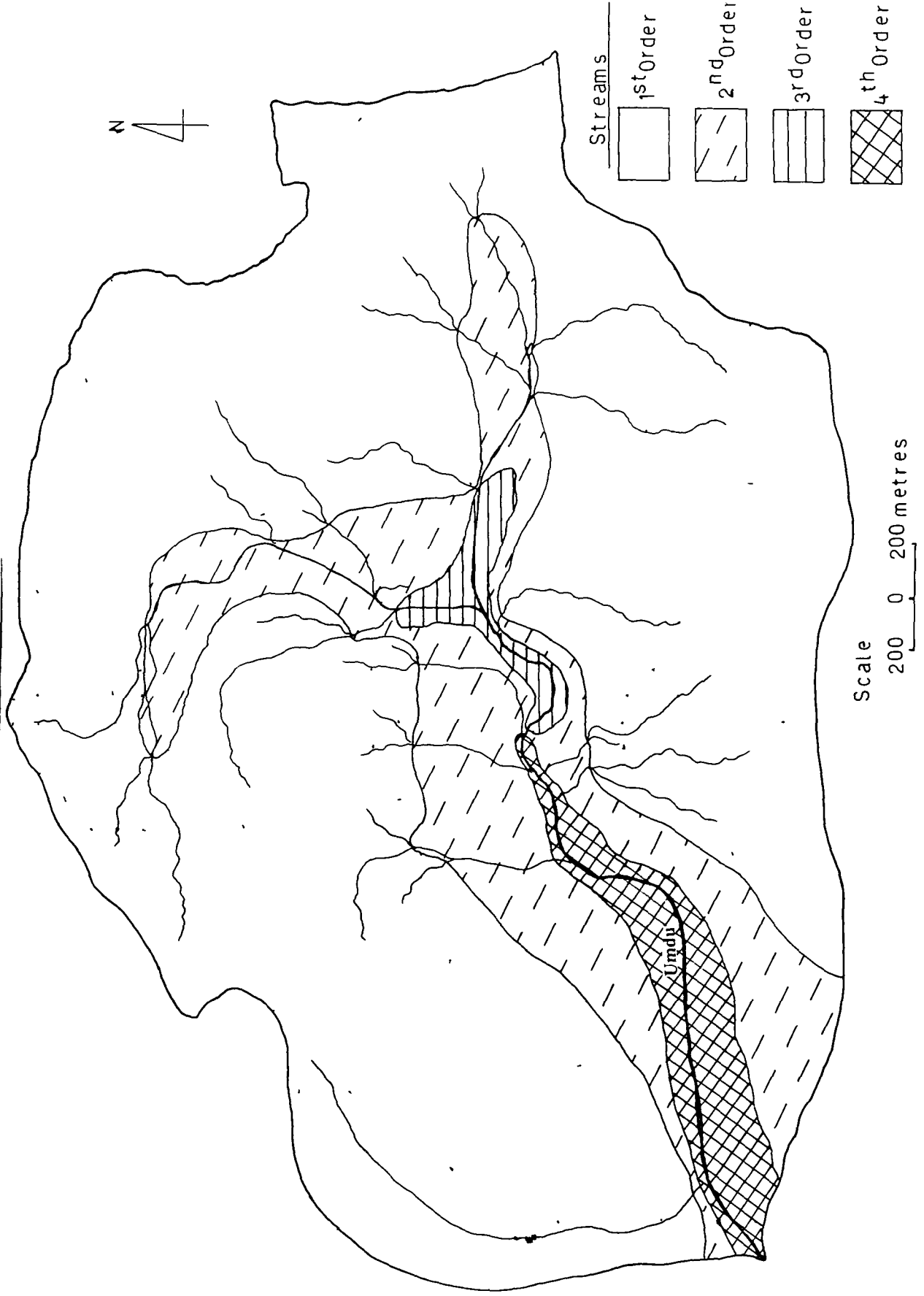
Stream Segment	Total number of Streams	Total length of Streams (m)	Area (ha)	Drainage Density (m/ha)	Bifurcation Ratio
1 st Order	29	18,800	917	20.50	-
2 nd Order	10	8,200	192	42.71	2.90
3 rd Order	2	1,500	12	125.00	5.00
4 th Order	1	2,260	44	60.45	2.00

The Table shows that the area of about 917 ha is covered the 1st order streams which accounts for about 78.71 percent of the total area of the watershed. Though the stream numbers are decreasing proportionately. However, the density shows that there is an increase in drainage density at the 3rd order stream system. This shows that there are excess amount of water during the rainy season and it often leads to over flooding of its banks (Fig.-3.9).

(d) Soil Fertility:

The soil fertility status and its relationship with physiography are studied by considering slope, soil depth, vegetal cover and rate of erosion. After analysing 31 samples from various slopes, it is found that the soils are moderate to high acidic (pH 5.0). This is due to heavy rainfall and resulted to leaching. However, Organic Carbon

Fig-3-9: DRAINAGE MAP
(Narang- Kongripara Watershed)



contents are recorded high (0.75%) in the area while Phosphate is recorded low (28.03 kg/ha) (Table - 3.15).

Table – 3.15: Fertility Status of Soil in Narang-Kongripara Watershed.

Sl. No.	S (%)	D (cm)	e	V	C	pH	OC	P ₂ O ₅	K ₂ O
1	32.5	25	M	Horticulture	B-Db	5.60	H	L	VL
2	1.9	> 75	L	Paddy	Lbg	5.88	H	L	VL
3	1.6	> 110	L	Paddy	Lbg	5.30	H	L	L
4	1.6	> 40	L	Paddy	Lbg	5.50	L	L	L
5	0.8	> 200	VL	Paddy	B-Db	5.00	H	VL	L
6	0.8	> 200	VL	Paddy	B-Db	6.04	H	L	VL
7	1.6	> 150	L	Paddy	B-Db	5.41	H	VL	M
8	2.5	> 25	L	Broad Leaf Trees	Yr	6.19	L	VL	VL
9	2.5	> 50	L	Broad Leaf Trees	Db	5.24	VH	L	L
10	2.5	> 25	M	Horticulture	Rb	5.32	H	VL	L
11	1.6	> 250	M	Horticulture	Rb	5.20	VH	VL	VL
12	1.6	> 140	L	Horticulture	Rb	5.42	M	L	L
13	2.5	> 30	M	Horticulture	Rb	5.62	VH	L	L
14	1.6	> 45	L	Horticulture	B	6.10	VH	L	L
15	1.6	> 80	L	Horticulture	B	5.90	VH	L	L
16	2.5	> 65	LH	Horticulture	B	5.42	L	VL	M
17	1.6	> 150	L	Paddy	B-Db	5.59	VH	L	L
18	1.6	> 15	L	Paddy	B-Db	5.85	VH	VL	M
19	1.6	> 55	VL	Paddy	B-Db	5.64	H	VL	M
20	1.6	> 25	VL	Paddy	B-Db	5.24	H	L	L
21	1.6	> 150	L	Paddy	B-Db	5.34	M	L	L
22	1.6	> 25	M	Paddy	B-Db	5.20	M	VL	VL
23	1.6	> 35	L	Paddy	B-Db	5.18	H	L	VL
24	1.6	> 55	L	Paddy	B-Db	5.05	M	L	VL
25	1.6	> 160	L	Paddy	B-Db	4.80	M	VL	M
26	1.6	> 220	L	Paddy	B-Db	5.85	H	L	L
27	1.6	> 25	L	Paddy	B-Db	5.50	H	L	L
28	1.6	> 30	L	Paddy	B-Db	5.30	H	L	M
29	1.6	> 80	L	Paddy	B-Db	5.59	VH	L	L
30	2.5	> 70	L	Broad Leafed Trees	Yr	6.35	H	L	L
31	2.5	> 55	M	Horticulture	Rb	5.65	H	L	L

Index: Character

d = Depth in cm.; S = Slope in %; e = erosion as low/medium/high
V = Vegetation; C = Soil Colour (B=Brown, Drb=Dark reddish brown,
B-Db=Brown to dark brown, Rb=Reddish brown, Yr=Yellowish red,
Lbg=Light brown grey, Vdb=Very dark brown)

The classification of soil samples and their average values show the general picture that the areas of strong to moderately strong slopes (11 – 17%), have the soil profile of more than 25cm in depth and also have medium rate of erosion, which are under the influence of horticultural crops. These areas have high Organic Carbon contents, while in the case of low to extremely low slopes (below 11%), the soil profile are more than 80cm deep with very low rate of erosion. The Organic Carbon content in such areas are recorded from high to very high with low in Phosphate content. One can say that the soil on the valleys and valley sides are more fertile.

(e) Climate:

On account of the location of the watershed on the low elevated area and very close to the Brahmaputra plain the overall climate is tropical in nature with moderately high rainfall (489.71 mm) received during the month of July and high humidity (92%). Monthly range of temperature varies from 13.2°C during the coldest month to 31.3°C during the hottest months. In this area, summers are hot and wet with more than 80 percent of rainfall is taking place during the months of April to September and a pleasant and dry weather during the months of October-March (Table-3.16).

Table–3.16: Monthly Values of Temperature, Rainfall, and Humidity in Narang-Kongripara Watershed.

Month	Temperature (°C)		Rainfall (mm)	Relative Humidity (%)
	Maximum	Minimum		
Jan	19.3	14.3	18.0	99
Feb	20.1	15.2	27.6	72
Mar	21.3	18.7	38.0	72
Apr	25.8	21.8	116.4	90
May	27.1	23.9	226.7	71
Jun	27.6	24.2	373.2	75
Jul	28.1	25.6	489.7	70
Aug	31.3	26.4	354.6	92
Sep	27.8	25.1	210.1	74
Oct	24.5	21.3	21.0	80
Nov	20.5	19.1	31.8	71
Dec	15.9	13.2	46.0	99

Source: Horticulture Farm, Burnihat, 1997.

(f) *Vegetation:*

The vegetation found in this watershed is of sub-tropical to tropical semi-evergreen forest. Here rainfall is still heavy and has a comparatively cooler winter. Here the species are of deciduous type. The types of species found in this region are *Elacocarpus floribundas*, *Dillenia pentagna*, *D. indica*, *Hovenia acerba*, *Ebretia acuminata*, *Careya arborea*, *Randia griffithii*, *Bochmeria*, *Sidaefolia*, *Eriobotrya angustissima* are some of the species found in the watershed.

