

**GEOMORPHIC STUDY OF
LOWER SUBANSIRI BASIN, ASSAM**



BY

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Thesis

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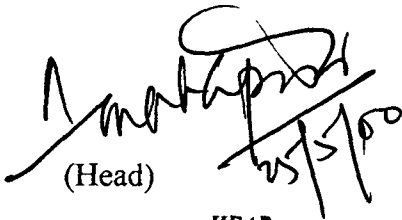
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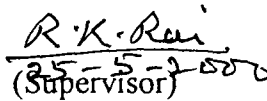
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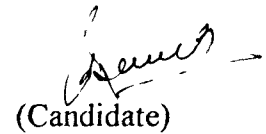
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CHAPTER - I

INTRODUCTION

Geomorphology is the study of landforms, their description and interpretation. The science of geomorphology is important not only as an academic discipline but also in its practical applications in the field of the soil science, economic, geology, geohydrology, military geology, engineering geology and rural and urban planning.

According to Brown (1970) Geomorphology is the science which describes the shape of the earth. The science of Geomorphology, which is primarily concerned with the form of the earth, is more than one hundred-years old. Traditionally the study of geomorphology was essentially that of origin and evolution of landforms.

According to Wooldrige (1958) Geomorphology is a fundamental science that is primarily concerned with the interpretation of the form and the study of the processes. However, today Geomorphology is the science which studies landforms and land forming processes.

On the other ~~hand~~ geomorphologists like Leopold, Wolman and Miller (1969) while observing that much of geomorphology is stratigraphic geology, have made the

study of contemporary processes, part of their methodological approach to the subject. But now geomorphology tells about the shapes of hills and valleys, the degree and frequency of slopes, the development of drainage patterns and nature of the material exposed in all available sections. Study of geomorphology is not limited to the academic sphere only. There has been a phenomenal development in the field of geomorphological studies in the twentieth century with several schools of thought. C.A.M. King (1966) in her book explains that there are three major groups. The first arises out of the work of Walter Penck and may be called the mobilistic view, the second one gives priority to the effects of climate in studying the characteristics of the landscape, and the third one is based essentially on an idea of correlation by altitudes.

The modern trend in geomorphological study is towards the increasing importance of the quantitative as well as of the qualitative methods. R.E. Horton (1945) described that the drainage and channel networks are purely quantitative science, providing the hydrologists with numerical data of practical value. A.N. Strahler (1942, 1954, 1956, 1964) and his associate Schumm (1956) Melton (1957) and Morisawa (1957) further developed Horton's ideas. It has also been noted that

the applications of modern geomorphology are based on the dynamic approach, systematic and mathematical approach for a better understanding of geomorphology. The works of the W.M.Davis, J. Playfair, G K Gilbert, L.C. King, W.D. Thornbury and B.W. Spark are outstanding contributions in the field of geomorphology.

Since 1960s a phase of intensification and concentration has emerged in the study of geomorphology in correct perspective. This has been facilitated through by increasing use of systematic approach, helped by model building and design, and more sophisticated techniques and methods of analysis. The significance of man as an agent of geomorphological processes is also increasingly emphasised. The study of the impacts of man directly or indirectly upon both surface processes and forms is included in the study of geomorphology.

Conceptual Framework

The science of geomorphology is concerned with the geomorphic characteristics of the earth's surface and processes, which are responsible for its development and evolution. In fact, the study of landscape processes responsible for the type of landform and rates of formation constitutes the science of geomorphology.

The term, *geomorphology* was first introduced in mid 1830's as the study of land formation. This was originally derived from the Greek words, 'geo' (earth) 'morpho', shape and 'Logos' (reasons); hence the study of earth's shape or a discourse on earth forms (Thornbury, 1988, p-1).

The aim of geomorphological research is to identify the landforms' types and the nature of their changes and also to find out the processes resulting in the development of landforms, the rate at which they work and the manner in which the landforms, change with the passage of time. Thus, the geomorphologist establishes the relationship between the forms and process and finally develops theories/models to explain the real world situation, in such a manner, so that it can be applied in a generalized form for the purpose of land evaluation. Geomorphologists generally consider the landscape on a spatiotemporal basis and the spectrum of approaches in geomorphic studies is based on the following perspectives.

(i) Historical studies attempting to deduce the erosion and deposition of the landscape and trace the sequence of historical event through which it has passed and

(ii) *Functional studies* of contemporary processes and the behaviour of the earth material, which can be directly observed. It helps the geomorphologists to understand the change of landforms (Chorley et al, 1984,P-1).

River basin as a Geomorphic Unit

The need for the precise description of the geometry of landforms, particularly those of dominantly fluvial erosion, has been a recurring theme for geomorphologists. One of the most important aspects has been the search for the basic areal unit within which such data could be collected. (Chorley, 1969,P-3). Drainage basin may be defined as the system of river and its tributaries, which drains an area. A major river and its tributaries reveal a hierarchy of channels which can be enumerated and studied quantitatively.

The drainage basin is considered as the most satisfactory geomorphic unit. In fact, the drainage basin is viewed as a geographical study of varied aspects such as (i) their existence in physical landscape and significance for producing fluvial landforms, (ii) their importance indirectly in relation to many other geomorphic processes in fluvial landforms and (iii) their significance for human use (Gregory and

Walling 1973, P-3) It forms a convenient unit for the consideration of the processes determining the formation of specific landscape in various regions of the earth (Leopold, Woolman and Miller, 1964, P-131).

It was Davis (1899) and his contemporaries who studied river valleys and examined evolution of progresses over a period of time(Thornbury, 1899, P-122) and postulated the concept of "The geographical Cycle" of landscape evolution. Other satisfactory units were also adopted by the workers like Playfair (1802) Wooldrige (1932) Savigear(1965) and U.S. engineers etc. The drainage basin is viewed as a topographic and hydrological unit which creates erosional and depositional landscape elements. It clearly defines topographic character and is considered as an open system in terms of input and output.

The drainage basins are evaluated in their dimensional form of properties, which include the evolution of linear, areal and relief properties of the drainage basin using morphometric techniques.

In a country like India, application of geomorphology in the field of land utilization particularly for agriculture, horticulture, forest development, selection of dam sites, transport and communication and human habitation is of great relevance to further development. But very little research works have been undertaken in the field of geomorphology in the Northeast India. This may be due to the lack of detail geological and topographical information, maps and related data.

In Assam limited research has been done in the field of geomorphology. Goswami (1988) studied "Suspended sediment transport, valley degradation and basin denudation, Brahmaputra River", Sarma (1989) studied "Geomorphological studies on the Dhansiri river Basin" (1989) wrote his doctoral thesis on "Jia-Bharali river basin," Saikia (1994) based his study on "Geomorphology of Kapili river basin" The aforesaid researches in this field have provided valuable informations regarding various geomorphic features and hydrological characteristics of the study area

Statement of the Problem

The present study intends to examine the morphological characteristics, fluvial processes and flood problem in the Lower part of Subansiri basin, Assam

Morphometric analysis has been used for illustrations and descriptions of the landforms, i.e. relief, slope, drainage network analysis etc. in relation to the geomorphology and fluvial geomorphology. The diverse topographical features of Subansiri basin have made a geomorphic study of the basin absolutely essential to acquire a detailed geomorphic information for the development of the basin.

Objectives of the Study

The following objectives have been taken into consideration for the investigation:

- (i) to study the structural and tectonic history of the basin area
- (ii) to find out the drainage network and evolution of the basin
- (iii) to study the fluvial action of streams and network system
- (iv) to study the nature of slope, drainage density pattern and their characteristic feature
- (v) to find out the flood prone areas and its impact on the agricultural land

Location and extent

The Lower Subansiri basin is located between 26°40' N to 27°45' N latitudes and 93°15' E to 94°35' E longitudes and covers an area of 9636 sq kms. The

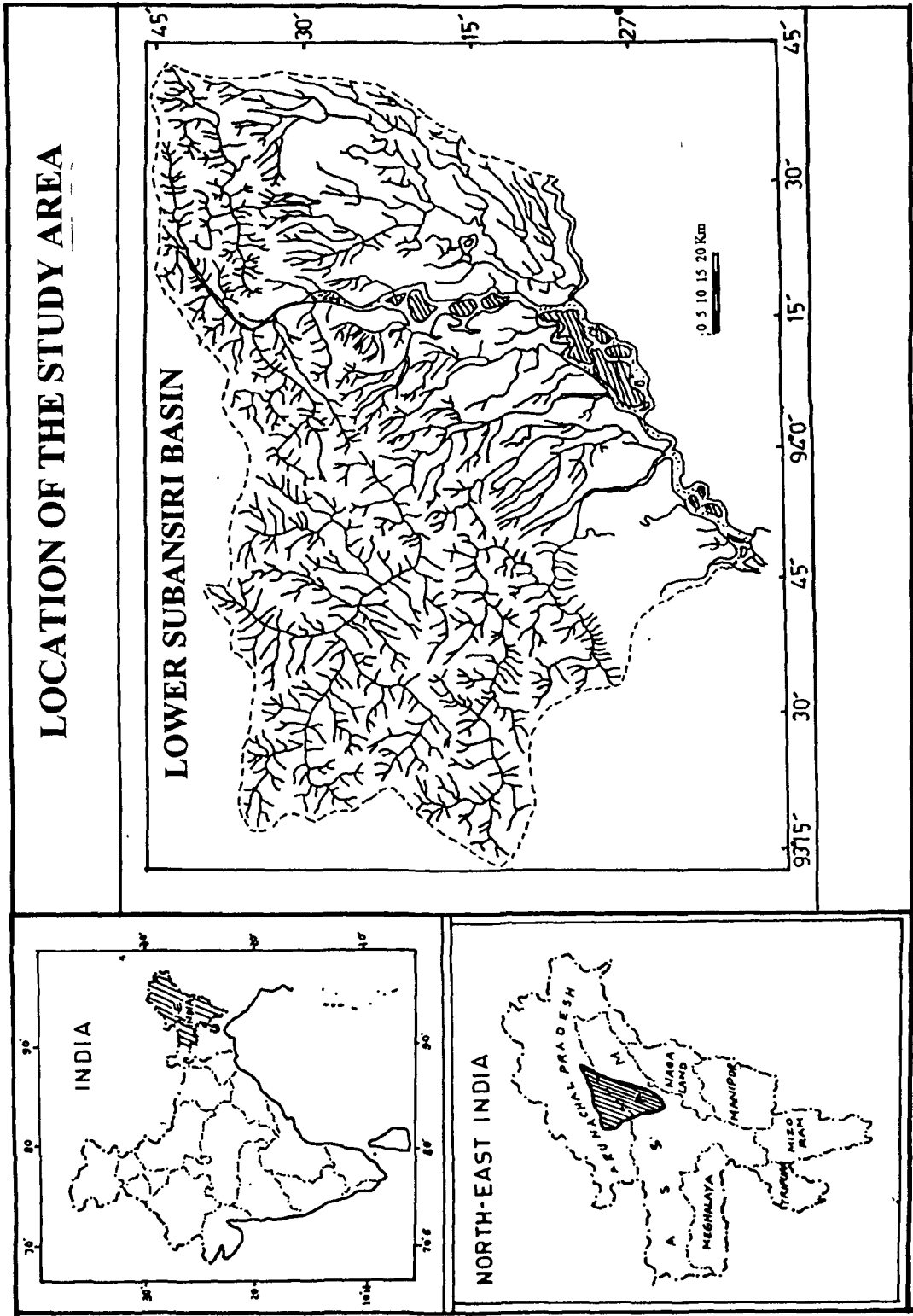


Fig. 1.1

Subansiri River is a main tributary of the mighty Brahmaputra River. It originates in Tibet Himalaya and flows through Arunachal Pradesh. For the convenience of research the lower Subansiri basin has been considered for the present study. (Fig.1.1).

River System of the Basin area

The Subansiri river is a major tributary of the mighty Brahmaputra. It originates in the great Himalayan range in the Tibet, which is the source of many rivers at an altitude of about 5000m above the m.s.l. The principal streams belong to Chu group in the Nye Chu, which may also be considered as the main source of the river. It originates in the snow-clad peaks of Kareng, Shobota, Baru and meta. another river Larochu near the Chyal and these join the Nye Chu by taking the name of Chayal Chu. The another stream Char Chu rising from snow clad peaks in the north joins the main river and crosses the international boundary to enter the Indian territory.

The river, as it approaches the Miri hills in the Arunachal Pradesh after crossing the international boundry runs in to the valley. The important sub tributary called Kamala rising in the southern part of Himalaya joins the Subansiri on the right

bank at a distance of about 95 kms. from the point of confluence of the Yume Chu and Tsari Chu. The river runs another 30 kms. through steep gorge to emerge from the hills through a short canyon to Subansiri river. The entire course of the Kamala is combined to a narrow gorge.

The main course of the Subansiri after entering the Miri hills in Arunachal Pradesh runs between Dafala and Abor hills. Debauching from the hills near Dolongmukh the course of the river lies in the fertile plain of North Lakhimpur district of Assam. In the broad and flat valley, the river flows in lazy and sinus curves. In fact during monsoon, it is a mass of water heavily charged with silt and in winter it becomes quiet and flows smoothly. After flowing for about 70 km from the hills, the river falls in to Kherkutiasuti

Subansiri is a composite basin with two major sub basins viz. the Ranganadi sub basin and Dikrong sub basin. Both these rivers originate in the Lesser Himalayan zone and flow through the hilly terrain and the plains of Assam and finally meet the Subansiri before the latter meets the Brahmaputra.

Ranganadi Sub Basin

The Ranganadi which is known as the Panir river in the upper course rises from the Dafala hills in the Arunachal Himalayas. Ranganadi is bounded by a series of peaks ranging in height from 2286m to 3658m. The important tributaries of the Ranganadi river in this zone are the Kying river, Pein river, Niorchi river, Kal river, Pangen river and Pite river.

The total length of the Ranganadi river in the hilly terrain is about 76 km and the river bed falls from about 1400 m. in the Dafala hills to about 150 m. near the Jaihing Tea garden in the plains of Assam. The total drainage area of Ranganadi is about 2500 sq.km. of which about 1900 sq.km. fall in the hilly terrain.

Dikrong Sub Basin

The other major tributary of the Subansiri is the Dikrong river which originates in Arunachal Himalayas. The Dikrong basin is separated from the Ranganadi basin in the north by a series of peaks ranging in height from about 2280m to 2600m and the southern margin of the basin runs along the series of peaks ranging in height from 1300m to 2300m.

The total drainage area of Dikrong sub basin is about 1950 sq.km. out of which about 1000 sq.km. falls in the hilly terrain, before it debauches in to the plain near Doimukh. The river traverses a distance of about 80 km in the Arunachal Himalayas. There is a network of tributaries of the Dikrong in Arunachal Himalayas. The drainage basin of Dikrong is more or less rectangular in shape.

In the upper reaches of the basin, its tributaries are fed by the melting of snow. The Arunachal Himalayas receive an average annual rainfall of more than 500 cm. The gradient of the river in mountain terrain is very steep and the tributaries are numerous.

Climate

The climatic conditons of the lower Subansiri basin are more endurable than the uper valley of Subansiri basin. The climate is cool and humid. The rain stops in the area in the month of October and temperature begins to fall. The average maximum temperature is 30°C. during the four succeeding months, the four succeeding months, the climate becomes increasingly cooler. In the month of December and January the maximum and minimum temperature is about 21°C and 10°C respectively. The period from June to September is the unpleasant part of the year. Heavy rainfall takes place

during these months as a result it becomes saturated with moisture and the climate is humid and hot. In this area the rainfall is much heavier than the plain. At Pathalipam located near the foothill the rainfall is about 426cm. Whereas at Lakhimpur and Dhakuakhana it varies between 324 cm to 256 cm respectively. The period from May to September is the rainiest and more than 70% of the total annual precipitation is confined to this period. November and December are the driest months and seldom visited by violent and destructive storms through an interval of dry weather. Hailstorms sometimes cause damage, especially to the Tea gardens.

Methodology and Research Design

The geomorphological investigation of river basins involves precise and correct understanding of the terrain attributes. It requires a scientific and methodological study of information collected through fieldworks and remote sensing data etc.

In the present study, special emphasis has been laid on the relief analysis as well as slope and fluvial processes. In addition, geological structure and history, weathering, soil and mass wasting and environmental degradation have also been

analysed and interpreted. The entire work has been carried out in different phases of pre-field work, field work and post fieldwork.

The following steps are taken in compiling the present research design

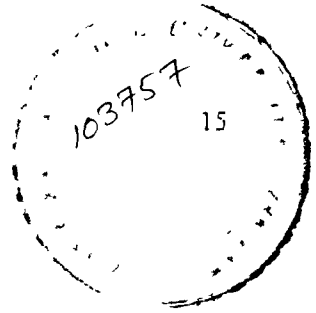
- (i) Preparation of base maps by using Survey of India topographical sheets on the scale 1:250000 showing drainage network and contours
- (ii) Collection of geological and lineament maps
- (iii) Cartographic representation of data in maps and diagrams.
- (iv) Identification of different flood prone areas.

Data Source and Research Material

The field work has been carried out for collection of the first hand data namely the identification of landforms, nature of soil, geomorphic processes active in the area, identification of flood prone areas, vegetation types and nature of environmental degradation etc.

For the present study the following materials have been used:-

- 1) Survey of India topographic sheets numbered 83E, 83F, 83I & 83J on the scale 1:250,000.



- 2) The aerial photograph at the scale on 1 25000.
- 3) The IRS-1C satellite imageries.
- 4) The reference books and reports published by GSI and differnt allide departments.

Chapter Scheme:

The chapter scheme for the present research work has ben designed as follows:

The first chapter deals with general introduction that provides an insight into the present reserach framework including conceptual framework, statement of the problem, objectives of the study, methodology and reserch design, data source and reserach materials.

In the second chatper, the geology of the study area (Lower Subansiri basin of Assam and Arunachal) has been discussed. The discussion broadly includes the geological formation of lower part of the basin. Basically there are three main geological formations in this part which have been formed in geological past.

Chapter three deals with a detailed description of weathering processes and soils of the basin area. It has been found that due to the prevailing climatic conditions in the area, physical weathering is found to be prominent. There is vast difference between the soil of the upper Subansiri basin and the lower part of the basin.

Chapter four concentrates on the analytical results of the relief and slope characteristics of the basin as evaluated on the basis of the field studies.

In the succeeding chapter (Chapter-five), the fluvial analysis that includes, the analysis of the suspended sediment load, gauge and flow discharge, identification of flood prone areas flood and drainage congestion etc. have been put forward in a tabular form accompanied by relevant diagrams.

In chapter six, environmental degradation of the area and its proper management techniques have been discussed in detail. Recommendations pertaining to the suitability and necessity in the present area have been put forward for the proper up-gradation of the basin area for all round development.

In the last chapter the general summary and conclusions of the study have been presented.

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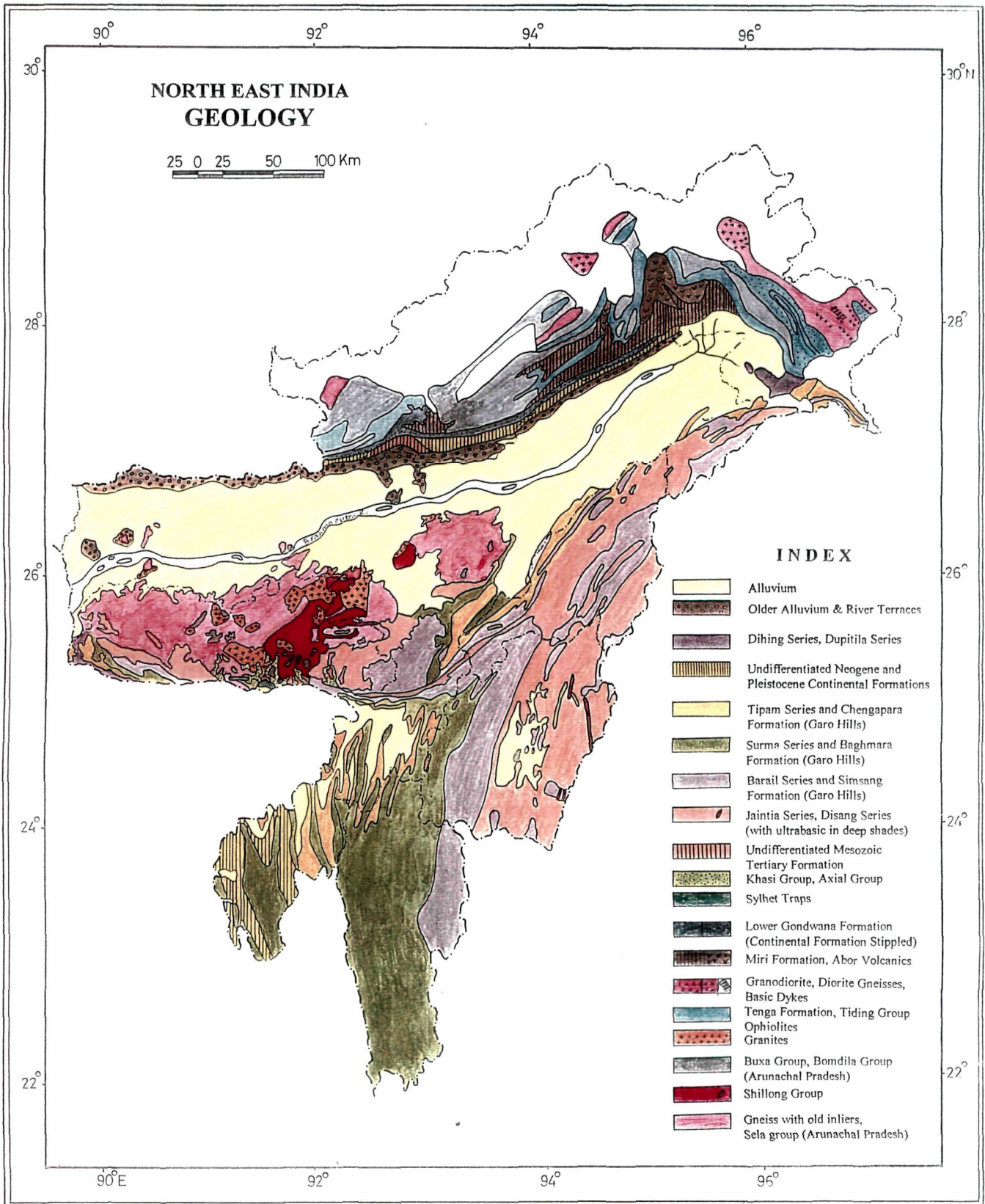
CHAPTER - II

GEOLOGY OF THE BASIN AREA

Geological formations of any area are the most important for the evolution of the landforms under the different processes. Geological structure always has a deciding influence on the formation and degradation of soils and landscape. Therefore, knowledge of geological formations is essential for an integrated view of land resources and their utilization. The geology of the basin is herein discussed in relation to its regional framework.

Various workers of GSI visited in different parts of Arunachal Pradesh and Assam, and collected geological information regarding stratigraphy and tectonism in this region. These workers include by A.K.Dey and G.C. Chatterjee (1949) in Lohit district, T.Banerjee (1950-52), Balasundram(1956) in Kameng district, and Laskar (1950-59) in Subansiri district. In 1963, geological works of Arunachal Pradesh, Himalaya and a part of Assam (Upper Assam) was carried out by Assam circle of GSI with a view to build up the systematic geological informations.

From this descriptive convenience, the lithostratigraphic succession and tectonic unit that met with the lesser Himalayan zones, are in two different parts. (A) Kameng Subansiri and Siang Himalaya and (B) Lohit Himalaya.(Fig. 2.3).



Source: Prepared from the Original Map of G.S.I. Misc. Pub. No. 32, Government of India, 1973

Fig. 2.1

(A) Kameng Subansiri and Siang Himalaya:-

The Subansiri basin covers a large area of about 27,000 Km². The catchment area is very large and extends upto the central Himalayan zone. The rock formation of the catchment area consist of Gondwana slates, Carboniferous shales and Tertiary formations of soft sand stone. On the basis of the geological data, so far collected by the geologists, the major rock units can be grouped into four major belts, Viz., Tertiary, Gondwana, Unfossiliferous sediment and a belt of metamorphites

Tertiary: -Tertiary rocks fringe (the Assam Plains) extend from east of Bhutan to a part of Siang district. Further east the exposed Tertiary rocks restrict themselves to a narrow zone which swerves(bends) towards south-east in the Dibang valley (Lohit district) . These rocks comprise hard gray and brownish sandstones with brown to gray - greenish silty clay, coarse to medium grained pebbly sandstones, subordinate clays or siltstones and boulders bed etc. Some dicot leaf impressions and fragmentary plant remains and lenses of lignite have been available

Recent-sub Recent - Alluvium and terrace deposits
 Pleestocene Zeto valley deposits, younger parts of
 Dihing beds (e.g. Dibrang beds), and
 upprmost siwaliks.

Pliocene Siwaliks Dihings
 (upper units) Namsangs

-----Unconformity-----

Miocene. Middle & lower siwalik units
 (equivalent to Tipams Surmas)

-----Unconformity-----

? Oligocene to Palaeocene Kimi bes, sanstone & [Equivalent
 Red shales, Sitly beds Barail-Disang
 with black rock and (Dewa thang)]

-----?-----?

? Mesozoic Basic trap rocks [equivalent to
 (lateritised) Sylhet traps]
 white quartzite.

-----?-----?

Permian	Gondwana	Sandstone slate, (with plant remain e.g Glossopteris. etc.)	[equivalent to Damuds (Barakars)]
-----?-----?			
Carboniferous to permo- carboniferous	Bichom Group	Marine ash green shales, calcareous shales etc (with the fossils like Bryozoa, Lamelli branches and Brachiopods) Boulder slates and quartzites.	? Rangit pebble beds.
-----Unconformity-----			
Silurian to Devonian ? Lower Carboniferous	Muri formation- Abor volcanics and	variegated slate with calcareous pink and whitish quartzites.	
-----?-----?			
Lower palaeozoic		Bands of dolomitic and carbonaceous slates: Whitish quartzite and conglomeratic beds: hematitic phyllites and quartzite.	(equivalent to Buxa)
	Tonga formation	Gray gritty and Schistose phyllites with whitish quartzites intercalations chlorite-talc schists.	(equivalent to Daling)
-----?-----?			

Early palaeozoic	Dirang and other schists (Kameng) porphyry and Khetabri schists (Subansiri, Sinag)	(equivalent to Daling)
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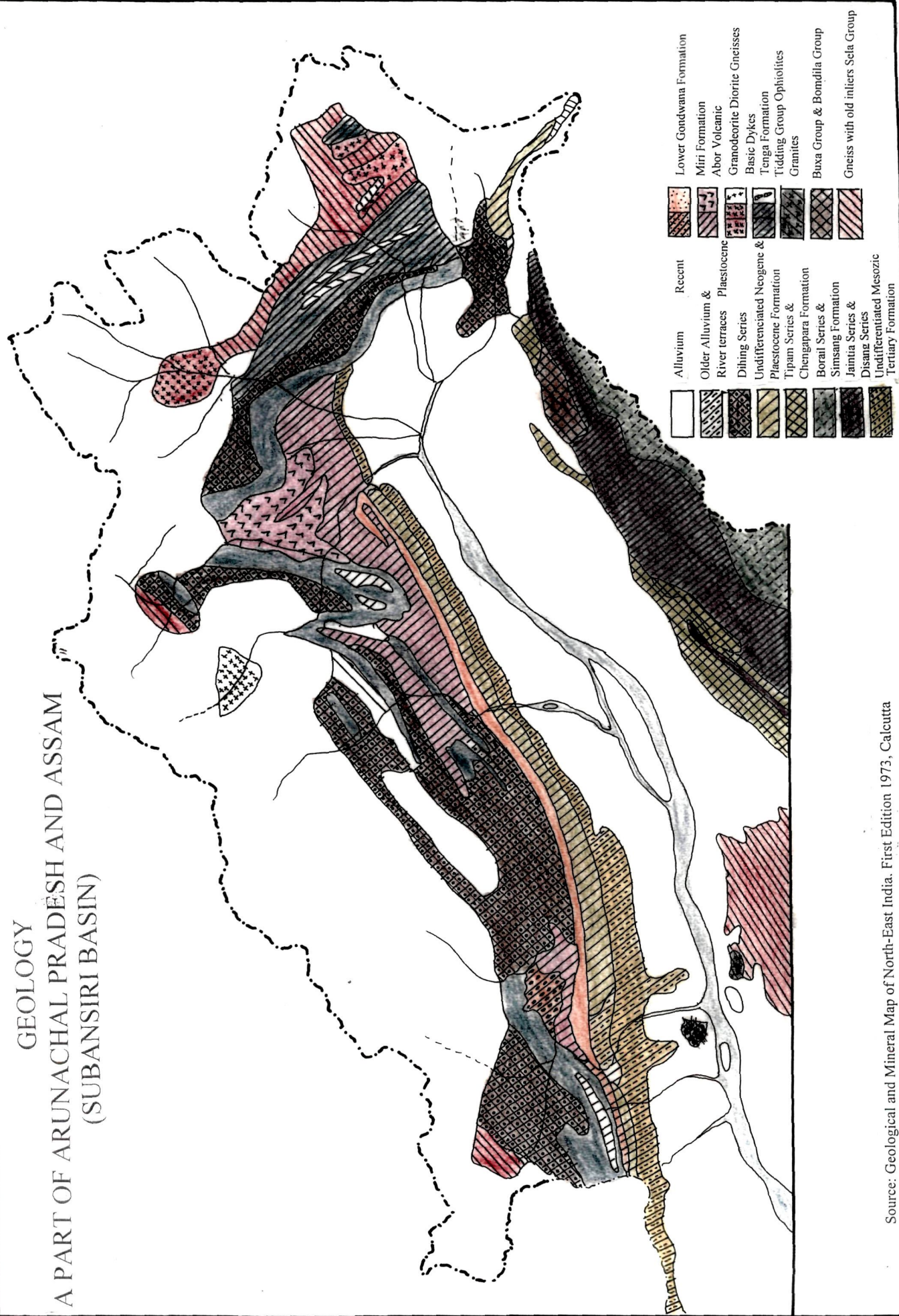
Bomdila Group	Zero, chakoo, Sepla, Daporizo, augen banded gneisses etc (palaeozoic gneisses of metasomatic nature(?))	(equivalent to Darjeeling gneiss etc)
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-----?-----?

Palaeozoic to Sela Group of precambrian. Higher Himalaya	Tourmaline granite (post-tectonic) Tertiary Schists migmatites, lit par-lit gneisses etc	(Unit above crystalline thrust)
--	---	---------------------------------------

Gondwana:- North of Tertiary belt, occurrence of rocks belonging to Lower Gondwana age were reported by GSI workers. Although pebbles containing marine (permo-carboniferous) fossils are available in Ranga valley of subansiri district. The Gondwanas were thus considered to constitute both fluvial and marine facies. On the basis of available data, it is, however felt that marine intercalations in situ with fossils like conularia, Larkeri, chonetes, productus, spirifer, pleurotomaria, crinoids etc. Which are better exposed in subansiri and siang district, belonging to the

GEOLOGY
 A PART OF ARUNACHAL PRADESH AND ASSAM
 (SUBANSIRI BASIN)



Source: Geological and Mineral Map of North-East India. First Edition 1973, Calcutta

Fig. 2.2

NEO-TECTONIC ACTIVITIES IN NORTH EASTERN REGION

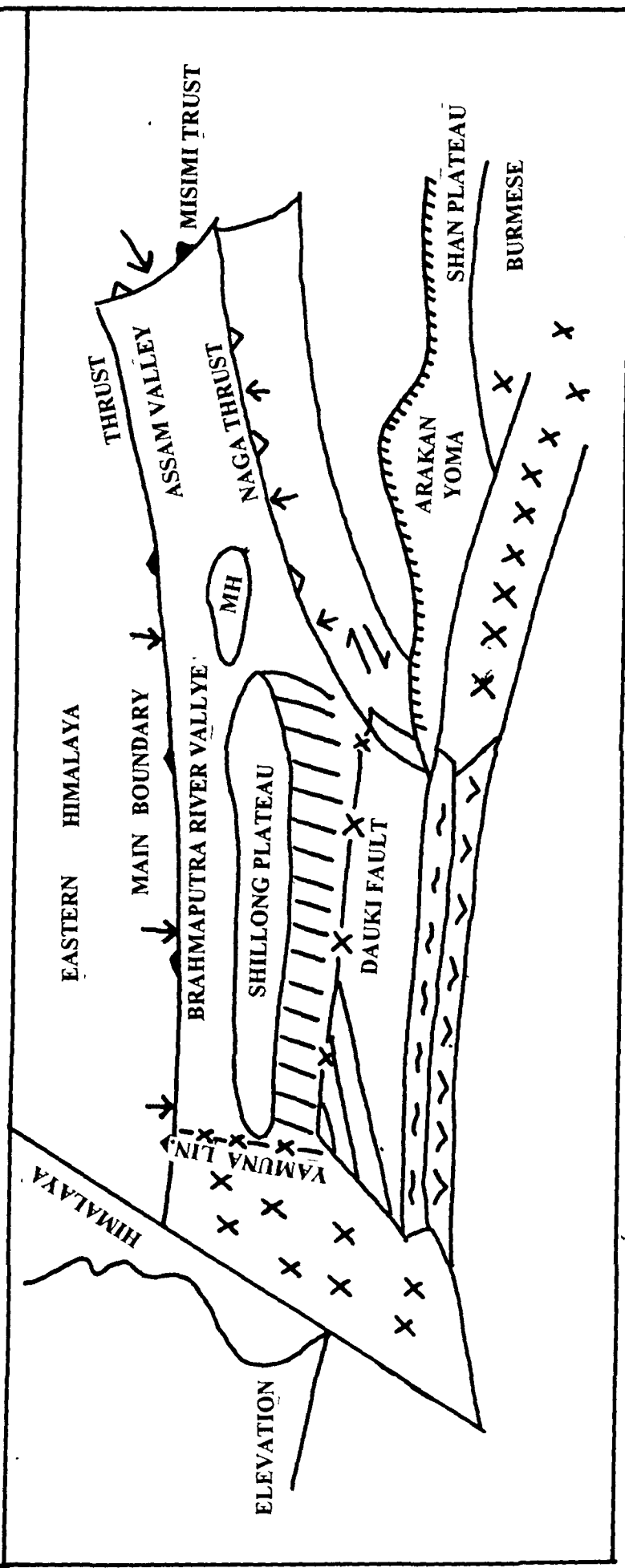


Fig 2.3

lower stratigraphic position. It comprised black shales with calcareous or cherty nodules and thin beds of brown to gray slaty shales etc. The fluvial deposits of Gondwana which is well developed in Kameng district belonging to probably to the upper stratigraphic position. Although some boulder to pebbly slates in Kameng district have been correlated with Talchir boulder beds, it is rather doubtful whether these actually belong to the Gondwanas or some other palaeozoic sediments.

Gondwana occur in a narrow and internally folded belt bounded between two thrusts, the northern thrust throwing the unfossiliferous sediments and meta sediments on or against it, whereas along its southern contact the Gondwanas up thrust against the Tertiores. (Fig.2.3).

The unfossiliferous sediments:- Some unfossiliferous dolomites, quartzites and shaly rocks were recorded by traverses undertaken in the parts of Tenga, Kameng, Subansiri, Kamala and Siang valleys. In the Kamala and subansiri valleys, the pink quartzites referred as Miri Quartzites were tentatively considered younger than the

Buxa type of sediments and older than the Gondwanas. The Abor volcanics of the Siang district were also available intimately associated with such sediments.

In the area between Subansiri and Kameng districts, continuation of these quartzite rocks with basic intercalation has been recorded in the Ranga valley. The whitish quartzites, phyllitic rocks and basic volcanics are thin and of restricted occurrence. Between Ranga and Subansiri valleys occurrence of pink quartzites (Miri Quartzites) and other calcareous rocks has been noted.

In the Subansiri and Kamala valleys and southwest of the Siyom valley in Siang district, basic rocks, phyllitic to slaty rocks, massive quartzites, conglomerate and dolomitic and cherty rocks are available. It is felt that even though the Miris may include quartzites etc. which are older than the carbonates, this provisional nomenclature may be retained.

Metamorphites:- The parametamorphites and gneisses with granite were noted by various workers in the lower Himalayan region of Kameng and Subansiri districts. The crystallines of the Higher Himalaya were also noted in the Sela area in the Kameng district. In the upper reaches of the Siang river the parametamorphites and the

gneissic rocks were reported to overlie the Abor volcanics, dolomites and quartzites etc.

On the basis of rock formations, the metamorphites have been divided into two groups. (Fig.2.2)

- i) Bomdila group of the lower Himalaya and
- ii) Sela group of the Higher Himalaya.

B. Lohit Himalaya.

The Lohit Himalaya forms easternmost part of the eastern Himalayan chain. This Himalayan sector is distinctive by the following features:-

- a) The regional trends are NE-SE unlike the NE-SW trend of Siang district.
- b) The Siwalik and Gondwana rocks, which are so characteristically developed upto Siang district, are practically absent on the frontal part of Lohit Himalaya.
- c) Existence of an extensive zone of ultrabasic rocks extending for about one hundred km. between Tidding and Twelang valleys.

B. Lohit Himalaya:

Plio-pleistocene	Upper Siwaliks	Upper Tertiary rocks (Dehengs)
Miocene to palaeocene	-----	Not exposed
Mesozoic	-----	Not exposed (covered in Lohit plains)
Upper palaeozoic	-----	Not exposed
Middle palaeozoic	-----	Rocks of Miri formation (Dibang valleys)
Pre-permian	Diorite-granodiorite	Complex-Metasomatic & intrusive phases.
Lower to middle palaeozoic	Tanga formation ? Miri formations	Carbonates, Tezu & Tidding limestones etc. And quartzites Metasediments-(Flysch ?) & serpentinites of Tidding and Tellu confluence area.
Early palaeozoic to pre-cambrian	Bomdilla Group	Para-gneisses high and low grade schists (Peillitic and graphitic) of Sewak pass, Lalpani etc.

The knowledge of Lohit Himalaya has remained, however extremely limited due to the hazards of this difficult terrain. Mac Laren (1904) pointed out the possible extension of the Burmese exials in the region. Many geologists made observations on the Mismi thrust vis-a-vis (Fig. 2.3) the patchy Tertiary exposures along it. The tragic effects of Minutang landslides (1949), the epicentral destructions of the 1950 Assam earthquake

and investigations connected with other geotechnical projects drew teams of geologists to this region.

On the basis of geological data so far collected by the geologists, the major rock units can be divided into three groups, viz. Tertiary rocks, metamorphites and Diorite granodiorite complex (Fig.2.3).

Tertiary rocks:- Small patch of tertiary rocks are recorded northwest of Tezu and in the region of Debang river. These NW-SE trending rocks are probably the equivalent of the upper units of the Siwaliks. The major part of the tertiaries is underlying the alluvial plain of Lohit, Kameng, Noa-Dihing river, where the eastward sloping basement is considered to be as deep as 5000 metres. The NW-SE low Manabum ridge exposed 2,500 metres thick Dihing formation in a well known anticlinal structure which plunges north-westward and is cut off southwest-wards by the Naga thrust (Fig.2.3). The Manabum ridge loses its identity and merges into the Lohit plains, and thus the Dihing may directly be underlying the alluvium. The constituent pebbles

and boulders of the Dihing led by many geologists to conceive of high mountains in Lohit district during pliocene period

Metamorphites:- Along the Misimi thrust (Fig 2.3) quartzites, quartz schists and coarse marble form the base of the front ridge for the Tertiary/Quaternary sediments of the upper Assam plains. These rocks are overlain by biotite, graphitic, garnetiferous schists, paragneisses. This high grade zone is overlain by quartzite, pinkish gray crystalline limestone, quartz-schist and chloritic schist. Some geologists opine that the parametamorphites of the frontal range form the core of a reclined overfold and the crystalline limestone and chloritic schists etc of Tidding represent the normal upper part of the same succession. The two linear bands of the serpentinite are to be separate rock bodies emplaced in the sequence. According to their view the diorite-granodiorite complex and all the parametamorphites are of pre-cambrian age

Diorite -granodiorite Complex:- It is constituted of foliated diorite gneiss-nonfoliated (sometimes banded) granodiorite, biotite gneisses, syenitic rocks,

metanoritic to doleritic dykes, lamprophyres, pegmatites and quartz veins. Besides, patches and bands of chlorites and amphibole - schists, marbles etc are also available within this region. That, this has been affected by intense structural disturbances is evidenced by the presence of Lohit thrust at its southern contact. sharp changes in foliations observed regionally and widespread equidotisation in almost all the rocks constituting the complex.

Recent Geological formations of Lower Subansari basin:-

Deposites are mostly of Quaternary period brought by the major tributaries from the Himalayas. These overlies the Siwalik formations. From the study of the characteristics of the landforms such as :

- (i) the dissection by the present stream system
- (ii) the relative height
- (iii) the characteristics of the Sediments i.e. oxidation, compaction etc.
- (iv) the nature of soil cover
- (v) type and pattern of streams, The geological in the lower Subansari basin may be arranged in the following sequence

Stratigraphy and correlation of the geographic units of at lower Subansiri basin :

Depositional Regime	Recent flood plain	Youngest
Partly Erosive Regime	Jaihing formation	North Lakhimpur Surface
Erosive Regime	Harmati formation	Oldest
----- Pedimentation -----		
Siwalik		

eological study of lower subansiri basin shows a new alluvial deposite. These can be divided in to three alluvial formations (Fig.2.4).

The youngest formation of this area is alluvial facies. These are represented by channel bar, meander scroll deposit, flood basin deposit etc. These features are found at diffeerent places along the bank of the subansiri where flood basin deposits are maximum .A detail discussion of this is done in chapter IV.

i) **North Lakhimpur formation** :- The North Lakhimpur formation is mainly composed of silt clay, compact and without a venner of soil. In this area thickness of the silt , silt clay zone is about 2 m and below this medium to coarse sand is seen within this section in the Bordeobam Tea garden area. Coarse sand is seen below the

GEOLOGICAL FORMATIONS LOWER SUBANSIRI BASIN

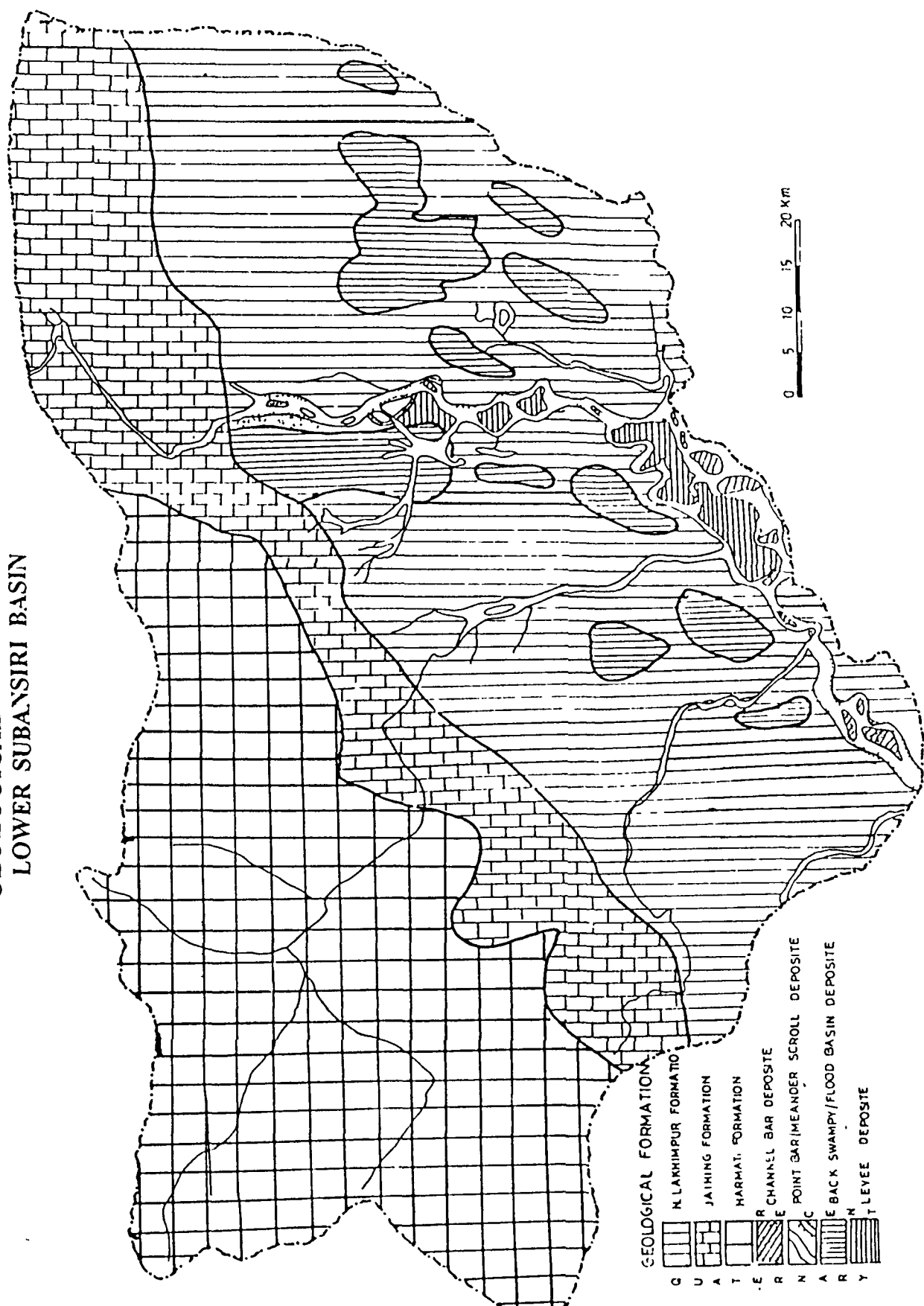


Fig 2 4

op silt, silt clay horizon at about 3m. In the Ghilamara area, the silt, silt clay horizons appear to be 1 to 2m in thickness. Below this, very coarse sand horizons are noticed. It is also observed that the new sedimentation does not show any oxidation.

ii) **Jahing formation:** This formation is mainly composed of pebble, grit, coarse to fine sand, silt, silt clay, primary sedimentary structures are poorly preserved. The pebbles and grits have mainly a sandy matrix and semi consolidated. This formation does not stand at a height more than 5m above the bed of the streams dissecting. This formation gradually slopes southwards and merges with the flood plain deposits of the present rivers. Since the constituents along the margin of this formation is very similar to that of the flood plain deposits. In this area the boundary roughly follows the 100m contours. In its lateral extent, the formation is present all along the foothills.

Good exposures are seen in a section of the Jahing Tea garden and section of the Ranganadi near the confluence with Dhekiajuli at the outskirts of the Jahing tea garden and formation are also seen in it. Exposures of this formation are also seen

in section of Harmati Tea Estate, South of Diyu Tea Estate , Lilabari Tea Estate, Silonibari Tea Estate and in the section of the Kakoi nala.(Fig.2.4)/

iii)**Harmati formation:** The Harmati formation composed of boulder, cobbles and pebbles mainly of quartzite, sandstone and gneiss rocks with argillaceous and siliceous matrix and are consolidated. The boulder, cobble and pebble are rounded to sub rounded and do not show any preferred orientation and sorting. This indicates that the materials were transported for quite a long distance and rapidly deposited. The finer fraction comprises mainly of coarse sand, silt and silt clay. The coarse fractions don't show any sedimentary structure, the finer fraction shows cross bedding and parallel laminations.

A characteristic feature of the Harmati formation is that the top part (more than 1m) is highly oxidized. The colour of the top corner is generally reddish brown to yellowish, and clay pockets contain ferruginous nodules.(Fig.2.4)

GEOHYDROLOGICAL MAP OF LOWER SUBANSIRI

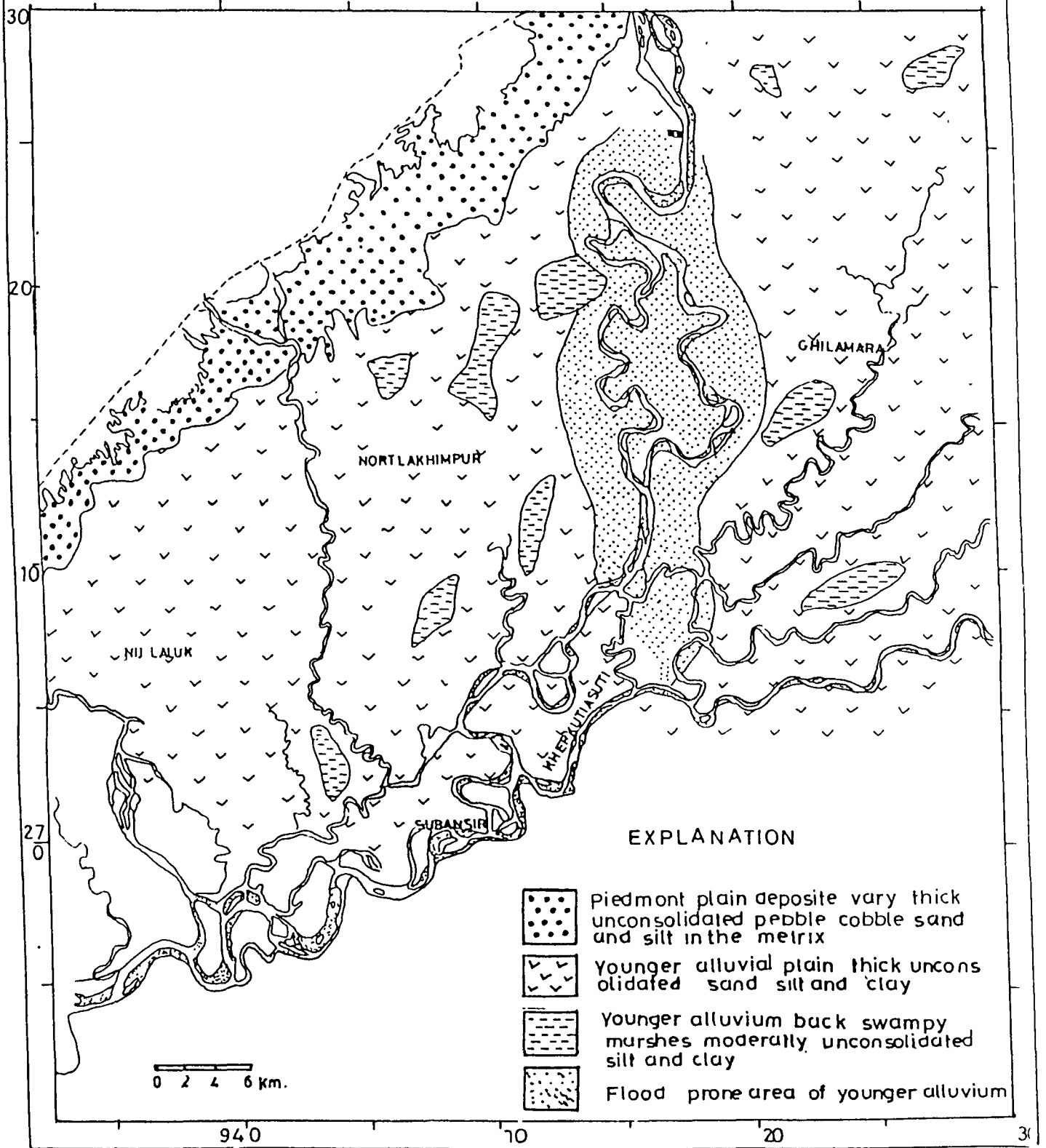


Fig 2 5

This formation is well exposed in sections of the Harmati tea garden after which it is named (plate) Here the exposed thickness of the section is about 15m and stands abruptly with scarp faces over the Jaihing formation. Boulders, cobbles and pebbles constitute the major part of the section, but the top most part is composed mainly of silt and silt clay, reddish brown in colour.

The kimin Diyu section as exposed near Kimin consist mainly of associated boulder , cobble and pebble near the foot hills zone but away from it ,in the Diyu Tea Estate . It is mainly silt, silt clay brown to yellowish colour. Another good section is exposed along the bank of subansiri in the pathalipam Tea Estate . Here the section is about 5m thick and is composed mainly of coarse to very coarse sand , silt and silty clay .Primary sedimentary structures such as parallel laminations, cross-bedding are well preserved.

The Harmati formation forms almost a tabular body above 120m contour and stands much above the beds of the stream cutting through it. From the morphological point of view, this zone may be called a terrace and suitable for tea plantations ; hence most of the tea gardens of this area are situated in this zone.

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CHAPTER - III

WEATHERING, SOIL AND MASS-WASTING

The three phenomena occur in nature in a sequence as part of circulation of matter. Weathering is the initial stage in the denudation history of any landscape, as rock must be weathered before the debris can be transported, and erosion is very limited unless the agents of transport are carrying a load of debris.

Soil is the phase through which much of the rock waste of the land undergoes before it is ultimately removed. The movement of rock debris on slopes is slowly but continually like soil creep. However, processes of mass-wasting cause sudden movement of large masses of materials followed by long period of quiescence.

Weathering or disintegration of rocks takes place over a period of time. Weathering is one of the major geomorphological processes. The degree of activity is generally higher in the humid areas while two main types of weathering namely chemical and physical weathering take place. The nature of weathering depends on the different factors like, climate, vegetation cover, bed rocks and so on.

Weathering can be defined as spontaneous change on rocks at the earth surface leading to physical disintegration and chemical decomposition, transforming massive rocks to elastic colloidal soluble state. The visible products of weathering are the unconsolidated mantle which includes (i) fragments of rocks and minerals and (ii) organic matter in various stages of decomposition. The energy for weathering processes is derived partly from the sun and partly from rock minerals themselves.

Chemical weathering refers to the disintegration on rocks through a chemical processes. This means that there is a change in the properties of rocks both physical and chemical due to the processes of chemical reaction. The weathering in humid areas like Arunachal Pradesh is high.

There are certain factors that govern weathering in humid and semi-humid areas.

These have been clearly dealt with following Table 3.1

Table No.3.1

Climatic factors

Temperature

High temperature increase the rate of endothermic chemical reaction

Precipitation

High precipitation increases the availability of the principal agent of weathering processes. Example:-Water.

Biotic factors

Vegetation cover

A dense forest canopy protects the surface from wash, process and provides organic

Geomorphic factors Land surface stability	acids which are capable of mobilization, of certain rocks minerals especially iron. Example:- Open vegetation of the savanna types favours immobilization of iron and favours surface run off.
	Weathering penetration is mobilized by a low rate of surface denudation prevailing on gentle slopes. Prolong stability allows deep profile development. Elevated site promotes downward movement and decomposition of rocks. Convergence run-off may have increased water supply but this may be combined with poor site drainage.
Geological factors Rock types	Presence of minerals particular to alteration increases rate of weathering penetration and may promote early disintegration of rocks.
Rocks texture	Rock texture effects the behaviour of the sole and weathering, crystalline rocks of course texture disintegration more rapidly, Fault, joint, fracture, grain boundaries promote weathering penetration especially in crystalline rocks.
Rocks feasibility	
Climatic change	Variation of climate and vegetation with time to time affects the balance of weathering and erosion .
Tectonic change	Variation of crystal stability affects land surface stability and the period availability of weathering penetration.

It has been noticed that the agent of denudation like surface water, due to high amount of rainfall and variation in temperature have played a dominant role in moulding the landscape of the study area. In this respect the dominant factors being weathering and erosion which under the tropical monsoon climate exerts a significant influence on the landscape of this area. Factors responsible for creating the weathering environment in the area under study have been climatic, biotic, geologic, and geomorphologic conditions. These factors have played an important role individually and collectively. It is true that structure and lithology have a great role to play in the intensification and extent of the weathering. The impacts of weathering can be seen more at two planes, foliating and joints planes. Relief is dependent on climate. The influence of climate is principally felt in an indirect way through the medium of vegetation and soils. Generally the presence of vegetation cover reduces the intensity of mechanical and chemical weathering. The roots of the trees penetrating along the vertical joints split the rocks and roots penetrate deeper, the joints and cracks of the rocks are widened. Extensive physical weathering has been noticed in the field.

From the table No 3 1 it could be inferred that how the deep rock weathering is high in this area. The maximum amount of rainfall over 400 cm. in a year is significant. As a result the work of water as a principal agent of weathering is enhanced. The

geomorphic factors are also responsible to a large extent for furtherance of deep weathering and processes of soil formation.

Table No3.2

Temperature Variation in different Stations of the Lower Subansiri Basin

Doimukh	1991		1992		1993		1994		1995	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
January	24.80	10.00	23.00	10.50	18.00	9.50	17.50	12.00	23.00	10.50
Feb	30.80	13.00	24.00	13.00	19.50	11.00	19.50	14.50	24.60	13.00
March	33.00	18.20	30.00	16.00	27.00	16.00	23.75	18.50	30.00	16.00
April	34.00	20.20	32.00	20.20	30.70	19.00	20.00	14.00	30.00	17.00
May	33.20	17.00	33.50	21.00	32.00	24.30	30.00	21.50	33.50	19.20
June	35.00	22.80	35.20	24.20	34.50	26.30	30.50	25.00	34.20	21.22
July	34.70	24.50	33.50	24.20	32.00	24.00	33.20	26.00	33.50	20.24
August	34.80	24.00	35.00	24.00	32.00	24.30	34.00	26.50	32.00	28.29
Sept	32.50	18.00	33.50	20.00	29.00	22.00	28.00	18.50	29.50	17.23
Oct	32.50	18.00	33.50	20.00	29.00	22.00	28.50	18.50	29.50	17.23
Nov	28.50	15.20	27.50	14.00	24.00	19.00	25.00	19.00	27.50	16.45
Dec.	23.00	11.00	21.00	10.00	22.50	16.00	24.33	NA	24.00	14.28

Ziro

Jan	21.00	4.00	15.00	5.00	16.00	7.00	21.10	1.10	16.70	3.90
Feb	21.00	6.00	17.00	6.00	18.00	9.00	21.10	2.00	17.80	4.00
March	24.00	8.00	21.00	10.00	19.00	10.00	21.00	4.00	22.00	7.00
April	28.00	10.20	25.00	17.00	23.00	12.00	28.30	7.80	25.00	9.00
May	33.20	11.00	30.00	17.00	29.00	17.00	34.40	12.20	31.00	17.00
June	35.00	12.80	35.00	21.00	33.00	21.00	34.40	15.60	31.00	18.00
July	34.70	16.50	34.00	21.00	34.00	22.50	34.40	16.70	33.00	20.00
August	34.80	14.00	33.00	20.00	31.00	22.00	33.40	15.00	36.00	19.00
Sep.	32.80	14.00	30.00	17.00	29.00	18.00	34.00	15.60	36.00	18.00
Oct	31.50	10.00	25.00	15.00	26.00	14.00	34.00	16.10	32.00	10.00
Nov	28.50	9.00	23.00	13.00	22.00	13.00	32.80	10.10	30.10	10.00
Dec	23.00	7.00	20.00	10.00	20.00	9.50	27.00	4.00	22.40	5.60

Table No3.2**Temperature Variation in different Stations of the Lower Subansiri Basin**

Itanagar	1991		1992		1993		1994		1995	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
January	20.91	8.55	19.21	7.55	18.50	8.50	17.00	11.20	21.00	13.00
Feb	20.39	10.64	20.42	11.46	19.00	11.00	19.32	14.28	24.00	15.00
March	26.00	16.24	23.38	15.33	21.00	13.00	23.44	17.29	24.00	18.00
April	28.15	18.30	27.55	19.28	23.00	19.00	27.41	19.20	28.00	21.00
May	32.26	21.00	31.43	22.44	31.00	21.00	29.30	21.20	27.00	17.00
June	29.84	23.88	33.42	23.42	35.00	20.00	33.10	24.23	36.00	17.00
July	28.65	24.42	29.88	19.28	29.00	19.00	31.00	26.20	35.50	21.00
August	30.50	27.00	29.88	19.28	29.00	19.00	31.00	26.20	36.00	21.00
Sept.	29.80	26.57	28.20	18.28	28.00	18.50	28.42	19.26	36.00	21.00
Oct.	28.19	22.42	25.38	15.36	29.00	22.00	28.00	17.00	32.00	13.00
Nov	23.60	15.66	22.44	11.22	28.00	8.00	24.23	16.12	27.00	8.50
Dec.	20.03	10.65	19.21	9.26	29.00	5.00	23.24	11.40	22.00	6.50

Table No3.2**Temperature Variation in different Stations of the Lower Subansiri Basin**

Lakhimpur	1991		1992		1993		1994		1995	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
January	25.53	11.50	24.00	11.00	24.30	11.00	24.75	12.00	23.75	11.00
Feb	30.75	13.50	24.50	14.50	24.50	12.00	25.15	13.00	26.00	14.00
March	33.50	14.00	29.00	14.00	28.00	12.00	25.12	13.00	27.00	14.75
April	34.50	19.00	33.00	16.00	32.00	14.00	29.00	15.00	30.14	16.25
May	34.50	22.00	35.00	16.00	35.00	19.00	34.00	19.12	32.00	19.00
June	35.33	24.00	32.00	15.75	34.00	21.00	35.15	19.75	34.35	21.00
July	35.75	23.50	35.00	15.50	34.50	24.00	33.75	22.00	32.70	21.73
August	34.75	24.00	32.00	15.00	31.00	23.00	32.29	24.00	34.50	21.00
Sept.	30.20	19.00	28.00	14.00	28.00	14.00	29.75	21.00	29.50	21.00
Oct.	28.50	19.00	28.00	14.00	28.00	14.00	29.50	17.00	28.70	19.00
Nov	28.00	18.00	25.00	13.00	26.00	16.00	24.60	16.00	26.25	17.00
Dec.	26.00	16.00	24.00	11.00	24.00	11.20	23.00	13.00	24.30	11.50

Table 3.3 Rainfall Variation in different stations of Lower Subansiri Basin.

Month	Station	Station	Station	Station
	Sagalee(in cm)	Doimuh	Ziro(in cm)	Lakhimpur(in cm)
January	94	6.34	2.68	7.30
Feb	NA	12.08	2.49	11.00
March	1.94	9.56	10.53	6.30
April	4.97	16.70	8.24	24.70
May	24.37	45.50	4.48	12.40
June	67.30	58.70	18.49	50.20
July	29.80	49.06	29.10	47.30
August	39.08	43.95	23.98	56.00
Sept.	14.52	21.43	13.37	37.00
Oct.	11.42	18.49	4.17	12.000
Nov	.95	.40	4.40	7.30
Dec.	.93	.72	2.60	.94

Source of data: Statistical hand book of Arunachal Pradesh and Lakhimpur.

RAINFALL AND TEMPERATURE VARIABILITY OF SELECTED STATIONS

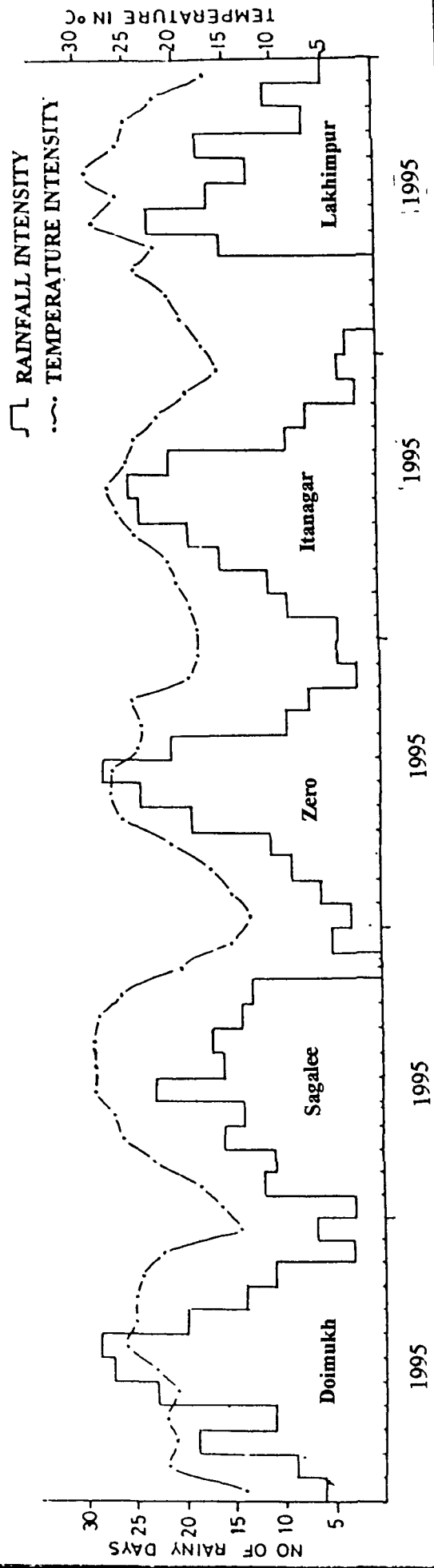


Fig. 3.1

Since the process of weathering accelerates more with the presence of water the rock texture becomes important, because it largely controls penetration of water into the rocks the porosity data for the common rocks are given in the table No.3.4

Table No.3.4

Rocks types	Porosity(in%)	Unconsolidate	Porosity(%)
Granite	1	Clay	45
Basalt	1	Silt	40
Shale	18	Sand	35
Sandstone	18	Gravel	25
Limestone	10	-	-

Source: Leopold, L.B. Wolman M.G and Miller J.P. et al. Fluvial Processes in Geomorphology, P.101.

Depending on the operative factor, weathering processes are roughly sub-divided into two types.

- (i) Physical weathering
- (ii) Chemical weathering

Physical Weathering

Physical weathering is caused by a variety of factors but those causing movement of rock particles play the decisive role. Oliver (1965) Thornbury (1961) and Spark(1952) have recognized various processes, however only slaking and weathering caused by temperature are noticed in this area.

The researcher has observed during fieldwork the disintegration of fine grain sandstone to a number of large pieces of about equal size in between the river bank of the subansiri and its tributaries. A large variation i.e., seasonal and monthly rainfall in this area helps to the processes of weathering (Table 3 3).

In this basin during the field study the researcher has noticed some evidences of physical weathering. Especially it shows the action of water in the joints indicating the initial stage of weathering. The development of cracks along the joints can be clearly seen and even the growth of vegetation along with the cracks can be seen in the photograph also(Plate No. 5.1 & 5.6). The thick regolith cover on the hill slopes and the disintegrated pieces of rocks strewn on the bed rocks are examples of physical weathering.

Chemical weathering

Disintegration of rocks is the result of chemical weathering. The following substances are most active chemically-oxygen, water, carbon dioxide and organic acids. The processes involved in chemical weathering may be classified as (i) Oxidation (ii) Hydration (iii) Dissolution and (iv) Hydrolysis. The oxidation process is very active in the Subansiri Basin of Arunachal Pradesh. The precipitated iron oxide is seen in water, and even pebbles and boulders have reddish colour

Effect of Vegetation and Precipitation during the Weathering Processes

Vegetation is important in governing the rate of removal of weathering products. Root hold the soil in place prolongs the weathering period until the protective plant cover is breached. Protective root system is generally not uniform under natural condition as a result there is an uneven thickness of the weathered material above the bed rocks. Due to shifting (jhum) (Plate 1.1) cultivation in the Papumpara district of Arunachal Pradesh the burning has destroyed the vegetation cover of the area. Subsequently, it leads to the ineffectiveness of the protective root system of the vegetation, there by causing soil erosion(table No.3.5).

Table 3.5
Jhuming and soil erosion calendar of study area

Month	Agriculture operation	Erosion Problem	Soil erosion in t./ hac
Month	Jungle cutting	Displacement of lose of soil material	0.0--6.3
February	Burning	Do	0.0--29.50
March	Clearing of hill slope	To down hill & earth warm scattig	6.0--67.59
April	Clearing continuous showing begin	Soil erosion as above wash due to rain	12.0--75.25
May	Showing/weeding	Heavy soil wash	10.0--32.00
June	Weeding	Heavy wash of soil aggradation	9.0--32.00
July	Weeding	Do	9.6--36.00
August	Harvesting & occasional weeding	Crops root exposed	10.0--43.00
Sept.	Harvesting	Mass appear soil erosion slow down	9.6--28.00
Oct.	Harvesting	Soil erosion very much reduced	0.0--0.95
Nov.	Harvesting	Slow erosion	0.0--0.95
Dec.	Har vesting	Do	0.0--0.76

Data Source: Rambabu et.al. 1978, rainfall erosion potential and iso-erodent map of India, Bulletin no.2, central soil and water conservation reserch and training institute, Dehradun.

Soil erosion value is the quantity of soil, which moves down to foothills and does not include the portion, which escapes with run off from the collecting point.

Effects of Precipitation

The various constituents of the soil are influenced by rainfall. In the basin area of subansiri 90% of the rainfall occurs during the monsoon period. It is reasonable to assume that mostly weathering occurs in this period

Table 3.6
Average monthly erosion index value(Metrix index)

Month	<u>Station</u> Guwahati	<u>Station</u> Shillong	<u>Station</u> N.Lakhipur
Month	-----	-----	0.50
February	-----	-----	1.80
March	5.6	4.8	6.20
April	40.6	17.8	18.90
May	14.2	55.4	102.50
June	146.9	122.4	242.90
July	149.5	56.7	288.90
August	139.3	50.0	268.60
Sept.	65.7	84.7	200.50
Oct.	9.6	----	43.90
Nov.	3.7	----	5.10
Dec.	----	----	1.80

Data source: Rambabu et. Al. 1978, rainfall erosion potential and iso-erodent map of India, Bulletin no.2, Central soil and water conservation Research and training institutes, Dehradun.

Rainfall is a major factor in causing soil erosion in this area. From the table no. 3.6 shown, above we observe that Subansiri basin has maximum soil erosion as compared to the other stations.

Soil erosion is associated with Shifting Cultivation

The process of soil erosion is highly intensified through jhum cultivation. With this downward movement of loose soil, some features leading to landslides. With the onset of monsoon; intensive human activities such as falling of trees, shifting cultivation etc. start and soil erosion processes are activated.

Table 3.7:- Soil erosion problem on hill slopes under various stage of shifting cultivation:

Month	1st jhum	2nd jhum	3rd jhum
Month	Forest cutting soil erosion	Corps residue decomposing regeneration of vegetation	Corp residue decomposing, No. Problem of soil erosion.
February	Begins with sliding cooling down dislodged soil look granular and earth	No problem of soil erosion.	do
March	Burning of cut material, final clearing.	Clearing of plantation for vegetation.	Vegetation comes up
April	Dibbing for forest species seeds in mixture.	Dibbing of looks very wet of less number of crops as compred to first.	No. Problem of appreciable erosion.
May	Corps comes up done with soil erosion get accelerated, heavy soil wash of loose particles	Do	Do
June	Crops grow well and develop	Due to heavy soil wash, surface looks	Good vegetation coverage of surface

	good canopy, crops clean. roots get exposed		Little surface erosion observed. It is due to splash and surface flow of run-off.
July	Some of the crops are harvest, heavy soil wash, good crops canopy concentration through run-off	Do	Almost all soil gets coverage due to vegetation.
August	Harvesting of crops, soil erosion slow down.	Do	do
Sept.	Harvesting gets in to the processes of decomposition.	Soil surface looks stable moss appears on soil surface.	do
Oct.	Crops reduced decomposition of forest well vegetation	Regeneration crops coming up, soil erosion very much reduced	do
Nov.	Regeneration of forest	Do	do
Dec.	Soil could get displaced regeneration of forest vegetation continues and no problem of soil erosion.	do	do

Source: Soil erosion hazard in N E. Hill Region, Research bulletin No.10. 1981. P.8-11.

Soil in the plain portion of the sub-basin lying in Assam can be broadly classified into three major groups. (i) Old plain (ii) Old alluvium on the old flood plain and (iii) New alluvium.

Along the foot hills, comparatively older alluvial soil types are found in the northern side of Lakhimpur and Dhemaji districts. Old alluvium on the old flood plain occurs in the middle part of the older flood plain and are comparatively newer than the foot hills soils. New alluvium on the recent flood plain is distributed along the tracts of the river Brahmaputra and its tributaries.

Soil in Arunachal Pradesh is mostly clay and loams where as crests of the mountains are covered with mostly sand stone Soil of Lakhimpur district and its neighbouring area are mostly sandy loam. In some places only sand is found at a depth of 6 to 10 cm. And river side is full of sand with silts.

Soil series (Tentatively)

Soil series is the basic unit of classification of the soil taxonomy. It is grouped according to the soil characteristic and other features except for surface texture. If the morphological characteristics of the soil is analysed, then we get some associated

characteristics or features which is furnished with this study. These characteristics and soil analysis datas help in interpretation of soil regarding its use and management.

The study area comprises of hilly terrain and that is why lower portion of the basin is mainly plain. That makes the soil series different between the upper and lower portion of the basin.

Table No.3.8

Soil series of Upper Area

Sl. No.	Series	Physiographic relation	Classification
1	Kombong	Mountain and hills	Coarse loamy mixed hyperthermic lithic dystrochrepts.
2	Gemotale	Flood plain	Fine loamy mixed with hypothermic types hapludalfs.
3	Doji	River terrace	Fine clay mixed hypothermic types ochraqualfs.
4.	Kareng	Flood plain	Loamy skeletal mixed hypothermic lithic dyatrochrepts
5.	Kabu	Levee	coarse loamy mixed Hypothermic mollic udifluvents
6.	Siyom	Filled river course	Coarsel mixed hypothermic aquic udorthernts.
7.	Passing	River terrace	Coarse loamy mixed hypothermic typic udifluvents
8.	Mori	Valley	Fine loamy mixed hypothermic typic.
	Lower as in		
9.	Jaihing	Piedmont slopes	Fine loamy mixed hypothermic typic dysteochrept.
10.	Balichapori	Filled river	Coarse loamy over sandy mixed hypothermic.

11.	Berpil	Flood plain	Coarse loamy mixed with haplaquetes.
12.	Kamalpur	Flood plain	Coarse loamy mixed with hypothermic typic fluvent
13.	Pasnoi	Flood plain	Coars loamy mixed hypothermic acqunte udifluvents.

Source: Statistical hand book of Arunachal Pradesh and Assam.

It is apparent that there is a large heterogeneity in the soils encountered in the North- Eastern region . Due to interacting effects of various soil forming factors, each factor influences, in different way according to varied situation.

In the hilly region the soil has developed largely on shales and to a lesser extent on slate and sandstone of different colors. High rainfall with optimum temperature favours thick vegetation growth, which in turn creates favourable biological activities. These factors are responsible for very deep weathering of rocks. The soil in situ except at foothills and near the water course where formed are of colluvial and alluvial origin.

Soil on steep slope in the upper part of the hills is very shallow and at places moderately deep. The soil is rich in organic matter and is fertile. Those are mostly under thick forest and where jhum is practised. Increase in soil acidity is accounted mainly in pockets where there are heavy leaching of soil.

To protect the soil, the steep slopes and hilltops are preferred to be under forest. The area under jhum cultivation should be under plantation crops beyond the slope gradient of approximately 33%. The soil series mentioned under physiography unit, hill slope and hilltop are according to the above category. The middle hill slopes have bamboo and thick forest. Most of the jhumming is practised in such types of terrain, which leads to maximum soil erosion and loses soil fertility. Jhumming should be replaced by permanent agriculture after taking conservation measures like terracing, boundaries etc. The soil series within the physiographic unit of mid slope fall under this category

Mass wasting plays an important part in the weathering of rocks in the humid and semi humid areas. This process is mainly gravity-induced movement of regolith. However it excludes those which are covered or transported by external agent like running water. Mass wasting is governed by different factors reflecting the diverse nature of their origin. Geology, slope gradient, climate, land-use and the degree of human interference are the factors responsible for mass wasting.

There are four major types of mass wasting which are designated as slow flow, rapid flow, landslide and subsidence. Among these landslides are the most important mass wasting phenomenon.

Landslide: Landslide is of profound interest to the earth scientists, environmentalists, and engineers. Landslide phenomenon is one of the most widespread and effective agents sculpturing the earth surface. Landslides destroy settlement or engineering structure like, road bridges, buildings etc. It may bring sudden death of people who have trusted their structure.

Landslides are a downward movement of slope forming materials, primarily composed of natural rocks, soil, artificial fills or combination of the material. Mass wasting may proceed mainly by three combinations.

(i) Falling

(ii) Sliding

(iii) Flowing

Landslide in the Study Area

In the study area , landslide zones are seen more frequently where the nusan activities are going on .During the rainy season when the water pressure increases the weathered rock weakens and crumbles During this time Itanagar is totally cut-off from other parts of Arunachal Pradesh (Plate No 52)

Conspicuously the part of area is falling in Papumpara and Lakhimpur districts and shows frequent indices of landslides. Incidentally all the active landslides of the area are encountered along the national Highway No.52 the important landslides of the area are described below:

Plate No.5.2 Between Nirjuli and Banderdewa, right side of the road. In this landslide area, soil is homogeneous in nature. Course to fine grained, loamy without any differential soil profile. This area falls between 10° - 15° slopes

Plate 7.1 After crossing the Arunachal University and before reaching Chagalli, we have seen another landslide in the left side of the Dikrong.

From the above description and photographs, various factors of mass-wasting are accounted and observed.

(i) The common landslides are being along riverside.(Plate No.5.2)

(ii)In the area the landslides are mainly caused due to the slope failure (Plate no.6.1).

(iii)The landslides are because of deforestation and steep slopes out along the highways.(Plate no.5.2 & 7.1).

Landslides can not be prevented, but can be minimized if suitable measures are taken before development scheme is implemented.

(i) Proper grading maintains of the slope within the area

(ii) Base wall and retaining wall to be made when new road construction is started.

(iii) Proper drainage, gullies and drain to be provided without any loose of landslides.

(v) Deforestation along the roadside should be stopped

(vi) Agricultural land grazing and residential construction activities along both sides of the highways and slide prone areas should be totally banned

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CHAPTER - IV

RELIEF AND SLOPE ANALYSIS

The study of relief and slope is a significant aspect of geomorphic studies to analyse the terrain and topography on a micro scale. Relief gained importance with focus on varying intervening ingredients, environmentally and geographically operating in an area to understand processes and stage of the development of landscape, which has affected human habitation and activities. Relief has to be explained especially in the mountainous and hilly areas. The average slope and relief of the subansiri basin have been discussed here. Average slope plays a significant role in determining erosional surfaces. For this purpose the area is divided into grids each grid representing 25 sq. Km. In Table 41 (Fig 4.2).

Table: 4.1

Sl.No.	Index value	Aea in sq km.	% in area	Remark
1	0--500m	4237	45	Very low
2	500--1000m	1338	14	Low
3	1000--1500m	781	8	Moderate
4	1500--2000m	1288	13	High
5	2000-2500m	1123	11	Very High
6	2500m>	596	6	Exceptionally or Extremely High.

DRAINAGE
LOWER SUBANSIRI BASIN

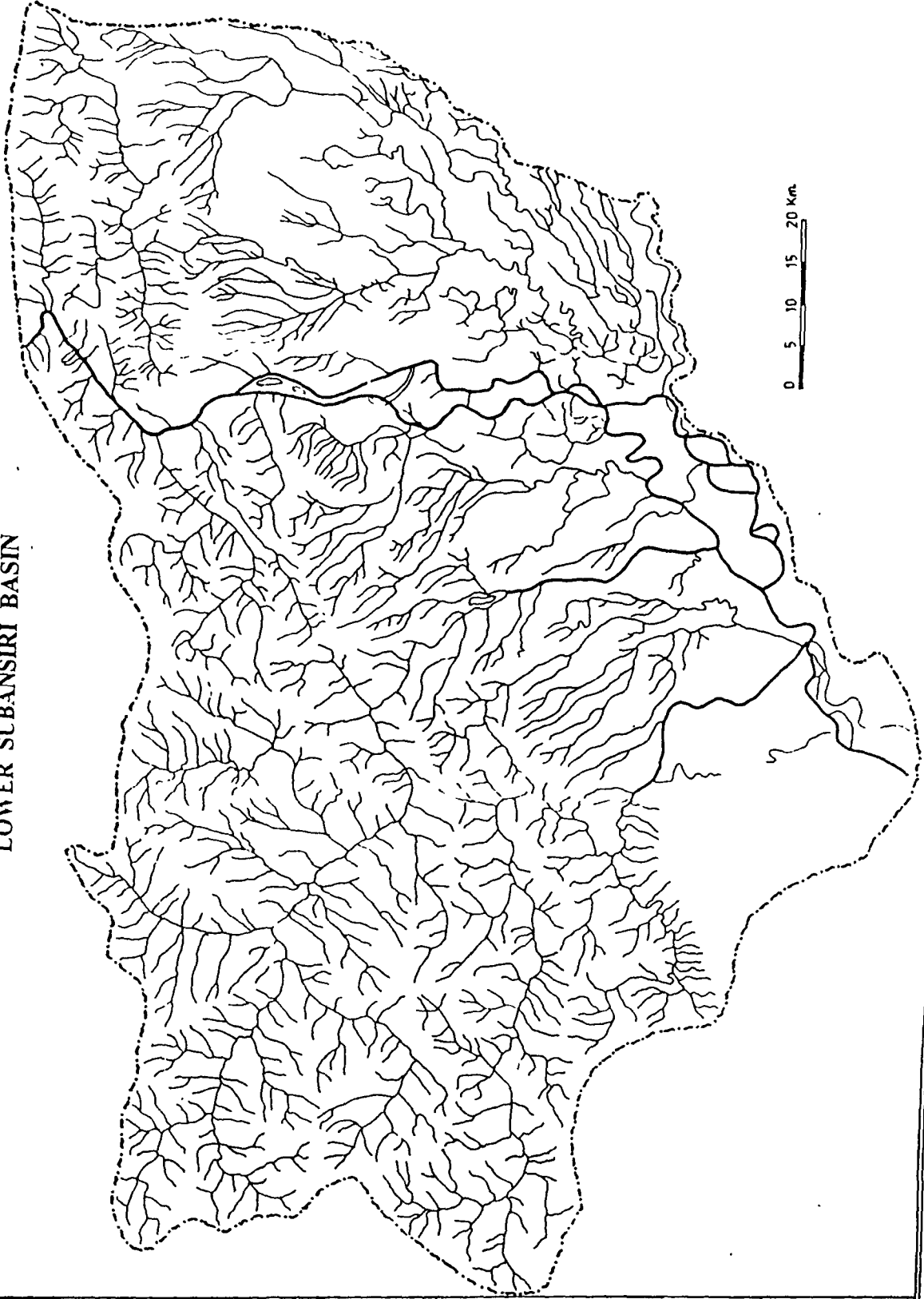


Fig. 4.1

**CONTOURS
LOWER SUBANSIRI BASIN**

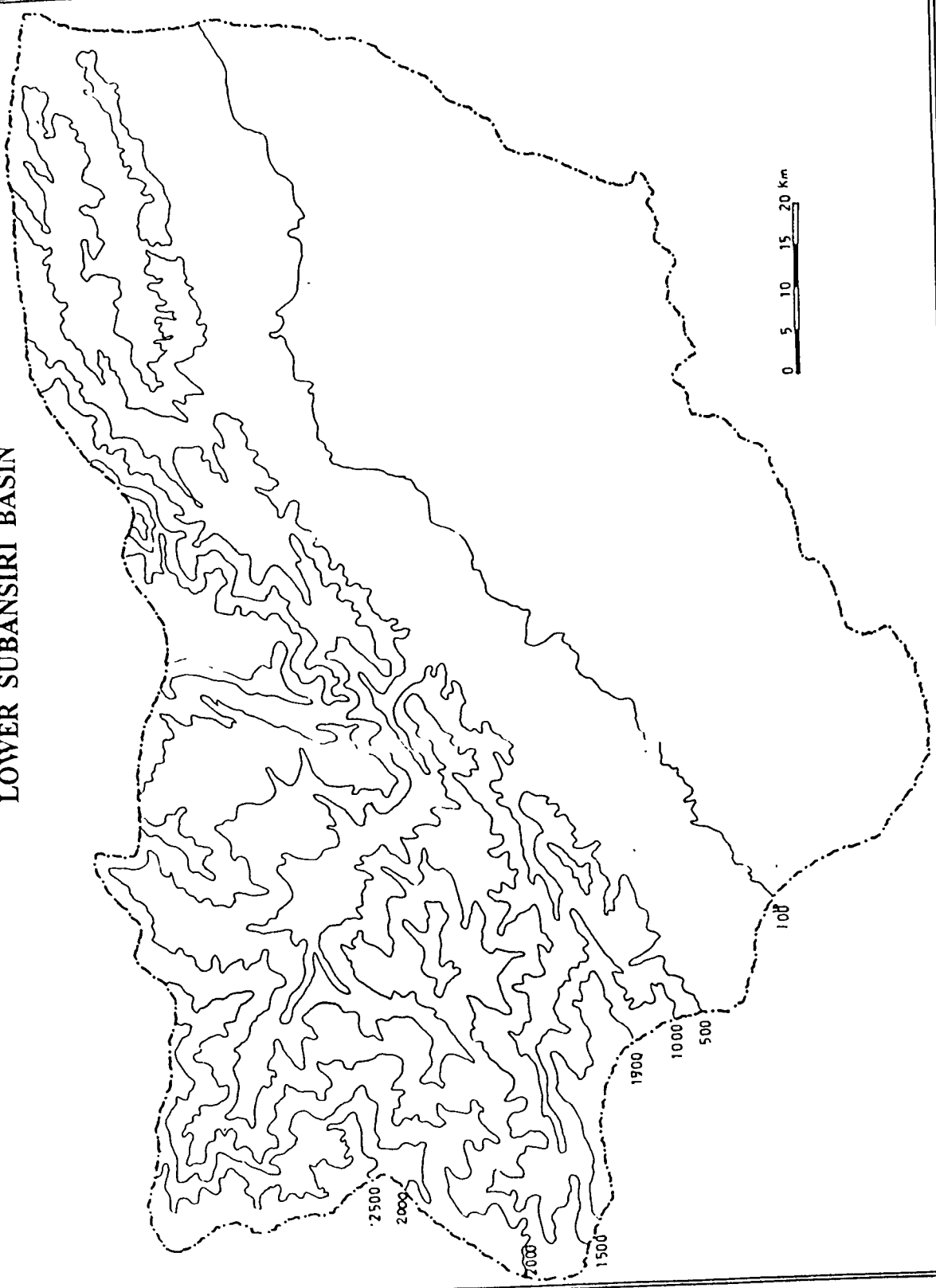


Fig 4.2

1. **Very low average slope:** It covers 4237 sq. Km.(45%) of plain area of Assam and some part of Arunachal Pradesh.
2. **Low Average slope:** The area covered under this category is about 1338 sq.km.(14%) covering mainly Arunachal Pradesh.
3. **Moderate:** It covers 781 sq.km.(8%) of the basin where erosion is medium.
4. **High:** It spreads over 2411 sq Km.(24%) of the basin in places, like Papumpara district of Arunachal Pradesh, where erosion process is medium.
5. **Very high:** It covers about 1123 sq. Km. (6%) area in the Lower Subansiri district and origin of the Dikrong and Ranganadi river. Fig.4.4.