4.0 Co-Associational Characteristics:

In the preceding sections, the systematic study of physical attributes of watershed has been carried out. However, there is a need of comparing and find out the co-associational characteristics of these attributes which would show not only the

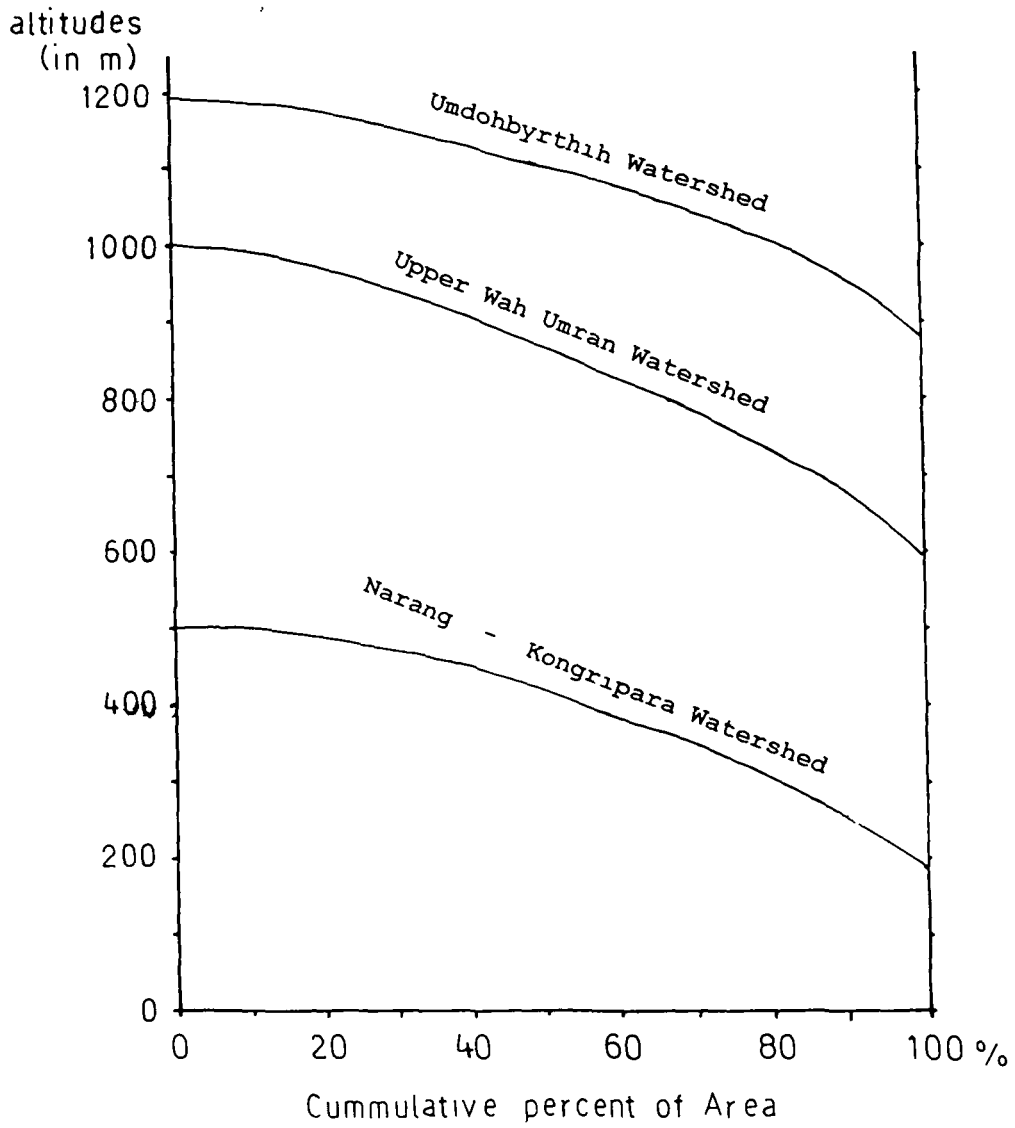
watershed characteristics of the area, but the general picture of the entire Northern slopes of Meghalaya. The co-associational characteristics are elaborated here by putting into four sub-heads as:

1. Elevation–area relationship, which must give a comparative picture of the relief features.
2. Comparison of the drainage pattern which would show the variation in the drainage change of the area.
3. Soil-physiography-geological relationship.
4. The co-associational characteristics of soil properties of the area.

4.1 *Elevation-Area Relationship:*

Preparing hypsometric curve for all the watersheds, it is found that the curve of the cumulative percentage of area by the different attitude is found to be smooth and slightly ‘convex’ (Fig.-3.10). This indicates that there is plateau type of topography of the upper ridges of the watershed, which is true for the general topographical features of these areas. The smoothness of the slopes shows that there is a proportionately smaller areas in the lower elevation of the watersheds. It is surprising to note that all the watersheds has similar type of topographic features because of the parallel tendency of hypsometric curve.

(Fig 3.10)
HYPSONETRIC CURVES



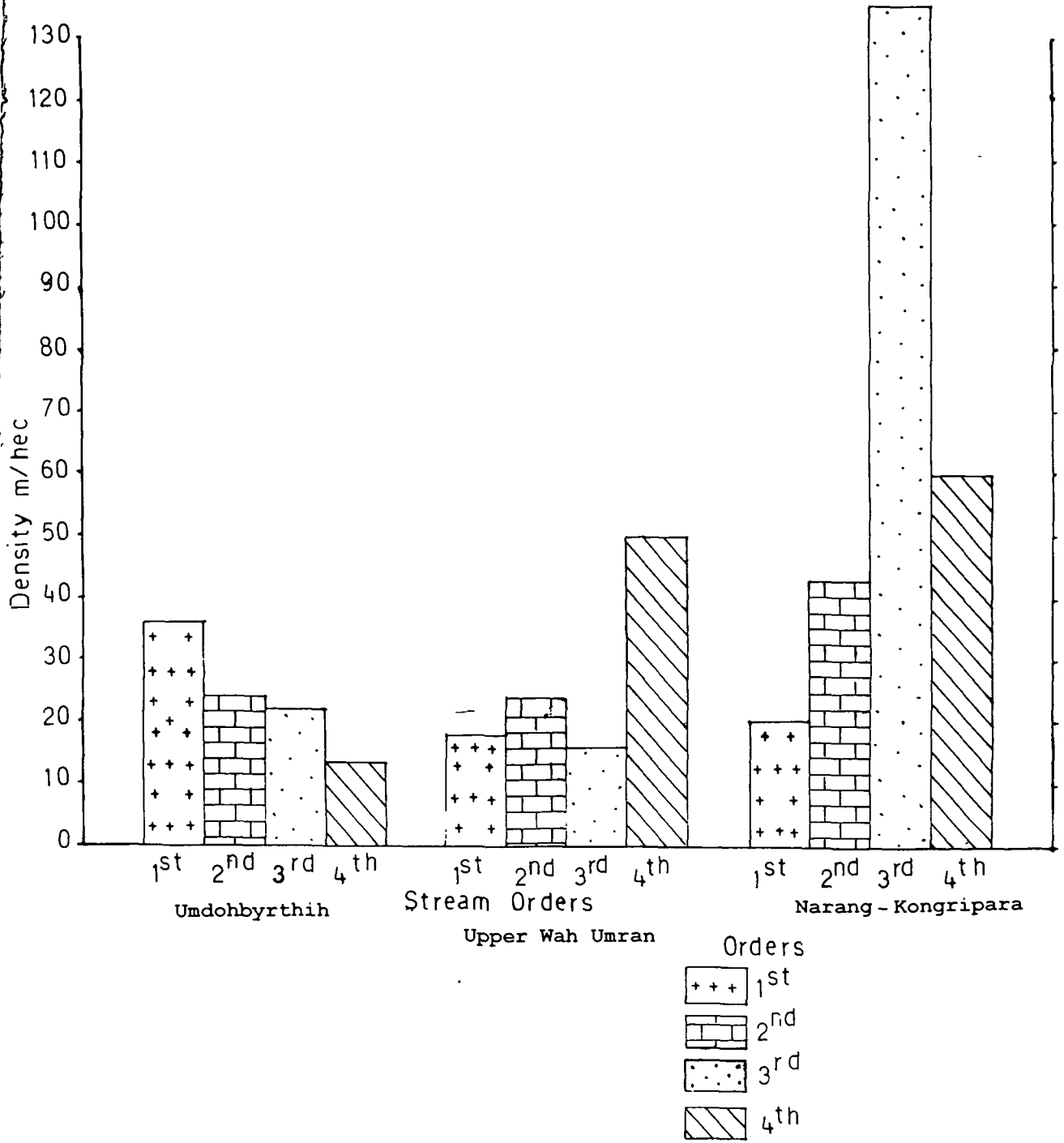
4.2. Co-Accociational Characteristics of Drainage System:

Drainage system is an important aspects of topography which is closely related to the intensity of rainfall (i.e., related to soil characteristics) and geomorphic characteristics which forms the topographic features of an area. The drainage system has a 'Trellis' pattern in Umdohbyrthih watershed whereas in the Upper Wah Umran and Narang-Kongrapara the drainage pattern are found to be 'Dendritic' in their pattern. However, the drainage system in all the three watersheds follows upto 4th order streams. The bifurcation ratios are recorded almost similar in all the watersheds except the Narag-Kongripara where the bifurcation ratio at the 3rd order is recorded 1:5. In fact, there may be more volume of water in the lower foothills of the Northern slopes where the bifurcation ratio is recorded higher. However, the intensity of rain is less in the area because of 'rain shadow effect'. For example, the 4th order stream of the Narang-Kongripara indicates the over flooded the surrounding areas of the main streams during the rainy season and even paddy fields of low-lying areas can be seen under water. Furthermore, a comparison of drainage density shows interesting results (Table-3.4, 3.9 and 3.14). Drainage density recorded very high in Narang-Kongripara which is situated in low elevation and the highest are recorded in the 3rd order streams (Fig.-3.11).

4.3. Soil-Physiography-Geology Relationship:

In order to understand the basic genesis of evolution of physiographic features of any area, the relief features, soil and geological structure can be studied together to find out the causes of the formation of soil as well as the evolution of relief features.

(Fig - 3.11)
DRAINAGE DENSITY AT VARIOUS STREAM ORDERS

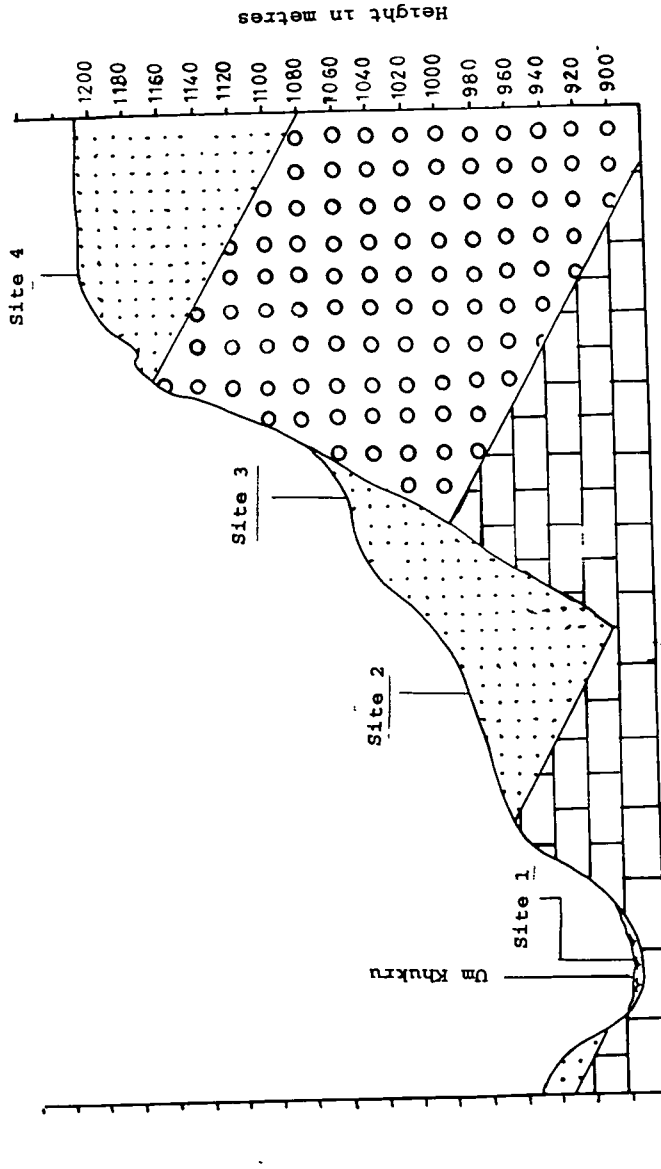


This relationship of three attributes are shown by preparing the cross-section of the relief features of the watershed. It is found from the cross-section and their lithological characteristics that:

- (a) The hilltops of the watershed are flat and have sandstone topography with the strike line of nearly 40° (angle of the dip of the rocks formation). Sandstone are exposed by the rivers on the hill slopes as well as valley slopes. Granite and gneiss are exposed somewhere, but are observed in the lower stratum of the watersheds.
- (b) In the upper parts of the slope (Umdohbyrthih watershed) the river valley of Umkukhru are found to be 'U-shaped' because of the deposition of the alluvial in the valley bottom. The same 'U-shaped' valley are also observed in Narang-Kongripara watershed because they are flowing towards an open valley. However, the shape of the river valleys are 'U-shaped' because of steep slopes and more erosion (Fig.-3.12 a, b & c).
- (c) So far as the study of soil profile of various slopes in the watershed are concern, it is observed that the soil depth in the upper part of the slopes (Umdohbyrthih) varies from 40 to 60 cm with very less horizon of humus content, only in the valley floor, the thickness of alluvium recorded 10 cm. The hill tops and slopes do not have humus content in all the three cases. Below humus content, the layer of sandy clay are found, thickness of 20 cm with yellow-red in colour due to laterisation process (Fig.-3.12 a, b & c).

Soil – Physiography – Geological Relationship

(Umdohbyrthih Watershed)



Soil Texture

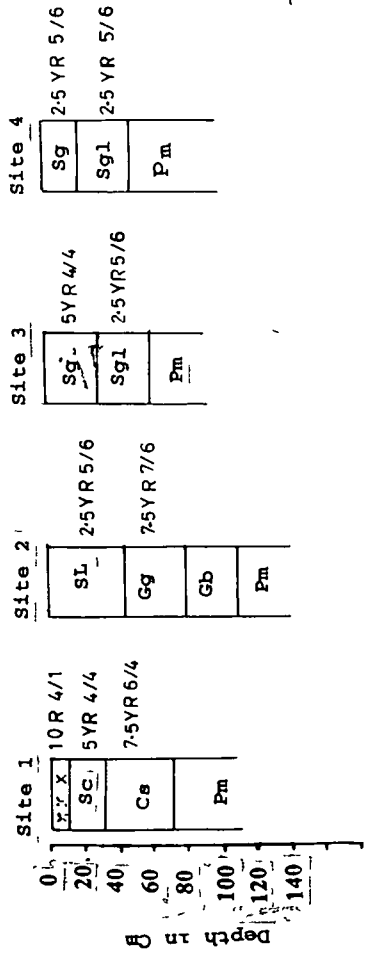
- xx - Humus
- SC - Sandy Clay
- CS - Clay Sand
- C - Clayey
- HC - Heavy Clay
- SL - Sandy Loam
- GC - Granite Chips
- Gg - Granite & Gravels
- Sgl - Sandy Gravely
- Ssb - Sandstone & boulders
- Pm - Parent material

Soil Colour

- YR - Yellow Red

Geological Structure

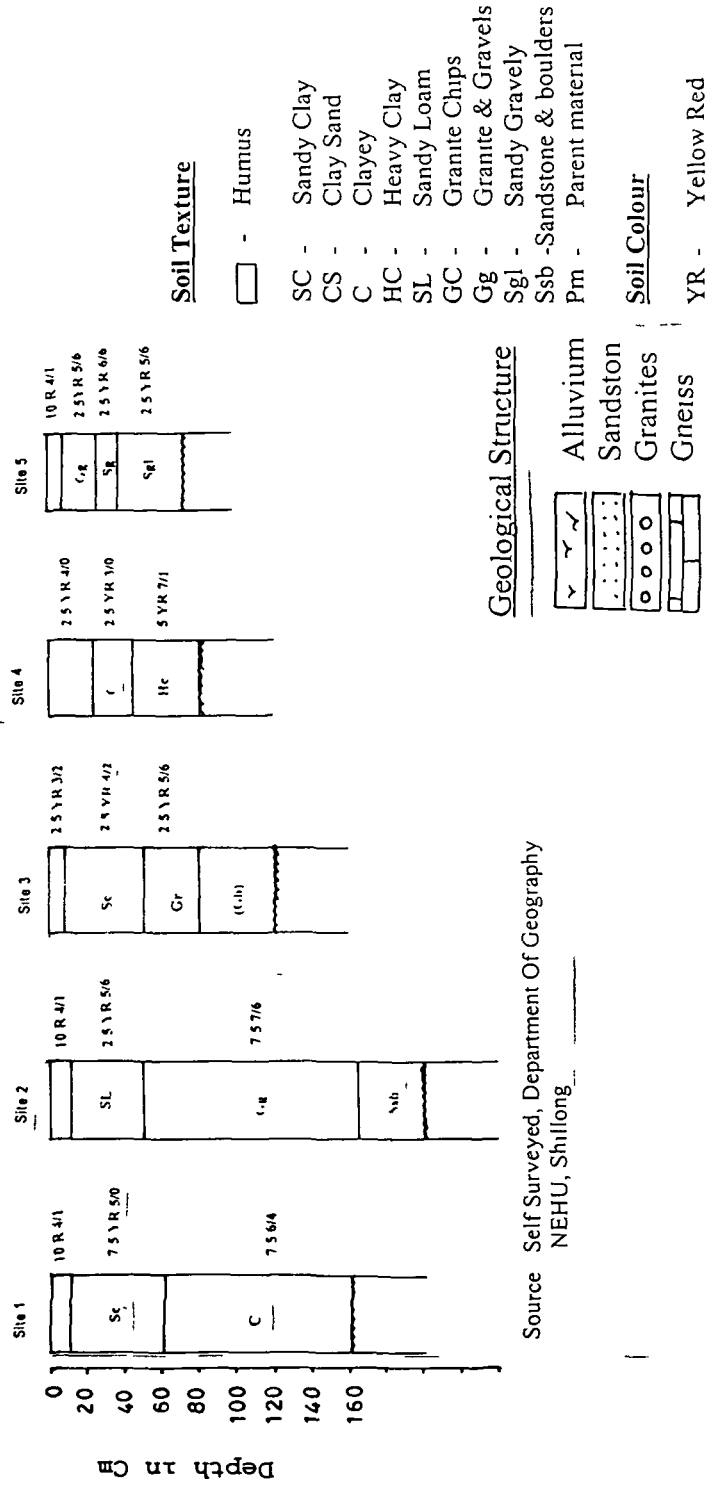
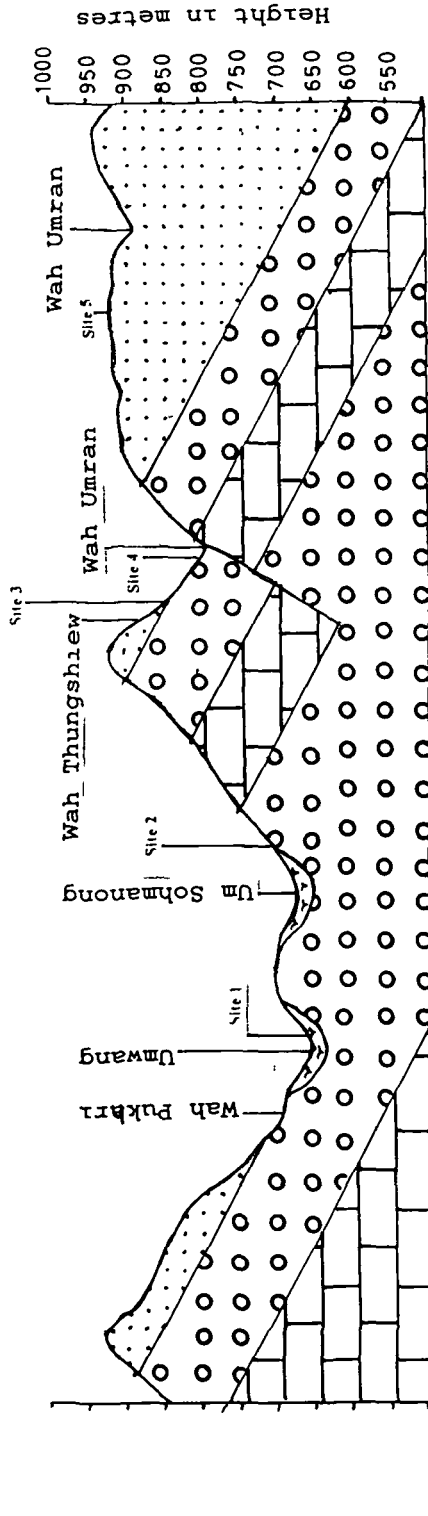
- ▽▽▽ Alluvium
- ⋮⋮⋮ Sandstone
- Granites
- Gneiss



(Fig-3-12 b)