From Table(4.4), slope requires scientific and mathematical analysis to provide both quantitative and qualitative basis for development projects viz. Construction of roads, bridges, dams and multipurpose projects etc. It is the single largest determinant of landform that effects human activities Morphometric analysis of

RELIEF
LOWER SUBANSIRI BASIN

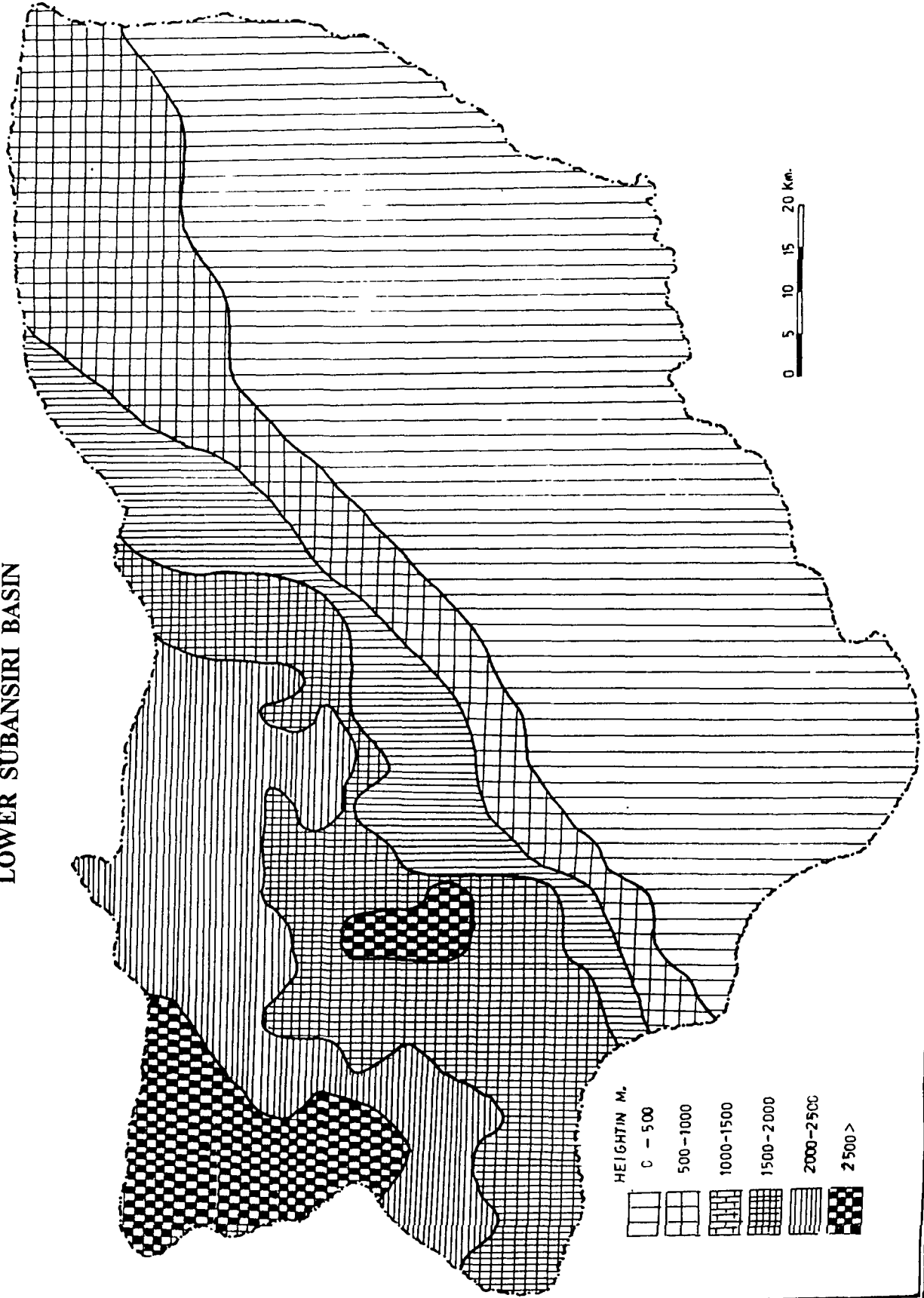


Fig. 4.3

slope in a region is the measurement and scientific analysis of the configuration. It is the shape or dimension of a region and that of its landforms.

Thus, in this chapter an attempt has been made to investigate, analyse and enumerate the slope form and its characteristics of Lower Subansiri basin with the help of morphometric techniques viz.

1. Slope frequency
2. Slope profile
3. Drainage density

Slope analysis is done for engineering, agriculture and soil conservation. Landforms have very rarely uniform slope, lithology, structure and climatic character. Slope may take place due to the transportation and deposition of weathered rocks on bedrock. Vital factors, which are responsible for the development of slopes are as follows.

1. Surface relief and the endogenetic forces causing upliftment of landforms either above sea level or from into the high altitudes

2. Both weathering and transportation of material on slope are affected by climatic factors in the tropical region viz., monsoon wind and rains.

3. The activity of stream at the base of the slope which erode and transport the material brought to it from the surface and surrounding steep slopes.

4. Human activities viz. Agriculture, jhum cultivation and construction of multipurpose dams etc.

The formula modified by Zekrzewska (1967) as given below has been used in computation of average slope with the help of 1:250000 scale sheets

$$\text{Slope in degree} = (\tan) \frac{V.N}{0.6366 K}$$

Where, V=Vertical contour interval in metre or feet

N=Number of contour crossing per km Or per mile

K=1000 for metric unit and 5280 feet or mile.

Profile curvature is being calculated with the help of the method suggested by

$$\begin{aligned} \text{Young viz. } C_{ab} &= Q_a - Q_b / 0.5(D_a + D_b) \cdot 100 \\ &= 200 \cdot Q_a - Q_b / D_a + D_b \cdot 0 / 100m \end{aligned}$$

Where, Q_a, Q_b are angle at a and b

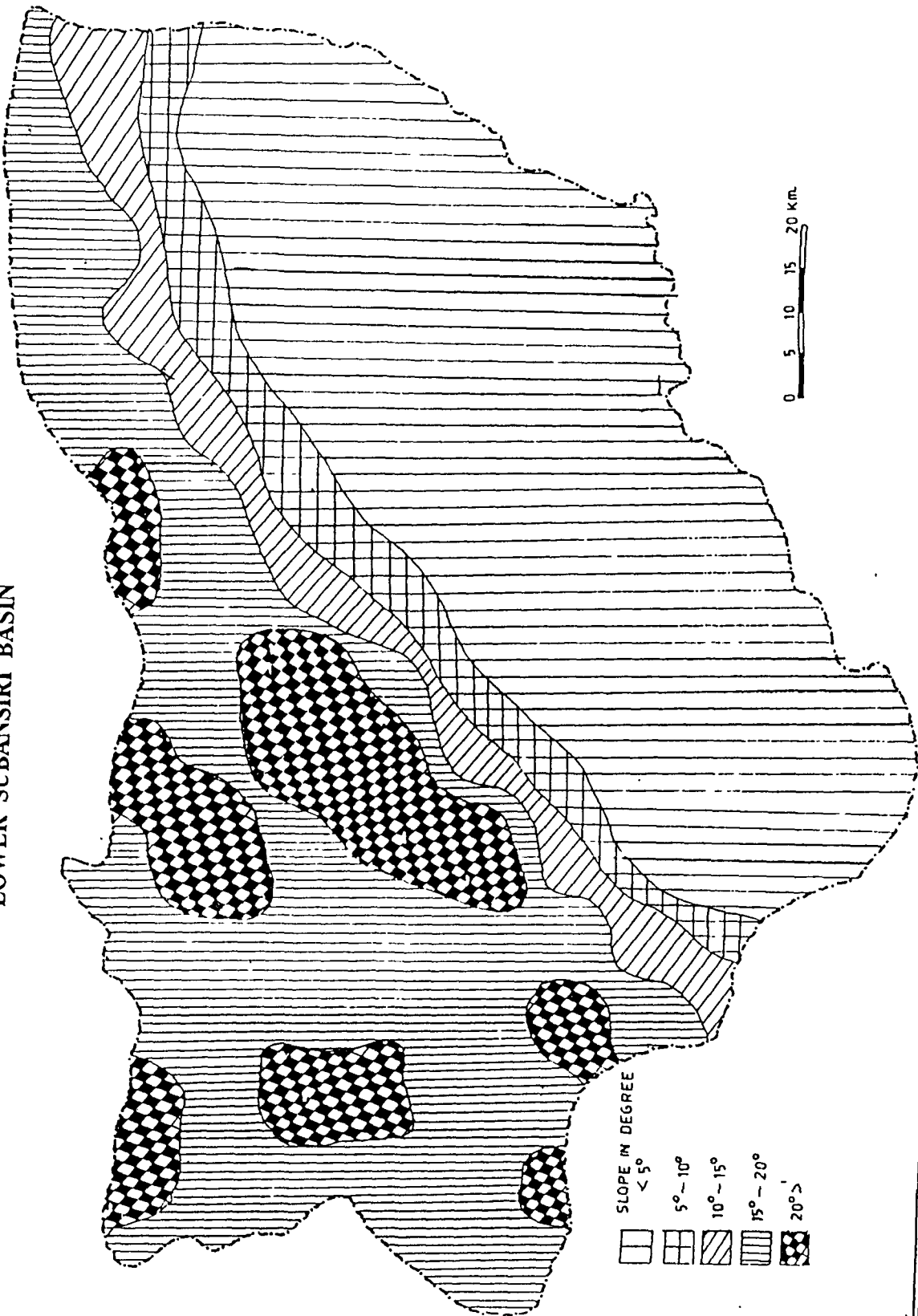
D_a, D_b are distance from a and b of a point and between a and b

Curvatures are obtained on the basis of the Theodolite traverse survey as given in the table (4.5) and representation of profile. The main river traverse line has been sub divided into four parts in large-scale maps to have actual nature of curvature. Some profiles of the important hill region are prepared to represent the nature of curvature and slopes along the north and south trending hills.

Average slope categories

(i) Very gentle slope (0-5°):- Very gentle slopes are predominant in the eastern part of the Subansiri basin and have developed along the main stream of syncline valley in between the hill ridges. Agradation of alluvial deposition from steep hill is mainly responsible for the development of these slopes, both in respect to space and time. This category occupies about 40% of total area of the basin. This area is best suitable for agriculture. (Fig.4.4).

AVERAGE SLOPE
LOWER SUBANSIRI BASIN



SLOPE IN DEGREE
< 5°
5° - 10°
10° - 15°
15° - 20°
> 20°

0 5 10 15 20 km

Fig. 4.4

(ii) Gentle slope (5-10°): Gentle slope has developed on the recent alluvium deposit . about 7% of total area have both very gentle and gentle slopes. This area is best suitable for agricultural purpose, settlement and construction of roads etc.(Fig.4.4)

(iii) Moderate slope (10-15°) : This category forms major part of hills and foothills region. Slope under this category is dominantly in northeast, central and south east part of the area, which forms major watershed in between the important river systems. The slopes are responsible for the development of intermediate stream of higher order. Shifting cultivation is also practised in this region, which occupy about 7% of total area.(Fig.4.4)

(iv) Moderate Steep slope (15-20°): These slopes occupy major part of northeastern basin where trellis pattern topography is visible. This slope category is responsible for the development of forests and occupies about 33% of area. Without any aids of modern techniques, cultivation is very difficult in this area. Heavy rainfall causes intensive soil erosion and materials are carried and accumulated in the valley region of gentle slope.(Fig.4.4).

(v) Steep slope and very steep slope (above 20°): These slope categories are visible in the higher parts of the ridges though occupies insignificant area, but significant from the climato-genetic point of view. These slope categories occupy about 13% of total area. (fig 4.4).

The area of Lower Subansiri basin exhibits endogenetic and exogenetic slopes. The endogenetic slope that have been produced by faulting, folding and compressions forces have been obliterated, altered and modified by exogenetic processes operating since Oligocene period. Most of the slopes of this basin are exogenetic in origin. Where slopes as both endogenetic and exogenetic character are based on complex geological formations. Gully erosion is prominent in the upper area and in the syncline valley of the lower area, where during the rainy season mass wasting and landslides mainly occur in the hills of steep and very steep slopes.

Element of Slope forms

On the basis of field observations, slope profiles, and lineament map of the area mainly four elements of slope forms have been identified

(i) Crest

(ii) Scarp

(iii) Debris slope

(iv) Pediment

(i) Crest slope:- This element is available in the summit areas of the hill tops where convex slope is on the high hill side. There is a critical distance over which least erosion takes place during rains by way of rills.

(ii) Scarp (free face):- It is the bedrock outcrop on the steep slope area, 20° and above. It is more active element in weathering of the slope as a whole. As the distance from the water parting is more, erosive power of water flowing is either in the form of rills or thin sheets which steepens the slope profile. In the steep scarps landslide occurs in the highest parts of hill regions.

(iii) Debris slope (constant slope):- It is formed by detritus moved from the above scarp. Coarse sand materials determine its angle. Weathering has reduced it to particles, which are removed by streams in the form of rills and generally $10^\circ - 15^\circ$ slopes angle forms this category. Due to moderately gentle slope of free face the maximum deposition of debris has been observed in the lower area of this basin. The processes of retreat of the debris slope keep pace with the retreat of the scarp slope.

(iv) Pediment slope:- The pediment slope is a broad convex range extending from the base of the slope element down to the bank of alluvial plain of adjacent streams.

In the slope profile of the area, the next to debris slope is another element known as pediment surface. In the study area the pediment surface is quite important for the land-use and settlement. The surface generally consists of heterogeneous material of particles which have accumulated on the lower part of the hill slope. The particles which have been transported under gravity, running water, are accumulated on the surface.

The River Profile of the Basin area

The Subansiri river originates beyond the Great Himalayan range (Central Himalaya) at an altitude of 3000 m above m.s.l. The Himalaya region comprising the high snow capped peaks locate at about 140 km. to 150 km from the plains. In the higher reaches, the Subansiri is known as Tsari Chu and is fed by numerous snow fed tributaries mainly, from the north.

The river cuts across the central Himalayan ridges where a series of high peaks (5000m and above) are found. It flows in a southeasterly direction along the

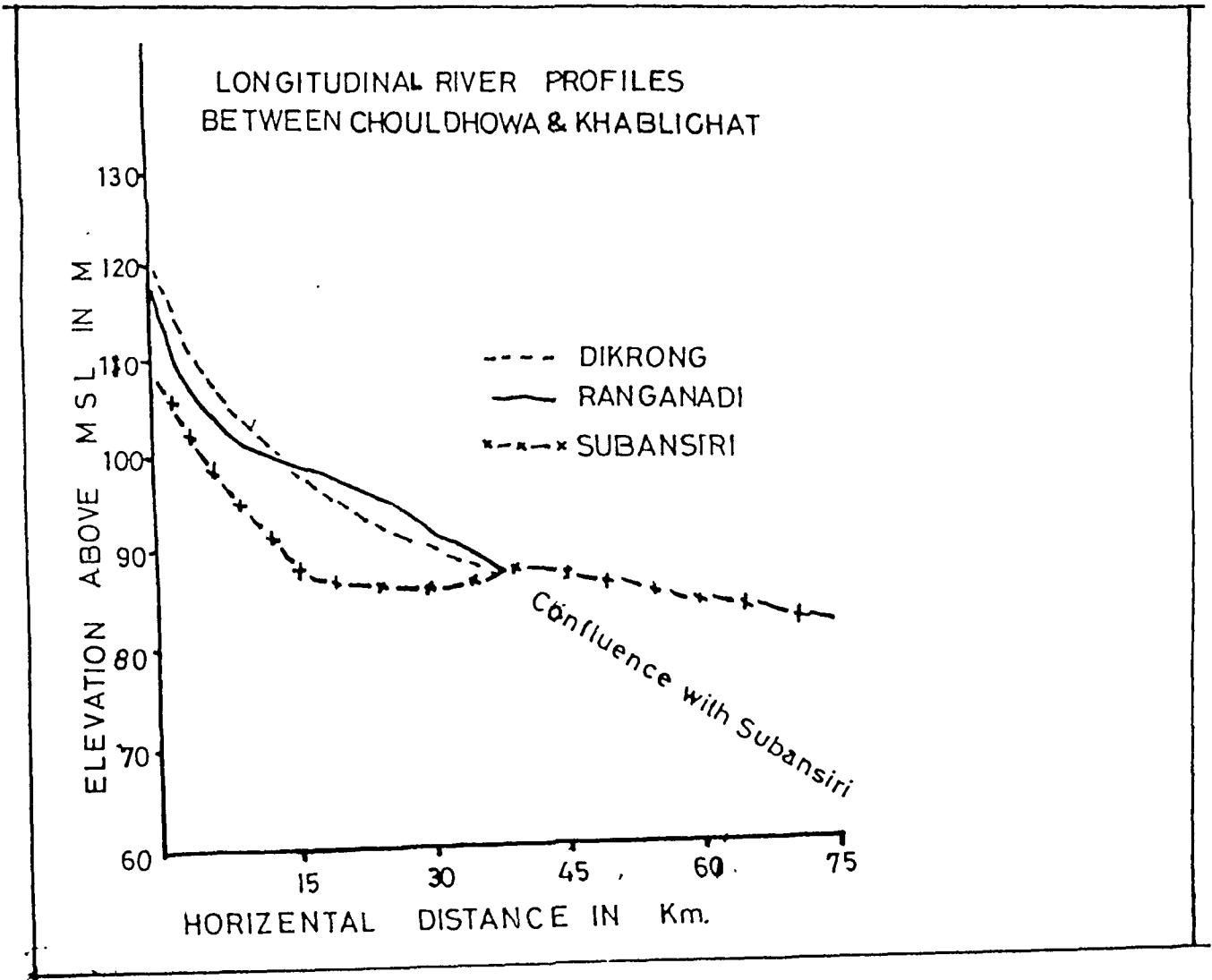


Fig.4.5

lesser Himalayan zone with an average height of 3000 m and designated as the name Subansiri.

After traversing through the Miri hills of the outer Himalayas (Siwalik foot hills) the Subansiri debauches, into the plains of Assam near Dulangmukh. Before entering in to plain the Subansiri river cuts a deep gorge of unique beauty through the Siwlik rocks of Arunachal Himalya. The total length of the river in the mountainous terrain is about 200 km. The river bed falls from a height of 4000 m. to 180 m near Dulangmukh in the foothills of Arunachal Pradesh. Through its journey from the central Himalyas to the Arunachal foothills, the Subansiri receives the discharge of numerous mountain streams.

The longitudinal profile of Subansiri after its emergence from the hills to plain depicts moderate slope. (Fig 4.5) The first slope corresponds to the braided reaches of the river, there after, the river starts flowing in a highly winding fashion followed by a small sector of straight course. Afterwards meandering continues through varying degree affected by the joining of one tributary to another. There is no abrupt drop in gradient close to the confluence with the Brahmaputra.

Three longitudinal profiles have been drawn (Fig 4.5)

Profile I: It is along the eastern part of the basin. The first slope break is approximately at the margin of the piedmont plain. The Bordeoban and Ghilamara block of the high ground are seen in this profile. Beyond this, the profile becomes very smooth.

Profile II: It is along the central part of the basin. The first slope break coincides with the southern limit of piedmont plain, from the range to Subansiri is very gradual. The ground gradually rises from the Subansiri to Brahmaputra river and this corresponds to the level of the latter.

Profile III: It is drawn along the western part of the area and the first break at about 150 m. coincides with the limits of the pedimont plain I, The second break near the Dikrong river coincides with the southern limits of the pedimont plain II.

Drainage Density.

Drainage density is the length of the streams per unit area. It is a multifunctional interplay of underlying lithology, topography, climate and tectonics operating in the study areas. Gray (1960) defined that drainage density is a visual expression of denudation, which is directly related to the amount of vegetation cover . Chorley (1957) said that the drainage density has a significant influence on human

activities and landform evolution of a region. Obviously the study of the drainage density and its functional relationship with causative factor seem to be inevitable in understanding of the existing nature of land configuration and the intensity of processes operating in the area. It is particularly seen in the Himalayan region where both endogenetic and exogenetic forces are operating. An attempt has been made towards measuring the drainage density to understand the relationship with other components of geomorphometry and to assess the degree of influence in the development of landforms in the Lower Subansiri basin

The unit area has been as used a simple device developed by Horton (1945) to measure the drainage density which can be obtained by dividing the total stream length. It can be expressed in mathematical formula as stated below .

$$Dd = I/A$$

Where Dd = Drainage density

I = Total stream length of the unit

A = Unit area

The drainage density has been assessed in terms of statistical measure the entire lower Subansiri basin has been divided in to 5 cm grid of 1 : 250,000 scale toposheets.

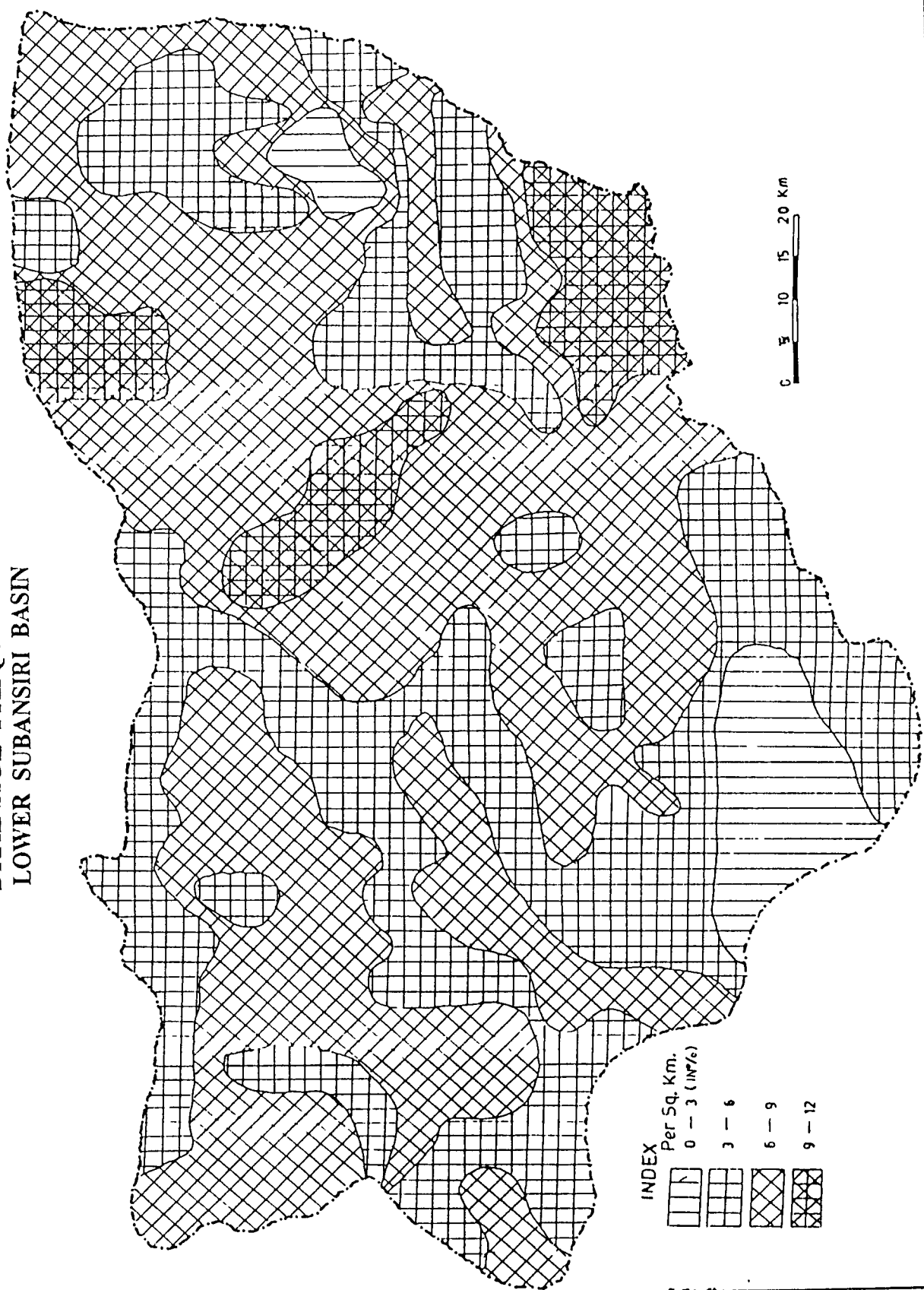
Table No.4.2. Distribution of drainage density

Category	Frequency	Area in sq.km.	% of area
.00 -- .10	X	746.43	7.97
.10 -- .20	X	2199.06	22.78
.20 -- .30	X	5851.00	60.00
.30 -- .40	X	740.65	7.00
.40 -- .50	X	98.98	1.05

From drainage density map Fig 4.7 and table No.4.2 it can be seen that the western part of the basin show high degree of drainage density because of the presence of recent rock formation. While, area in the east shows low drainage density due to the structural control as the alluvial formation has been restricted to branching of rivers along the joints. Besides that vegetal canopy also covers central part of the basin and higher drainage density is in the lower zones of the rare vegetal cover.

The total range of drainage density has been divided according to convenience in five categories with an interval of 0.01.

DRAINAGE FREQUENCY
LOWER SUBANSIRI BASIN



INDEX

Per Sq. Km.	Symbol
0 - 3 (IN/c)	[White box]
3 - 6	[Vertical lines]
6 - 9	[Diagonal lines (top-left to bottom-right)]
9 - 12	[Cross-hatch pattern]

0 5 10 15 20 Km

Fig. 4.6

The table no.(4.2) and Fig 4.5 exhibit that maximum frequency lies in the 3rd category the percentage of 60% in the entire basin. The entire basin falls in lower moderate drainage density and the remaining 1.05% fall in the last category.

Stream Frequency

Stream frequency is an important morphometric analysis of the drainage basin, which indicates the number of streams per unit area. Computation of the stream frequency has been done with the help of following formula

$$F_s = N/A$$

Where, F_s = Stream frequency

N = Total no. of stream

A = Area(unit area per 25 sq km)

Table no.4.3 Distribution of Stream frequency

Sl No.	Texture	Stream Category	Stream frequency	Area in sq.km.	% in area
1	Coarse	0 --- 3	Low	482.37	5
2	Medium	3 --- 6	Moderately low	3441.20	36
3	Fine	6 --- 9	Moderate	4944.40	51
4	Very fine	9 --- 12	High	769.71	8

DRAINAGE DENSITY LOWER SUBSIRSIRI BASIN

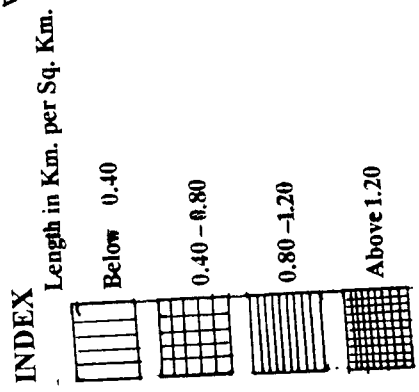
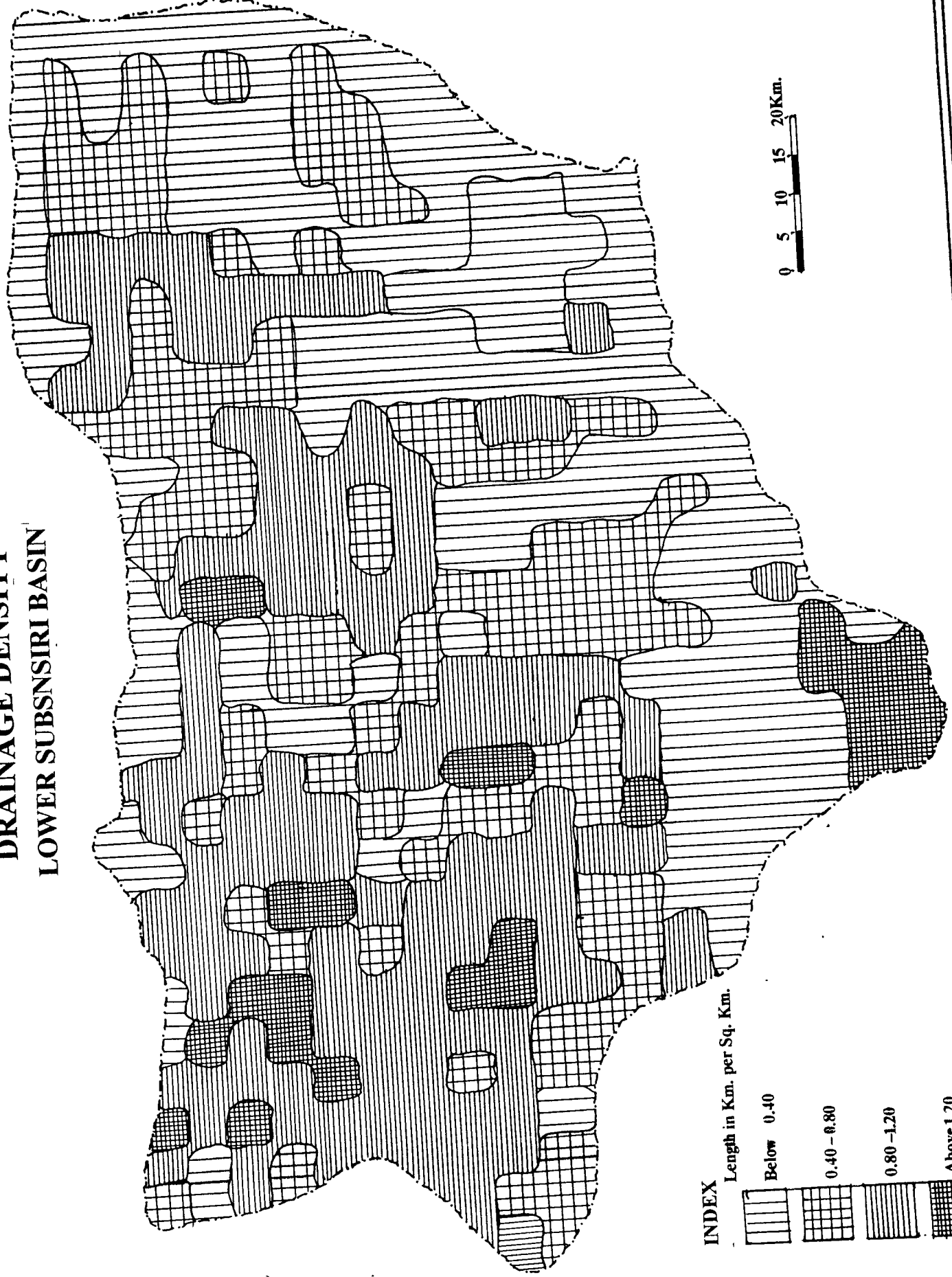


Fig. 4.7

The isolate map is drawn according to the above mentioned categories to study the spatial variation of the stream frequency over the surface at various parts of the region as covered by the category of moderate frequency i.e. (6--9). Stream per 25-sq.km., which is 51% of total geographical area of the basin (Fig.4.6).

Climatic factor and intensity of rainfall, combined with other geomorphic element viz. Vegetation, ground water potential, rocks structure, lithology, altitudes, slope etc. Play an important role in the development of stream frequency. The greater part of lower Subansiri basin is covered with vegetation, like grasses, creepers, cane, bamboo etc. Vegetation increases the amount of moisture in air and soil, which has immense impact on the development.

Channel Migration in the Basin area

One of the notable features in the lower Subansiri basin is the frequent shift of the meandering river course within a short period of time. Channel migration has mostly taken place, which means that a river at particular point abandons its original channel starts flowing in another channel. It is noticed that newly formed channel in course of time develops the pattern of the original one. By this, each meander loop of a

stretch of a river has gradually shifted and with the passage of time, that stretch of the river has deviated much from its original position. (Fig 4.9, 4.10, 4.11).

Alluvision added by the development of successive meander scrolls is quite common with the long history of Dikrong and Ranganadi river and migration has not followed any preferred direction all along the channel length. But in case of Subansiri, it is noticed that right from the foothills up to Khabilighat the river has shifted westward (fig.4.10).^b Between Gogamukh and Chouldhowaghat the shift is about 6 -- 8 km.^w Within the last fifty years.

Dissected flood plain of the Basin area

It stretches southward from the 100m contour up to the north bank of the Brahmaputra. This plain has been subdivided into two geomorphic units. (i) The distinct high ground projecting out from the recent flood plain, which are the remains of some old flood plain and (ii) The recent flood plains which are in building process by lateral and vertical accretion of the existing river.

The following surface is identified in the dissected flood plain of the lower basin.

(i) North Lakhimpur Surface:- One of the striking features of Subansiri basin is that beyond the southern limits of the pediment plain i.e. approximately south of the 100 m. contour, the fall of gradient especially in the eastern part of the basin is very low. The terrain exhibits a very flat topography forming the flood plain of the present stream system. Within the floodplain stands a few isolated patches of high ground which are above the flood level of the existing river. North Lakhimpur town is situated on such high ground and surface has been designated as North Lakhimpur Surface. The Bordeoban tea garden area and the Ghilamara area are also situated on such high grounds.

The deposition of this older sediments cannot be explained with reference to any of the present course of the river. The North Lakhimpur high ground may be levee deposits of the old Ranganadi which is now flowing about 5 km. to west. The Bordeoban area may be the levee deposit of the abandoned Subansiri River

(ii) The Recent flood plain:- The recent flood plain is in the process of building up by the deposition of the present stream system. This deposition can be broadly classified

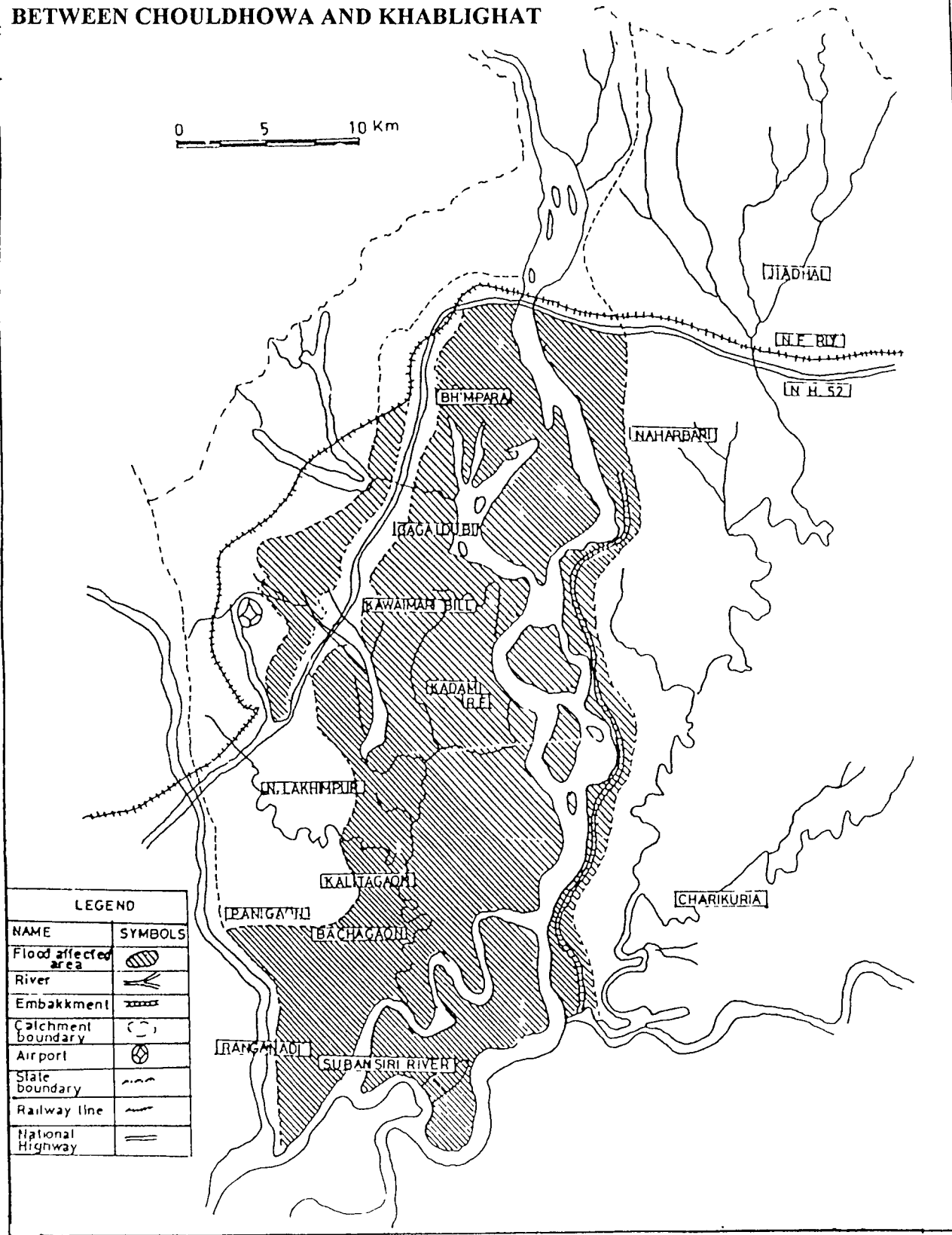
into two main groups. The first group is formed by the lateral accretion due to the migration of the river channel resulting in the formation of the channel bar, point bar, etc. The second group has been formed by the vertical accretion of the suspended sediment after over bank flow and includes the natural levee, back swamp etc. The flood plains of the Subansiri basin are formed by the river system of Subansiri, the Ranganadi Dikrong River and other tributaries.

Morphological element of recent flood plain

(i) Point bar:- Point bar is an important geomorphic unit of the Subansiri which has a very sinuous course through its journey into the plain of Lakhikpur district and around the plain. Such point bar deposits are varying in size and. Point bar deposits are formed on inside the convex of the river bed by lateral accretion. Point bar deposits as meander moves down stream and an accretion topography results with successive meander scroll. The accretion topography of the point bar is characterised by a gently rolling alternative series of narrow swell and somewhat wide ridge.

(ii) Channel bar:- Channel bar deposits are characteristics of a braided river. Subansiri being a meandering river, channel bar deposit is not common, but is seen about 5-km. South of Dulangmukh. Development of a braided pattern of this river may

**SUBMERGENCE OF LAND DUE TO 5 YEAR FLOOD
BETWEEN CHOULDHOWA AND KHABLIHAT**



Source: Brahmaputra Board, Govt. of India.

Fig. 4.8

be due to reduced velocity, caused by the abrupt fall of the gradient of the river bed. Since the river cannot transport the sediment load, especially the coarse fraction furthers downstream. The deposition takes place which leads to the formation of mid Channel bar.

(iii) Natural levee:- Natural levee is formed by the deposition of the sediment as flood water overtops the channel banks. During the overtopping, velocity is reduced and coarse suspended sediments are deposited near the channel bank, while finer material moves down the levee from considerable distance away from the bank and merge with the flood plain deposit. Thus the deposits are thickest and coarse at the creast along the riverbank and rapidly become thinner and finer away from it

(iv) Back swamp:-Back swamp are low lying areas of the flood plain beyond the natural leveee. A typical back swamp is generally narrow and elongated in shape and a network of drainage inherited from the older drainage system characterizes it. The features of back swamp area are eventually buried by gradual alluvial during periodic flood, yet original drainage lines remain open and act as both tributary and distributary streams during the flood.

Due to the low-lying nature of Subansiri basin and the rapid migration (Fig.4.10 & 11) the stream channel is short span of time, the back swamp are many and quite extensively developed in the basin. Some of the submerged areas during the flood seasons dried up soon after the flood season is over, while some flood basins have perennial water whose level fluctuates seasonally. Relief and some old drainage system are commonly seen in flood basin of lateral types. In the Subansiri basin there is some flood basins that receive floodwater from the two or more streams and form a common back swamp. It is to be noted that the network of embankments along the banks of the Subansiri, Ranganadi and Dikrong and some of the artificial channels are constructed recently to protect the area from flood.

(v) Channel Fills:-In the Subansiri basin abandoned channel fills are common and these are mainly formed by stream avulsion. The abandoned channels in the course are filled up fully by sediment. Though filled up to various extent and culturally modified, the abandoned channels are recognizable on aerial photographs by their characteristic shape and landforms. The sediment consisting mainly sand, the bed load materials of Endotgoan have been abandoned and consequently filled up by sand, silt and silty clay and is now under cultivation. Similarly, is the case for the old course of the Ranganadi from Potabil migration to south of Juriguri. Most parts of the Mara-Dikrong have been

completely filled up by similar sediment and have been culturally modified except the deeper stretches, which still remain as swamps.

Evolution of Land forms including Channel Migration.

A detailed study of the toposheets and aerial photo-mosaics reveals that, the part of Subansiri basin in the plain forms a vast tracts of low-lying area liable to be flooded annually. If we imagine the Subansiri basin without the network of embankment, particularly the entire area, except a few patches of high ground will be submerged during floods. In the Subansiri and its tributaries, it appears as a vast sheet of water. It may be added that some of the embankment are 6 - 7 m. high above the ground level .

Due to active sedimentation of Subansiri and its tributaries and the Brahmaputra, the low-lying area is distinctly anomalous. This anomaly can be only explained by assuming sinking of the whole or part of the basin. It is also clear that the basin floor is not stationary; in that case, the active sedimentation of the river would have soon brought the level of the adjacent plain above the flood level mark. The valley floor is apparently subsiding due to tectonic movement and depression is more

CHANNEL LOCATION BEFORE 1950 EARTHQUAKE OF SUBANSIRI
 RIVER BETWEEN CHOULDIHOWAGHAT AND KHABLIGHAT

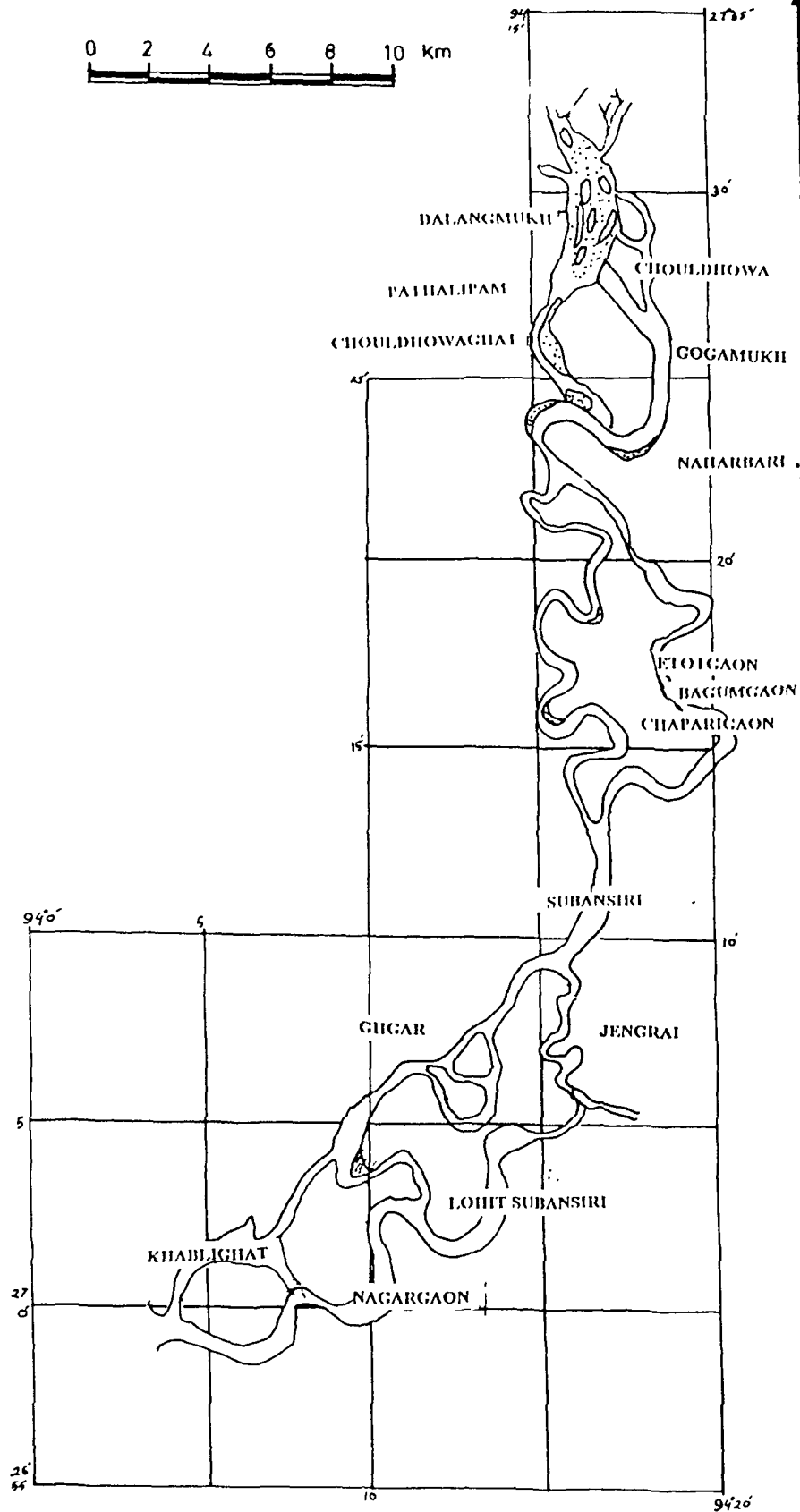


Fig. 4.9

CHANNEL LOCATION AFTER 1950 EARTHQUAKE OF SUBANSIRI

RIVER BETWEEN CHOULDIHOWAGHAT AND KHABLIGHAT

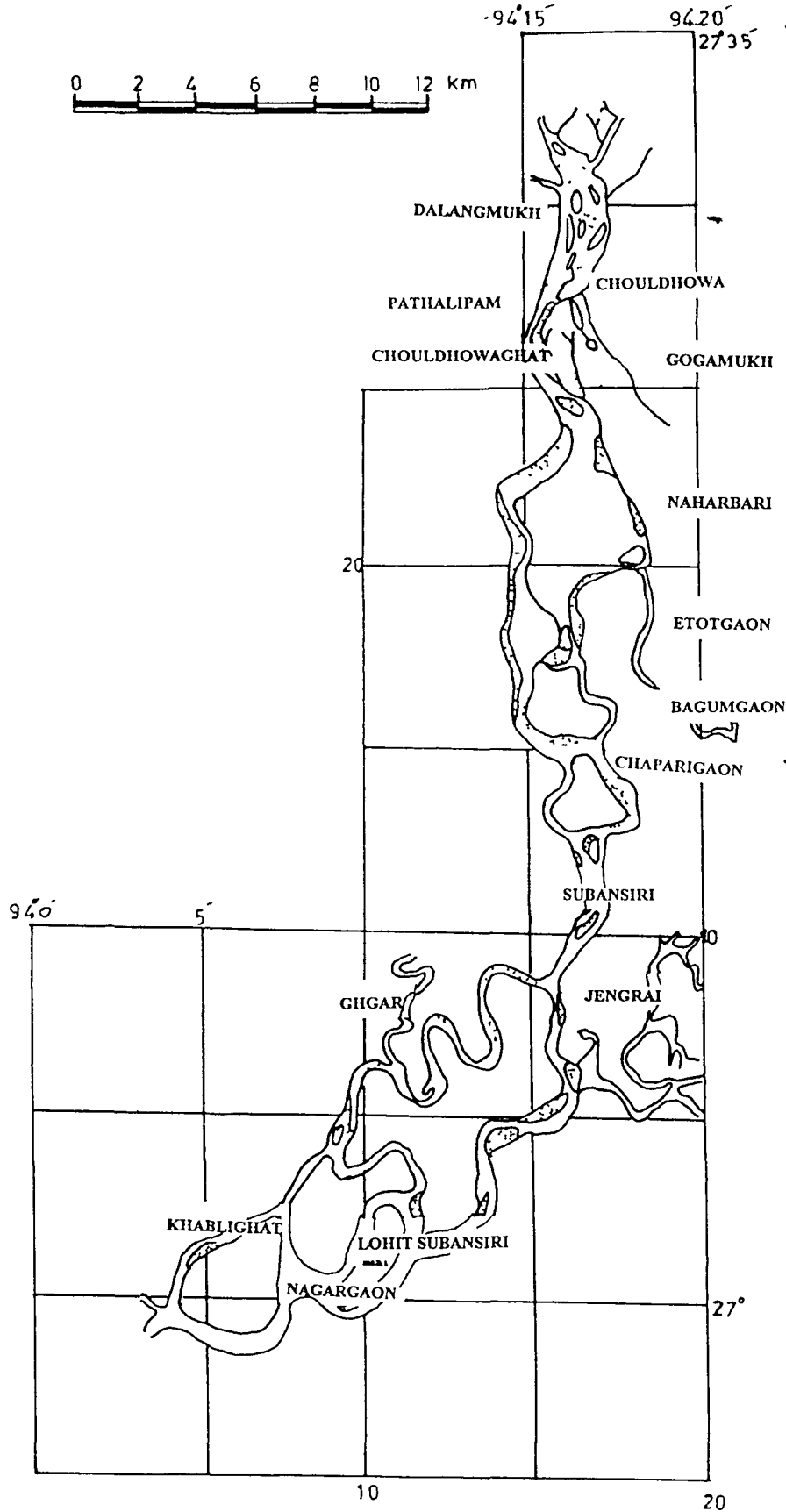


Fig. 4.10

CHANNEL MIGRATION OF LOWER SUBANSIRI BETWEEN, CHOULDHOWAGHAT AND KHABLIGHAT

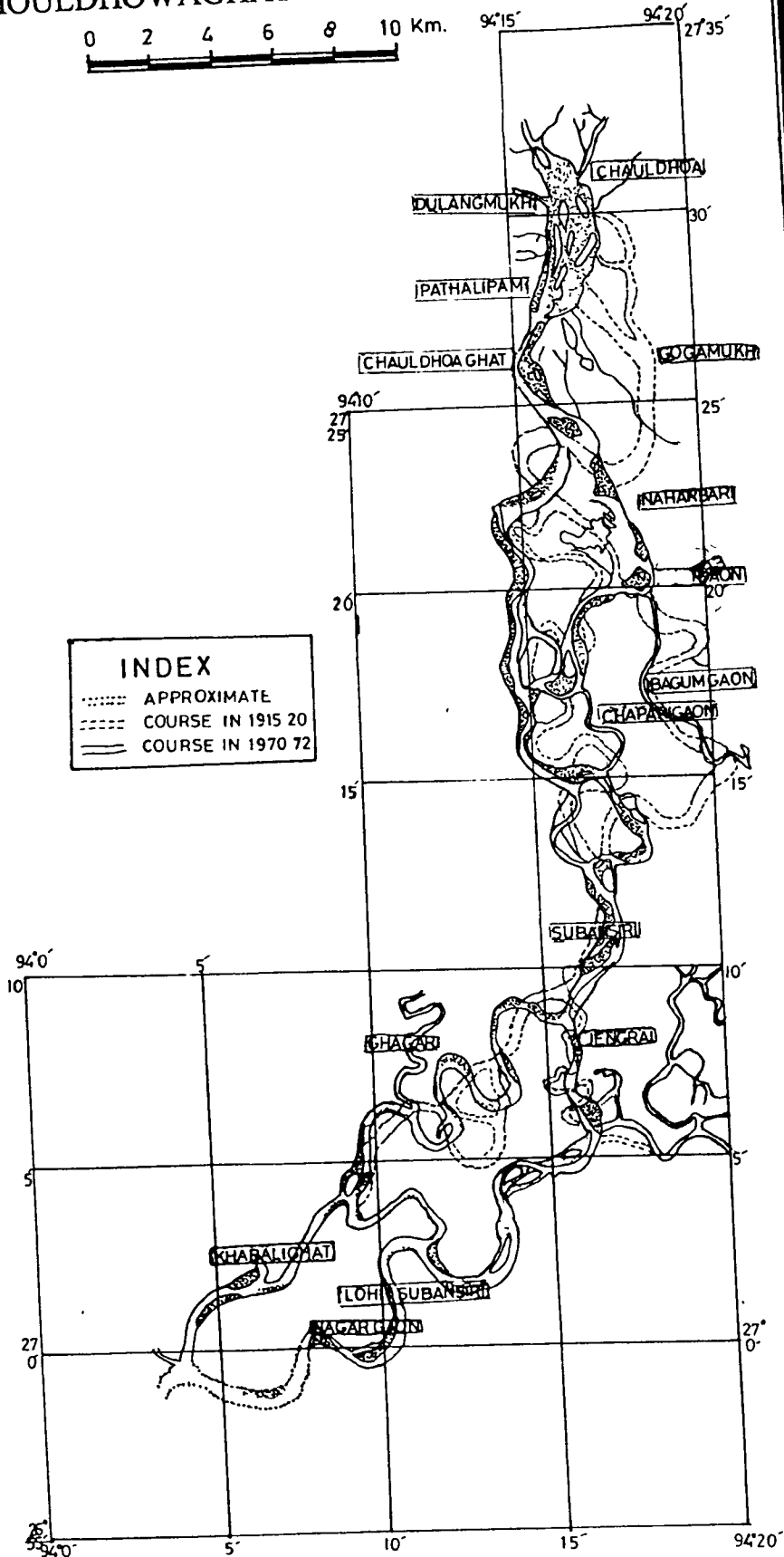
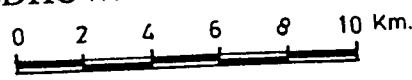
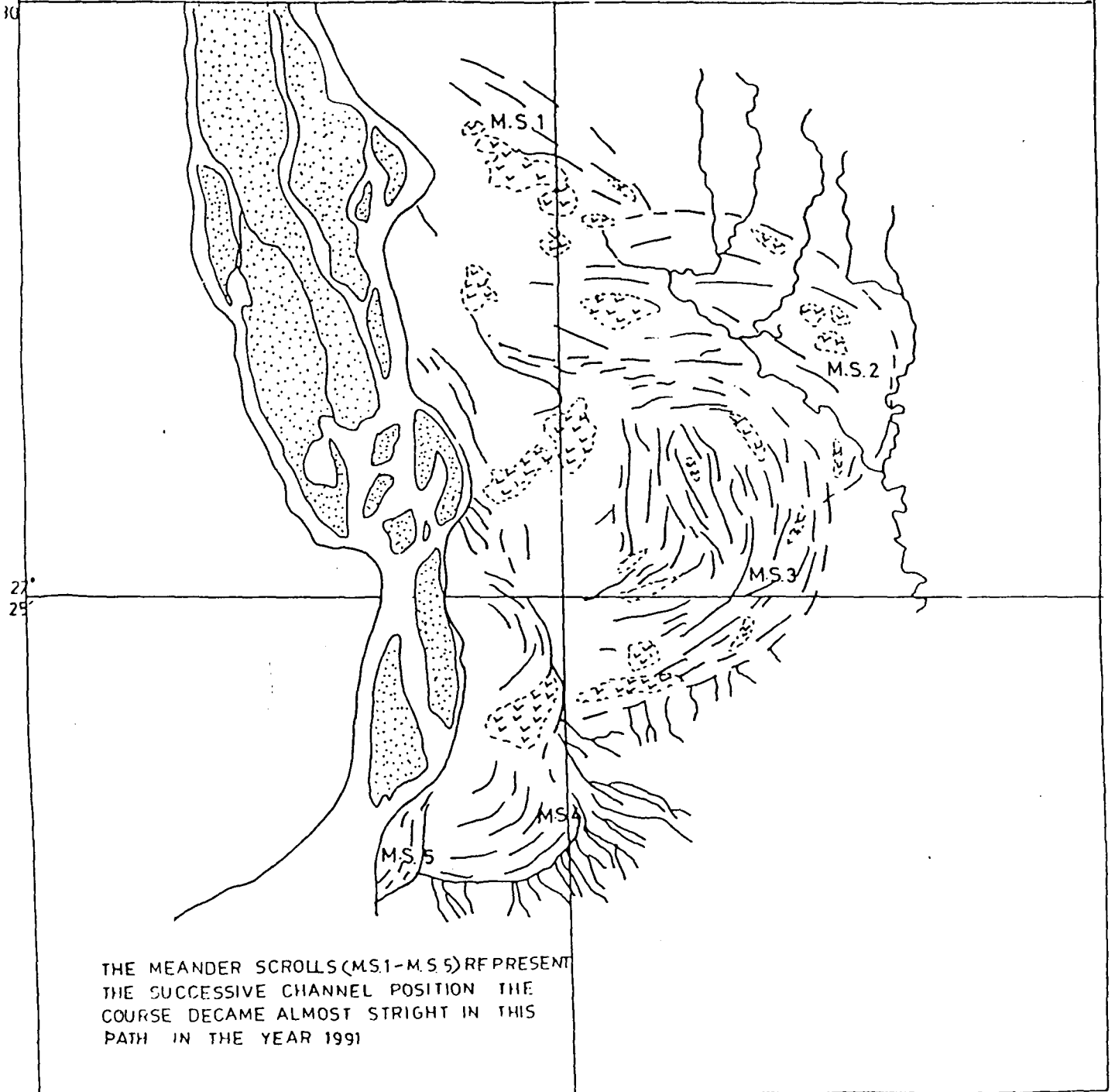


Fig. 4.11

**MAP SHOWING CHANGES IN THE CHANNEL PATTERN OF THE
SUBANSIRI RIVER**

0 2 4 6 km.



THE MEANDER SCROLLS (MS.1-M.S.5) REPRESENT
THE SUCCESSIVE CHANNEL POSITION THE
COURSE DECAME ALMOST STRIGHT IN THIS
PATH IN THE YEAR 1991

15' Based on Aerial Photos,

94°20'

Fig. 4.12

rapid than in any other basin. This may be due to its position, in between the Himalayan and Patkai Arakan movement.

There is some direct evidence in support of the assumption that the valley floor is sinking. Pasco (ibid. P.1997) mentioned that at Pathalipam, in the Subansiri basin, some years ago a floor washed away a considerable area under tea plantation, exposing 3 m to 4.5 m. below the former level. The remains of an old forest with stumps of tree projecting from a bed of blue clay. The stumps have been identified as belonging to the local bhi, a tree of the woolly family.

The author in course of the present study has observed evidence of subsidence in some part of the basin in recent years. That the southwestern part of the Bhimpara bil complex and the adjoining area have undergone subsidence is evident from the presence of the dry tree standing erect, half buried in the bill water. The greater earthquake of 1950s caused the subsidence of the area. The earthquake of 1950s also caused about 8-km. Northeast of North Lakhimpur town subsidence a part of the area between Gohaingoan, Kadamgaon and Tenggaon. At present the area remains water logged for most part of the year and the remains of the wooden bridge over the old approach road to the Kadam tea garden from the North Trank road is seen in this low-

lying area. There is report of subsidence locally in the order of few feet at many places in the basin caused by the devastating earthquake of 1950.

The Subsidence of the basin might have taken place along with some basement faults rejuvenated from time to time by tectonic activities. Due to deep-seated nature, the surface expression of these faults is lacking. However, a major fault trending parallels to the mountain front is suggested on the basis of the following observation (i) the continuous high escarpment of the mountains front facing the alluvial plain (ii) the triangular facets, rills, and "V" shaped valley hanging in the escarpment.

Another striking feature in the Subansiri basin is the rapid migration of the stream channel through a very short period of time. The most surprising geomorphic feature is flat tracts, which may be classified as, flood basin or back swamps still carry relicts of the original stream pattern. On the one hand, the transient nature of the stream channel of the Subansiri and on the other hand it shows that in almost no time how previous channel elements subside a little to become back-swamp, subsidence transforms particularly every former channel in to a flood basin. But in almost all place where subsidence is not so active a stream channel becomes isolated in to an

ox-bow lake. The net result in the Subansiri basin over a significant time will probably be reflected in transitions of stream channel elements in to flood basin.

The change in the course of the Subansiri, Ranganadi and Dikrong rivers along with general low-lying nature of the entire basin and the depth of the Subansiri gorge are most probably the result of positive and negative epeirogenic movements during the quaternary period. The earthquake shock so often felt in this region is indicative of its instability and rejuvenation in the Upper Tertiary and Quaternary and the Subansiri basin is still in the process of setting the migration of the river course

It is generally agreed that, change of level is taking place in the Himalayas and it is still rising. Frequency and violence of earthquakes in the Himalayas belt and in the region lying at the foothills point to the same inference. This indicates that the Himalayas is yet in a state of tension and relief is therefore sought by the subsidence of some tracts and the elevation of other.

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CHAPTER - V

FLUVIAL ANALYSIS

The studies of fluvial activity in the basin area help a great deal in understanding the geomorphic features. Moreover, lithology also plays an important role in the development of the present landscape. Hence the study of drainage and fluvial activity will contribute a lot in the understanding of the configuration, and evolution of landforms.

The intensity of fluvial erosion in this basin depends much on the nature of soils and rocks. The monsoonal type of climate influences this region with rainfall occurring for about six months. During this period the fluvial action is highly active. With the upper reaches of the basin area belonging to the Arunachal Himalaya (Lesser Himalaya) it is found to have steep slopes varying from 15° - 20° . (Fig.4.4) The fluvial activity in this region is very high. It is observed that channels have been developed along area with weak rocks and soil which is common in youngest mountain. The processes of the weathering, mass-wasting and sheet wash are significant in this area and at times change the course of the river. The study of fluvial activity in this area reveals the involvement of the mechanism of morpho-dynamic type. The various interesting morphological characteristics are sand bar, braided nature of streams, slumping, solifluction and bank deposits along the bank of the rivers. The present chapter deals with the interpretation of

fluvial processes associated with morphological features and suspended sediment, load transportation, erosion and deposition, and flood hydrology, flood damage and its probable remedies for flood control.

Source of the Surface Water of the Basin Area

The surface water in the basin is contributed mostly by atmospheric precipitation, melting of Himalayan snow and to limited extent by ground water discharge in the form of effluent seepage and springs. By far the most abundant source of surface water is the rainfall. The average annual rainfall in this area is approximately 400 cm. The major portion flows to the Brahmaputra as surface run-off.

There are eighteen rain gauge stations within the basin area. The rain gauge stations selected for the study are well distributed within the lower hills catchment of Arunachal Pradesh and the plain of Assam. The existing and proposed rain gauge stations in and around the area are given in the table.

Rainfall intensity at some representative raingauge Station (in cm)

Station	1'day	1+1 day	1+1+1 day
Bahadurchauk	11.0	27.20	35.00
Khablighat	16.20	23.50	37.00
Lohit .I B.	30.80	43.60	36.10
Gerukamukh	22.80	39.50	46.90
Ananda T.E.	26.00	53.00	64.50
Daporijo	11.50	19.00	20.90
Tamen	13.50	16.00	22.40
Genst	25.00	49.50	69.50
Rega	11.30	14.80	26.40
Muri	9.00	16.40	28.80
Lilabari	25.00	37.50	41.60
N.L. Civil Hospital	18.40	34.00	39.90
Lilabari airport	23.30	30.10	42.10
Darring	20.60	38.70	39.90
Damin	11.00	14.40	42.10
Daporijo	11.60	30.00	22.00
Nyapin	9.40	15.10	21.50
Ziro	25.00	29.90	16.50

Data source: Borjar Airport meteorological station office Guwahati.

It is observed from the above data that Ananda T.E and Gensi stations recorded the highest rainfall intensity in basin.

Hydrological Analysis

Gauge Observation

The river gauge records of Subansiri have been collected from the site namely Chouldhowaghat, Dikronghat and Ranganadighat. The availability of gauge data is as given in table: (5.2) (Fig.5.2-5.18)

Table - 5.2 Gauge and Flow discharge at the cross-section of Chouldhowaghat

Month	1991		1992	
	Gaige(m)	Discharge(Cm ³)	Gauge(m)	Discharge(cm ³)
January	94.61	386.28	94.51	471.22
February	94.63	437.24	94.42	488.18
March	95.08	283.33	95.11	1189.87
April	96.02	669.40	95.65	1795.52
May	97.42	1335.14	96.26	1795.38
June	98.11	4816.17	97.47	3297.38
July	98.07	6218.83	98.06	4171.26
August	97.90	4051.49	97.94	1391.41
September	98.90	1946.57	97.04	2422.64
October	96.83	511.53	96.85	1777.48
November	95.31	337.40	95.46	1062.76
December	94.79	354.00	94.81	662.80
Month	1993		1994	
	Gauge(m)	Discharge(cm ³)	Gauge(m)	Discharge(cm ³)
January	94.90	565.96	94.60	604.46
February	94.82	597.84	95.15	619.52
March	95.28	742.28	95.20	746.13
April	95.80	1023.19	96.20	1030.36
May	96.96	2155.56	96.97	2204.79
June	97.87	4416.63	98.09	4429.66
July	97.84	4902.16	94.43	6672.66
August	98.71	6907.87	98.95	7592.80
September	97.52	5392.18	97.78	5792.09
October	97.47	97.25	94.34	4401.90
November	95.93	801.99	96.21	812.55
December	95.32	596.14	95.25	568.69

Table 5.3 Gauge and Flow discharge at the cross-section of Dikrongmukh

Month	1991		1992	
	Gaige(m)	Discharge Cm ²	Gauge(m)	Discharge(cm ³)
January	75.39	91.28	74.26	95.89
February	76.28	96.88	74.25	102.49
March	78.21	102.48	74.48	104.28
April	78.50	130.29	74.49	171.33
May	79.11	168.11	79.11	194.24
June	82.13	191.25	83.14	210.10
July	84.16	103.42	84.33	240.33
August	86.29	180.21	81.26	243.21
September	81.49	163.29	79.84	184.23
October	76.25	121.43	75.33	163.30
November	74.33	113.39	74.49	151.00
December	74.26	96.28	74.20	96.29

Month	1993		1994		1995	
January	95.45	613.25	74.56	103.24	71.26	101.76
February	95.16	632.79	74.28	91.29	72.53	156.23
March	95.08	616.04	74.47	118.79	72.96	176.76
April	95.12	718.70	75.69	151.63	74.33	181.87
May	96.89	869.19	76.91	194.28	78.14	349.28
June	98.15	2404.66	78.33	247.71	81.22	634.28
July	94.12	6220.85	78.49	403.29	84.22	792.71
August	98.98	6854.50	79.28	486.28	83.76	439.63
September	98.04	7474.09	81.46	324.26	78.63	413.19
October	96.85	4800.38	79.21	316.69	74.21	210.29
November	95.88	3906.36	74.33	281.46	69.46	256.00
December	95.85	940.15	74.24	123.45	65.28	69.85

Table 5.4 Gauge and Flow discharge at the cross-section of Ranganadi mukh

Month	1991		1992	
	Gaige(m)	Discharge Cm ²	Gauge	Discharge
January	78.44	104.28	798.21	110.49
February	79.11	113.96	79.49	123.14
March	80.11	140.28	80.24	146.31
April	81.43	169.28	81.44	175.43
May	84.33	436.23	83.25	1243.09
June	85.14	824.33	85.26	743.12
July	85.92	723.53	85.71	843.29
August	81.22	821.03	84.28	814.35
September	78.44	463.11	81.44	396.27
October	79.41	234.11	80.21	217.91
November	78.56	213.46	79.68	159.26
December	78.92	106.14	79.21	140.26

Month	1993		1994		1995	
	Gaige(m)	Discharge Cm ²	Gauge	Discharge	Gauge	Discharge
January	78.94	129.63	79.16	140.28	81.09	156.28
February	79.13	163.29	71.00	163.29	81.63	193.69
March	79.63	174.20	72.09	210.79	81.79	229.49
April	81.20	296.29	76.76	263.54	81.92	346.33
May	84.28	892.28	83.23	241.26	82.16	429.43
June	85.11	476.28	84.28	596.09	84.96	732.86
July	82.31	443.28	84.91	524.16	85.44	792.48
August	82.16	296.15	83.29	432.19	83.29	534.28
September	81.26	243.20	82.16	192.40	81.46	291.46
October	79.41	213.11	81.48	163.21	79.67	159.33
November	79.41	196.32	81.13	142.01	78.28	114.61
December	73.26	124.36	79.28	113.16	78.63	105.56

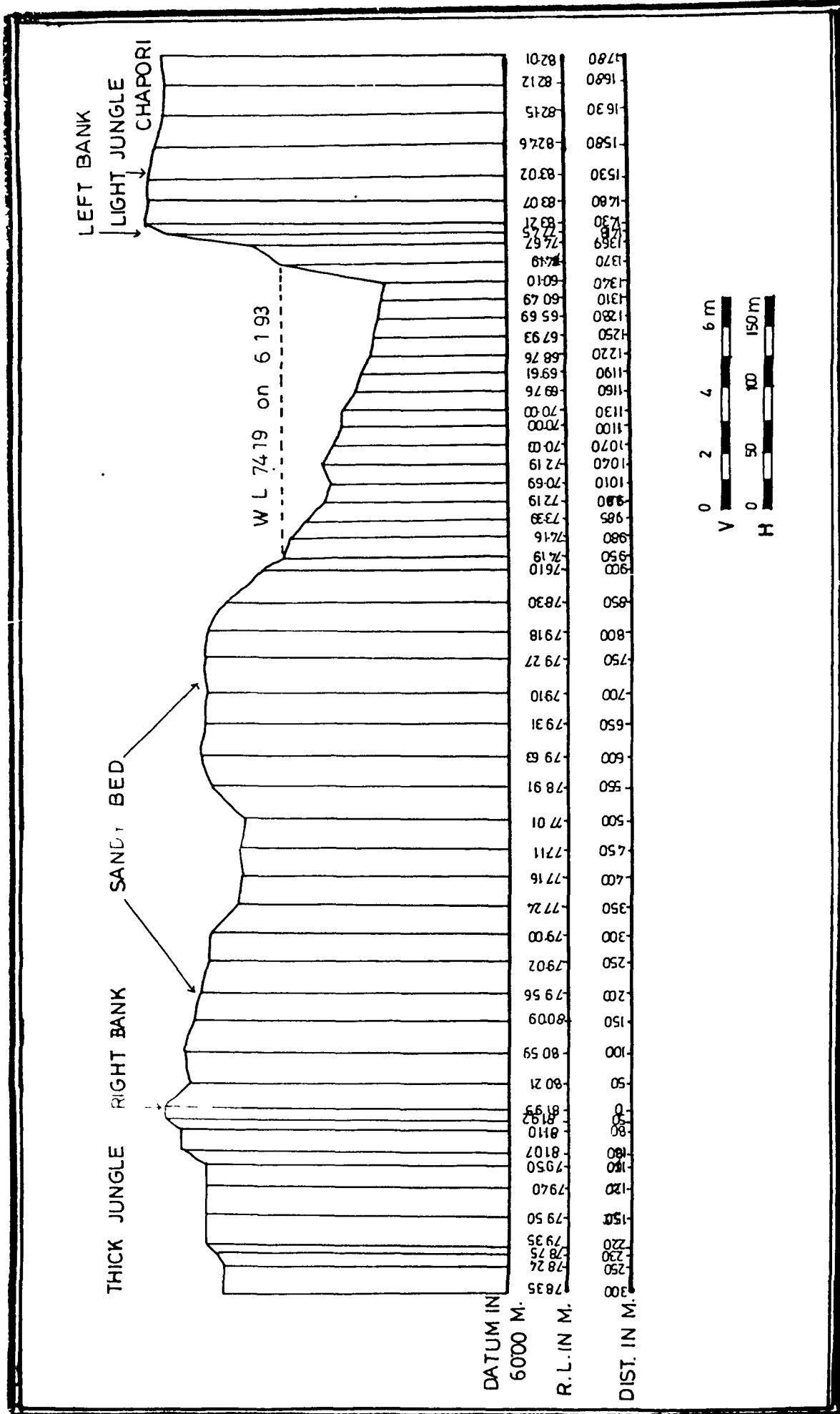
Chouldhowaghat cross-section gauge and discharge data from 1977 to 1995, show that the maximum and minimum water level at Chouldhouwaghat is 100.79m and 94.14m. the danger level at Chouldhowaghat is 90.40m (Fig.5.35).

Similarly the cross sections of Ranganadimukh and Dikrongmukh gauge are given in the following tables (5.4) and fig.(5.6) From this table if we compare five-year discharge gauge of this basin then we have found that the water level is fluctuating. During the summer season water level is high as compared to that of the winter season, because of heavy rainfall.

Measurement of Stream Discharge

Discharge is the most important parameter of channel flow and its measurement usually involves consideration of both stage and velocity. Units used are those of volume time and values are generally reported in cubic metres per second(cm^3)

The most commonly encountered method of discharge measurement is the velocity area technique. The velocity area technique is the most widely used method for measurement of discharge. Discharge by definition is the product of velocity and cross sectional area of flow, and this procedure evaluates the discharge in a stream at a



CROSS SECTION OF RIVER SUBANSIRI AT CHOULHOWAGHAT. Source: Brahmaputra Board, Govt. of India.

Fig. 5-1

**GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
CHOULDHOWAGHAT, L. S. BASIN
1991**

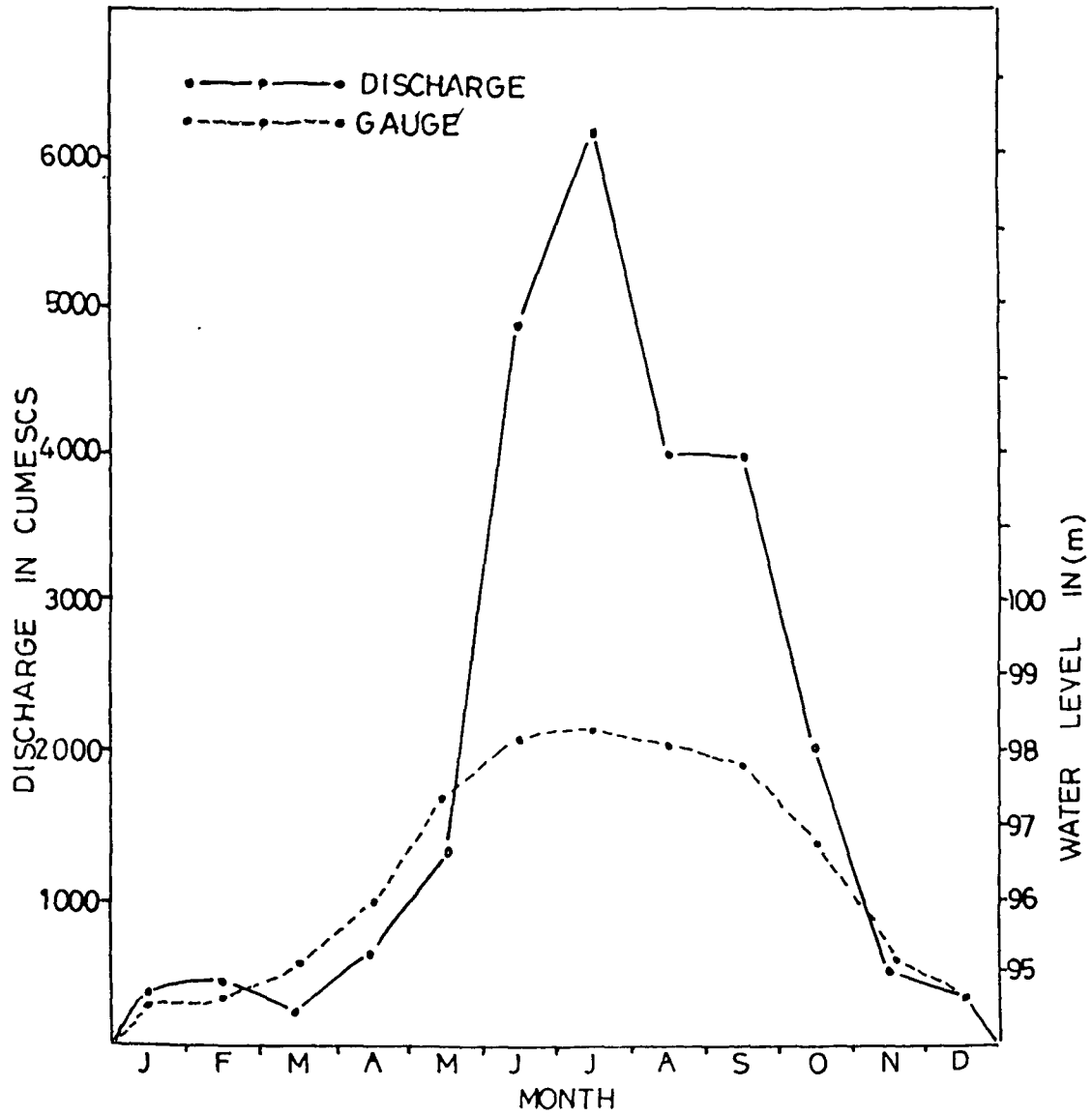


Fig.5.2

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
 CHOULDHOWAGHAT L. S. BASIN
 1992

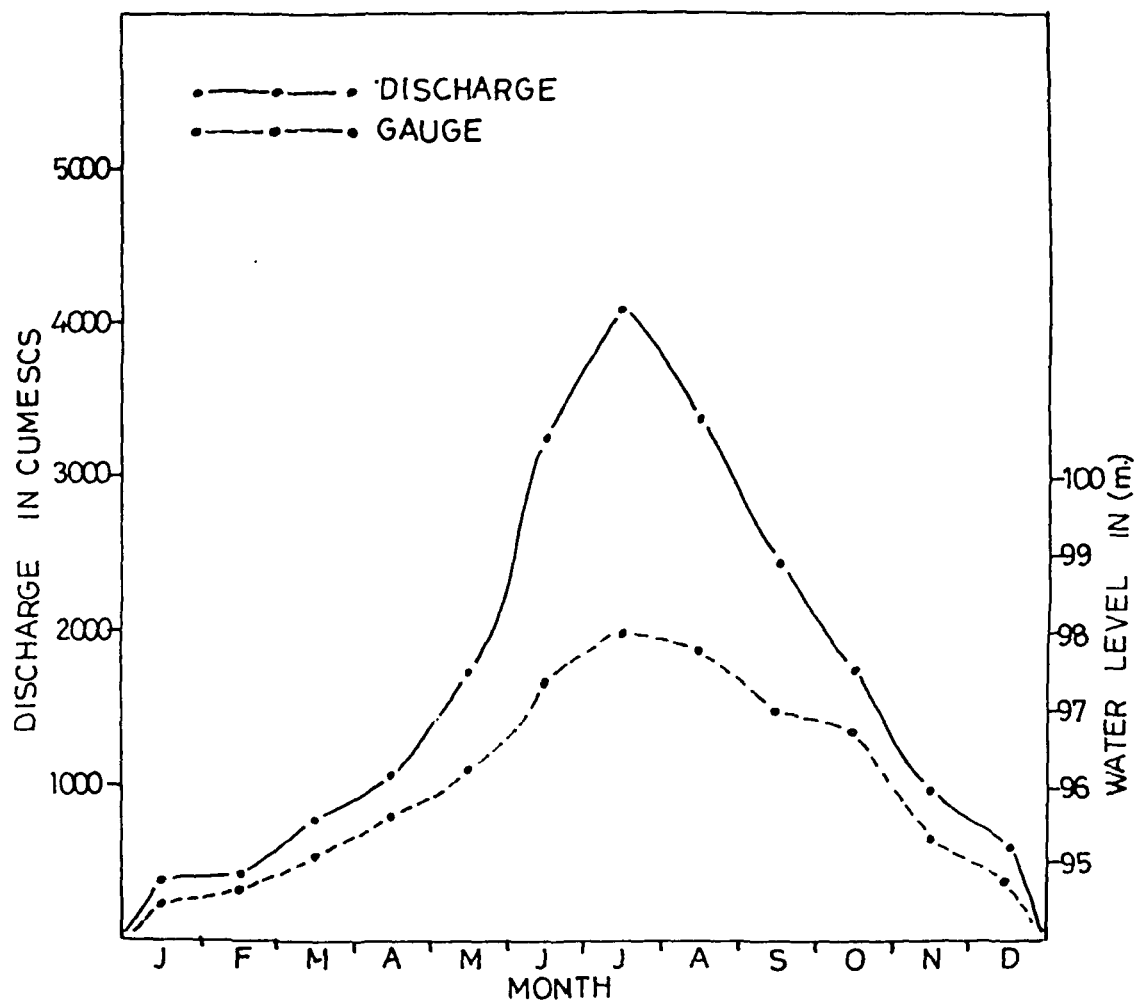


Fig.5.3

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
 CHOULDHOWAGHAT L. S. BASIN
 1993

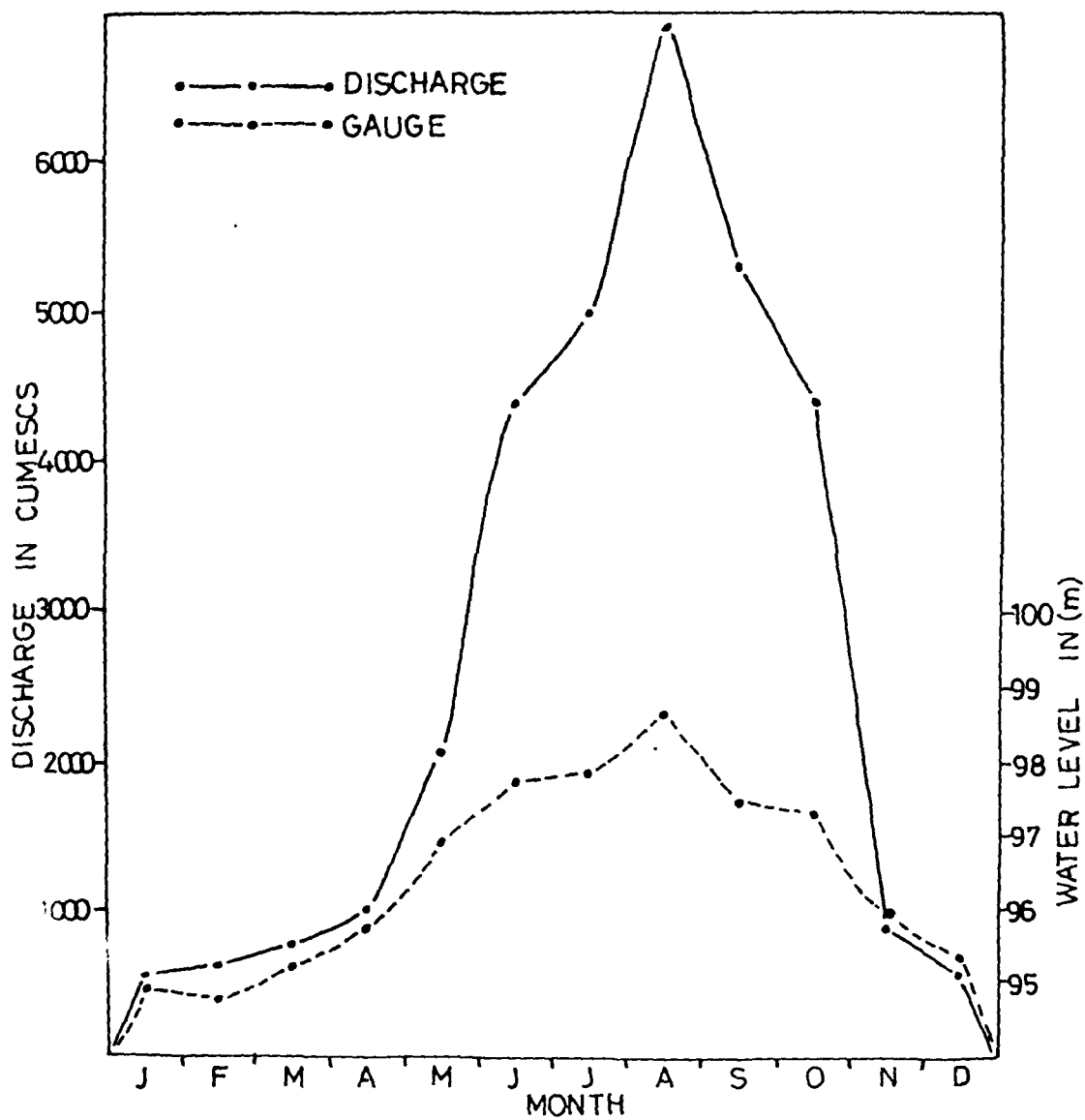


Fig.5.4

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
 CHOULDHOWAGHAT L. S. BASIN
 1994