Soil – Physiography – Geological Relationship

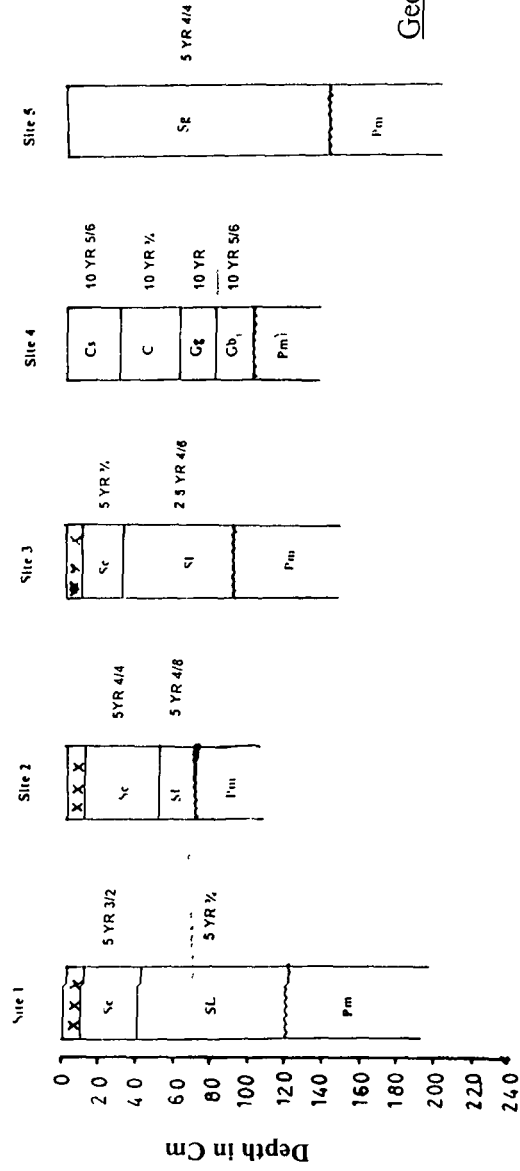
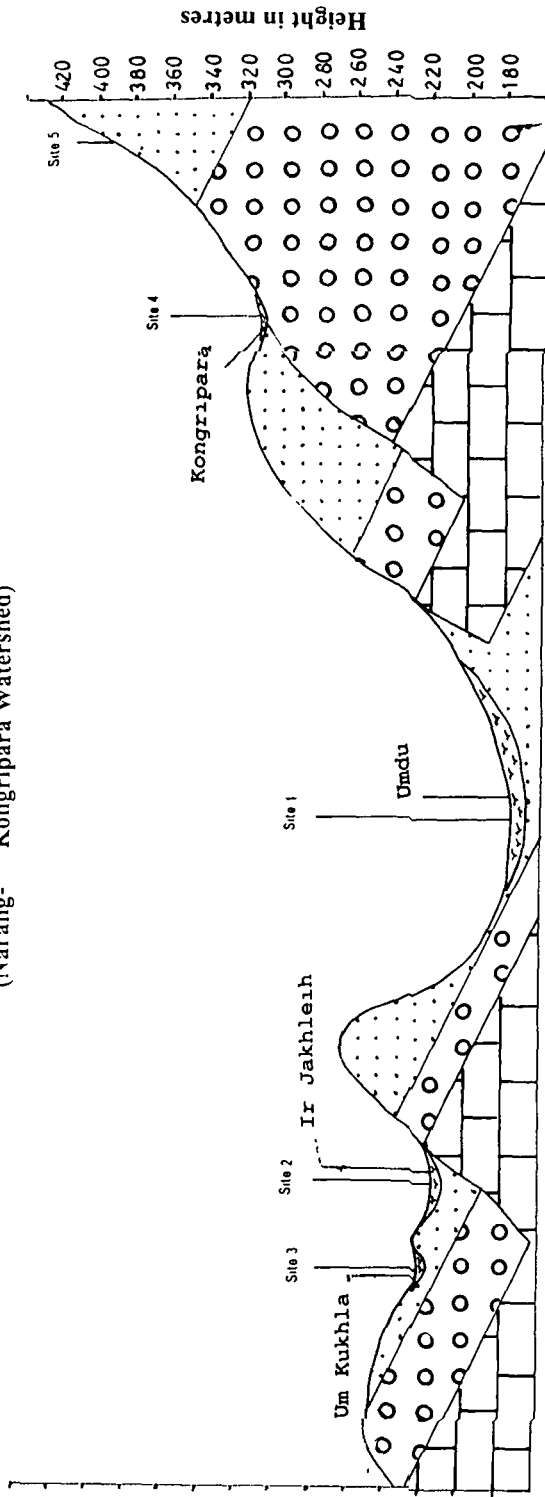
(Upper Wah Umran Watershed)



Source Self Surveyed, Department Of Geography
NEHU, Shillong

Soil – Physiography – Geological Relationship

(Narang- Kongripara Watershed)



Soil Texture

X X - Humus

SC - Sandy Clay

CS - Clay Sand

C - Clayey

HC - Heavy Clay

SL - Sandy Loam

GC - Granite Chips

Gg - Granite & Gravels

Sgl - Sandy Gravely

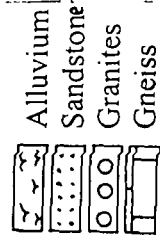
Ssb - Sandstone & boulders

Pm - Parent material

Soil Colour

YR - Yellow Red

Geological Structure



Source Self Surveyed, Department Of Geography
NEHU, Shillong

4.4 Co-Associational Characteristics of Soil Properties:

It has already been analysed that pH value was recorded 4-6 in all the watersheds. This mean that the reaction of soil on the Northern slopes is slower and soils are acidic in nature. However, there is a slight variation of pH value from the upper parts of the slope to the foothills. It is interesting to know that Organic Carbon was recorded medium in almost all the soils in the valley. The Narang-Kongripara watershed has more Organic Content from high to very high in the flat lands. Phosphate contents are recorded very low in all the areas and soil are not very fertile on the top reaches (Table - 3.5, 3.10 & 3.15).

The more detail findings regarding the co-associational features of soil fertility may be highlighted by calculating co-efficient of correlation separately in the last chapter of the project.

5.0 Concluding Remaks:

The present analysis of the various attributes and parameters of physiographic features of the watersheds shows that there is similarity in the characteristics of relief features, evolving drainage pattern and soils characteristics in general in the Northern slopes of the Meghalaya plateau. But it can be concluded that soils are fertile in the valleys and flat lands with alluvial and more moisture contents, which may be directly related to the existing pattern of landuses. Therefore the impact of physiographic factors on landuse pattern may be seen by studying landuse pattern separately.

CHAPTER – IV

LAND USE CHARACTERISTICS

1.0 Introduction:

Landuse and land cover pattern are the reflection of the interaction of the activities of man with nature. Especially in the hilly tracts, natural environment continues to dominate, land resources are kept in its natural ways. As a result, land cover study becomes more important. On the other hand, in the flat land areas, human interactions with nature have intensified, where man applies modern technology for operating the land and landuse pattern evolved. This relationship can be seen by studying the landuse/land cover characteristics of these watershed.

The Land use/Land cover pattern are the result of physical as well as socio-cultural and economic factors. The physical factors have already been discuss in the preceding chapter in detail. But there is a need of giving the background of social as well as land tenure system under which the present day landuse pattern are evolved.

A clear understanding of the land tenure system is very essential to assess the landuse pattern in these basin. In the whole Ri-Bhoi district, there are no private land. Land in these areas are known as *Raid Land* that is land belongs to the people. On the recommendation of a competent local authority, a person can utilise the land and even pass it to his/her heirs. If a person do not utilise the plot allotted to him even after utilising it for some period of time and leaves it idle, the land is taken back by the

community. No land can be left without utilisation for a period of more than seven years (Bareh, 1986; Lyngdoh, 1965).

Under this kind of land tenure system careful utilisation of land is not a top priority, for a person knows for sure that he can shift to another plot in case he stops using the one allotted to him. This may be one of the factors for massive deforestation in these areas. However, this system is an excellent land management procedure that the ancestors have evolved, it promotes profitable usage of land and restrict unwarranted idle land holdings.

Keeping in view of the above aspects, it is clear that physiographic factors as well as socio-economic factors influence the landuse/land cover to a greater extent. The effect of these factors can be seen after interpreting the landuse pattern of the various watersheds, so that a correct picture of the impact of physiography on landuse can be derived.

2.0 Landuse/Land Cover Pattern in Various Watersheds:

Before interpreting the silent features and pattern of landuse/land cover of any area, it is worthwhile to discuss the sources of landuse statistics and its reliability. For the same there are standard classification/ criteria given by the Ministry of Agriculture, Government of India, New Delhi, but this landuse criteria is highly traditional as it is biased towards a simple landuse features of cultivated and non-cultivated land (Table-4.1). This has been used in compilation of agricultural statistics at district level in the country. Hence, it is not planning oriented and cannot handle

practical problems of landuse. Another base of landuse/land cover classification is given by the National Remote Sensing Agency (NRSA), Hyderabad which is used to generate data of various landuse/land cover in the form of authentic and scientific manner by using satellite data (Table-4.1). This criterion seems more reliable and practicable specially for the hilly states/regions where land is operated by its natural processes. Therefore, the NRSA criterion of assessing landuse pattern is adopted here and the available broad categories are used for the landuse/land cover for the sample watersheds. The landuse/land cover statistics are self generated and mapped accordingly.

Table-4.1: Landuse Classification According to Various Agencies.

Landuse Categories According to Ministry of Agriculture	Landuse/Land Cover Categories According to NRSA, Hyderabad
A. Uncultivated Land 1. Forest	A. Land Under Cultivation 1. Settled agriculture (a) Rabi, (b) Kharif, (c) Double cropping 2. Shifting cultivation
B. Cultivable Land 1. Area under non-agricultural use 2. Land and miscellaneous trees and groves 3. Cultivable waste land 4. (a) Fallow other than current fallow (b) Current fallow land	B. Forest Cover 1. Evergreen forest 2. Degraded forest and deciduous forest
C. Cultivated Land 1. Net sown area 2. Area sown more than once	C. Barren Land 1. Barren 2. Rocky barren 3. Snow cover
	D. Other Uses 1. Water bodies (a) Lakes/reservoir/tanks (b) Rivers/streams 2. Built up areas (a) Settlement (b) Roads

On account of micro scale of the watershed, there may not be much variation in landuse/land cover. However, there are some micro landuse pattern that can be featured by generalising the data according to NRSA criteria which is given above. Therefore, for the present purpose, the entire landuse/land cover is classified into 4 broad categories – (1) Land under cultivation, (2) Forest cover, (3) Land under barren and rocky barren, (4) Other uses (land under water bodies, settlement and roads).

Land under cultivation is further divided into two categories, i.e., settled agriculture and shifting cultivation. Therefore overall, the landuse patterns of these watersheds are studied putting land under these categories broadly and the spatial features are compared. The general pattern of landuse/land cover in different watersheds are given below.

2.1 Landuse/Land Cover of Umdohbyrthih Watershed:

Since the location of the watershed is in the upper parts of the Northern slopes of the plateau, Umdohbyrthih watershed represents the landuse pattern of the upper of the Meghalaya plateau. It will be reflected in the detail landuse pattern.

(a) Barren and Rocky Barren:

Nearly 1/3rd of the total land is under barren and rocky barren (34.87%). It shows that the soil profile is weak and thin and is not fertile for cultivation especially in areas of the upper ridges with slopes of more than 50 percent. The areas of barren and rocky barren are also located in the Eastern most part of the watershed where slope is between 20-50 percent and exhibits rugged topography. Soil profile has not

developed properly in these areas. However, drainage systems are well developed and drainage density is comparatively high in these areas.