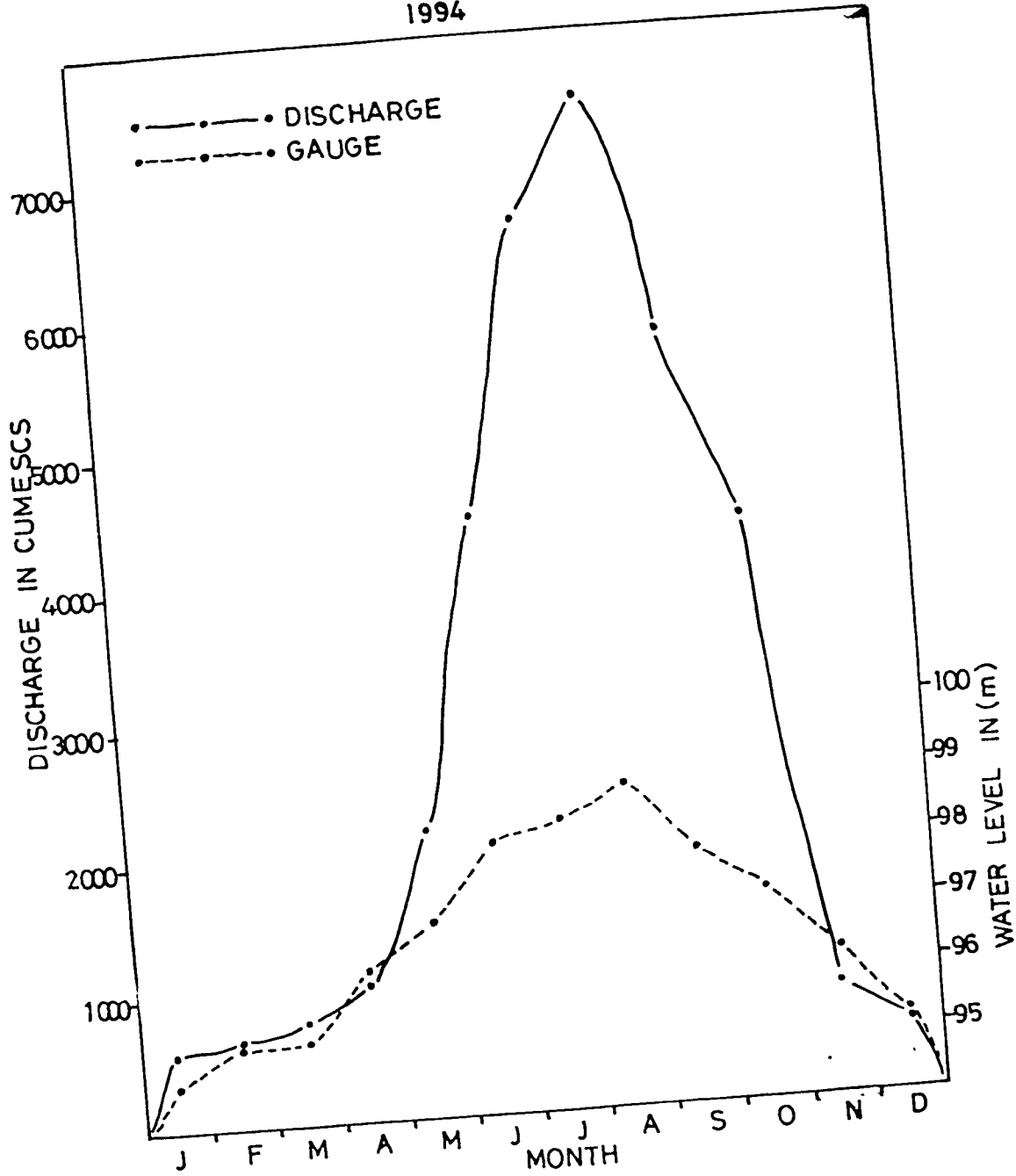


Fig.5.5

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
 CHOULDHOWAGHAT L. S. BASIN
 1995

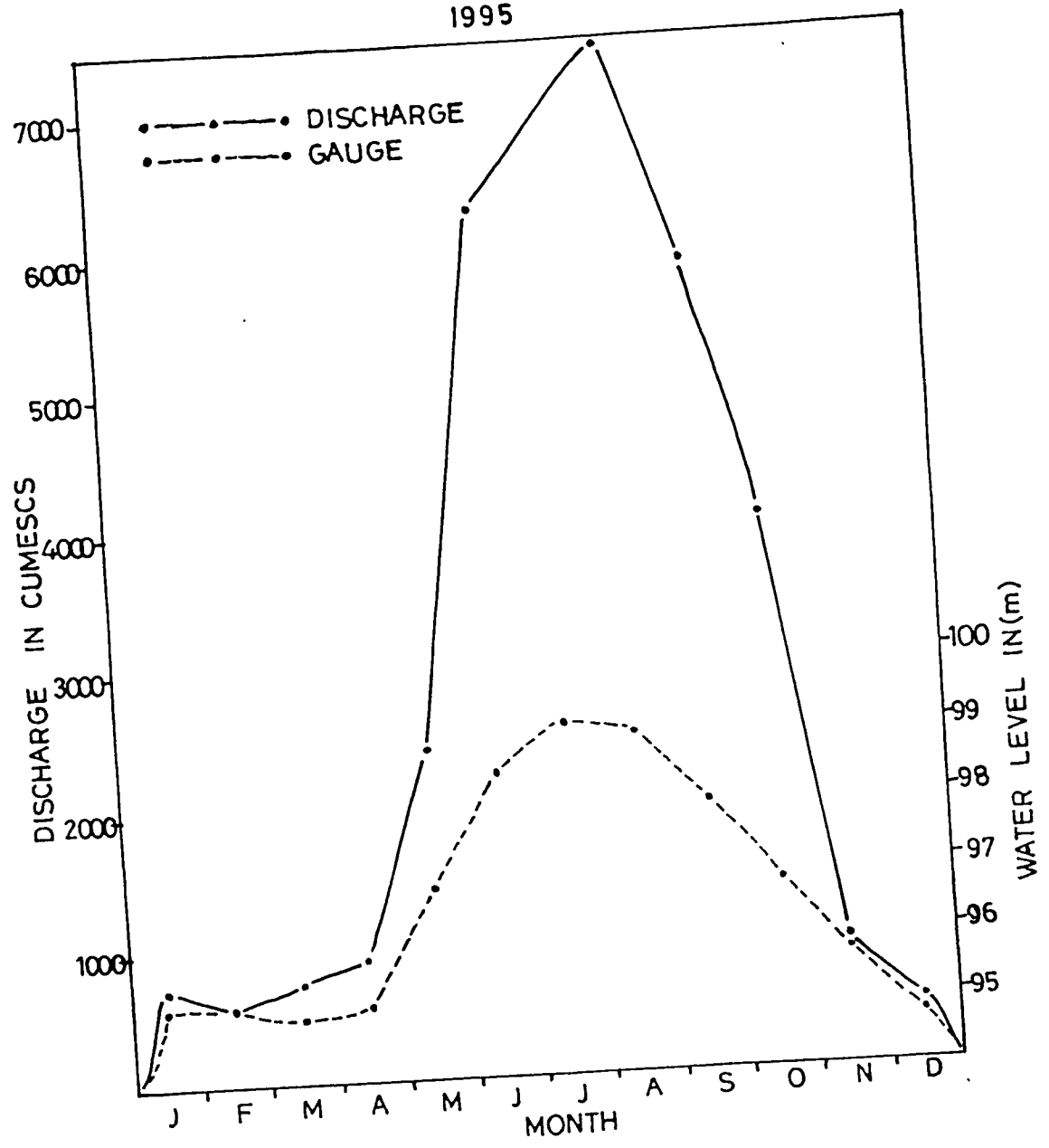


Fig.5.6

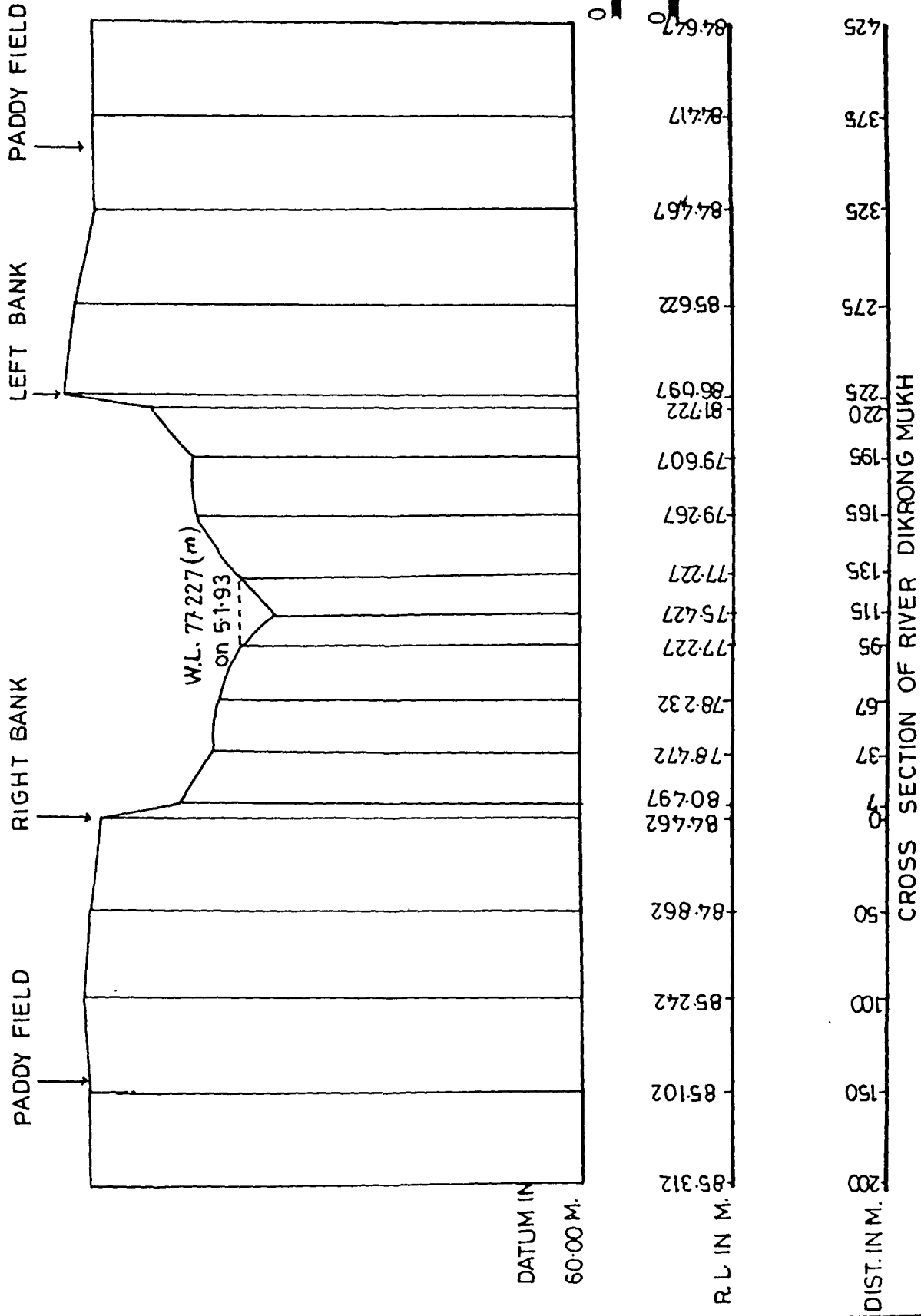


Fig.5.7

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
DIKRONGMUKH L. S. BASIN

1991

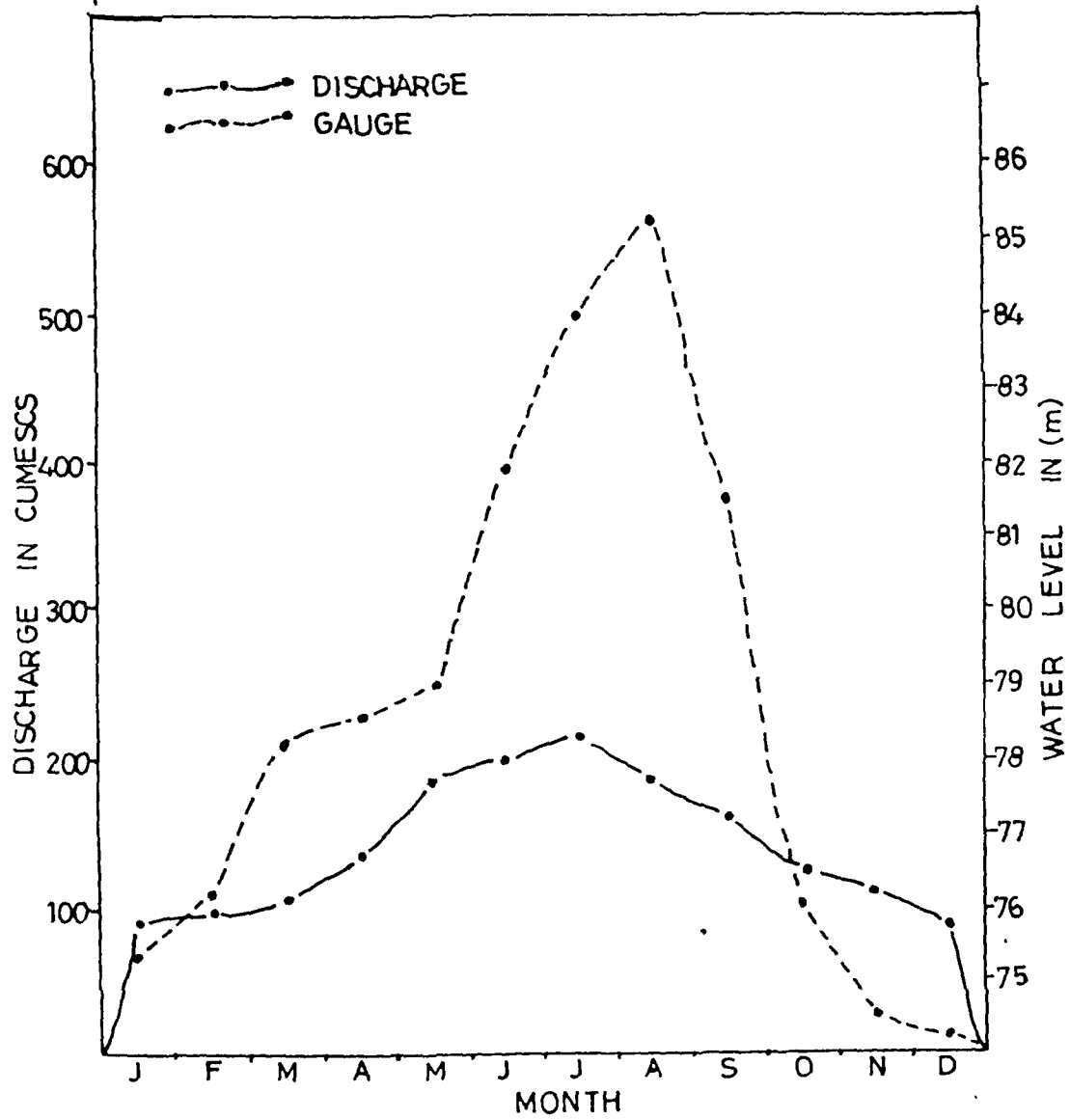


Fig.5.8

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
 DIKRONGMUKH L. S. BASIN
 1992

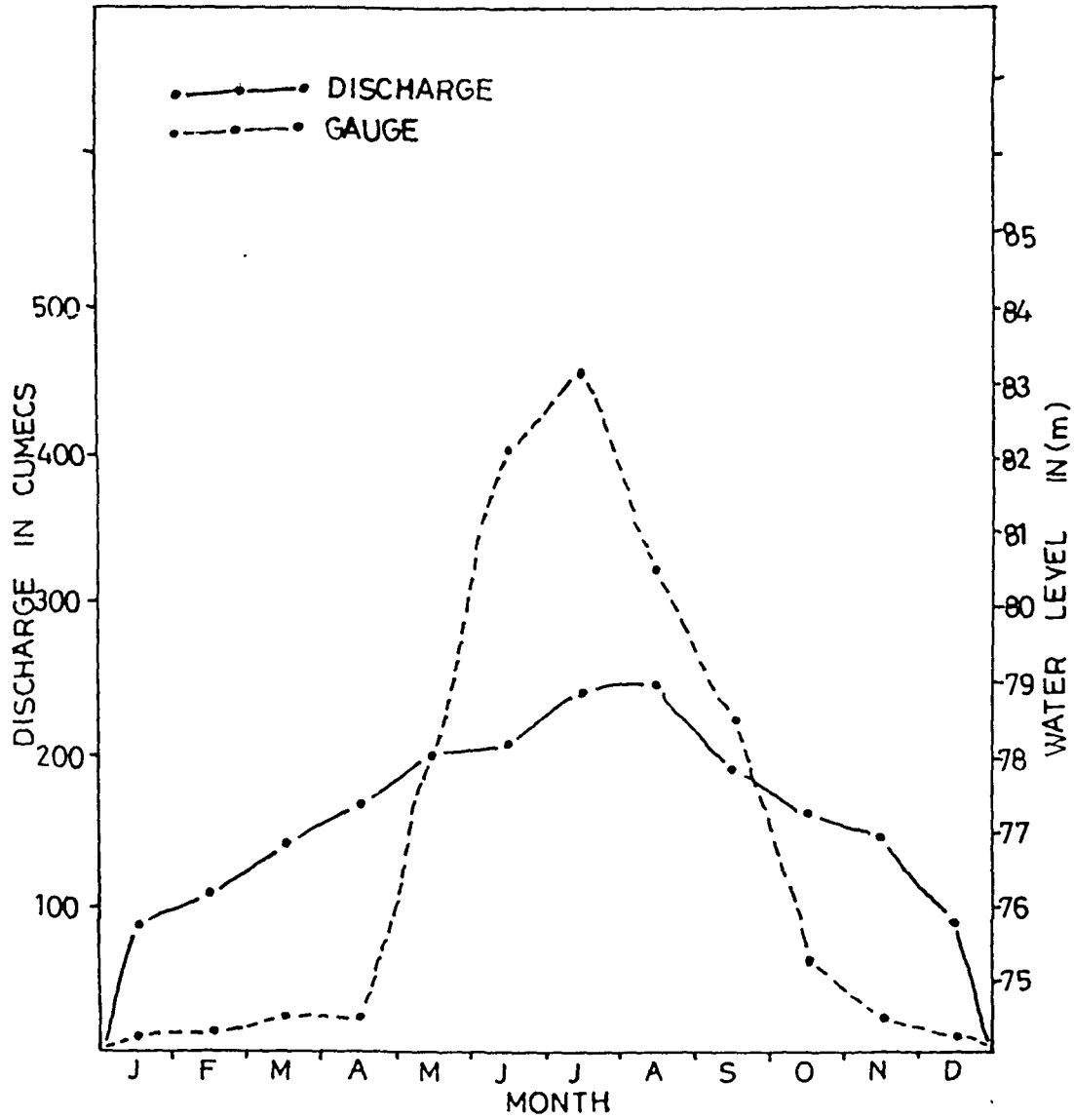


Fig.5.9

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
 DIKRONGMUKH L. S. BASIN
 1993

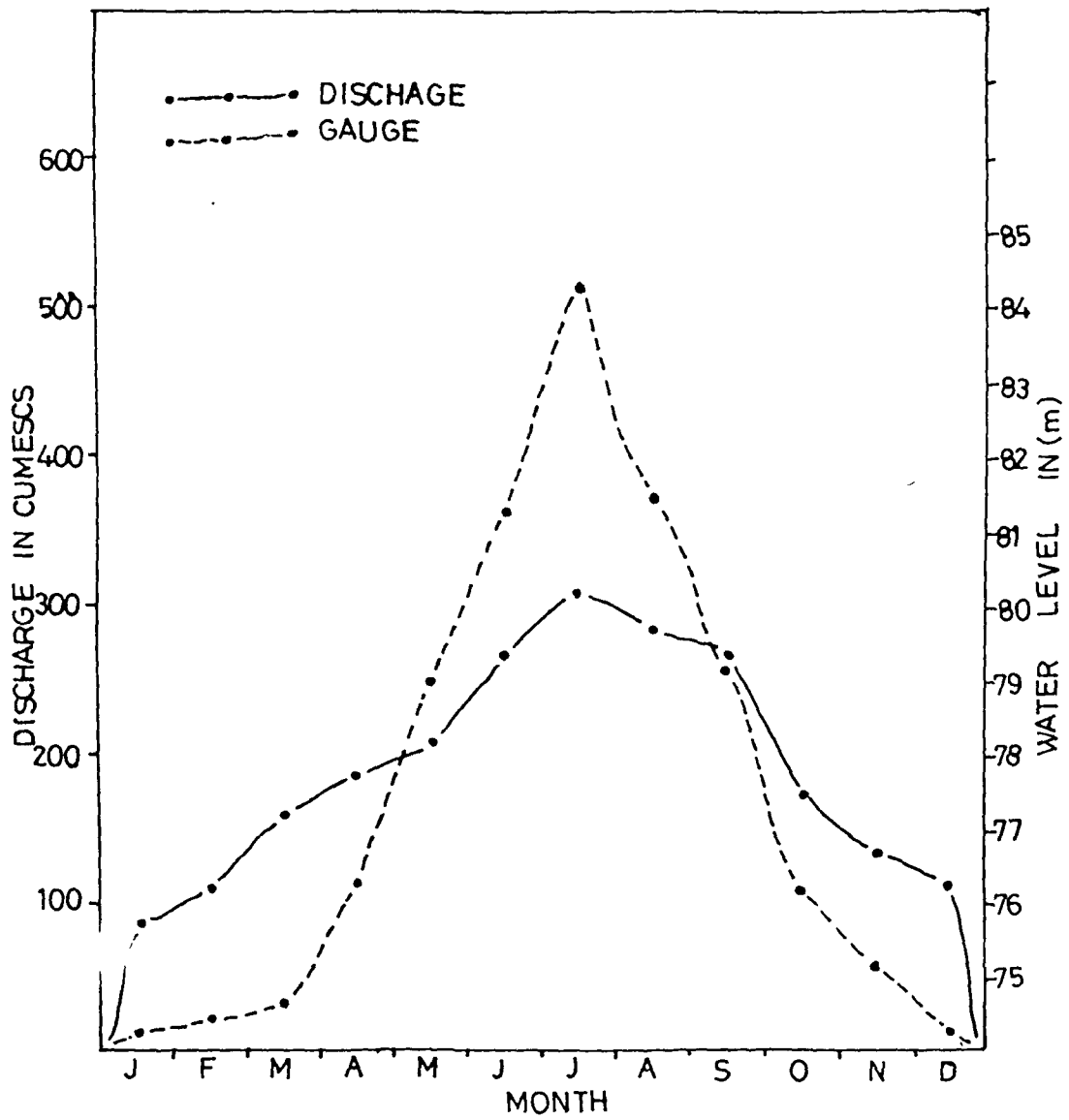


Fig.5.10

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
DIKRONGMUKH L. S. BASIN, 1994

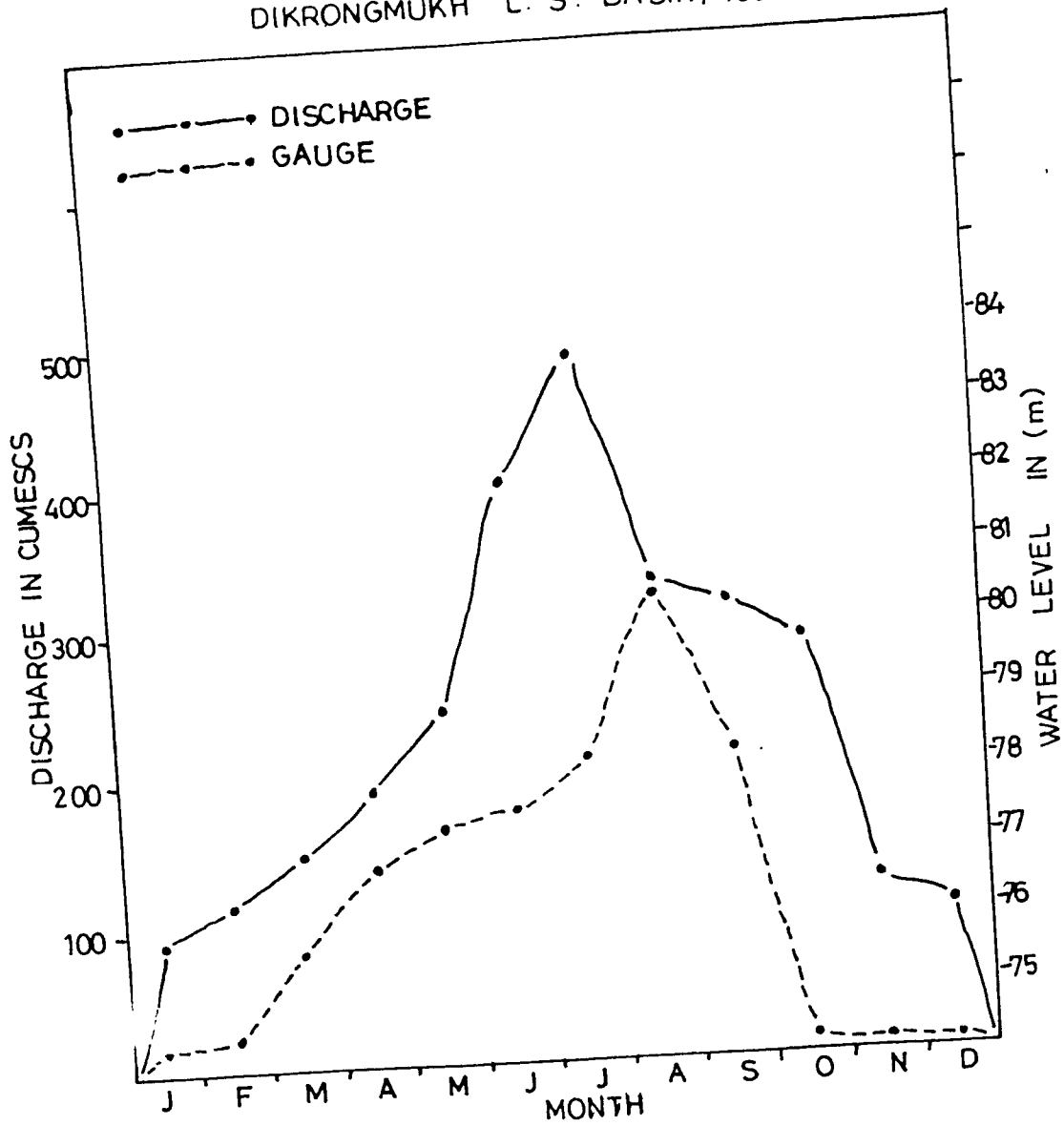


Fig.5.11

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
DIKRONGMUKH L. S. BASIN, 1995

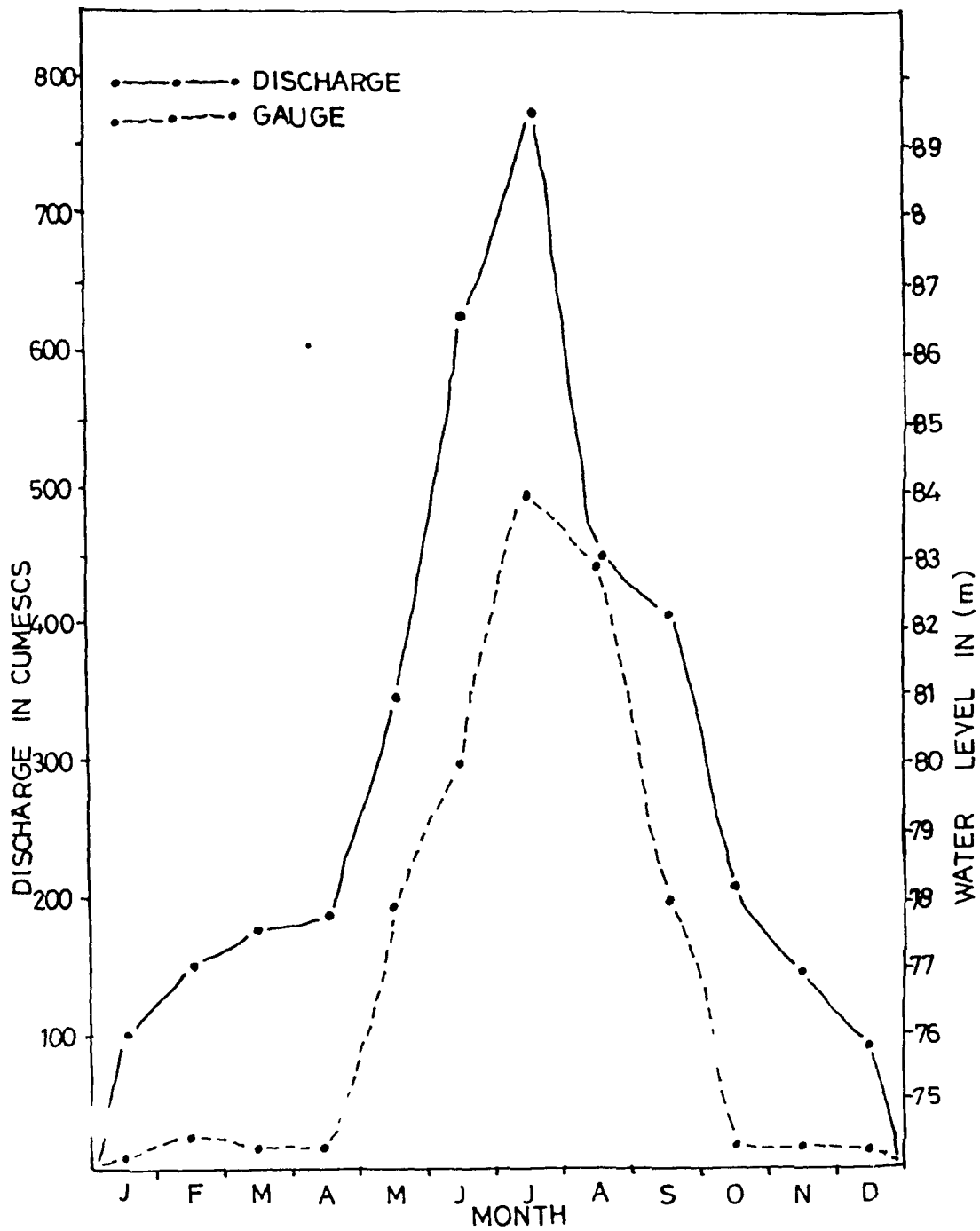
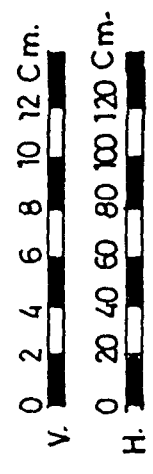
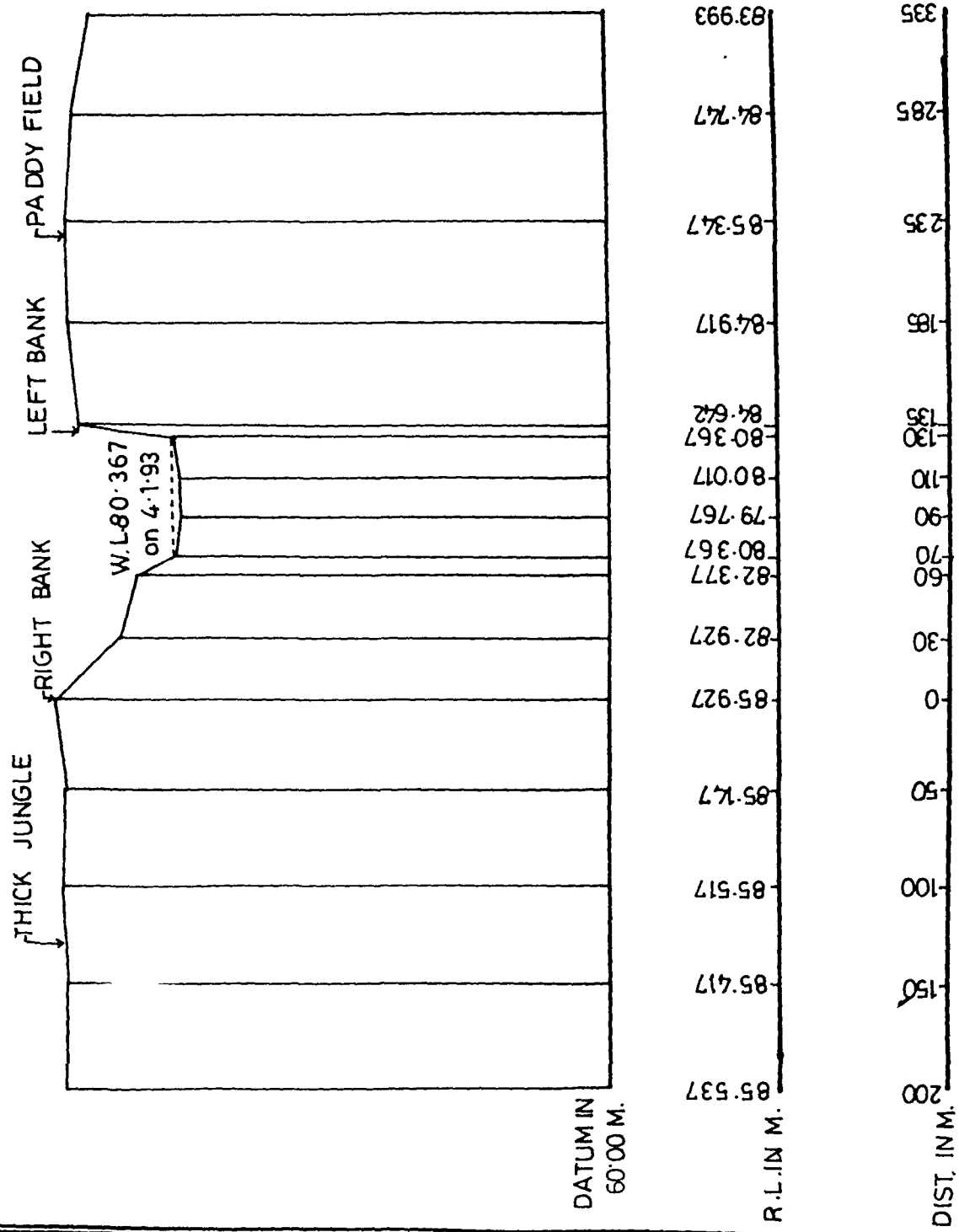


Fig. 5.12



CROSS SECTION OF RIVER RANGANADI

Source: Brahmaputra Board, Govt. of India.

Fig. 5.13

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
RANGANADIMUKH L. S. BASIN
1991

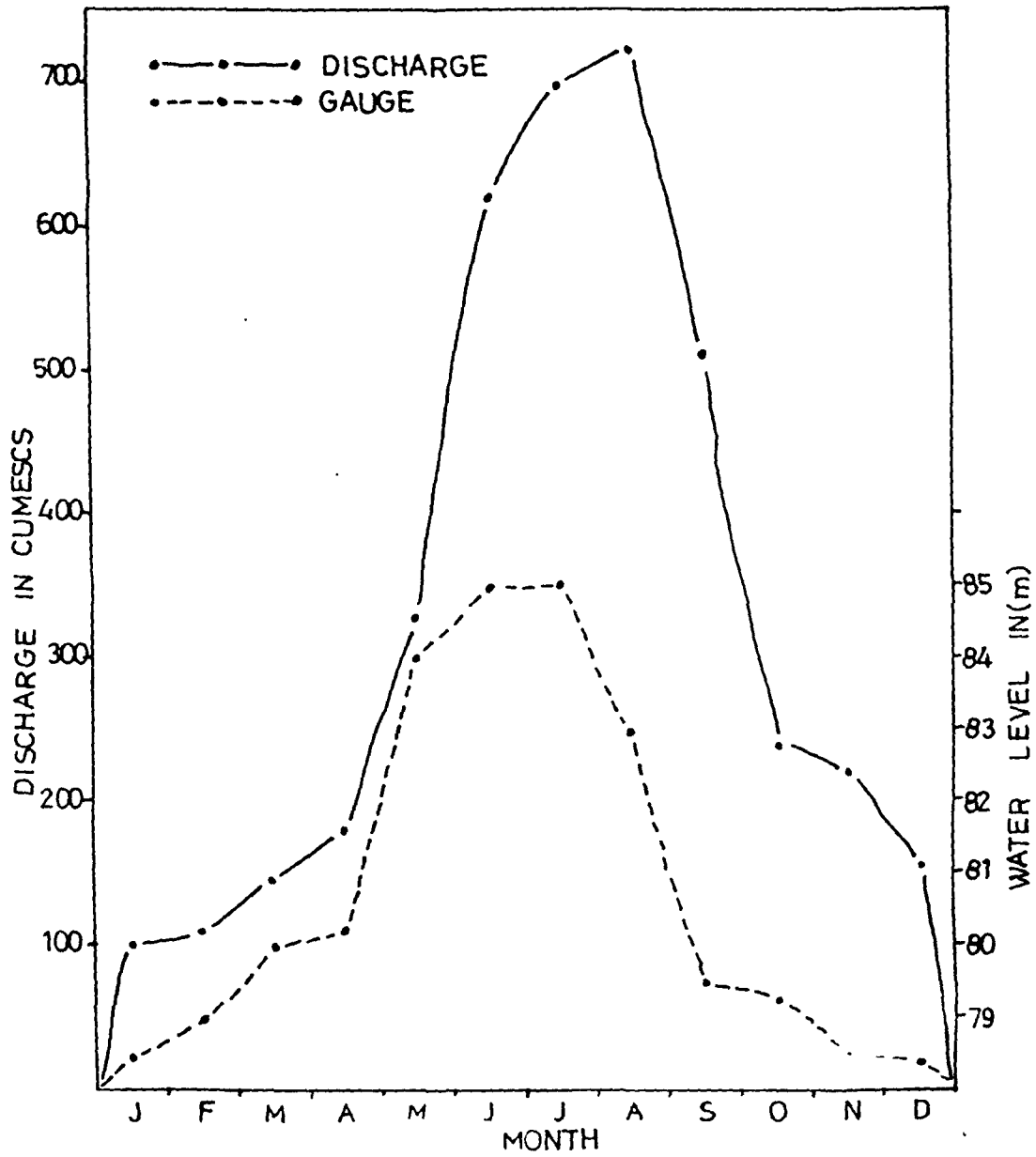


Fig. 5.14

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
RANGANADIMUKH L. S. BASIN
1992

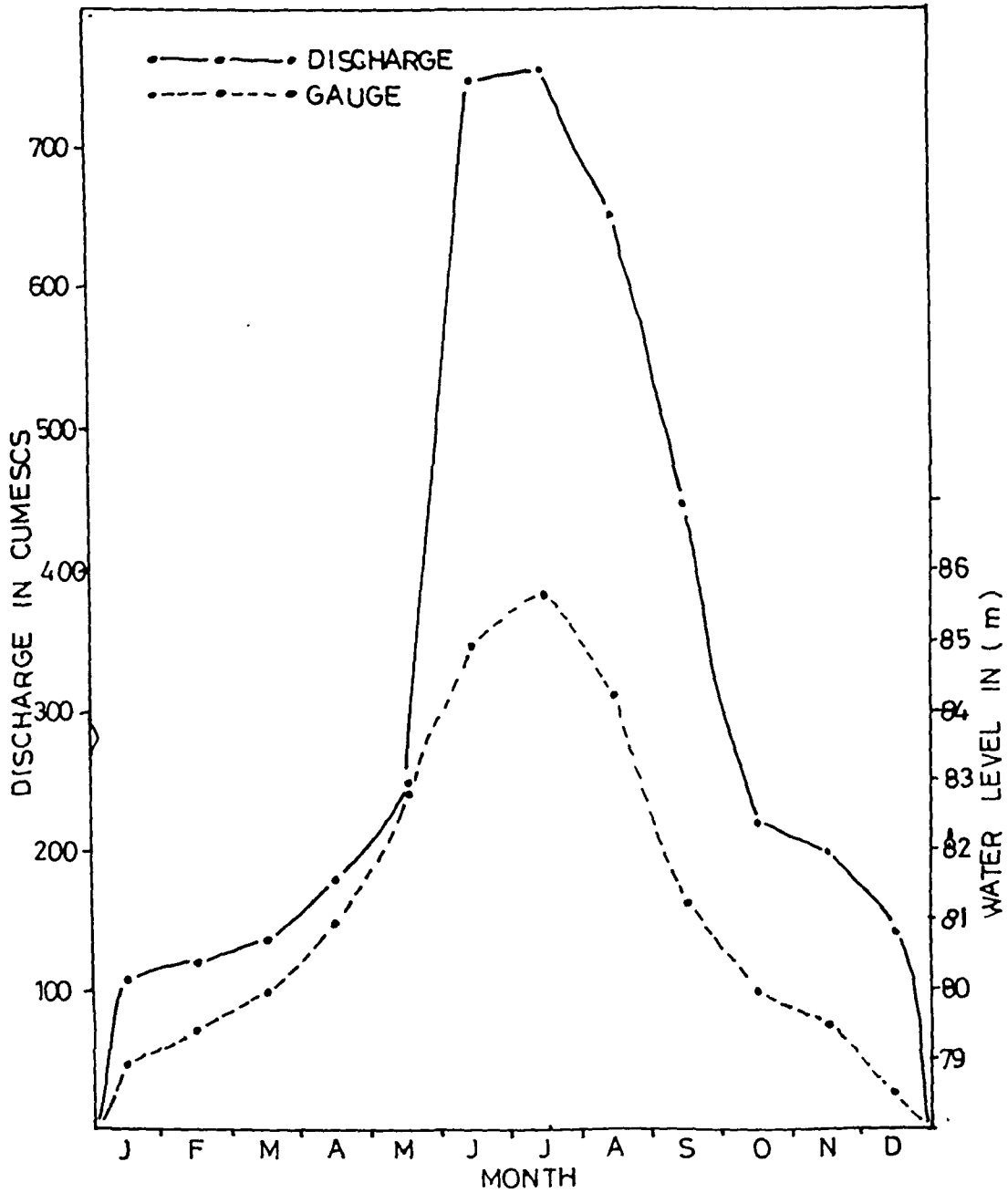


Fig. 5.15

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
RANGANADI MUKH L. S. BASIN
1993