(b) Settled Agriculture:

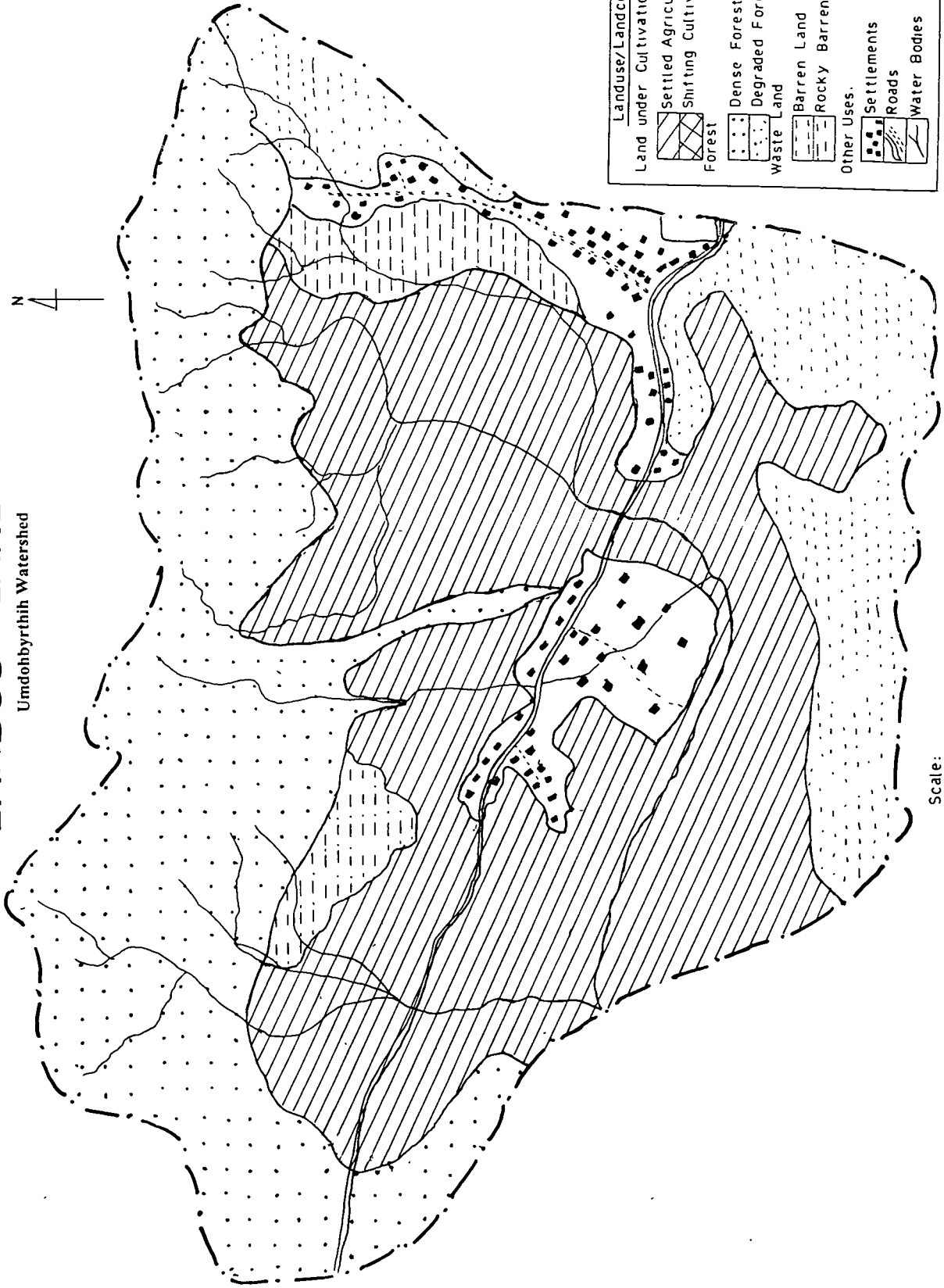
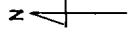
Because of better road connectivity (Umdohbyrthih and Laban Saro are the two villages connected with pukka roads), the available fertile land of Umdohbyrthih and the village (newly form alluvial soil of the flat land) is noticed where regular water supply from the perennial stream (moisture content are high in soil) is available. The land use are dominated by settled cultivation (Fig.-4.1). Paddy is significant crop grown in the Kharif season (May-August) while some patches of flat lands which are very close to the settlement areas, are intensively used for cultivation (double cropping). Nearly 1/3rd of the area (34.90%) of the watershed is recorded under this category, with slope of 25-50 percent where the dominance of the 2nd and 3rd order drainage system flows.

(c) Forest Land:

Area under forest is classified into two sub-categories (dense and degraded). The area under dense forest covers an area of 35.43 ha (8.30%) and is pine-dominated species. They are secondary trees planted by the Forest Department, Government of Meghalaya, especially in the barren and rocky land of the Northern parts of the watershed. On the other hand, the degraded forests are dominated by deciduous species. These are the indigenous species of the area. The area under the degraded

(Fig-4-1)
LANDUSE/LANDCOVER

Umdohbyrthih Watershed



Landuse/Landcover	
	Land under Cultivation.
	Settled Agriculture
	Shifting Cultivation
	Forest
	Dense Forest
	Degraded Forest
	Waste Land
	Barren Land
	Rocky Barren
	Other Uses.
	Settlements
	Roads
	Water Bodies

Scale:
100 0 100 metres

forest covers an area of 20.93 ha (4.90%) found on the Southern parts of the watershed. As a result, the landuse has changed to a greater extent.

(d) *Other Uses:*

Only 17 percent of land is under settlement, roads and water bodies. This category dominates the Central parts and South-Central parts of the watershed where land are flat (Table-4.2).

Table – 4.2: Landuse/Land Cover in Umdohbyrthih Watershed.

Category	Area (ha)	Area (%)
A. Land Under Cultivation		
1. Settled agriculture	149.32	34.96
2. Shifting cultivation	-	-
B. Forest		
1. Dense forest	35.43	8.30
2. Degraded forest	20.93	4.90
C. Barren and Rocky Barren	148.88	34.87
D. Other Uses	72.43	16.96

Source: Self Surveyed.

N.B.: Landuse/Land Cover Categories are Classified According to NRSA Criteria.

2.2 Landuse/Land Cover in Upper Wah Umran Watershed:

The location of this watershed is in the middle parts of the Northern slopes of Meghalaya. It represents the landuse pattern of the middle part of the plateau that will reflect the landuse pattern of the region.

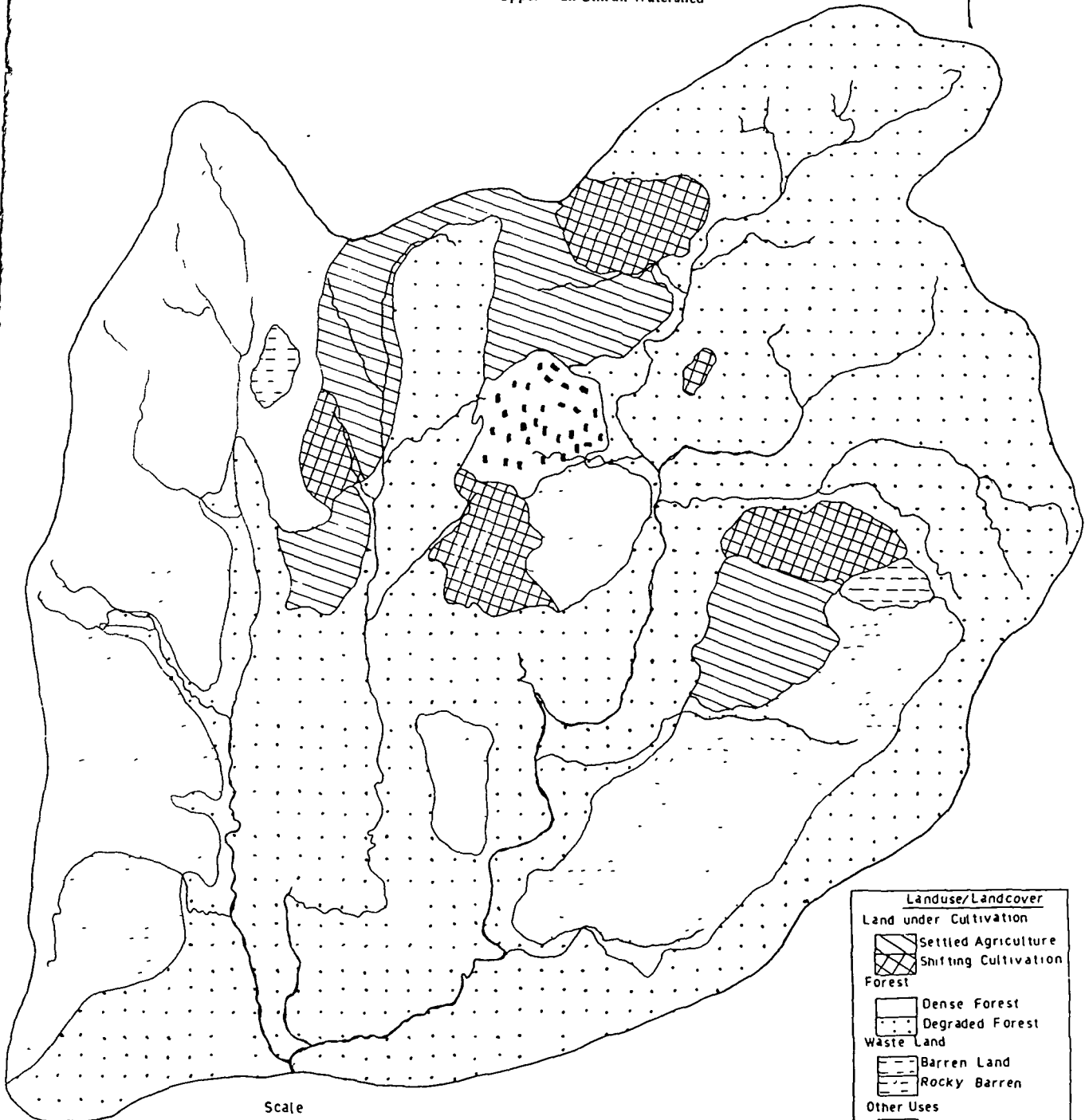
(a) *Forest:*

Area under forests is sub-divided into two categories (dense and degraded). The area under dense forest is nearly one-half of the total area of the watershed. It covers an area of 857 ha (43.85%). The important tree species under this category are deciduous as well as pine, which are the introduced species, planted by the Forest department, Government of Meghalaya on the degraded and barren areas of the watershed. On the other hand, the area under degraded forest covers nearly one-third to the total watershed area (i.e., 796 ha & 36.64%). The forests are found on the Western and South-Eastern part of the watershed (Fig.-4.2).

(b) *Areas Under Agriculture:*

Agricultural areas are still at the subsistence level. The settled agriculture covers an area of about 34 ha (i.e., 6.85%). These areas are found on the Northern and Eastern parts in vicinity of settlements. Agricultural land is not a problem in this watershed, it may be that the land have not been brought under cultivation because of less pressure of population on land. Another activity that is found here is shifting cultivation covering a significant area of 122 ha (6.24%). This may be one of the causes for the degradation of forest. Paddy is the significant crop in the area (lowland rice as well as hill rice). Besides paddy, other tuber crops and vegetables are grown on the lowland (slope of 20-30%) as well as shifting cultivation is carried out on steep slopes (30-40%).

(Fig - 4 2)
LANDUSE/LANDCOVER
 Upper Wah Umran Watershed



Scale
 200 0 200 metres

Landuse/Landcover	
Land under Cultivation	
	Settled Agriculture
	Shifting Cultivation
Forest	
	Dense Forest
	Degraded Forest
Waste Land	
	Barren Land
	Rocky Barren
Other Uses	
	Settlements
	Roads
	Water Bodies

(c) *Barren and Rocky Barren:*

Area of barren and rocky barren are found on the North-Western parts of the watersheds. There are many other barren areas which are negligible on the map. The area under such category accounts to 80 ha (4.09%) located on the steep slopes (30-40%).

(d) *Other Uses:*

Land under this category accounts to only 2.30 percent which are under settlement areas, roads and water-bodies. This category dominates the Northern parts of the watershed (Table-4.3).

Table – 4.3: Landuse/Land Cover in Upper Wah Umran Watershed.

Category	Area (ha)	Area (%)
B. Land Under Cultivation		
1. Settled agriculture	134.00	6.85
2. Shifting cultivation	122.00	6.24
B. Forest		
1. Dense forest	857.00	43.85
2. Degraded forest	716.00	36.64
C. Barren and Rocky Barren	80.00	4.09
D. Other Uses	45.00	2.30

Source: Self Surveyed.

N.B.: Landuse/Land Cover Categories are Classified According to NRSA, Hyderabad.

2.2 Landuse/Land Cover in Narang-Kongripara Watershed:

Since Narang-Kongripara watershed is locate on the lower parts of the Northern slopes of Meghalaya plateau, the watershed represents the landuse pattern of the lower parts and foothill region of the plateau on the North. This will reflect the landuse pattern.

(a) *Forests:*

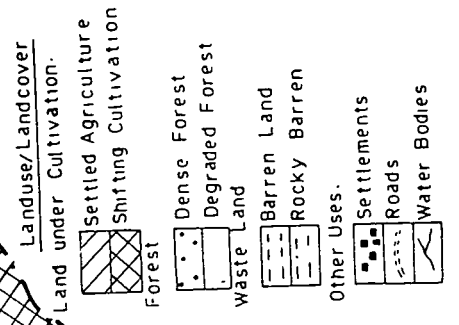
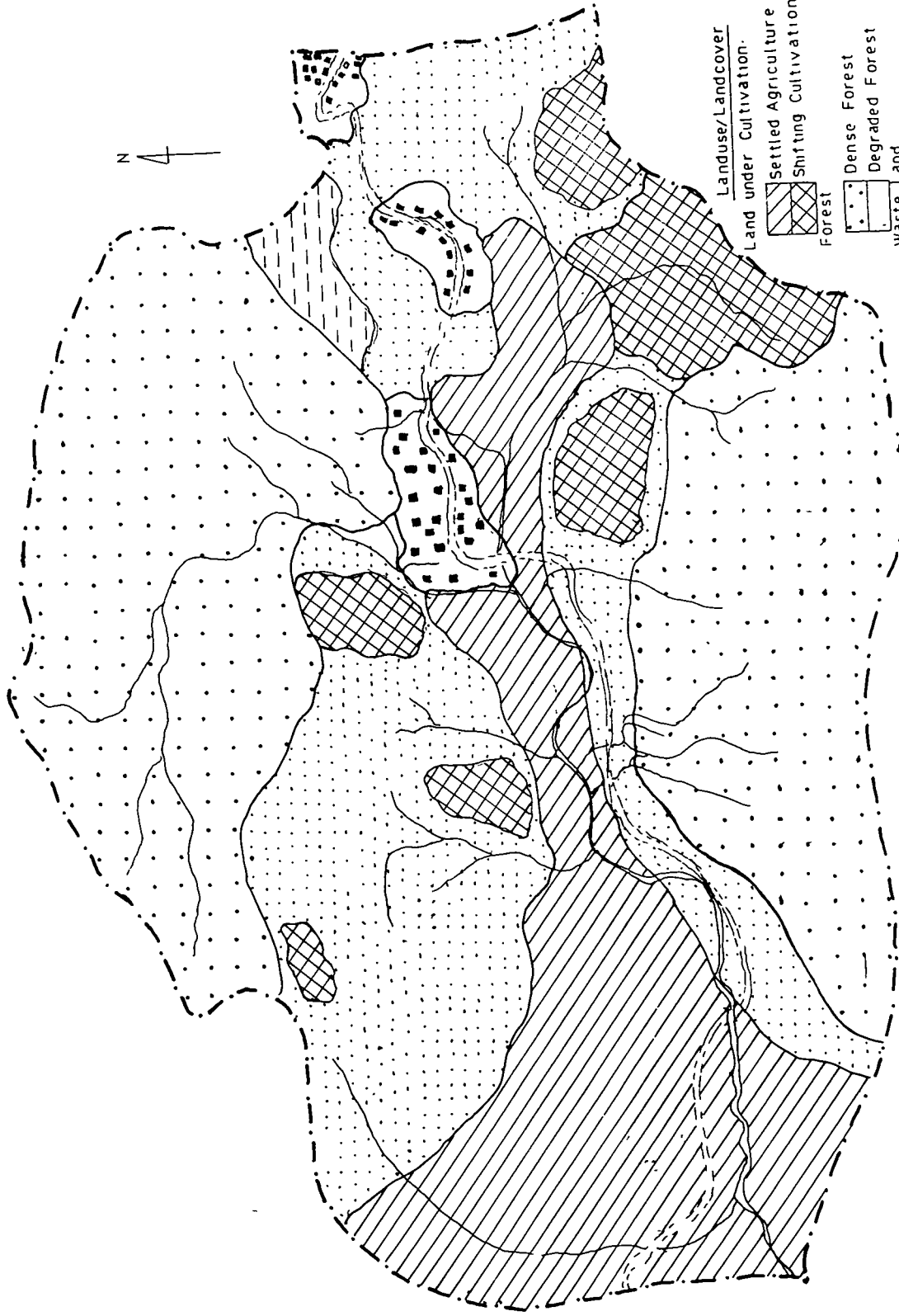
More than 1/4th of the area of the watershed is under forest, covering an area of 343.85 ha (29.52%) with deciduous type of vegetation. The area under forest cover can be further sub-divided into dense and degraded forests. The dense forest are found in the high ridges on the extreme North and Southern parts of the watershed where slopes are moderate (above 17%). These areas under dense forest cover and area of 191.93 ha (16.47%) as well as there are areas on the gentle slopes 11-17 where forest are degraded covering an area of 151.92 ha (13.04%). Thus resulting a change in the landuse pattern in the watershed (Fig.-4.3).

(b) *Agriculture:*

Because of the availability of road connectivity (Narang and Kongripara are big villages), the availability of fertile land in the valley is observed with regular supply of water. The landuse in the central part of the watershed is dominated by settled agriculture which accounts for 26.79 percent to the total area. Paddy is a significant crop grown during the Kharif season (May-August) while some lands on the slopes are under shifting cultivation, which accounts for 14.41 percent area in watershed.

LANDUSE/ LANDCOVER

Narang- Kongripara Watershed



Scale: 200 0 200 metres

(c) *Other Uses:*

Area under other uses includes 18.85 percent. The category under other uses are settlement areas, roads and water-bodies. Since the area is drained by numerous streams, as a result the percentage under other uses shows more.

(d) *Barren and Rocky Barren:*

Though the area under barren and rocky barren shows an area of 49.44 ha (4.24%). The areas are scattered into small fragment situated on the slopes and foothills area and cannot be shown on maps (Table - 4.4).

Table – 4.4: Landuse/Land Cover in Narang-Kongripara Watershed.

Category	Area (ha)	Area (%)
C. Land Under Cultivation		
1. Settled agriculture	312.13	26.79
2. Shifting cultivation	167.87	14.41
B. Forest		
1. Dense forest	191.93	16.47
2. Degraded forest	151.92	13.04
C. Barren and Rocky Barren	49.44	4.24
D. Other Uses	291.71	18.85

Source: Self Surveyed.

N.B.: Landuse/Land Cover Categories are Classified According to NRSA, Hyderabad.

3.0 Comparison of Landuse Patterns:

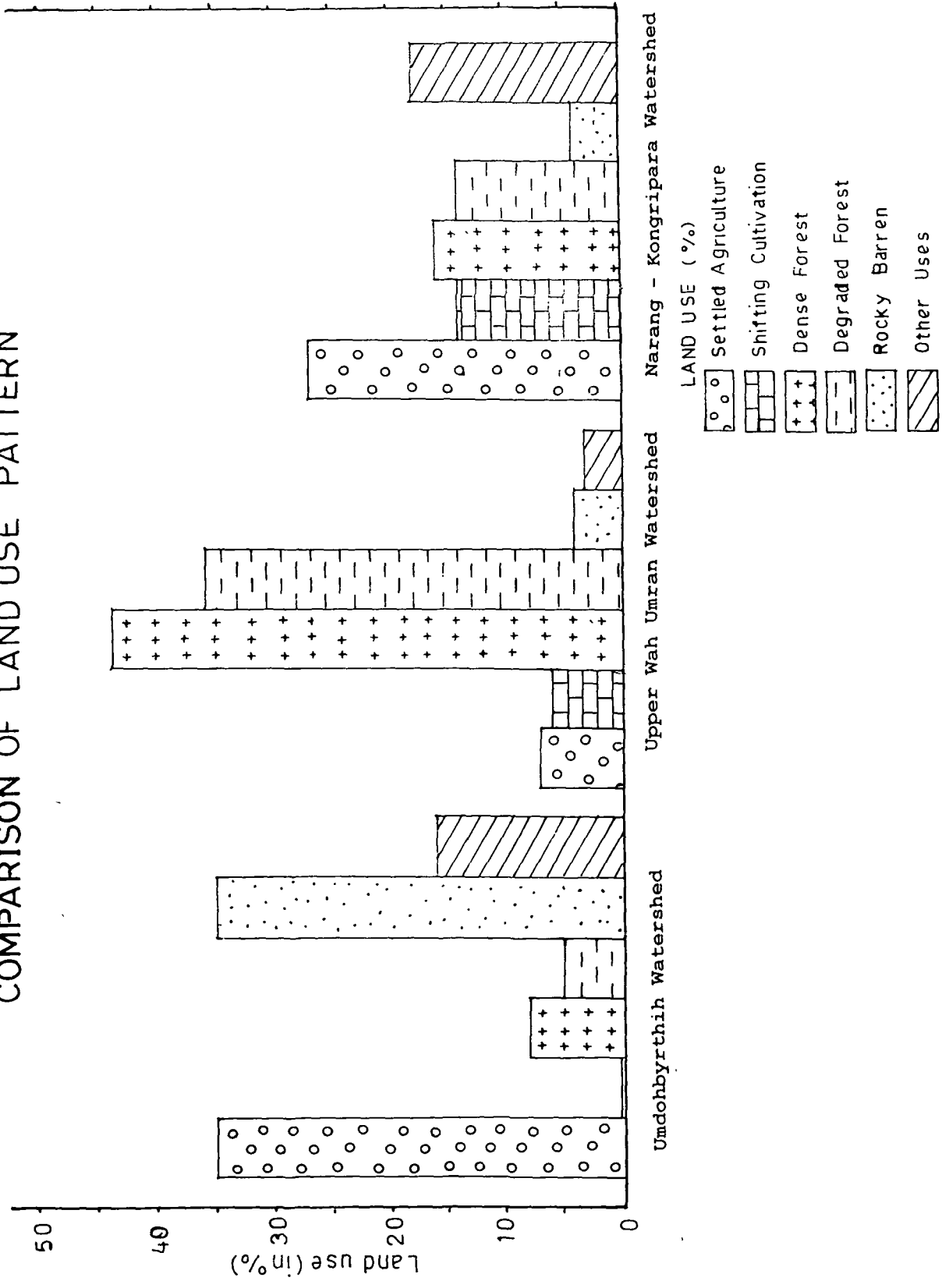
In the previous section of the chapter, the landuse/land cover patterns are analysed by giving the cause of their areal variation within the watershed. A comparative picture of the landuse can also be visualised so that the causes of variation can be studied in their overall environmental conditions of the Northern slopes. The following are the main conclusions.