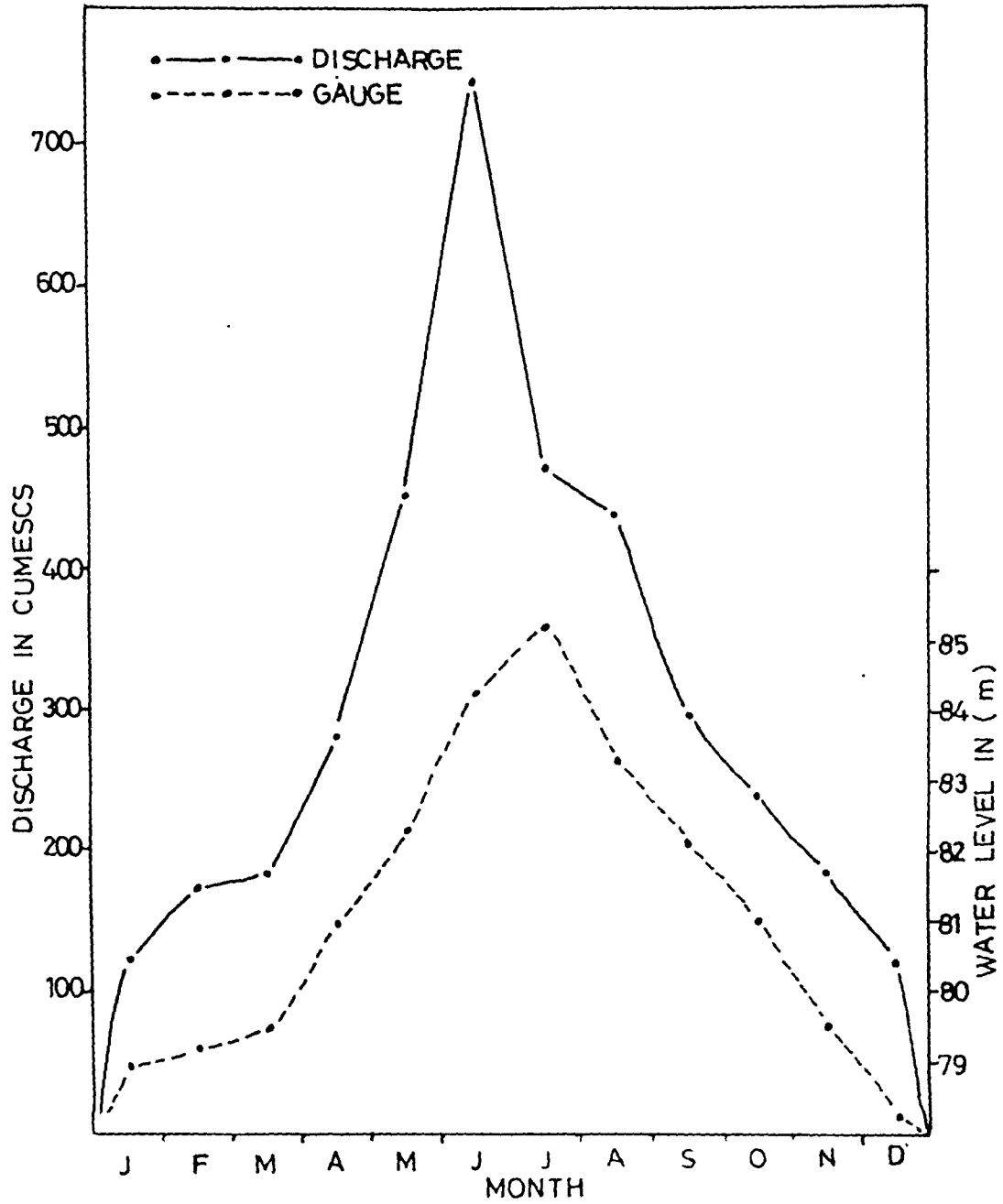


Fig. 5.16

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
RANGANADI MUKH L. S. BASIN
1994

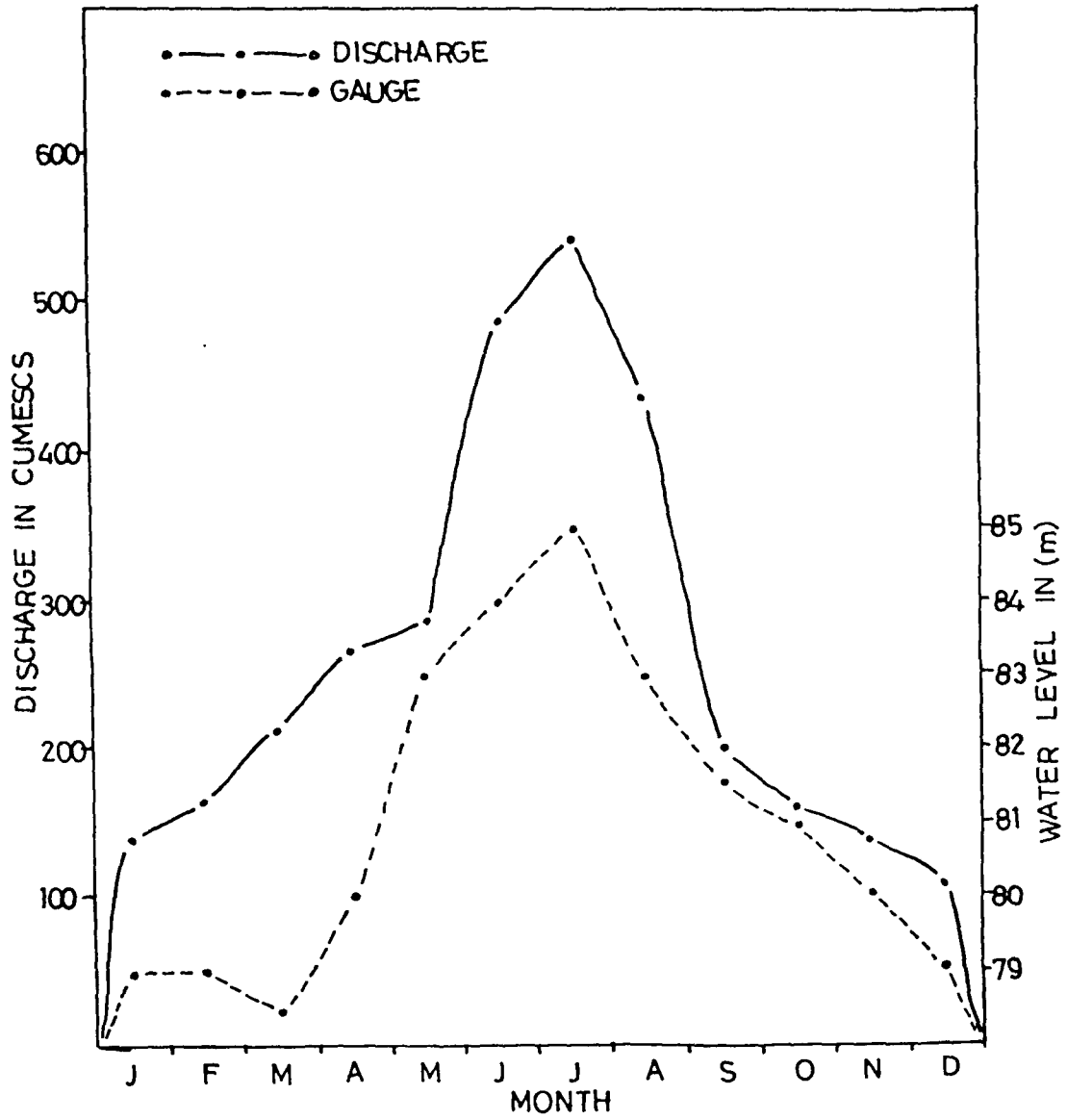


Fig. 5.17

GAUGE DISCHARGE HYDROGRAPH AT THE STATION OF
 RANGANADIMUKH L. S. BASIN
 1995

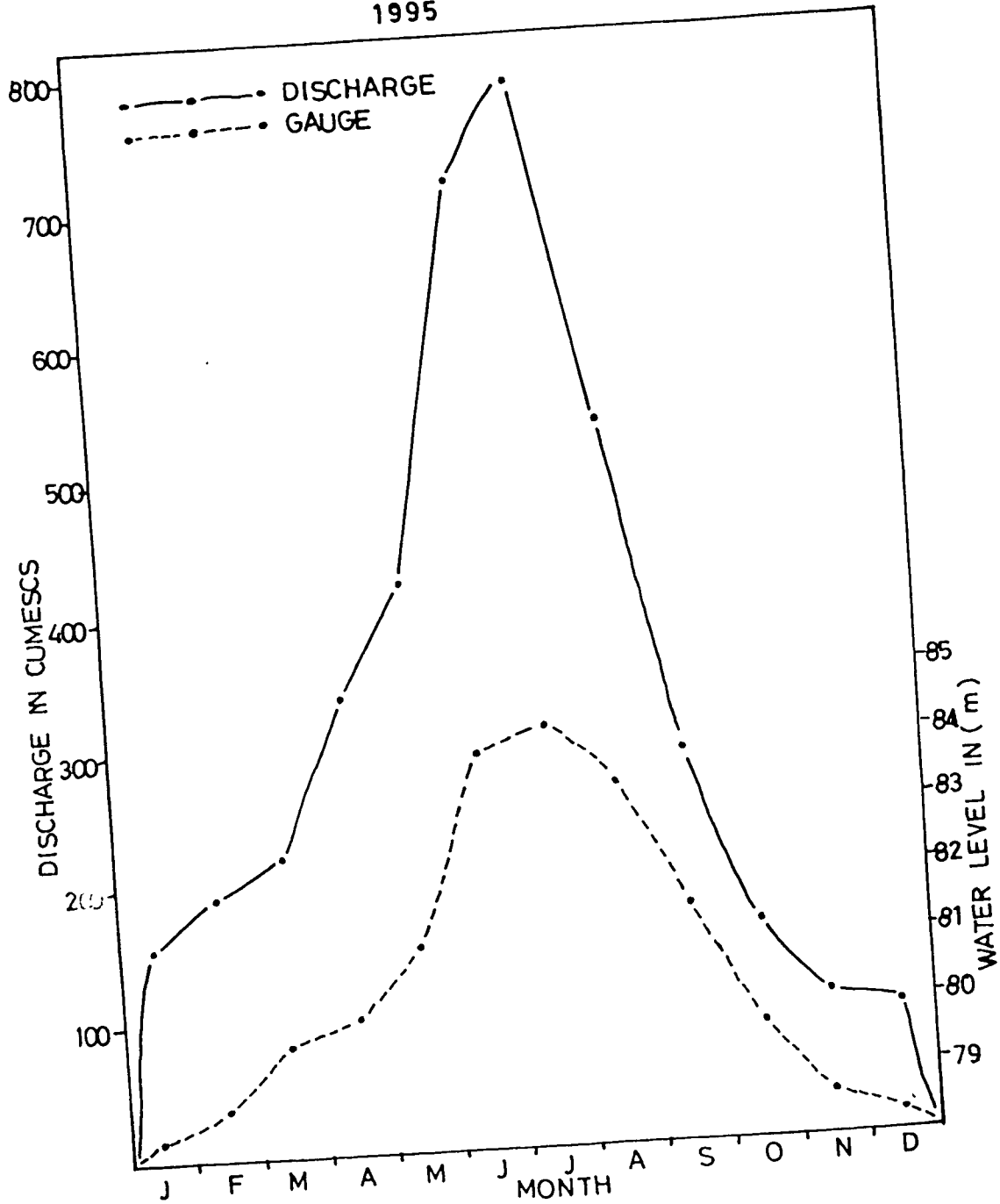


Fig. 5.18

particular point of time. It is difficult to determine the mean velocity of the overall cross-section, and the channel. Therefore it is divided into a number of segments for each of which the mean velocity, the cross section area and the section discharge are determined and then total discharge computed as the sum of the section discharge value.

(i) Discharge observation

Discharge is observed at Chouldhowaghat Dikrongmukh and Ranganadimukh cross section. The maximum and minimum discharge recorded at Chouldhowaghat is given in the table (5.2,5.3,5.4) the monthly mean, annual mean, maximum and minimum discharge and monsoon yield of Chouldhowaghat and other two rivers are shown in the table (5.2) and it is found that monsoon yield at Chouldhowaghat is 72.02% of total average yield. The maximum monthly mean discharge at Chouldhowaghat is 1972.49cm^3 during June and July and minimum is 18365cm^3 , which occurs in February.

The average yield is 6.406 ha.m at Chouldhowaghat. The maximum annual yield at chouldhowaghat was 7.1710 ha.m. in 1987. The flood waves and their duration over danger level at Chouldhowaghat and Dhalghat are shown in table (5.4 and Fig-5.35) for the period of 1977 to 1995. The danger level is 90.40 m. It is seen that from 1977 to 1995 the danger level has been crossed each year. The water level remained above

danger level for 26 days continuously during 1982 (from 6-7 to 31-7-82) and 1988 (from 5-7-88 to 30-7-88)

Sediment load

Transportation and deposition of erosive sediment material is also important in fluvial processes in the river catchment of Subansiri. In fact, more than 80% of the basin is geomorphologically undulating sloppy, where hydraulic forces are significant throughout the year. The sub tributaries of Subansiri, Dikrong and Ranganadi system transport a quite significant amount of weathered material, boulder and soil towards the north bank of upper Brahmaputra alluvial plain. The amount and kind of suspended sediment load, which is transported by the river depends on the velocity and discharge of water. It is a fact that the higher discharge rate of water flow transports bigger volume of suspended sediment load and vice-versa.

The sub Himalayan range of Subansiri generally consists of course sandstone and easily weathered rocks, steep slope and shallow braided channels are the main factors of channel direction. This results in transportation of sediment load of the size of 0.2 mm. up to 2 mm. diameter in suspension.

Due to granulometric characteristics of the soil, in the river basin the density of depositions and extent of coverage are guided by the energy potential of the flood volume based on the run-off. Due to intensity of precipitation during May to October the bulk of the discharge is also concentrated during this period. As the gradient along the hills is steep, sediments deposited at the foot hill are larger and heavier.

(ii) Sediment Observation

A number of sites have been set up at Chouldhowaghat, Ranganadi and Dikrongmukh similar to discharge observation on lower Subansiri river to measure the suspended sediment load all the year round. The coarse, medium and fine sediment carried by the river Subansiri has been estimated by collecting samples at 0.6 D (D-Depth of river from the surface).

Classification of Sediments

The sediments are classified in to three grades on the basis of particle size

(i) **Coarse:** Particle size from 0.020 mm. diameter and above

(ii) **Medium:** Particles size varying from 0.075 mm to 0.020 mm.

(iii) **Fine fraction:** Particle size varying from 0.075 mm and less

Annual Sediment Load

The annual sediment load viz. coarse, medium and fine are shown in the table (5.5) The data from 1991 - 1995 are found to be inconsistent with data of the earlier period due to change in either observation sites or method of observation. To examine the consistency of sediment, the Brahmaputra Board, Govt. of India collected samples, through the depth. Integrated sample were analysed.

These results have been compared with those of the samples collected by the Brahmaputra Board, Government of India and Integrated soil sampler and results are found to be varying to large extent.

Sediments	Multiplication factor (in mm)
(i) Coarse sediment	2.66
(ii) Medium size sediment	2.52
(iii) Fine sediment	1.00

If the above diagram (Fig.No.5.22) is compared with the five-year sediment yield at the station of Chouldhowaghat, we have seen that the sediment yield is increasing from the year of 1991-1995. If the sediment yield is going to increase in this way then in future

whole basin area would be devoid of soil within a short period. This also implies that there is some kind of disturbances in the hills of the basin.

**Statement is showing the Sediment Load at the Chouldhowaghat(in ha.m.)
(1974-95)**

Table no.5.5

Period	Suspended sediment ha.m.	Bed load	
	Coarse	Medium	Fine
1974	1157.98	1496.30	621.74
1975	713.97	1181.70	468.32
1976	396.18	997.82	42.56
1977	236.15	356.20	33.74
1978	325.81	745.57	624.22
1979	318.87	898.69	751.33
1980	223.27	517.64	482.66
1981	360.59	481.60	381.32
1982	206.79	373.34	247.01
1983	389.26	547.08	261.67
1984	287.30	239.35	363.05
1985	808.80	578.54	264.50
1986	277.41	177.07	258.78
1987	1422.87	831.70	296.56
1988	617.41	489.62	176.96
1989	439.93	362.96	100.45
1990	338.27	169.05	11.57
1991	848.15	511.78	346.11

Table no.5.6

**Suspended Sediment Load at the Cross-section of Chouldhowaghat
(in ha.m) 1992**

Month	Coarse	Medium	Fine
January	0.0020	0.0070	0.0240
February	0.0150	0.0710	0.0030
March	0.0350	0.0240	0.0050
April	0.0520	0.0300	0.0110
May	0.1260	0.0810	0.1370
June	0.3400	0.2040	1.3790
July	0.4330	0.3880	1.5640
August	0.5220	0.1080	3.7050
September	0.4570	0.3800	1.7620
October	0.2810	0.1850	1.4990
November	0.0629	0.0435	0.4140
December	0.0330	0.0270	0.1150
Total	2.2589	1.5485	10.6180

1993

January	0.0020	0.0090	0.0260
February	0.0170	0.0090	0.0040
March	0.0360	0.0240	0.0050
April	0.6540	0.6300	0.0120
May	0.1350	0.0880	0.1490
June	0.3640	0.2310	1.3920
July	0.4780	0.2310	1.3620
August	0.5390	0.4710	3.5900
September	0.4990	0.4070	1.7990
October	0.2820	0.1890	1.5320
November	0.0650	0.0116	0.4460
December	0.0350	0.0270	0.5870
Total	3.1240	2.5096	11.2350

1994

January	0.0260	0.0310	0.3260
February	0.0370	0.0280	0.01880
March	0.6300	0.0700	2.4060
April	0.2290	0.5470	3.6430
May	1.7570	1.4590	4.7650
June	3.5730	2.9530	10.7650
July	3.8530	3.4280	10.4270
August	0.5520	0.4990	1.5200
September	0.3840	0.3440	1.2290
October	0.2440	0.2190	1.2290
November	0.0950	0.0790	0.2190
December	0.1320	0.6560	0.0290
Total	11.5120	36.8360	59.2190

1995

January	0.0180	0.0050	0.0480
February	0.0460	0.0310	0.2230
March	0.6630	0.6660	2.3720
April	1.3030	0.5210	4.8960
May	1.3680	1.4778	4.7210
June	3.7740	2.8100	12.4560
July	3.9170	3.7160	10.6200
August	0.5850	5.0560	1.6150
September	0.4200	0.3730	1.3040
October	0.2630	0.2420	1.3040
November	0.1040	0.1070	0.2460
December	0.1380	0.0650	0.0310
Total	12.5998	15.0690	39.8340



Table no 5.7

**Suspended sediment load at the cross-section of Dikrong mukh.
Dikrong river (in ha.m.)
1991**

Month	Coarse	Medium	Fine
January	0.0110	0.0016	0.0029
February	0.0137	0.0396	0.0169
March	0.0028	0.0126	0.0267
April	0.0176	0.0936	0.0124
May	0.1103	0.1033	0.0670
June	0.1207	0.1400	0.2001
July	0.1379	0.1631	1.2130
August	0.2340	0.2146	1.2239
September	0.0937	0.0760	0.0914
October	0.0806	0.0365	0.0900
November	0.0026	0.0081	0.0026
December	0.0240	0.0041	0.0016
Total	0.8699	0.8931	3.9485

	1992		
Month	Coarse	Medium	Fine
January	0.0016	0.0012	0.0203
February	0.0069	0.0032	0.0341
March	0.0073	0.0073	0.0036
April	0.0169	0.0193	0.0192
May	0.0642	0.1136	0.1246
June	0.0926	0.1249	1.1639
July	0.1003	0.1600	2.0360
August	0.1430	0.1200	1.0936
September	0.1503	0.1003	0.1346
October	0.0269	0.0013	0.1003
November	0.0269	0.0013	0.0029
December	0.0316	0.0076	0.0016
Total	0.6542	0.6683	0.7177

1993

Month	Coarse	Medium	Fine
January	0.0030	0.0013	0.0026
February	0.0019	0.0021	0.0026
March	0.0027	0.0096	0.0143
April	0.0091	0.0099	0.0763
May	0.0123	0.1760	0.1034
June	0.0176	0.1134	0.4369
July	0.0197	0.1096	1.0031
August	0.0126	0.1046	1.1028
September	0.0093	0.0178	1.1063
October	0.0069	0.0092	0.1642
November	0.0049	0.0064	0.4200
December	0.0038	0.0028	0.0028
Total	0.1017	4.4484	4.4333

1994

Month	Coarse	Medium	Fine
January	0.0016	0.0130	0.2167
February	0.0029	0.0276	0.1946
March	0.0091	0.0961	0.4260
April	0.0123	0.0949	1.0928
May	0.0193	0.1091	2.0492
June	2.0961	3.2496	4.3267
July	2.0961	2.4826	4.3267
August	0.0911	0.9762	1.2673
September	0.0340	0.6739	1.2673
October	0.0200	0.4391	0.9629
November	0.0091	0.0924	0.6133
December	0.0061	0.0029	0.0921
Total	0.3962	8.2529	12.1457

1995

Month	Coarse	Medium	Fine
January	0.0018	0.0003	0.0021
February	0.0043	0.0013	0.0310
March	0.0630	0.0391	0.0146
April	0.9628	0.1343	1.4361
May	0.9200	0.9963	1.2109
June	1.1300	1.1926	2.4360
July	2.0936	3.4163	4.2109
August	0.9142	0.9126	4.2109
September	0.0900	1.0371	1.4623
October	0.0234	0.0921	0.2146
November	0.0346	0.0924	0.3121
December	0.0011	0.0276	0.2110
Total	6.2135	7.8952	11.8087

Table no.5.8

Suspended sediment load at the cross section of Ranganadimukh,
Ranganadi river. (in ha.m.) (1991-1995)

Month	Coarse	Medium	Fine
January	0.0010	0.0040	0.0123
February	0.0023	0.0071	0.4126
March	0.0073	0.0092	0.6281
April	0.0091	0.193	0.6925
May	0.0126	0.0210	0.9240
June	0.1376	0.0763	0.0027
July	0.4928	0.8624	1.0493
August	0.3976	0.9328	1.1023
September	0.0231	0.8753	0.9341
October	0.0139	0.2146	0.8624
November	0.0121	0.1528	0.2483
December	0.0029	0.0926	0.1249
Total	1.1123	3.092	8.9935

Month	Coarse	Medium	Fine
January	0.0034	0.0093	0.0126
February	0.0091	0.0126	0.0825
March	0.1290	0.0463	0.0916
April	0.0476	0.0983	0.1463
May	0.1921	0.3641	0.8625
June	0.2460	0.6825	0.9267
July	0.0349	0.1246	1.0347
August	0.4538	0.8126	1.1203
September	0.0146	0.0916	0.9146
October	0.0213	0.0428	0.7211
November	0.0029	0.0162	0.6341
December	0.0015	0.0091	0.2113
Total	1.0401	2.3201	6.5583

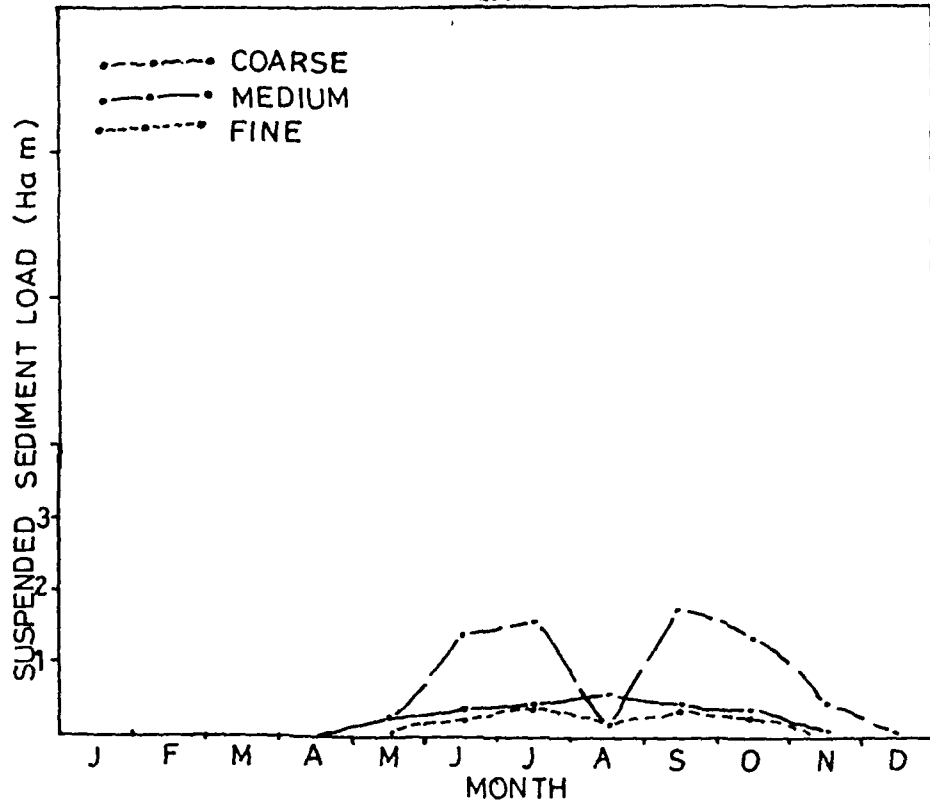
Month	Coarse	Medium	Fine
January	0.0140	0.0430	0.0632
February	0.0347	0.0876	0.1241
March	0.0912	0.1024	0.3126
April	0.1349	0.4621	0.8126
May	0.4738	0.6342	0.8733
June	0.5113	0.8423	0.9876
July	0.8112	0.9113	1.2133
August	0.8433	1.0041	2.4133
September	0.6428	0.8113	0.9123
October	0.0391	0.1123	0.2140
November	0.0211	0.0961	0.1231
December	0.0043	0.0463	0.0929
Total	3.6217	5.1130	8.1423

Month	Coarse	Medium	Fine
January	0.1020	0.1463	0.4633
February	0.2496	0.3419	0.6345
March	0.2400	0.3976	0.6344
April	0.2936	0.4829	0.8149
May	0.4623	0.6286	0.9132
June	0.4923	0.6211	0.9761
July	0.6031	0.8169	1.1420
August	0.6003	0.7365	1.3205
September	0.2400	0.3496	0.8763
October	0.2100	0.4311	0.5192
November	0.0233	0.1349	0.4321
December	0.0019	0.0197	0.4722
Total	3.4584	5.1071	9.2987

Month	Coarse	Medium	Fine
January	0.1147	0.1920	0.2411
February	0.1340	0.2131	0.3691
March	0.1920	0.3416	0.8153
April	0.2476	0.4673	0.8426
May	0.3410	0.8614	0.9149
June	0.6143	1.2966	2.4316
July	0.6933	1.4633	3.4917
August	0.5421	2.2491	2.6710
September	0.2113	0.9621	0.2976
October	0.0341	0.8566	1.1129
November	0.0141	0.0021	0.0394
December	0.0021	0.0049	0.0143
Total	4.1466	8.9100	15.0415

SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

CHOULHOWAGHAT 1991



SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

CHOULHOWAGHAT 1992

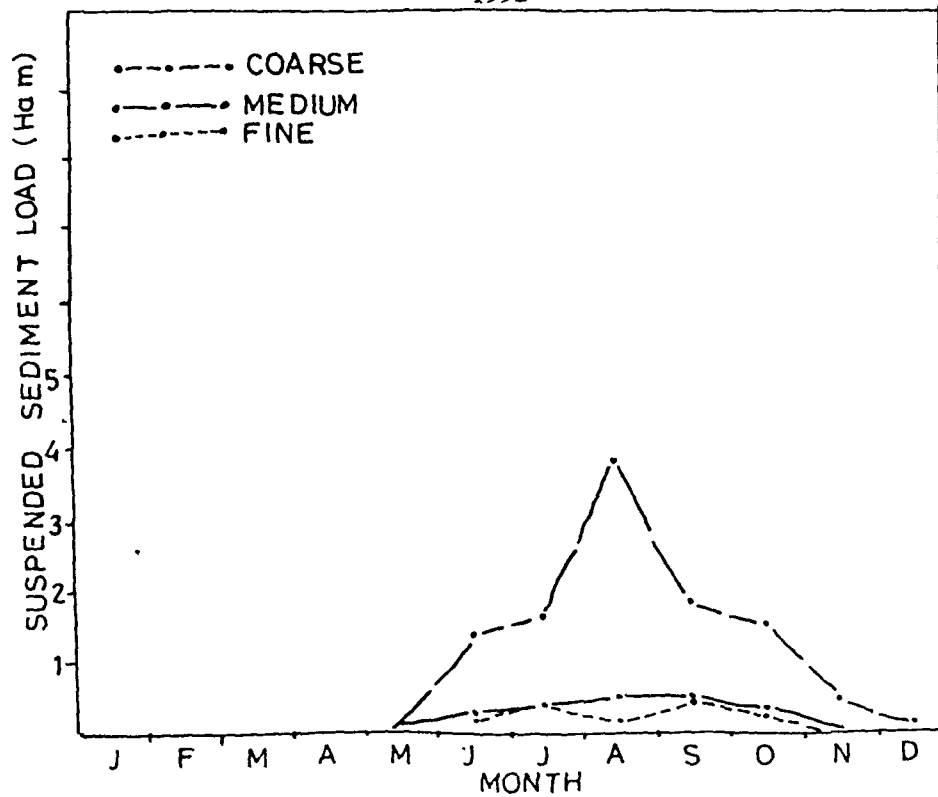
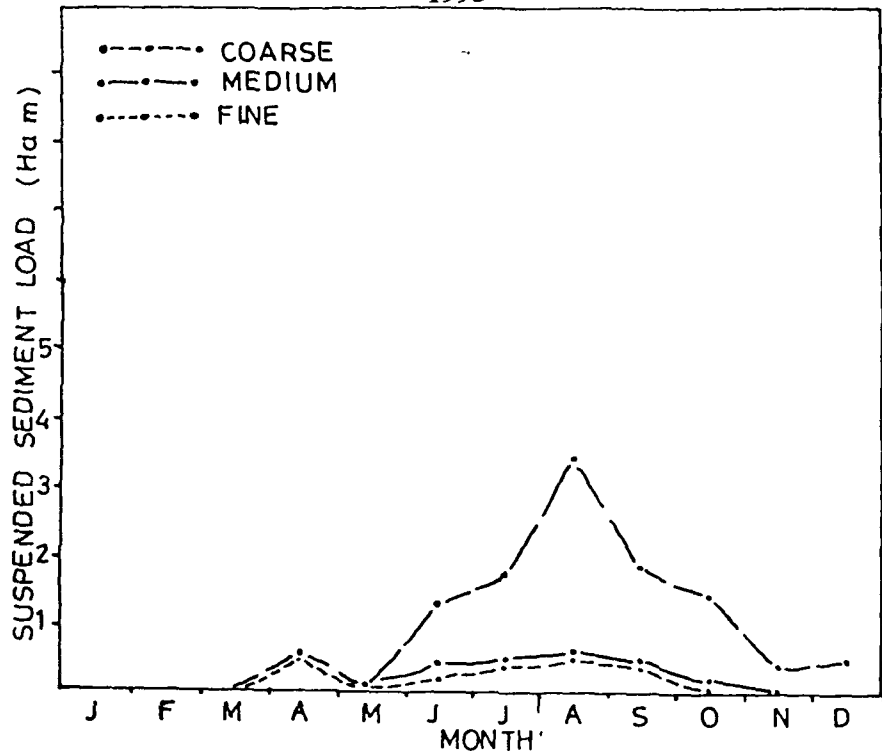


Fig. 5.19

SUSPENDED SEDIMENT LOAD AT THE CROSS-ECTION

CHOULDHOWAGHAT
1993



SUSPENDED SEDIMENT LOAD AT THE CROSS-ECTION

CHOULDHOWAGHAT
1994

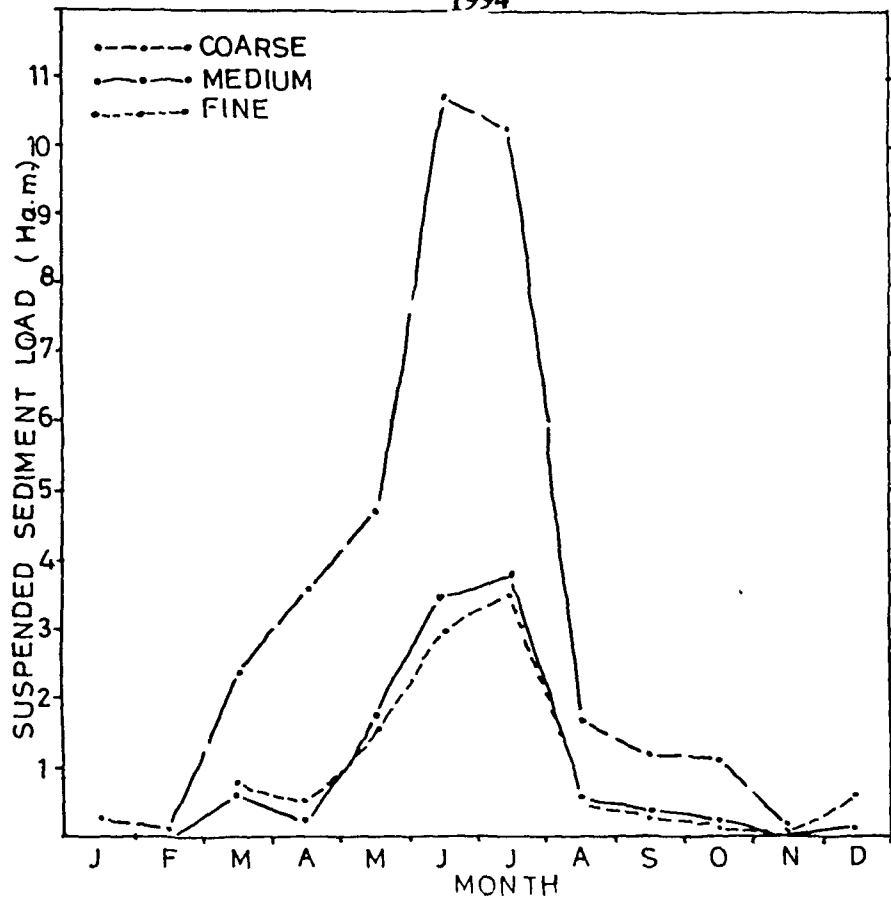


Fig. 5.20

SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

CHOULDHOWAGHAT
1995

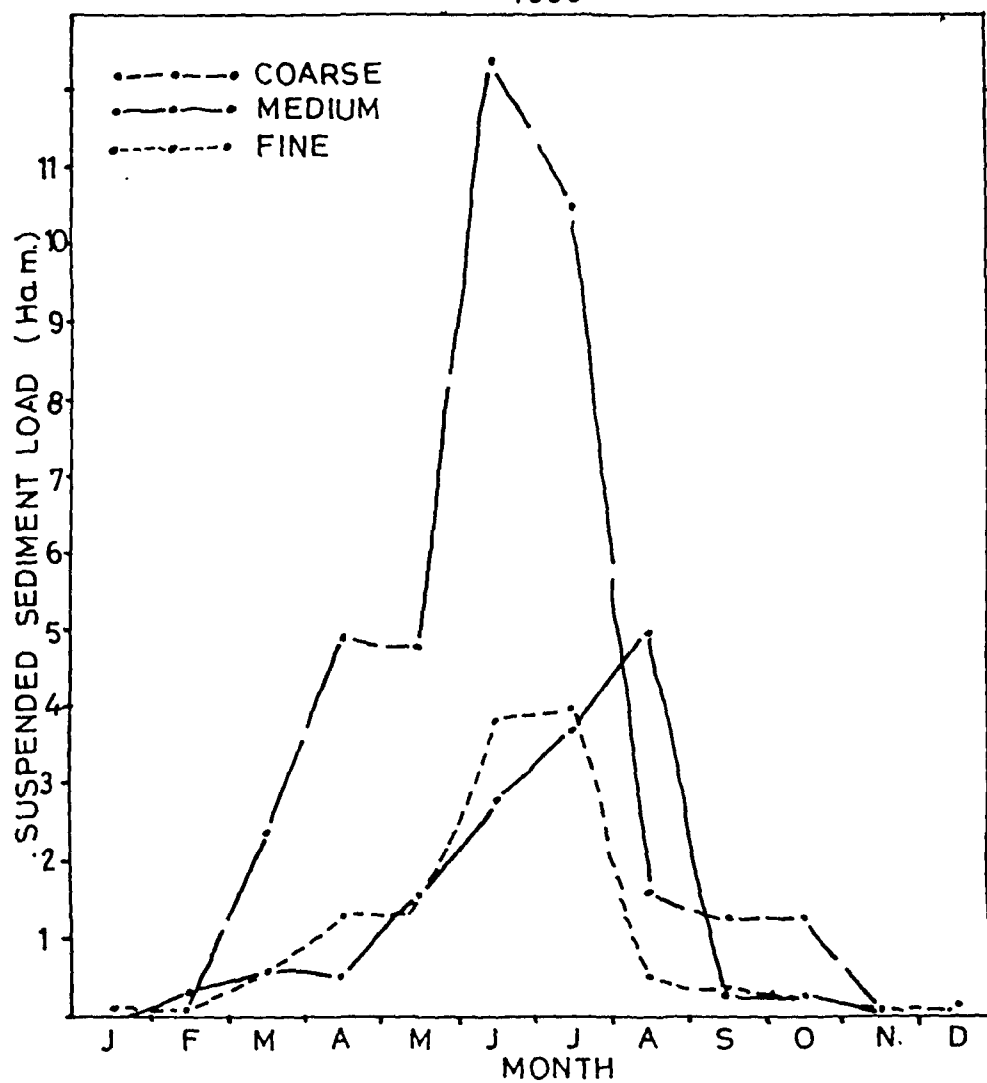


Fig. 5.21

SUSPENDED SEDIMENT LOAD AT THE CROSSSECTION

CHIOULDIHOWAGHAT

(1991-1995)

- COARSE
- MEDIUM
- FINE

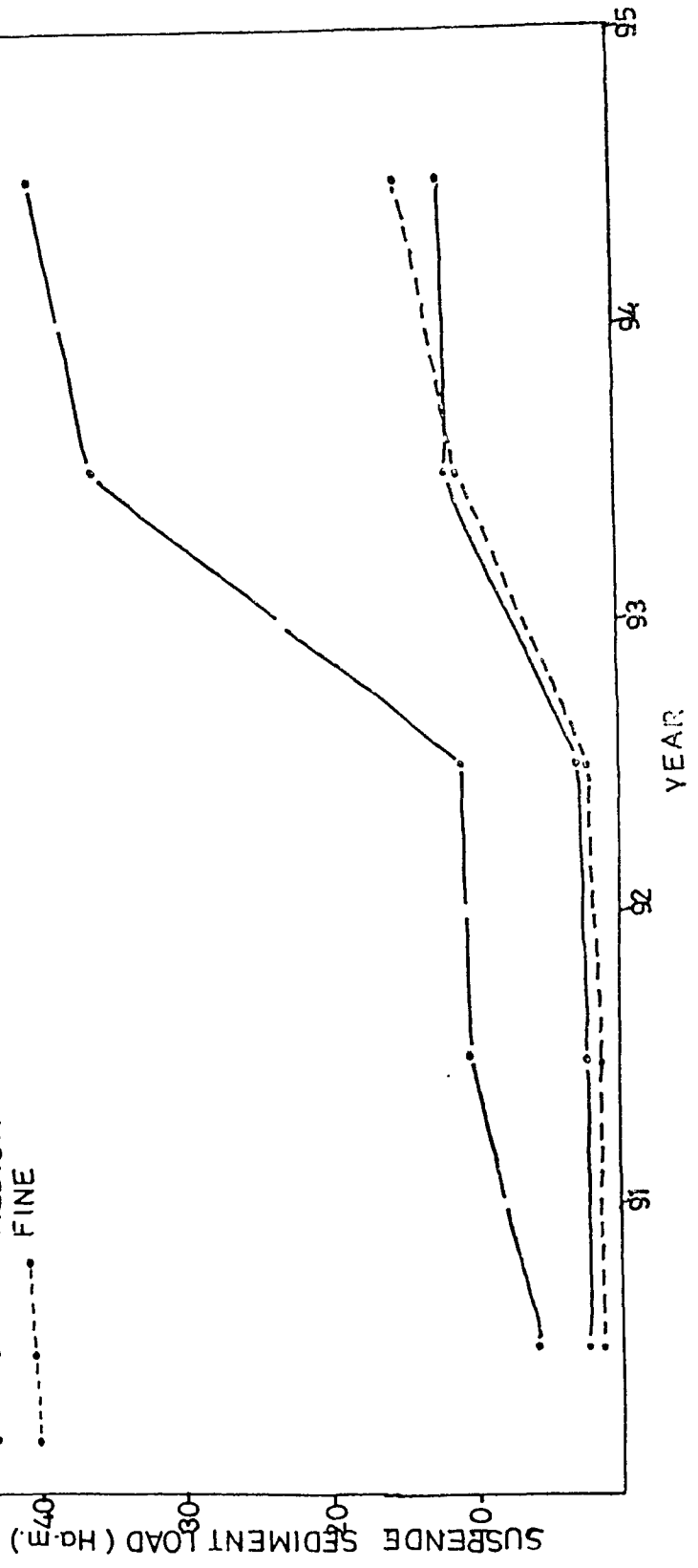
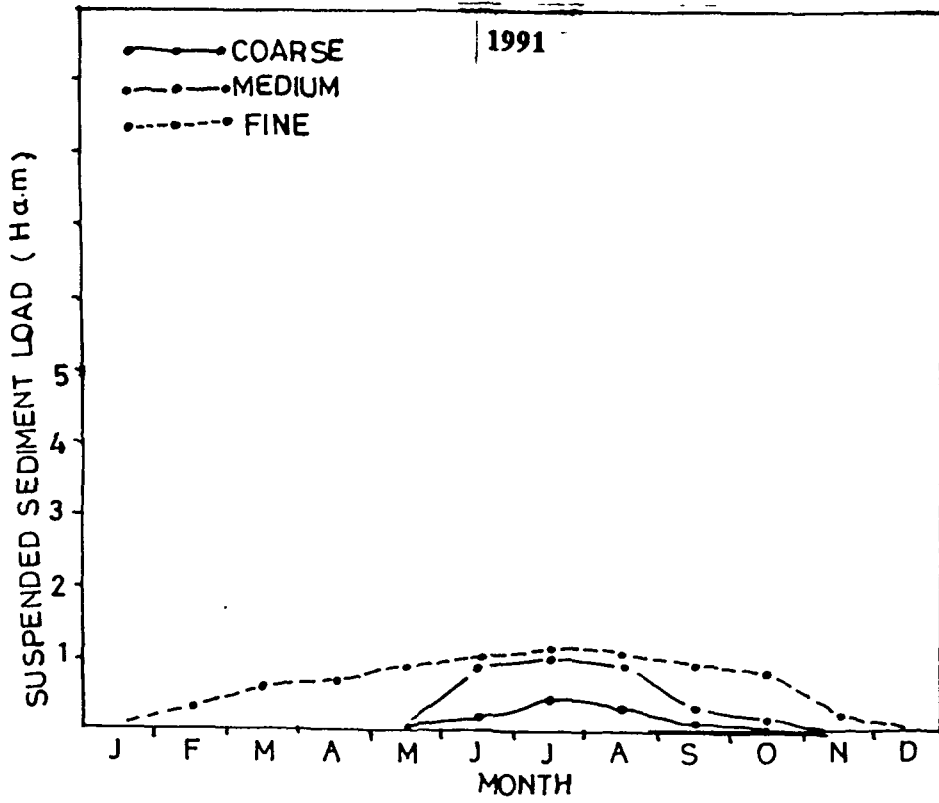


Fig. 5.22

SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

RANGANADI MUKH



SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

RANGANADI MUKH

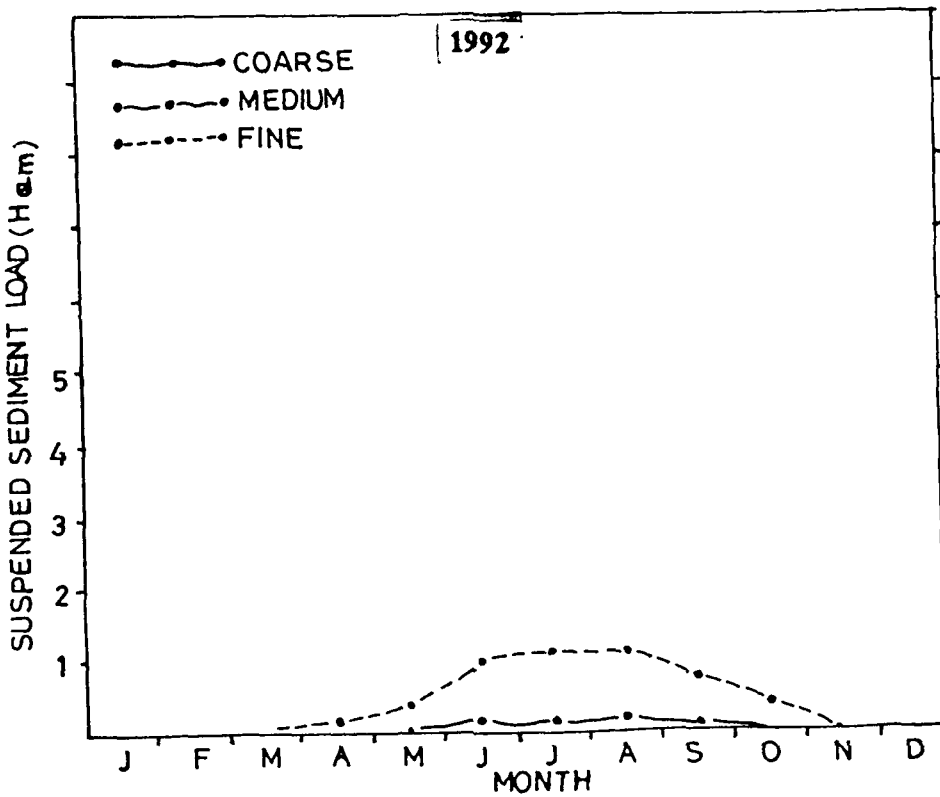
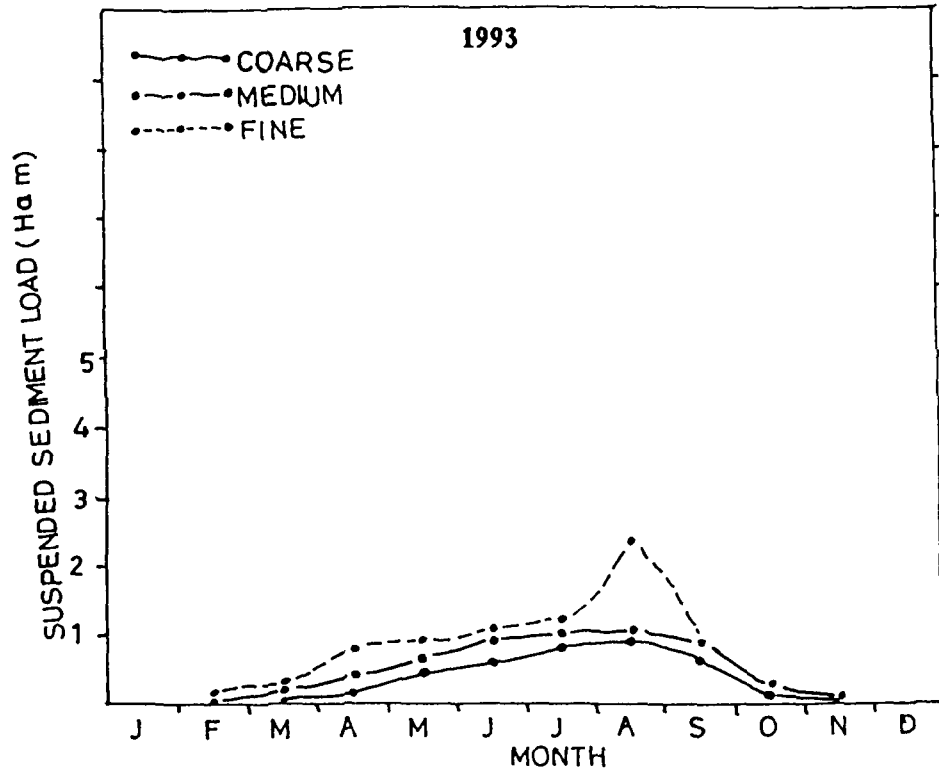


Fig. 5.23

SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

RANGANADI MUKH



SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

RANGANADI MUKH

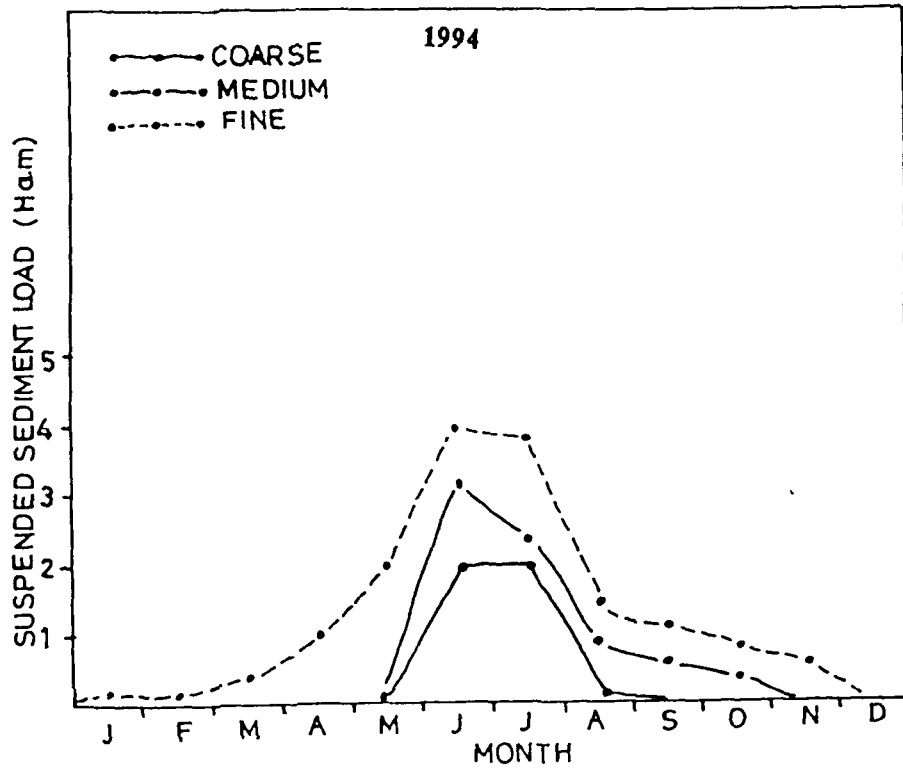


Fig. 5.24

SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

RANGANADI MUKH

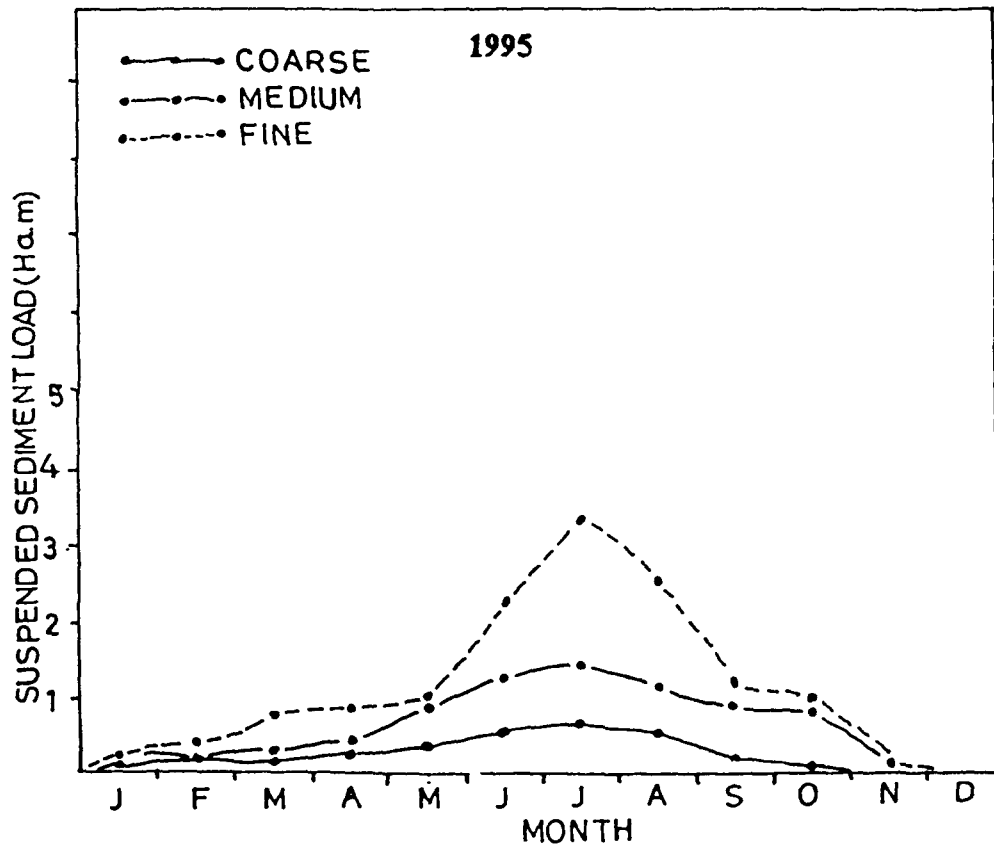


Fig. 5.25

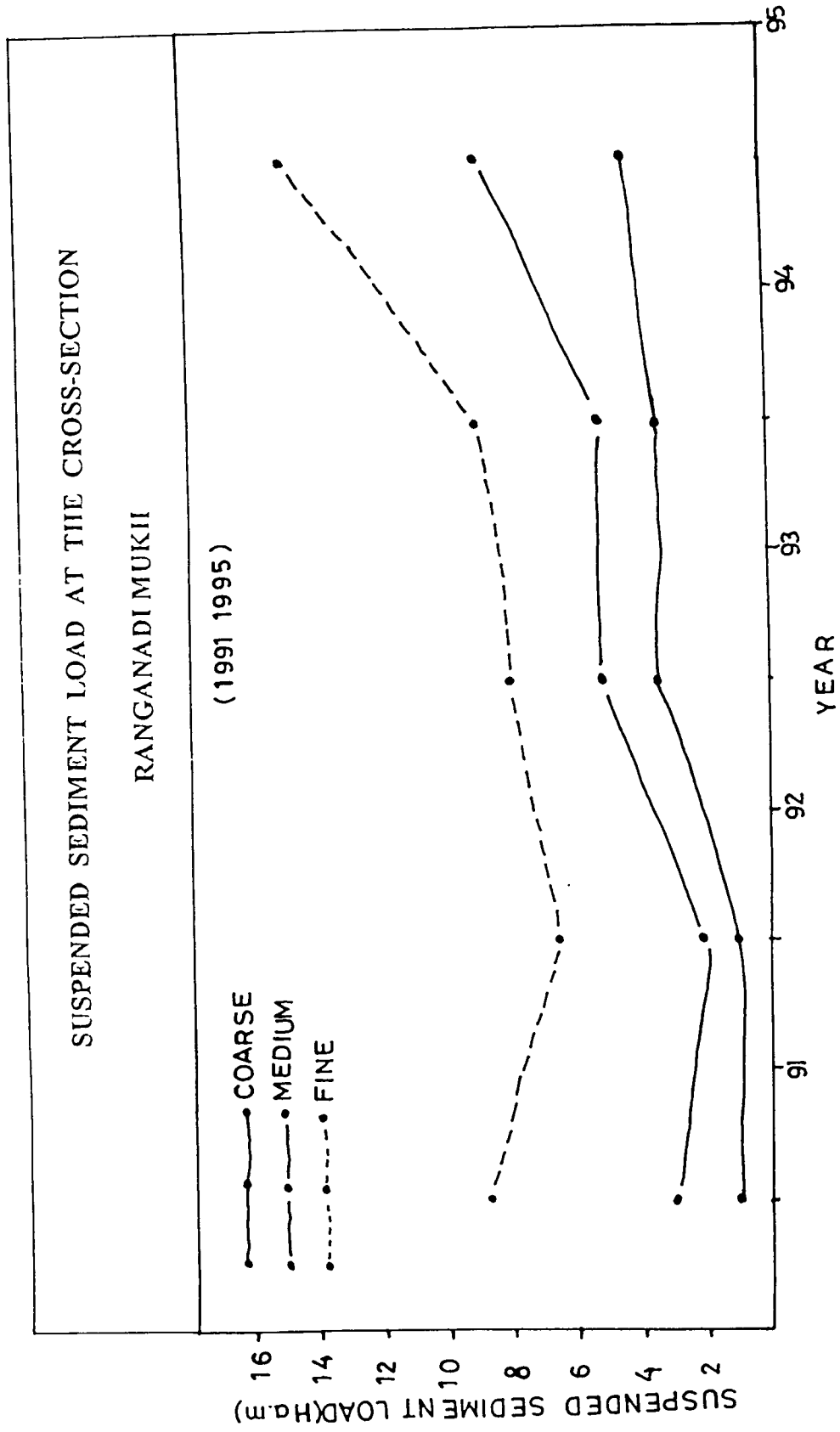
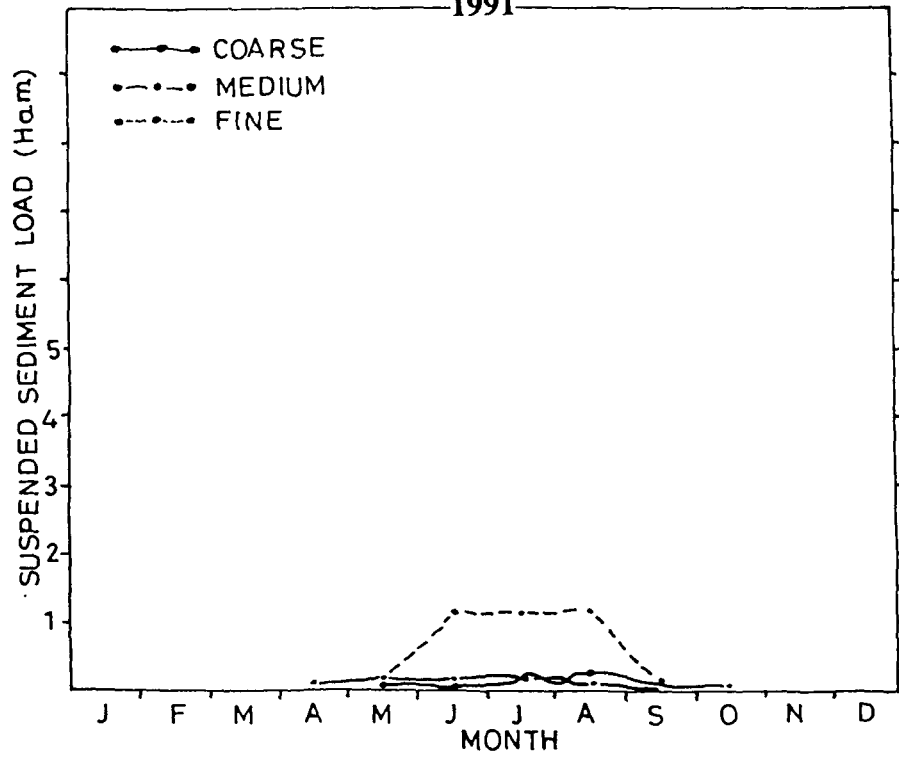


Fig. 5.26

SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

DIKRONGMUKH

1991



SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

DIKRONGMUKH

1992

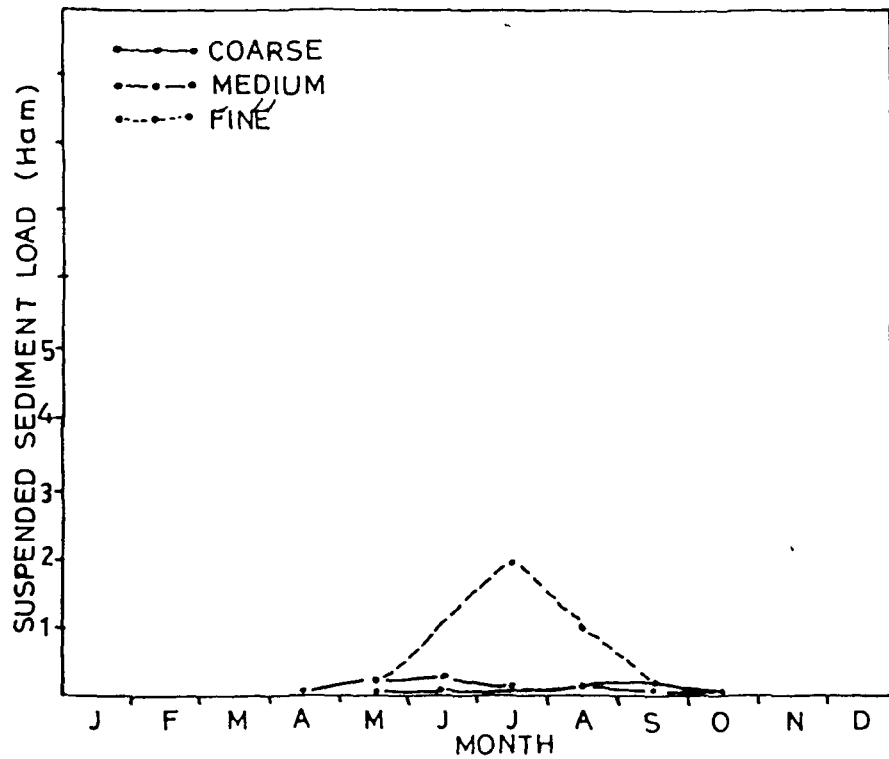
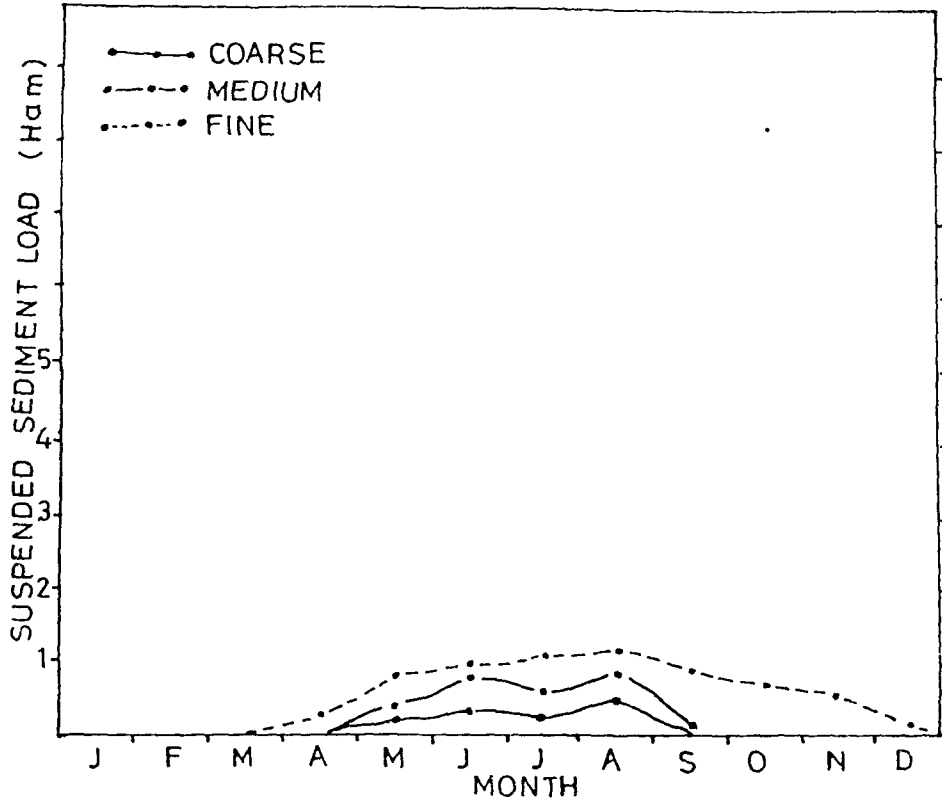


Fig. 5.27

SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

DIKRONGMUKH
1993



SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

DIKRONGMUKH
1994

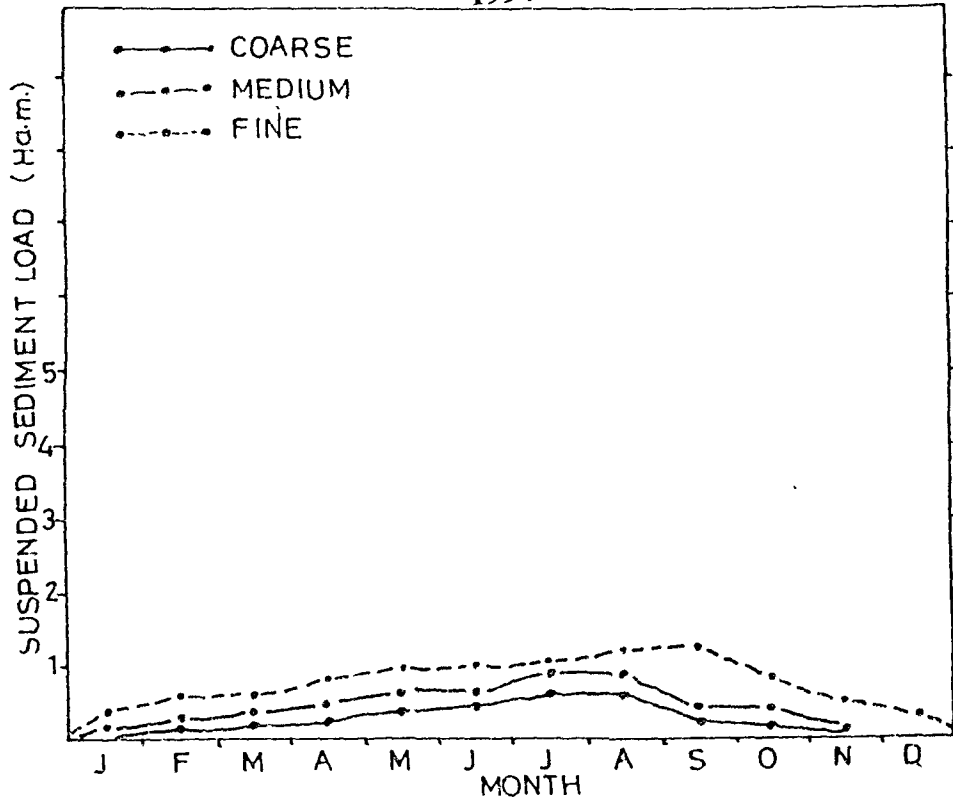


Fig. 5.28

SUSPENDED SEDIMENT LOAD AT THE CROSS-SECTION

DIKRONGMUKH

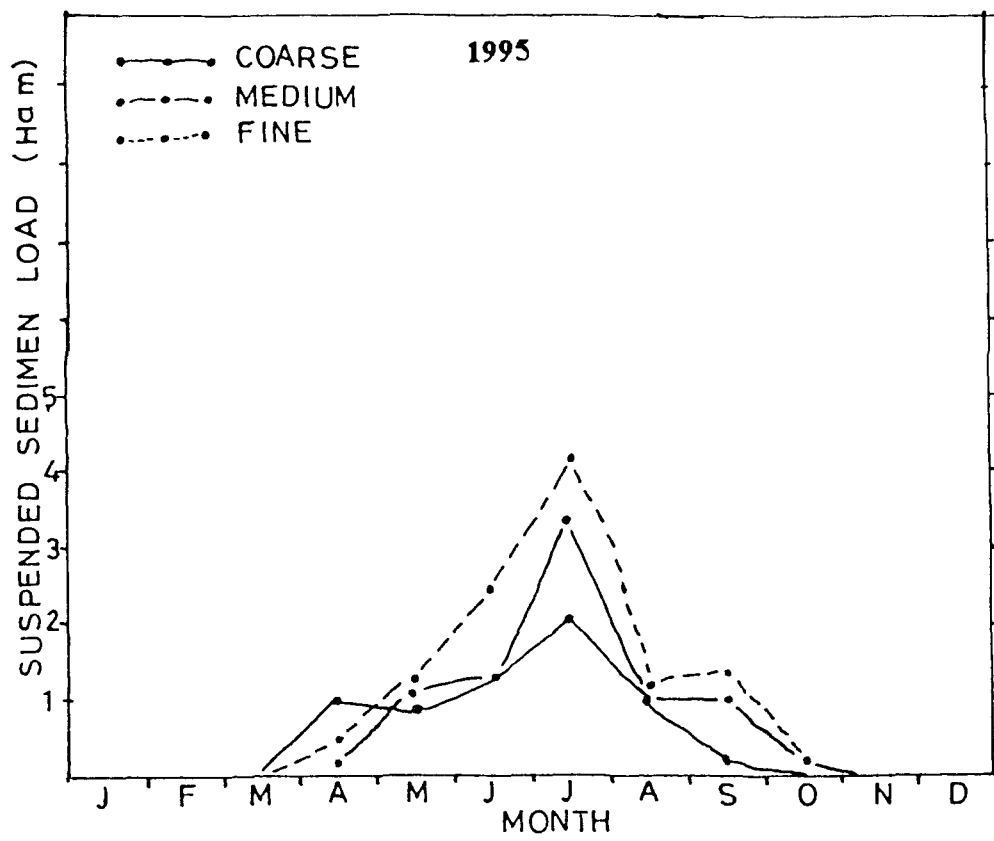


Fig. 5.29

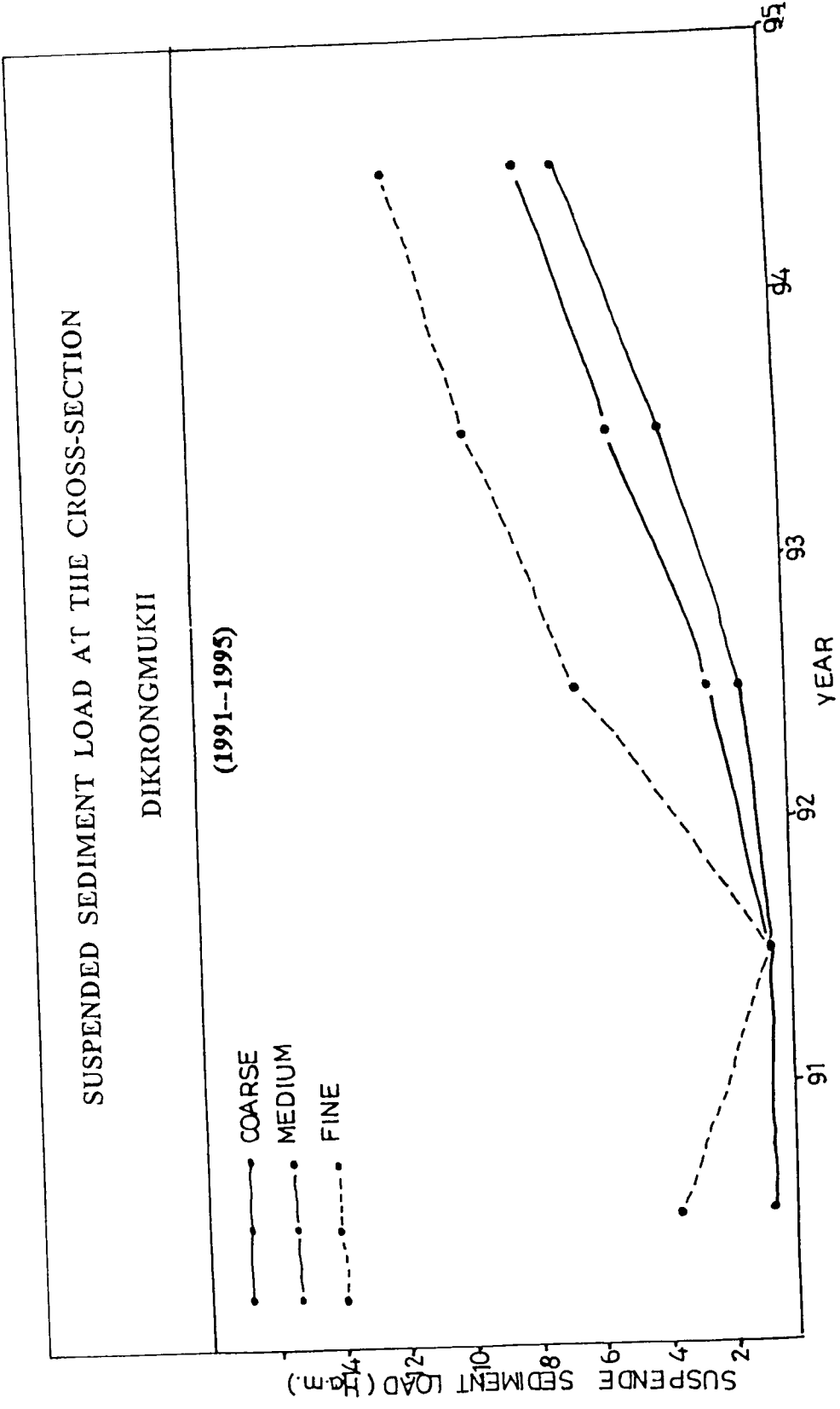


Fig. 5.30

Morphology of alluvial Stream

In the basin area there are innumerable streams which after traversing the Arunachal Himalaya debauch abruptly in three main valleys. There are three major streams namely the Subansiri, Ranga, and Dikrong which come across while moving from east to west. The last two rivers join the Subansirimukh above the confluence of the Subansiri with the Brahmaputra. Fig. (4.5).

The approximate length of these three streams in the alluvial plain is as follows:

The Subansiri is 175 km. Ranga 80 km. and Dikrong approximately 50 km. These are mainly meandering rivers and the table below shows the sector wise channel pattern from the foot hills to down streams as deduced from the sinuosity ratio Fig (1.1) table-5.9.

Table no. 5.9.

Subansiri		
Channel length in km.	Sinuosity ratio	Remark.
From foot hills		
0--20	1.08	Straight, braided pattern
20--40	2.01	Tortuous meandering
40--60	1.06	Straight
60--80	1.86	Highly meandering
Above 80	1.05	Meandering

Ranga		
0--20	1.10	Straight
20--40	1.41	Below the meandering stage
40--60	1.52	Highly meandering
60--80	1.95	Tortuous meandering
Above 80	1.90	Highly Meandering
Dikrong		
0--20	1.46	Just below the meander
20--40	1.90	Highly Meandering
40--60	1.25	Nearly Straight
Above 60	1.80	Highly meandering

From the above table (5.9) and Fig.(4.5) it is clear that the change of sinuosity ratio in these three rivers is due to the variation of high discharge and sedimentation, from one place to another to the velocity of river action.

Flood Hydrology and Frequency

The flood frequency analysis is one of the important studies of river hydrology. It is essential to interpret the past record of flood events in order to avail future probabilities of such occurrences. The estimation of the frequency of flood, rainfall etc. is essential for the quantitative assessment of the flood problem. Selecting the extreme value series on annual flood frequency analysis has been done.

The extreme value series has been obtained by selecting maximum value of the daily discharge of every year. The statistical distributions used for flood frequency analysis are:

- (i) The Gumbels Extreme value Distribution.
- (ii) The Long Pearson Type III Distribution
- (iii) The Pearson Type III Distribution

The distribution has been attempted by selecting peak, discharge data of 31 years. Brahmaputra Board estimated the returned period of floods at Chouldhowaghat is presented in table (5.10)

Result of Flood Frequency Analysis

Table no. 5.10

Name of site	Return period	Gumbels E.V. distribution	Pearson type III	Long Pearso type III
Chouldhowaghat	5	11,555	N.A.	N.A.
	10	13,169	13,109	13,074
	25	15,208	14,400	14,848
	50	16,720	15,235	16,120
	100	18,222	15,986	17,256
	200	19,718	16,676	18,574

Table 5.11

Statement showing flood waves and their duration above danger level for different years of river Subansiri at Chouldhowaghat

Location: Chouldhowaghat

Danger level: 90.40 m.

Year	SLNo. of waves	Duration above D.L.	From to	At 6 A.M
1976	1	4 days	14.6.76 to	17.6.76
	2	2	29.6.76	30.6.76
	3	1	1.7.76	
	4	10	2.7.76	11.7.76
	5	6	13.7.76	19.7.76
	6	1	on 19.8.76	
	7	4	23.8.76	20.8.76
1977	1	3	1.6.77	3.7.77
	2	9	12.6.77	20.6.77
	3	2	12.7.76	13.7.77
	4	7	21.7.77	27.7.77
	5	3	29.7.77	31.7.77
	6	2	1.8.77	3.8.77
	7	5	16.8.77	20.8.77
	8	3	26.8.77	28.8.77
	9	1	30.8.77	

1978	1	6	23.6.78	28.6.78
1979	1	1	on 29.6.79	
	2	1	30.6.79	
	3	7	1.7.79	6.7.79
	4	2	16.8.79	17.8.79
	5	2	24.7.79	25.7.79
	6	4	28.7.79	31.7.79
	7	2	1.8.79	2.8.79
	8	4	20.8.79	23.8.79
	9	4	28.8.79	31.8.79
	10	2	4.9.79	5.9.79
	11	4	6.9.79	9.9.79
	12	7	11.9.79	17.9.79
1980	1	4	9.6.80	12.6.80
	2	6	17.6.80	22.6.80
	3	1	On 4.7.80	
	4	15	9.7.80	23.7.80
	5	1	on 29.7.80	
	6	21	1.8.80	21.8.80
	7	5	25.9.80	29.8.80
1981	1	1	30.6.81	
	2	6	2.7.81	7.7.81
	3	6	15.7.81	20.7.81
	4	2	1.8.81	2.8.81
	5	2	22.8.81	23.8.81
1982	1	11	20.6.82	30.6.82
	2	1	1.7.82	
	3	26	6.7.82	31.7.82
	4	5	21.9.82	25.8.82

1983	1	1	8.6.83	
	2	3	9.6.83	11.6.83
	3	8	17.6.83	
	4	1	28.6.83	
	5	17	2.7.83	19.7.83
	6	8	21.7.83	28.7.83
	7	1	20.8.83	
	8	10	22.8.83	23.9.83
	9	1	1.9.83	
	10	12	8.9.83	20.9.83
	11	2	22.9.83	23.9.83
	12	3	27.9.83	29.9.83
1984	1	5	16.6.84	
	2	4	27.6.84	30.6.84
	3	21	1.7.84	21.7.84
	4	3	28.7.84	30.7.84
	5	5	1.8.84	5.8.84
	6	11	21.8.84	31.8.84
	7	3	1.9.84	3.9.84
	8	1	9.9.84	
	9	3	13.9.84	15.9.84
	10	8	16.9.84	23.9.84
1985	1	1	5.6.85	
	2	1	16.6.85	
	3	3	25.6.85	27.6.85
	4	2	29.6.85	30.6.85
	5	7	5.7.85	14.7.85
	6	9	5.7.85	23.7.85
	7	7	25.7.85	31.7.85
	8	5	23.8.85	28.8.85
	9	9	3.9.85	11.9.85
	10	3	28.9.85	30.9.85

1986	1	4	18.6.86	21.6.86
	2	7	24.6.86	30.6.86
	3	1	6.7.86	
	4	4	17.7.86	20.7.86
	5	1	20.7.86	
	6	2	3.8.86	4.8.86
	7	6	24.8.86	29.8.86
	8	1	31.8.86	
	9	5	12.9.86	16.9.86
1987	1	6	8.7.87	13.8.87
	2	5	24.7.87	28.7.87
	3	3	1.8.87	3.8.87
	4	2	15.8.87	16.8.87
	5	9	1.9.87	9.9.87
1988	1	4	28.5.88	31.5.88
	2	1	1.6.88	
	3	26	5.7.88	30.7.88
	4	3	1.8.88	3.8.88
	5	3	13.8.88	15.8.88
	6	13	13.8.88	15.8.88
	7	1	1.9.88	
	8	11	5.9.88	14.9.88
1989	1	3	7.9.89	9.6.89
	2	5	15.6.89	19.6.89
	3	8	2.7.89	9.7.89
	4	1	12.7.89	
	5	6	14.7.89	19.7.89
	6	3	29.7.89	31.7.89
	7	1	1.8.89	
	8	7	10.8.89	17.8.89
	9	2	22.8.89	23.8.89
	10	9	18.9.89	26.9.89

1990	1	6	7.6.90	12.6.90
	2	3	19.6.90	21.6.90
	3	6	22.6.90	27.6.90
	4	24	8.7.90	31.7.90
	5	4	1.8.90	4.8.90
	6	4	15.8.90	18.8.90
	7	2	28.8.90	29.8.90
	8	2	19.9.90	20.9.90
	9	3	24.9.90	25.9.90
	10	3	28.9.90	30.9.90
	11	1	1.10.90	
	12	1	3.10.90	
	13	2	10.10.90	11.10.90
1991	1	15	3.7.91	18.7.91
	2		8.8.91	13.8.91
	3	6	25.9.91	30.9.91
1992	1	3	24.7.92	25.7.92
	2	8	1.8.92	6.8.92
	3	15	8.8.92	17.8.92
	4	6	19.8.92	21.8.92
	5	3	22.8.92	25.8.92
	6	4	27.8.92	29.8.92
1993	1	14	24.6.93	29.6.93
	2	13	13.7.93	16.7.93
	3	9	19.7.93	23.7.93
	4	11	26.7.93	31.7.93
	5	16	1.8.93	1.8.93
	6	6	16.8.93	21.8.93
	7	3	25.8.93	28.8.93

1994	1	2	25.6.94	28.6.94
	2	4	29.6.94	29.6.94
	3	7	1.7.94	4.7.94
	4	16	5.7.94	11.7.94
	5	19	14.7.94	19.7.94
	6	26	22.7.94	29.7.94
	7	11	1.8.94	7.8.94
	8	6	11.8.94	14.8.94
	9	7	16.8.94	18.8.94
	10	5	22.8.94	29.8.94
	11	2	1.9.94	9.9.94
1995	1	3	22.6.95	22.6.95
	2	7	27.6.95	26.6.95
	3	11	1.7.95	7.7.95
	4	16	11.7.95	14.7.95
	5	22	15.7.95	19.7.95
	6	19	22.7.95	26.7.95
	7	14	27.7.95	2.8.95
	8	9	9.8.95	13.8.95
	10	6	15.8.95	17.8.95
	11	3	18.8.95	21.8.95
	12	4	23.8.95	27.8.95
	13	1	28.8.95	30.8.95
	14	1	1.9.95	4.9.95

From the table (5.10) it is observed that flood varies from 15,986cm³ to 18,222 cm³ in the hundred years by different distribution. It is recommended that the peak flood discharges of 18,222 cumese for 100 years return period by Gumbels distribution may be adopted for the highest observe discharge 18,785.54 cumese which has a return period of 130 year by Gumble distribution flood.

Drainage congestion and erosional problems

National Flood Control program was started in 1954, for management of floods in the Subansiri basin initially with construction of embankments and anti-erosion programme. When the Brahmaputra Board was established in the year of 1980s the problems of flood damage were considered seriously. By these embankments and antierosion were wash off due to the changes in the siltitation of the river. As a result the water overflowed over the constructed embankment of the basin.

A new embankment of 10 km was constructed on the right bank of Subansiri by the Brahmaputra Board to protect the overflow of the river Subansiri and Baginadi. The area likely to be benefited is around 16180 ha

The basin area has been facing some flood erosion problem for the last five years

- (i) Due to rise in the bed leading to overtopping
- (2) The embankments are not being maintained adequately again cut due to playing of bullock carts and grazing of cattle on the embankments
- (3) The villagers use the embankment as temporary shelter during flood time which also damage the embankments
- (4) Flooding in the lower embankment reach.

The excessive silt change attributed to the following facts.

- (i) Heavy rainfall (Table no.3.3)
- (ii) Steep slopes (Fig.4.4)
- (iii) Unique and fragile soil formation (Plate no 7.1)
- (iv) Deforestation (Table no.6.1)
- (v) Jhum cultivation in the hills (Plate no 1.1)

Drainage problems

There is a drainage congestion of about 15 cm in the jengri area in the left portion of the sub basin in the lower reach before its confluence with the Brahmaputra. The drainage congestion is due to backwater effects of the Subansiri. This is more acute when the Subansiri and Brahmaputra are in high spate (Fig. 4.3).

Erosion problems

The main causes of erosion in the basin can be summarised as below.

- (i) Heavy rainfall and fragile nature of soil in the hills (Plate 7.1)
- (ii) Wide spread practice of shifting (Fate 1.1) cultivation which accentuates erosion in hill sides
- (iii) Increase in population and consequent encroachment of flood plains

From time to time protection schemes have been taken up to prevent the erosion. The Subansiri right bank embankment from Bhimparaghat to Na ali village which is about 8 km. has been affected by erosion which requires immediate attention (Fig 4.8)

The Flood Scene in the basin area

The basin area has been suffering from serious flood and its associated problems since historical time mainly because of high monsoon rain and the existence of the mighty Brahmaputra, Subansiri and its tributaries flooding their narrow and constricted valleys. Floods in Assam have become more frequent and disastrous especially after the 1950s great earthquake, even though the average annual rainfall during recent years is found to be less by 25 per cent of the rainfall that had occurred during 1875-1970. The Subansiri

has more tributaries. All these tributaries and sub tributaries have been spotted by floods of different intensities at different times and location . Figure (4.8) shows the 5 years flood submergence zone of the basin area.

High occasional precipitation, decreasing carrying capacity of the channel, bank erosion, seasonal downward shift of the glacier snow of the Eastern Himalayas have been the major causes responsible for the occurrence of floods in the area The trend of flood occurrences has increased since the 1950's great earthquake. ✓

The floods in Assam have profound impact on land and people of the area Recurring floods in the lower Subansiri basin area causes extensive damage to crops, public and private properties and loss of human lives The flood damage data of the different years is furnished in the table (5 11)

The lower Subansiri river is unstable which carries a large volume of sediment and varying discharge. The problem of bank erosion, local aggradation, over bank spills inundation, changes in the river course and drainage congestion are some of the serious

problems of the area. The remedial measures to control the flood in this area are to be adopted after analysing the causes.