- (1) It is visualised from the tables that in all the watersheds, two categories of landuse/land cover are dominating in these areas, i.e., (a) land under forest cover where the interaction of human activities are minimal and (b) land under cultivation where the human interactions are prevailing more. In the upper parts of the slope (e.g., Umdohbyrthih watershed) agriculture and barren rocky land dominate in landuse/land cover categories. It may be because of steep slopes. Less fertile soil on the top ridges where barren rocky landuse category prevails. While the flat land has settled agriculture, shifting cultivation is negligible.
- (2) In the middle as well as the lower part of the slopes (Upper Wah Umran and Narang-Kongripara are the representative watersheds), forest cover dominate in the landuse. It may be because of the persuasion of the state government, where transplantation has taken place in the barren areas. In the foothills, there is nearly 30 percent land under forest, while 40 percent land are recorded under cultivation including shifting cultivation in Narang-Kongripara watershed, this means that the pressure of population also influence the landuse pattern, e.g., smaller villages with small number of population requires a small amount of food crops. So people put less effort on landuse under cultivation and *vice-versa*. No doubt, community still prevails for landuses, therefore, agricultural practices are still traditional and less expensive.
- (3) In the watershed where the percentage share of land is less under cultivation, forest cover is thick and dense, but degraded forest also prevail in land uses. Therefore,

there is a negative relationship between the cultivated land and forested land in the area (Fig.-4.4).

- (4) Within the category of cultivation the areal share of settled and shifting cultivation is almost equal especially in the middle as well as the lower parts of the Northern slope. While in the upper parts (Umdohbyrthih watershed), shifting was recorded negligible. It means the farming communities of the village prefer shifting cultivation because it is a traditional way of land use. Due to pressure on land, gradually they are coming to the settled agricultural practices. Therefore, the period of shifting cycle has been reduced and even the patches of shifting areas has been converted in to settled agriculture even on the sloppy areas of the ridges.
- (5) Paddy is the dominating food grain in the cropping pattern of the region. Generally, in the shifting as well as settled agriculture, the cultivation of paddy is being carried out on the hilltops as well as on low-lying areas. Therefore, there are two types of paddy according to topographic conditions, hilltop paddy (upland paddy) and lowland paddy. The location of village is the main factor which influences the spatial pattern of landuse. Since more than 90 percent of villages on the Northern slopes are located on the top of the ridges, shifting cultivation as well as settled agricultural areas are found close to the settlements. Location on the flat top ridges, where slopes are comparatively low at higher elevation (e.g., the watershed of Upper Wah Umran has generally the settled as well as shifting cultivation on the hills where Mawrong village is located). Same is the case of Narang-Kongripara and Umdohbyrthih.

(Fig - 4.4)
COMPARISON OF LAND USE PATTERN



- (6) The lowland cultivation also prevails in the area, but the cropping intensity is recorded very low because these flat lands are far from the settlements. In some of the open valley they are connected with metalled roads even then, they are not productive though they have thick alluvial soil with high fertility and moisture content which is suitable for cultivation. Paddy is the only crop grown in the flat land which is 4 months seasonal crops. The rest of the year nearly 8 months, the valley land remains fallow.
- (7) There is a lot of scope for the intensification of agricultural practices in the valley lands. A few remunerative crops can be grown like potato and other vegetables while on the slopes of shifting cultivation, broom as well as horticultural crops may be suitable.

CHAPTER – V

INITIAL FINDINGS AND CONCLUSION

1.0 Introduction:

In fact, the previous chapters of the dissertation have details of the analysis and facts regarding the physiographic characteristics as well as landuse pattern prevailing in the Northern slopes of Meghalaya plateau. The characteristics and pattern are studied systematically following the ‘Topical’ approach in the present study. However, the facts may be compared and correlated for finding out the common features of land-use and even to show the impact of physiography on landuse in the area. It is generalised by various scholars that landuse in the hilly and mountainous tracts are directly influenced by the physiographic conditions (Panda, 1983; Agarwal, 1994; Hagerstrand, 1976; Prasad, 1995). There may be other factors that influence the landuse pattern, these factors are not considered though they are related to the landscape and changes the landuse pattern in the hilly areas. Undoubtedly, it can be said that physiographic attributes itself are interrelated which form complexity in its nature and influence to the land uses. Therefore, the study of the genesis of the landuse pattern within the specific sets of physiographic conditions can only be highlighted by comparing and correlating the whole set of physiographic attributes with landuse pattern. In this Chapter, we have tried to generalise the landuse pattern under the

specific physiographic conditions and its influencing factors in the form of initial findings.

2.0 Initial Findings:

Putting all the facts together, the following generalisations of landuse pattern with special reference of the physiographic conditions of the Northern slopes of Meghalaya are forwarded in the following manner.

2.1 Soil-Physiography Relationship:

Since the soil forming processes, its textural as well as chemical characteristics which are closely related to landuse/land cover characteristics (types of the species as well as plant growth) are directly related to the climatic conditions and geological structure of the area, there is not much significance in the climatic variation from the upper to the foothill of the Northern slopes because the entire area comes under the rain shadow region of monsoon climate. Temperature varies significantly and changes the forest types of the area. However, landuse/land cover is related to the texture and chemical properties of the soil.

These soil characteristics are studied in detail and found that the congenial relationship between topographic features and soil conditions as studied in Chapter-III, concluded here. The valley cross-sections show that hilltops are eroded because of steepness of slopes and high drainage density. The materials are deposited in the valley floor where thick alluvium of 10 cm are found. As a result, valley floor (these

are called flat land topography) are more fertile and favourable for settled and intensive cultivation. The upper strata of soil have more humus content with yellow-red colour in the valley floors. The soil profiles of the valley slope as well as the scarps have sandy gravelly soil with only 40-60 cm of soil depth everywhere in the Northern slope. If all the soil profiles are classified according to topographic features, specific properties of soils column can be define as:

- (a) The soils of the flat land of upper ridges have the depth of 40-80 cm with sandy gravelly soil (somewhere sandstone and boulders) which are exposed with the parent material of sandstone and granite rock of Shillong series of exposed rocks in geological structure.
- (b) The valley slopes have soil thickness of about 60-120 cm with granite chips and somewhere sandy loam in the foothill areas of the Northern slopes. Sandstone dominates in the form of geological structure.
- (c) The valley floor has alluvial of about 10-20 cm thickness in almost all the watersheds followed by the lower strata of about 20 cm of sandy clay.

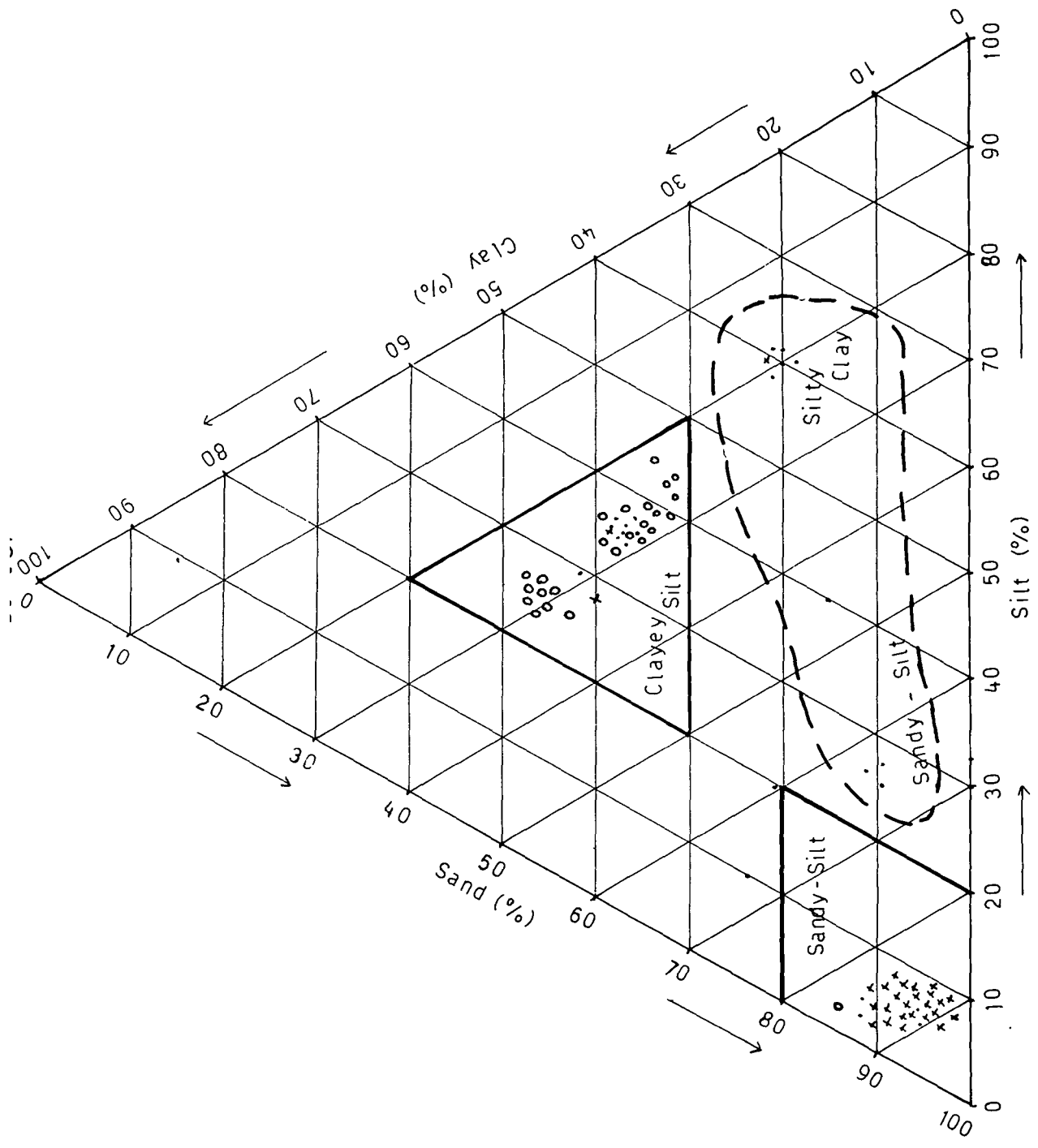
2.2 Soil Texture Characteristics:

There is a significant difference in the soil texture according to slope which has been interpreted in the earlier chapter, while defining the Soil type. However, a general view of the soil texture in different sample watershed which refers to soil characteristic of the Northern slope of Meghalaya is interpreted here by calculating the

percentage share of sand, silt and clay of the soils sample and shown them on the “Ternary” diagram (triangular graph) U.S.D.A. textural classification of soil may be followed here to generalise the result. But the soil samples are not very large. Therefore, only the grouping method is used to interpret the homogeneous characteristics of the soils texture (Fig.-5.1).

On the graph, three important areas of the distribution are obliterated. Surprisingly, these three groups of distribution represent the characteristic of the watershed separately. According to the distribution, the soil texture of the Northern slopes are characterised as follows:

- (a) The sandy-silt and silty-clay dominate in the upper part of the Northern slopes (Umdohbyrthih Watershed). The sand content is more; it means the particles of the soils are thicker and soil are still immatured in its nature.
- (b) In the middle part of the Northern slopes of Meghalaya plateau (Wah Umran Watershed) where sandy-silt dominates in the textural classification, the percentage of sand is more on the soils. However, silt contents are recorded to be more in the flat land. It means in the valley side siltation started because of depositional processes which have more nitrogen content and high water holding capacity.
- (c) In the foothill areas of the slope (Narang-Kongripara Watershed), most of the samples of this area fall under the central part of the diagram which is a reflection



- Umdohbyrthih (Upper Slope)
- ▲ Upper Wah Umran (Middle Slope)
- Narang Kongripara (Foot hill)

of clayey-silt dominance. It means that clay contents are more on the soil of foothill areas with its high fertility status.

It can be generalised that the soil forming processes are controlled by the depositional process in the foothills and erosional processes in the upper parts of the Northern slopes. It is true in the other parts of the country also in the hilly areas.

2.3 Soil Fertility Relationship:

- (a) It is a fact that soil fertility varies according to slopes which influences the landuse of the area. It has earlier been stated that the soil of steep slopes have medium to low Organic Content, low Phosphate (P_2O_5) and even low Potassium (K_2O) with below neutral reaction while the areas of flat land have slightly high pH value (but not more than 6.5) with high to medium Organic Carbon, low Phosphate and very low potassium.
- (b) The correlation matrix of fertility elements was prepared. It is found that the reaction of soil is acidic (pH 4.5). In some areas soil has mild acidity (pH 4.5-6.0) with medium Organic Contents. This is found in almost all the soils in the Northern slopes of Meghalaya. Areas of steep slopes have less pH values. As a result, the relationship between slopes and reaction of hydrogen is negative. It is calculated at -0.06 in Umdohbtryhih watershed which is located in the Upper part of the Northern slopes of Meghalaya -0.346 in Upper Wah Umran watershed which is located in the middle part of the Northern slope and 0.152

in Nanang–Kongripara watershed which is located at the foothills, due to variation of rainfall on the Northern slope of Meghalaya plateau (high rainfall in the Upper parts of Meghalaya plateau and less rainfall in the foot hills). The reaction of hydrogen ions are observed lesser in the foothills which rises the value of pH (from Acidic to mild Acidic). As a result, pH is more on the hill top and less on the foothills and relationship is positive though insignificant. But inverse is the case between slope and pH in the Upper parts of Meghalaya because of high rainfall.

Slope influences the Nitrogen contents of soil as well. It can generally be mentioned that steep slopes has less nitrogen content and *vice versa*, because of high erosion rate on steep slopes. It is true in our study also. Areas in the middle elevation and foothills have negative relationship of slope with Organic Carbon. However, it is surprising to note that Umdohbyrthih watershed located in the Upper part of the plateau has positive relationship among them ($r = + .338$). It is realised in case of Upper parts of the plateau that natural vegetation is more important than slope which affects the quality of nitrogen in the soil. On account of dense pine forest in the Upper parts of Meghalaya plateau the Organic Carbon relationship with slope is recorded positive, while pine trees are Nitrogen fixation plants. Generally in the areas of pine, the Organic Carbon is always recorded medium to high.

It is surprising to note that slope has positive impact on Phosphate contents in the soils of Upper parts of Meghalaya plateau ($r = .033$ in Umdohbyrthih) and negative in Upper Wah Umran ($r = - 0.245$). While it is recorded negligible in the foot

hills areas. This means that the steep slopes of the Upper parts of Meghalaya plateau has high contents of Phosphate and *vice versa*.

The case of Potassium availability in the soils in relation to steep slope has been recorded negative in the Upper parts of the plateau ($r = -0.475$) i.e. in Umdohbyrthih and positive in the middle part of the area (Upper Wah Umran $r = 0.2776$). This means that steep slopes has high Potassium contents in soil in Upper Wah Umran watershed.

The relationship among the element itself shows that soil have a specific complex nature in Umdohbyrthih watershed, e.g., high content of Potassium in the soil have low content of Phosphate with high pH value. Therefore, the acidic soils have high Potassium rather than Phosphate in the soil, especially in the Upper parts of the plateau. But the case is reverse for the middle part of the plateau.

Table – 5.1: Correlation among Various Fertility Elements of Soil in different Watersheds.

B. Umhohbyrthih (No. of Soil Samples = 25)

	S (%)	pH	OC	P ₂ O ₅	K ₂ O
S (%)	1	- 0.0597	0.3379	0.0327	- 0.4749
pH		1	- 0.1336	- 0.3889	0.1612
OC			1	0.0891	- 0.3266
P ₂ O ₅				1	- 0.0627
K ₂ O					1

Upper Wah Umran (No. of Soil Samples = 27)

	S (%)	pH	OC	P ₂ O ₅	K ₂ O
S (%)	1	- 0.3459	- 0.2482	- 0.2456	0.2977
pH		1	- 0.1907	0.1951	- 0.0770
OC			1	0.2651	- 0.964
P ₂ O ₅				1	0.3379
K ₂ O				--	1

Narang-Kongripara (No. of Soil Samples = 31)

	S (%)	pH	OC	P ₂ O ₅	K ₂ O
S (%)	1	0.1521	- 0.2183	∞	- 0.0707
pH		1	0.1221	∞	- 0.1303
OC			1	∞	- 0.1103
P ₂ O ₅				1	∞
K ₂ O					1

Note: ∞ - Negligible.

The Organic Carbon and Phosphate have positive relationship in all the three sample watersheds. High Nitrogen content of the soil has higher content of Phosphate, this relationship is significant in the middle parts of the plateau, but it is seen to be insignificant in the Upper parts as well as in the lower parts of the area. On the other, hand Organic Carbon has negative relationship with Potassium in all the three cases. It is inversely related.

In the end, it can be concluded that soils of the Northern slopes of Meghalaya plateau may be characterised by medium to high Organic Carbon contents with positively related Phosphate and negatively related to Potassium in the area. Slope has negative relationship with this complex nature of soil fertility status especially in the middle part & lower parts of the plateau. While in the Upper parts, this relationship is recorded positive because of the effect of dense pine forests.

3.0 Land use Characteristics:

In Chapter-IV, the detail study of land use pattern is carried out in relation to physiographic factors in the watersheds. On the basis of influencing factors of land use

and the comparison of land use / land cover categories, a general land use model can be highlighted here. There are various studies on land use which shows the impact of slope or drainage pattern (Panda 1983) to establish the relationship with the slopes. King's slope profile (crest, waning, waxing and concave) was used to study the land uses in most of the studies. Therefore, the model which was given by Panda for the hill areas of plateau is biased towards the slope factor only. Now-a-days when market forces and means of transportation are equally important factors for determining the land use pattern even in the watershed of hilly areas, the land use characteristics can be interpreted not only in relation to slope or physiography but socio-economic factors also.

There is a general observation during the time of survey conducted in the sample watershed that the location of settlement is the most important factor for determining the land use pattern in the hilly areas. Say for example, the settlement in Wah Umran watershed is located on the top of the scarp with the intensive practice of land use in its surrounding on one hand and shifting cultivation on the other. In spite of the proper connectivity of settlement with metalled road which intensifies the interaction of human activities with the low lying areas of the fertile valley, the settled intensive cultivation is not being practised in the valley side. Therefore, the productivity and production scale are recorded low in the fertile valleys. The same is true for the foothills of Meghalaya plateau as well. Two categories of land use dominate in land use pattern. They are cultivation and forest land. Cultivation which also includes shifting has the peculiar pattern in the spatial organisation of land use.

Settlement location is specific since most of the location of settlements are on the Upper ridges (at higher elevation) in the Northern slopes. The shifting as well as settled agriculture are being practised on the hill tops and hill slopes with its traditional way of practice.

The valley cross section and land use pattern (Fig. – 5.3) show that there are settlements in the transitional zone between flat lands of Upper ridges and valley slopes. Shifting cultivation is generally practised on the valley slope in the close surroundings of settlements and the Upper flat land of the ridges are used for settled cultivation. The valleys and flat lands are fertile but not under the use for intensive cultivation because of the remoteness from the main settlements. Therefore, historical factors and the location of settlement are important influential factors rather than valley slopes, if the land use pattern at micro areal level in the watershed are considered (Fig – 5-3).

4.0 Conclusion:

In the previous section, land use characteristics, physiographic attributes and soil profiles and even elemental relationships of various factors are studied to highlight the main findings of the present work. On the basis of these facts, it can be concluded that the Northern slopes which are under the transitional zone of climatic conditions in rain shadow area with significant variation of temperature from Upper part of the plateau to its foot hills, the area of Northern slopes have a significance in its physiographic conditions as well as in its land use pattern. Settled and shifting

cultivation are dominated in the surroundings of settlements in the watershed. The location of settlements are at Upper ridge at higher elevations and therefore, land use pattern are concentrated in upper flat ridges rather than valley-flats. Settlement location is the most important factor for the spatial arrangement of land use pattern. While fertile valley are still less productive where farming practices can be interpreted through modern technology.

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APPENDIX-I
PERCENTAGE SHARE OF SOIL TEXTURE IN DIFFERENT WATERSHED.

Samples	Umdohbyrthih Watershed			Upper Wah Umran Watershed			Narang-Kongripara Watershed		
	Sand	Silt	Clay	Sand	Silt	Clay	Sand	Silt	Clay
1	90	5	5	28	37	35	90	5	5
2	90	5	5	28	37	35	28	37	35
3	85	10	5	20	60	20	28	37	35
4	65	25	10	20	60	20	28	37	35
5	45	40	15	28	37	35	25	30	45
6	45	40	15	20	60	20	25	30	45
7	20	60	20	20	60	20	28	37	35
8	20	60	20	28	37	35	20	60	20
9	20	60	20	20	60	20	20	60	20
10	45	40	15	90	5	5	20	60	20
11	28	37	35	90	5	5	28	37	35
12	45	40	15	90	5	5	28	37	35
13	20	60	20	90	5	5	28	37	35
14	20	60	20	90	5	5	28	37	35
15	28	37	35	90	5	5	28	37	35
16	25	30	45	90	5	5	28	37	35
17	28	37	35	90	5	5	25	30	35
18	28	37	35	90	5	5	25	30	45
19	28	37	35	90	5	5	25	30	45
20	28	37	35	90	5	5	25	30	45
21	28	37	35	90	5	5	25	30	45
22	28	37	35	25	30	45	25	30	45
23	28	37	35	25	30	45	25	37	45
24	65	25	10	25	30	45	28	37	35
25	65	25	10	25	30	45	28		35

**APPENDIX-II
SOIL RATING CHART**

Element	Low	Medium	High
Organic Carbon (%)	0.50	0.5-0.75	0.75
Phosphate (kg/ha)	28.03	28.03-56.05	56.05
Potassium (kg/ha)	134.50	134.50-336.30	336.30

pH Value Index	pH
Strong Alkalinity	Above 7.5
Slight Alkalinity	7.0-7.5
Neutrality	7.0
Slight Acidity	6.0-7.0
Moderate Acidity	5.5-6.0
Moderate to High Acidity	5.0-5.5
High Acidity	4.5-5.0
Very High Acidity	Below 4.5

Source: Research Lab, Department of Agriculture, Government of Meghalaya.

N.B.: Soil samples have been collected from the watershed and their elements like the Organic Carbon, P₂O₅, K₂O and the pH value have been analysed.

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