Table no..5.11

Flood damage assessment of report of the basin area

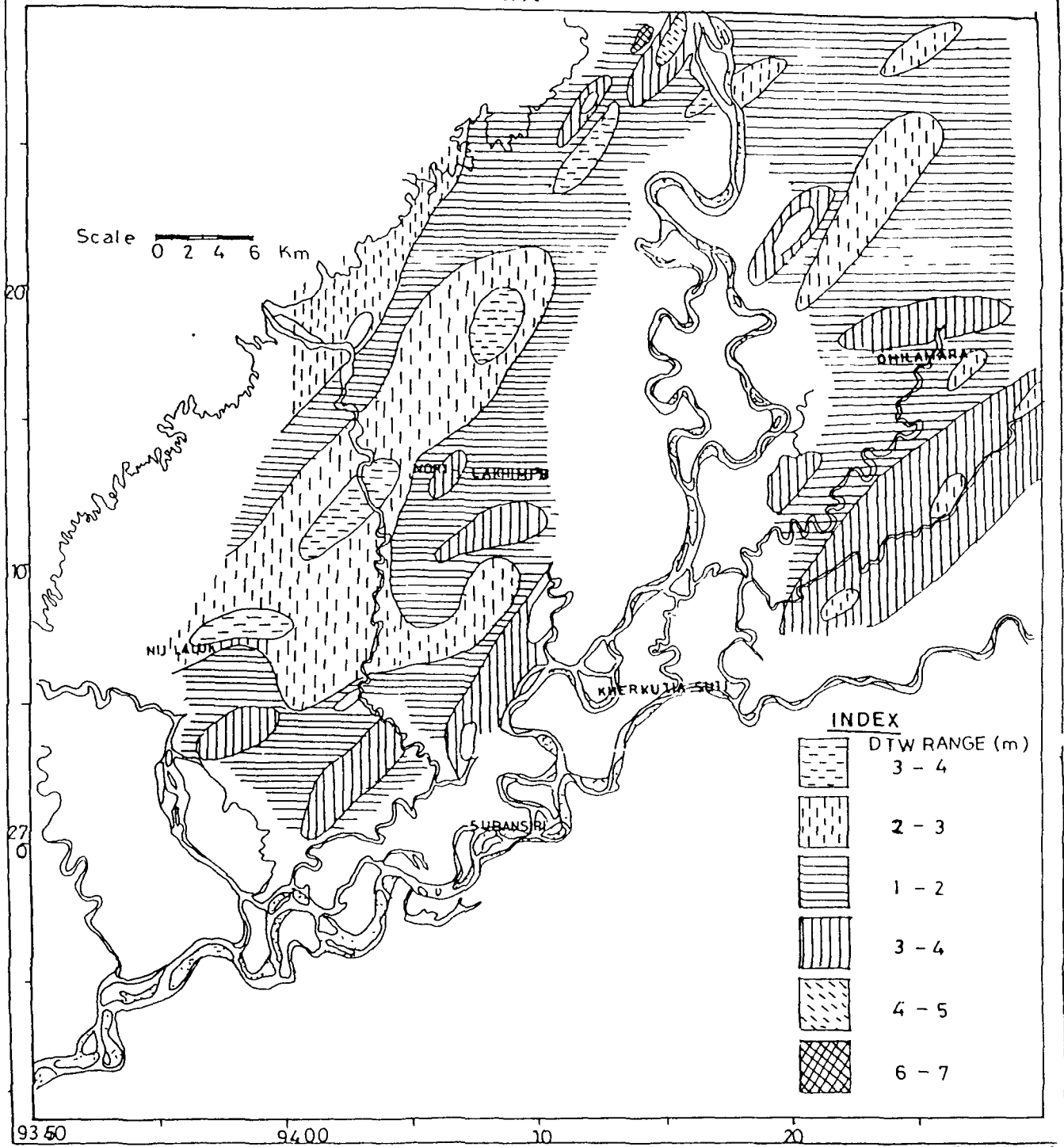
Area	Year	Affected area in hect.	No of affected villages	Populati on affected	No.of human lives	No. Of cattle lost	No.of houses damaged (fully)
Lakhimpur	1985	150	15	2609	Nil	Nil	14
	1986	1737.33	NA	10494	Nil	Nil	8
	1987	28340	NA	579.3	Nil	7	283
	1988	24000	NA	110000	Nil	76	98
	1989	40500	340	81000	Nil	14	132
	1990	25018	317	150310	1	1508	19978
	1991	74015	304	81000	2	251	1769
	1992	27818	236	247945	1	53	1611

Source: Brahmaputra Flood Control Commission, Guwahati-3.

Problems of the Area

- (i) Encroachment in the flood plains and extensive damage to agriculture(Fig 5 8)
- (ii) Drainage congestion due to accumulation of water from the upper side against the embankment during the high spate of river.
- (iii) Increasing of the bed level of tributaries of this river leading to over bank flow
- (iv) Increase in the soil erosion due to wide sprad practices of shifting cultivation, development works like road construction etc , earthquake, landslides, deforestation and high rainfall(Plate No 1.1;7 1) and (Table 3.3)
- (v) Earthquakes and landslides are causing rise in bed level change in drainage pattern and increasing congestion (Example 1950s earthquakes)
- (vi) Changes in the current direction at upstream location lead to erosion of the extensive land down stream, such channel change and shifting river island lead to significant change in the braiding pattern(Fig 4 10)
- (vii) Shiffig of the river causes, considerable change in the confluence of the tributaries(Fig.4.9 & 4 10)

DEPTH OF WATER ZONE, LOWER SUBANSIRI
 (JANUARY - FEBRUARY)
 1991



Source: Central Ground Water Board, Regional Centre, Guwahati.

Fig. 5.32

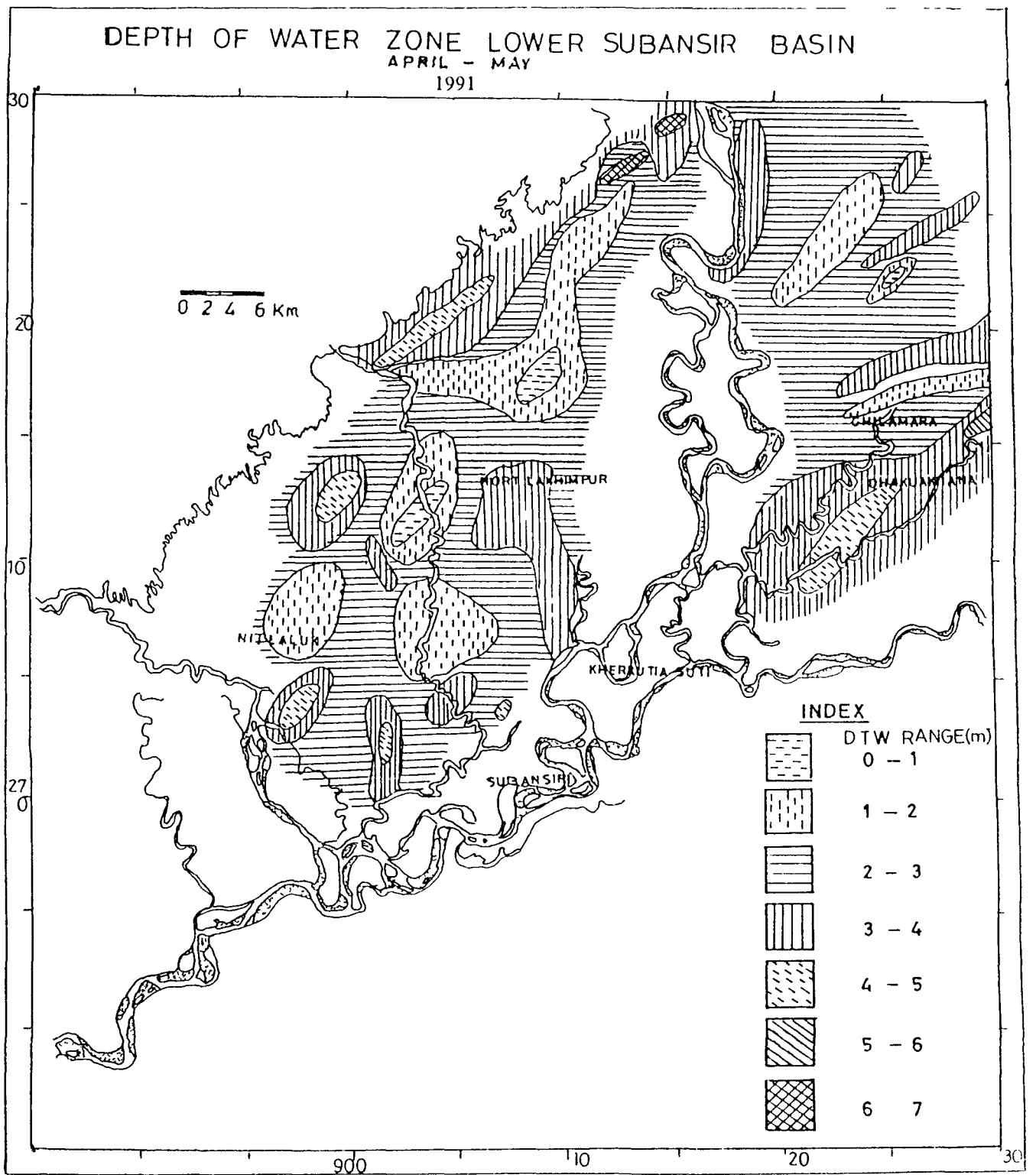
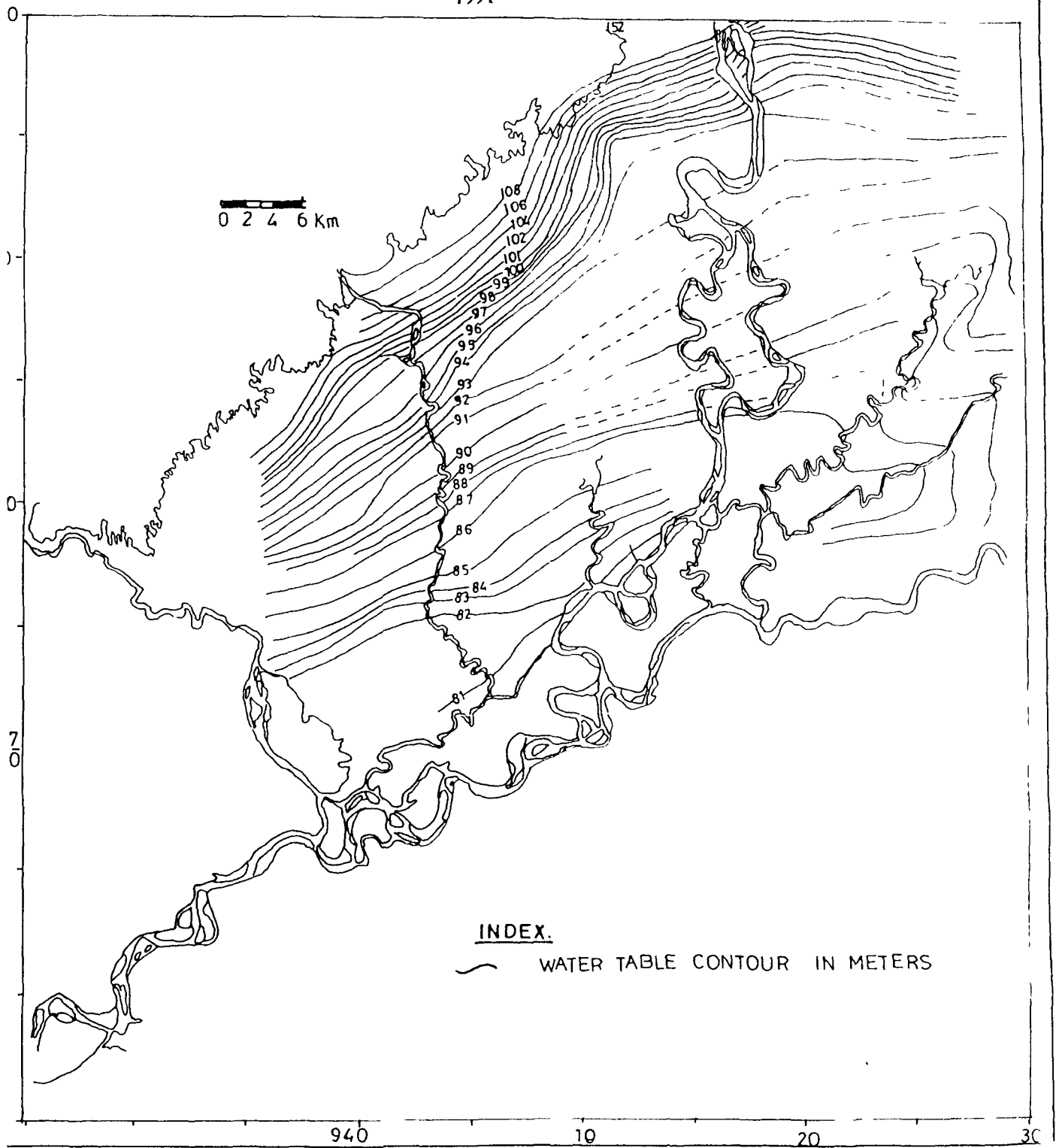


Fig. 5.33

Source: Central Ground Water Board, Regional Centre, Guwahati.

WATER TABLE CONTOUR OF LOWER SUBANSIRI BASIN
(APRIL - MAY)
1991



Source: Central Ground Water Board, Regional Centre, Guwahati.

Fig. 5.34

FREQUENCY OF CROSSING THE DANGER LEVEL OF
SUBANSIRI RIVER AT CHOULDHOWAGHAT

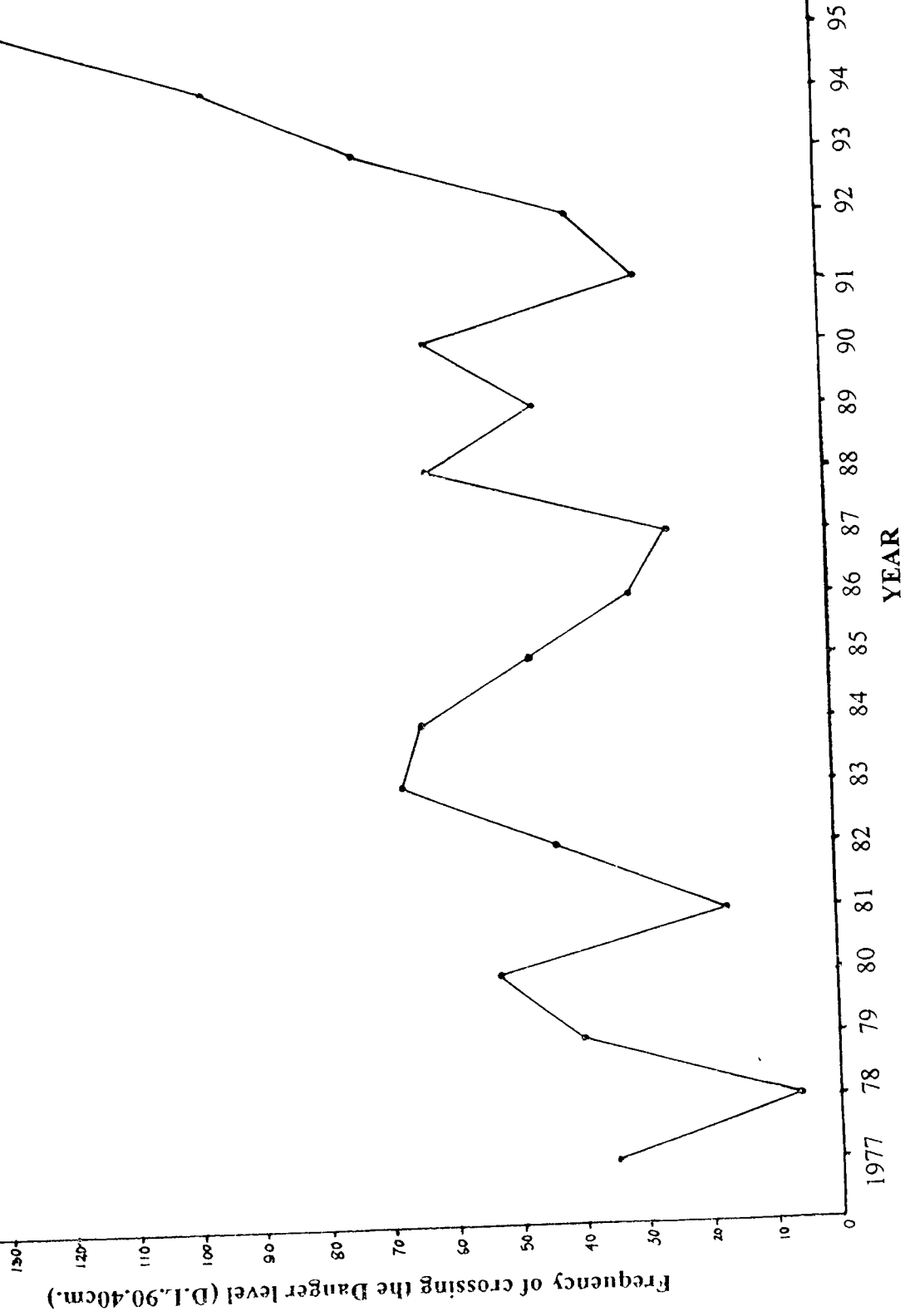


Fig. 5.35

Possible remedies

- (i) Plantation of fast growing vegetation along the bank to arrest bank erosion
- (ii) Flattenig of the natural bank may help in reducing the bank erosion

Ground water table in the study area

Ground water occurs under water table condition of shallow depth in the interconnection aquifer system of the area. The depth of water level ranges from 0.70m to 5.5m. in the pre-monsoon period and 0.51 to 1.50 m. in the mid monsoon period and also .60 to 5.50m in the post monsoon period. The minimum and maximum seasonal fluctuations recorded are 0.353 m and .75m respectively. (Based on data collected in April and August) Fig.5.32 & 5.33.

Because of absence of any tube-well or bore-hole in the entire area no specific information is available about the nature of deeper aquifer. The water table contour map (Fig.5.34) prepared for the month of January and February influence the nature of area. This is, of course is expected as the water in the coarse materials of the alluvial fan has migrated southward in to the finer material. South of the pediment zone up to the confluence of the Ghunasuti and the main flow of the Subansiri, the ground water and

river water is in equilibrium. Downstream of the confluence, the Subansiri becomes effluent and the effluent nature persist it to join the Kherkutia Suti. The master slope of the Subansiri river is towards south-east and the gradient is 1:3500 west of the Ranganadi river, the water table slope is more or less towards the south.(Fig.5.34).

East of the Subansiri in the northern part, the slope of the water table is towards south and gradient is 1:500. In the southern part the contour first takes as N-S and E-W turn indication effluent nature of the both *Koren* and the *Charikuna Nala*. Both these streams are perennial and ground water fed in the dry seasons. The ground water high in between the *Koren* and *Cherikuna* is a residual mound formed as a result of discharge of ground water both in the *Koren* and *Cherikuna Nala*. Thus due to increase in the flow the Subansiri offsets the river flow of ground water (Fig.5.34).

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CHAPTER – VI

ENVIRONMENTAL DEGRADATION AND ITS MANAGEMENT

Environmental geography is defined as the branch of geography, which studies the composition, and function of different components of the natural environmental system (including man as a biological organism). Man depends on different components, various processes of the component and the interaction of different components with each other and among themselves. The interaction of man with different components of environment and the natural processes result into certain modification and changes in them. Sometime causing environmental degradation as well. Therefore, man has to not only thought about how to utilise the environment, but manage pollution and degradation of environment

The environmental geography includes three basic aspects of environmental sciences, which are as follows:

- (i) Fundamental concept and aspect of environment and its relation with man and society, man and nature environment and society, ecology, and ecosystem, ecology and geography.
- (ii) Ecosystem and environmental degradation, pollution structure, component of ecosystem, energy flow in the ecosystem, biogeochemical cycles and circulation of matter in the ecosystem, ecosystem stability and unsuitability, spatial distribution of plant and

animal, nature and magnitudes of environmental degradation and pollution control programmes.

(iii) Environmental management concept and its classification assessment of ecological resources and planning of environmental management.

(iv) The general awareness to ecological imbalances has led the scientific world over to closely scrutinize development, related human activities. The indiscriminate and unscientific exploitation of land resources has posed serious threat to the various development linked utility services.

The uncoordinated exploitation of land resources lead to rapid environmental degradation ultimately causing severe soil erosion (Plate no.6.1 & 6.2). Soil erosion, sedimentation, and flood hazards are major environmental concerns of modern times. The magnitude of the problem could be realised from the facts that annual loss of agricultural land is high. This problem is very acute in hilly and upland region.

Causes of Environmental Degradation

Natural and anthropogenic activities are responsible for the degradation of the environment. But the role of the later is greater than the former. Anthropogenic activities include communication, multipurpose river projects, and establishment of industrial activities and implementation of the mining projects. Scale of degradation varies from

activities to activity. Communication affects the least area while mining and construction of multipurpose river projects affect the nature to a great extent. In multipurpose river project a large area of land comes under water which adversely affects the faunal and floral activities of the particular area. So we see that we have achieved development at the cost of the surrounding environment. Planned activities are more vulnerable to environment. The major factors, which are responsible for environment degradation are:

(i) Population explosion leads to the deficiency of food and shelter. (ii) Pollution affects the natural resources to a great extent. Pollution results from considerable activities, which is the result of development. (iii) Planning attributes (iv) Use of different unplanned work is a great threat to erode the optimum level of the environment

The series of environmental degradation is treated not only as an individual, but as a typical chain of events, which, leads to land degradation, hunger and poverty, ill health. This leads to migration to overcrowded cities, which by a series of positive feedback will generate future poverty.

Environmental Degradation and Geomorphic Processes

The term environmental degradation is the multitudes of natural and human activities and attributes in an area closely related to each other and interact with one another and determine to explain the various phenomena in a particular place. The relationship between external environment and human beings due to the development of science and technology is termed as humanization of nature. There are several environmental factors in the processes of humanization of nature, which create the social difference.

During the last two or three decades a global awareness has been created about environmental degradation. Initially the problem of environmental degradation is limited to indiscriminate felling of trees, upland cultivation, fast depletion of non-renewable sources of energy and atmospheric pollution through the industries.

Environmental degradation is inevitable under the operation of natural geomorphic processes. The resultant outcome is an equilibrium state at a given point of time. However the problem becomes grave or the imbalance comes to play when man interferes with the natural processes and accelerates these processes.

The chief geomorphic processes of environment degradation are:

- (i) Weathering
- (ii) Mass-wasting
- (iii) Erosion processes
- (iv) Soil erosion
- (v) Landslides
- (vi) Fluvial processes

In course of time, any terrain due to the impact of these processes tends to evolve landforms in a cycle, which is known as "Cycle of erosion". But the greed of man to harness natural resources must often then not over exploit the land resources. The land resources activity is mainly responsible for environmental degradation.

Weathering is the initial phase in the denudation history of the landscape. The surface rocks are weathered and running water transports the loose material. The process of erosion is very limited unless the agent of transport carries load debris. Physical and biological weathering has occurred in the area. This has been apparent from cracks between the rocks and growth of plant within the fracture of rock

Only a few centimeters of soil over the bedrocks that was formed within a few million years due to natural denudation of rocks is used for agriculture. But over use of land, deforestation and other mismanagement results in rapid soil erosion. It is estimated that world over in the next 20 years, an area equal to the entire cultivated area of India may be lost if soil erosion continues unabated.

Nearly 5 - 7 million hectares of good agricultural land are being eroded every year all over the world. The other causes of environment degradation of land are water logging and salinity. About 20% - 30% of the study area is subjected to serious environmental stress due to soil erosion, water logging and salinity. In the summer season maximum area is submerged due to flood.

Mass-wasting is an important gravity controlled movement of materials over the earth surface. This evolves slowly due to the sudden downward and out ward movement of material and perhaps is the most important agent that sculpture and reduces the earth surface. A landslide is one of the major causes of mass wasting, which are of profound interest to the earth scientists, environmentalists and engineers. A landslide unforeseen and improperly monitored may destroy settlements, buildings etc. Or structure like roads, bridges, etc. Or impair their usefulness. Thus bringing about sudden death to people. Due to large scale deforestation of arable lands and also by the active degradation by flood, huge

mass wasting occurs in the study area. The actual amount generated by these activities is yet to be determined.

During the summer season mass-wasting and landslides of this basin, sometimes create problem for the human beings. Sometimes connections are cut off from other station of North-East India. (Plate. No.5.2 and 6.1 & 1&2)

Landslides denote downward and upward movement of soil forming processes, which are primarily composed of natural rocks, soil, artificial fills or combination of this material. They are more frequent landslides where the development activities have modified slope profile. Particularly making the profile segment steeper in section. These make the slope unstable with a tendency to fall as and when the equilibrium is disturbed. Incidentally, all the activities of landslides in the area are uncounted along the foot-hills of Arunachal Pradesh in the river side. (Plate N.4.1 & 4 2).

Fluvial process is another most dominant geomorphic agent in sculpting the landscape of the area. The activities of stream or running water could be either erosional or depositional. Progressive dissection and degradation of the higher lands are carried by fluvial process. Due to erosion, different types of valley and inter fluvial ridges are formed

depending on the stage of development and the drainage pattern of the river and structure of the area.

FOREST (Area in Hect.) 1989-1990

Name of the Districts	Decedious Evergreen forest	Degraded forest	Forest Blank	Forest Plant	Mangrove	Total
Lower Subansiri & Papumpa Districts	1061260	0	87050	0	1106	1149416
Laakhimpur Dhemaji	36206	0	3239	0	0	39445

AGRICULTURE LAND (Area in Hect.)

	Built up land	Kharif crop	Rabi crop	Double shown	Net area cropped	Gross land	Fellow	Agr. Plant	Total
Lower Subansiri & Papumpa Districts	1690	4800	0	0	4800	4800	0	0	4800
Lakhimpur Dhemaji	546	304976	90875	88260	307591	395851	0	98709	406300

Data Source: NRSA , Deptt. Of Space, Govt. of India. Report on area statistics of land use/land cover generated using Remote sensing data.

The study area is a huge sprawling landmass made up of extensive countless hills and river valleys, which rise in the Arunachal Himalayas. It is the highest rainfall intensity zone of the country and richly endowed with water and other natural resources. However, the study area presents a grim picture on the growth of natural vegetation. This area has 70% of cultivable land mostly of which falls in the valley of the flood plain.

Flood is one of the most devastating natural calamities that have seriously affected the plain area of this region and affected the agriculture in a big way. Flood causes damage to the crops, soil, irrigation channel, livestock and wildlife. Increasing agricultural productivity and improving economy of the area means proper management of flood as well as management of land and water resources.

In this area the rivers, narrow valleys, steep slopes, fragile formations, heavy rainfall with long monsoon season, large population, high seismicity and many such factors create the problems of flood drainage congestion and bank erosion. These are further accentuated by increasing flood plain encroachment and other activity developments both in the plains and the hills.

Proposal for land and water Management to be Practised

As is well known the N E. region is endowed richly with water and land resources. The abundance of water received from the heavy rainfall in this region, combining with the steeply sloping hilly terrain has caused many problems and has so far not proved to be a boon. Jhum cultivation, involving the cutting and burning of forests as practised by the farmers in the hills has caused large scale land degradation, soil erosion.⁶ And loss of soil fertility ultimately resulting in the heavy silting of the river beds and flooding in the plains. The main drawback of this system of cultivation is resource degradation, environment damage, low productivity and the tendency to have large families.⁷ However inspite of drawbacks the shifting cultivation system still persist in the area. The farmers in this area have indigenously developed and adopted some unique farming system, which within a short span of time it provides highest production of crops from eco-friendly point of view. Paddy cultivation on bench terrace in hill with continuous flow of water. Apatani water management system and paddy cum fish culture are some of the innovative and eco-friendly practices prevalent on this area, for centuries, which need popularisation with a little improvement in agro-climatic conditions for enhancing agricultural production without any harm to resource conservation.

Role of Geomorphological factors in the Land-use management

When we study about the land use management of an area we see that geomorphological factors have a great role to play in the evolution of the existing land use pattern. The local people who have settled in this basin area for a longer period of time have selected better lands for their occupation and economic activities. The migrating people mostly use the hilly areas for cultivation. It is therefore seen that the hilly and low-lying areas are used differently. The plain areas are used for permanent cultivation. There is a corresponding relationship between the geomorphology and existing land use pattern to a large extent.

To mention the relationship, a little elaboration/explanation is required. The slope is limited due to obvious reasons of the area, Jhuming, which is practised on the slopes, have been proved to be uneconomical.

The plain areas are used for the settled food crops cultivation mostly due to the availability of modern mechanised form of cultivation such as tractors and power tillers, some time used for the preparation of the field beside the bullocks that have been used for a long time. Human occupation of land is very much guided by the physical and economic

reasons. It is clear that sometime natural environment is so much powerful that human efficiency is reduced, on the other hand the economy largely depend on the favourable, natural environment that human hands can not just guided itself to reach the projected destination.

The general awareness to ecological imbalance has lead to the development, which is related to the human activities. The indiscriminate and unscientific exploitation of land resource has posed serious threat to the various development linked to utility services.

The uncoordinated exploitation of land resources leads to the rapid environmental degradation ultimately causing severe soil erosion. (Plate No.6.1 & 7.1) Soil erosion and sedimentation is a major environmental concern in the study area. In the study area the environmental degradation has the following three aspects:

- 1) Deforestation
- 2) Upland Erosion
- 3) Wasteland

i) **Deforestation:** The deforestation is attributed to the timber exploitation and jhuming in the area (Plate No 1.1) It is responsible for the changing land-use pattern in the area. The peculiar problem in the whole of North-Eastern region is that much of the forest is owned by public or community organisation. The nodal agencies have little say in the

management of forests in this part of the country. The classification of forests of area are given in the table no.6.1.

Forest though a renewable resource has not been exploited in a sustained manner. Lack or slow growth of industries in the region made forest resource exploitation an easy income-generating proposition. The public ownership of forest lead to their rapid and indiscriminate exploitation as it provides easy remuneration with low financial inputs. The situation has aggravated due to jhuming practice on slopes in the region. The resulted scenerio is the huge tracts of deforestation. According to statistical handbook of Assam and Arunachal Pradesh (1989-90) , the forest area is less than as compared to other states of North East India (Table No.6.1).

To evaluate the damage due to deforestation and flood hazards in the area, the landuse pattern variation has been studied. The flood damage assessment is varying every year. (Table No.6.1)

It should be mentioned here that the primary forest of the area has almost disappeared. Yet present forest represents secondary small trees only. These secondary small trees are also under indiscriminate exploitation. As a result large patches of deforested land is visible on the slopes and forests older than 20-30 years

2) Upland erosion: Upland erosion is related to rainfall and is also known as fluvial erosion. It is one of the most fundamental and universal processes occurring on hill slope and loose soil forming. Management of soil and water resource in hilly and upland track has assumed paramount importance. The deforested areas are prone to rapid soil erosion because, the area does not have “canopy” protection. This results in higher “raindrop impact” induced soil erosion, and loose soil forming factors.

Soil erosion causes problems as well as on-site degradation (Plate No.5 2 & 9.2) Sediments from erosion can cause downstream sedimentation by filling distance reservoirs or nearby road ditches. Soil erosion is a diffused process having widely varied rates over a landscape.

Therefore, direct measurement of soil erosion at a number of points is impracticable. It requires atleast 10 years of data to be collected for the best conditions to obtain an accurate measurement of annual soil erosion (Foster, 1988)

According to Walling (1988), abundant sediments yield data on global basis is available. But such data normally returns to the suspended sediment load of the river. The bed load component is not included because of the practical difficulties in obtaining such measurement.

Global maximum yield of sediment of 25,000 t/km²/year is reported from Dali river, China from a drainage area of 96.1 km². Values less than 1.0t/km²/year are reported from several rivers of Poland. The Dali river represent soil erosion rate of the order of 250 t/km²/year.

Soil erosion in the study area

The principal kinds of erosion in the area are:

- i) Sheet erosion (Plate No.6.1)
- ii) Rill erosion (Plate No.6.1, 6.2 & 9.2)
- iii) Concentrated flow
- iv) Gully erosion (Plate No.5.2,6.1 & 6.2)
- v) Stream channel erosion (Plate No 9.1)

The area has presently followed land-use pattern, the change in landuse during the period of last 50 years is shown in the table no.6.1

- i) Forest land
- ii) Agricultural land
- iii) Township
- iv) Deforested land
- v) completely deforested land

The estimates of soil erosion for these different land-use patterns are not available. However an idea of total soil erosion can be taken from published data estimated for analogous areas.

Landuse /Land cover categories and their spatial distribution in the study area

This major landuse/land cover categories that are identified in the study area are built-up land, agriculture land, forest land, wasteland, waterbodies and other. The area occupied by each of these major categories is shown in the table no 6.1

Table -6.1

Sl no	Categories	Area in (ha)	% to the total geographical area
1	Built-up land	567.00	0.19
2	Agricultural land	225730.00	75.04
3	Forest land	22518.00	7.49
4	Wasteland	4888.00	1.63
5	Waterbodies	14310.00	4.76
6	Others	32432.00	10.78
	Total	3000300.00	100.00

Source:-Assam Remote Sensing Application Centre, Guwahati.

The detailed landuse/land cover statistics of the area for the years 1986-87 is given in the table 6.2 and their brief description of the landuse classes in each of the major categories are as follows

Table 6 2

Land use /Land Cover Statistics, Lower Subnsiri/Basin

Sl No.	Category	Area in ha.	Percentage to total Geographical area
1.	Built up land	567.00	0.19
2.	Agricultural land		
	i. Kharif	165542.00	
	ii. Rabi	56222.00	
	iii. Double cropped Area	53603.00	
	NET AREA SOWN	168161.00	55.90
	2.2 FALLOW		
	2.3 Plantation	57569.00	19.14
3.	FOREST		
	3.1 EVERGREEN/ SEMI EVERGREEN FOREST	20889.00	6.94
	3.2. Deciduous Forest or Scrub Land		
	3.3 Degraded Forest	1629.00	0.54
	3.4. FOREST BLANK		
	3.5 Forest Plantation		
	3.6. Mangrove		
4.	WASTE LAND		
	4.1. Salt affected land		
	4.2 Waterlogged Land.		
	4.3 Marshy/Swampy Land	4109.00	1.37
	4.4 Gullied/Ravious Land		
	4.5. Land with or without Scrub land	779.00	0.26
	4.6 Sandy Area (Coastal & desertic)		
	4.7 Barren Rocky/ Stony Water/Sheet Rock Area		
5.	WATERBODIES		
	5.1 RIVER STREAM	1410.00	4.75
	5.2 Lake/Reservoir/ Tank/Canal	355.00	0.12
	5.3 River sand		

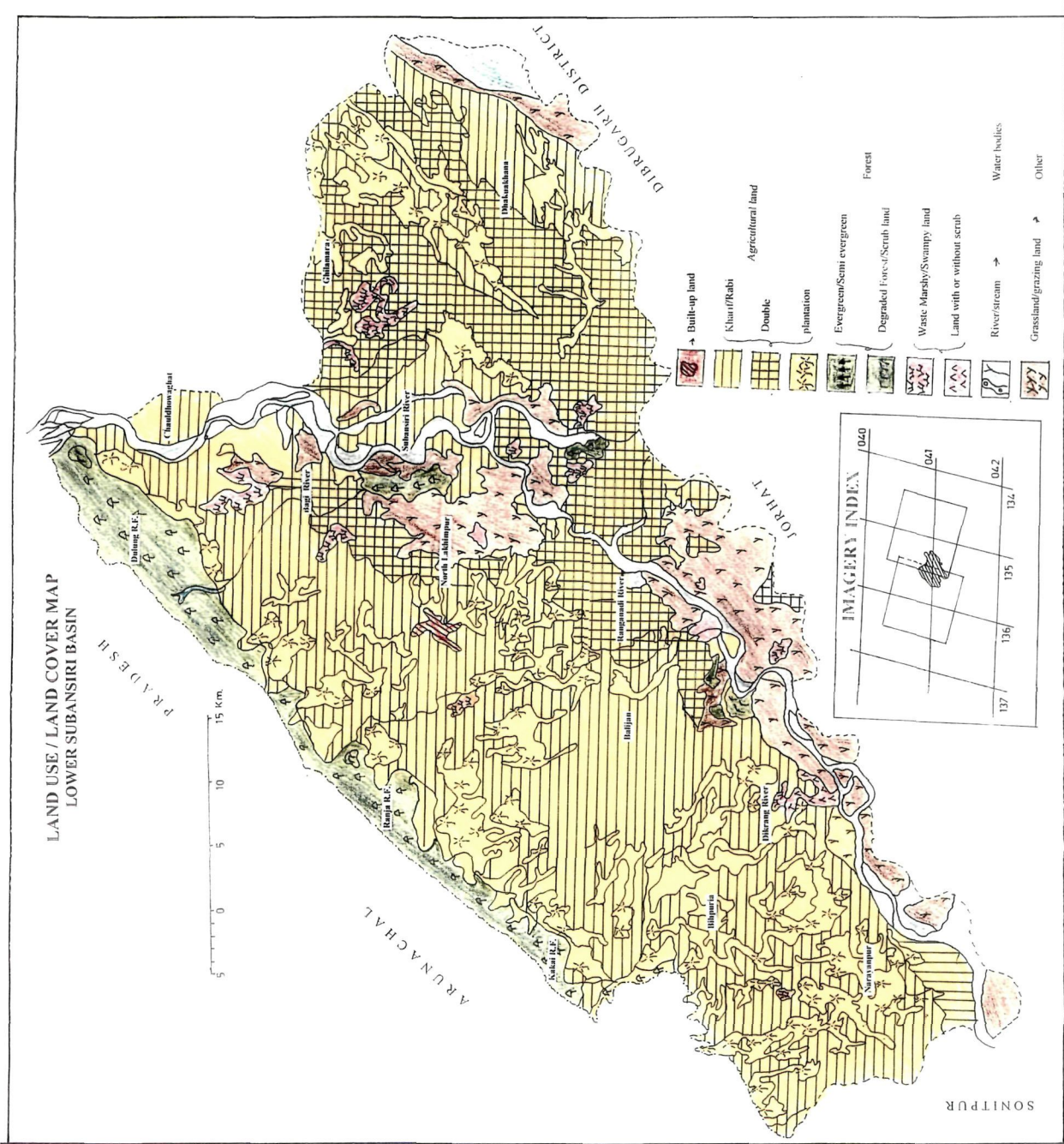


Fig. 6.1

6.	OTHERS		
	6.1 SHIFTING CULTIVAGTION		
	6.2 Grass Land/ Grazing Land	32432.00	10.78
	6.3 Snow Covered Glacial Area		
	6.4 Mining area		
	TOTAL	300800.00	100.00

Built Up Land: Only big town Lakhimpur could be delineated and mapped in to their large area coverage. Other medium and small/minor settlement could not be mapped due to the scale factor. It appears in the landsat(TM) imagery as dark bluish tinge. The area under this category is 57 hectares and accounts for 0.19 percentage of the total geographical area.

Crop area(Kharif Season): The image of November, 1986 clearly reveals that the kharif crops includ mainly sali paddy . These crops appear on landsat(TM) image in distinct red colour as uniform patches and discrible for the purpose of mapping The area occupied by the kharif crop is of the order of 1,65,542 hectares and accounts for 73.34% of the total geographical land Table 6.3.

Crop area (Rabi Season): Paddy, mustard, winter vegetable, etc are the main crops cultivated during Rabi season in the area Since the imagery of the Rabi of the Rabi season is not proper, so in some areas though it appears fallow, after ground verification the

information incorporated in mapping. The area occupied by Rabi crop is 24.91% of the total agricultural land (Table 6.3)

Double Crpped area: All these area where crops are grown more than once in the agricultural year 1986-87 have been included under this category. It is clearly evident from the study that the double cropped areas lie in the eastern part of the area. The area estimated in this category is 23.75% of the total geographical area.

Agricultural Plantation: This category includes mainly tea garden and arecanut, banana plantation and bamboo groves. The houses in the villages are surrounded by all these trees. The area under this category is account for 73.04% of total agricultural land (Table 6.3).

Forest: All of the forest of the area fall in to the evergreen/semievergreen category and take a strikingly prominent appearance in the Ranja, kakai and Dulung reserve forest. Halong, sam are the major species around in the area. The total area under this forest is 7.49% of the total geographical area. (Table 6.1).

Water bodies: River/stream, ponds lakes include in the categories of waterbodies. River sands are also included in this category. The water bodies appear in the imagery in black

to dark colour and easily discernible for the purpose of the mapping. The area estimated to be covered by river is around 4.76% in the total geographical area table 6.1.

Environment involves everything, living or non-living, that surrounds us, for example, air, land, water, people, plants, animal, minerals etc, therefore, an overall system of management is required to integrate our efforts in this direction.

Every one of us has a right to live in an environment of quality. Therefore, it is essential to understand the function and interaction of physical and biological elements of the environment and apply this knowledge in sound management programme to conserve the natural resources and culture. Management of renewable resources is necessary to continue the development activities. In Assam a major portion of land is affected by flood. The conservation and maintenance of natural resources can be possible through proper management. It is more prominent in developing countries where degradational activities are moving fast. The important aspects in which environmental management is necessary are as follows:

- i) to create a pollution free environment
- ii) to protect living organisms from pollution
- iii) to protect the bio-diversity of globe

- iv) to establish co-ordination between government and non government organisation to protect the environment.
- v) to analyse the impact of developmentl plans on the environment.
- vi) to help in formation of natural and regional environmental policies

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SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The Subansiri River is a major tributary of the mighty river Brahmaputra. It originates at an altitude of about 5000m in the Great Himalayan range in Tibet that is also the source of many mighty rivers. The principal streams of the Subansiri belong to Chu group of the Nye chu, in the upper reaches, which may be considered as the main source of the river. The major tributaries of the Subansiri river originate in the snow clad peaks of Kasreng., Shobota, Baru and Meta. Every year devastating flood take place in the river basin area in multiple waves affecting the economy of the people and often caused much loss of life and property. The erosional activity of the river, mainly of bank-eating type, resulting frequent changes in the course of the river that makes the situation worse. The present study focused on identification of some of the geomorphic features and natural hazards, which are most responsible for the adverse situation of the area.

The catchment area of the Subansiri basin has an extensive mountainous terrain of about 9636 km² out of the total basin area of 27,000 km². Physiographically Subansiri basin comprises of rugged hilly terrain, therefore, rivers gush down with high speed due to the high gradient of the slope. The fall in gradient of rivers are quite significant and on an average there is a fall of 2500 m to 150 m within a distance of 75 km to 100 km. About

4000 km² catchment area in the mountain region lies above the snowline therefore, in the upper reaches river Subansiri and tributaries are fed by melting of ice and snow. However, in the lower part of the basin it receives very high rainfall of an average of 400 cm per year

The geological formations of Subansiri basin are complex one. The rock types of the area belong to highly sheared Gondwana shale, phyllite, carbonaceous shale and the tertiary rocks consisting of mainly soft sandstone which are prone to landslide. These are the exposed soft rocks in the outermost hill ranges which contribute enormous quantity of sediments to the basin area. The large plain and low lying area which covers an area of 2,700 km² in Assam and Arunachal Pradesh. The fall of gradient from the foot-hills to the Brahmaputra river in the south is very low.

During the monsoon period, due to heavy rain in the catchment area, some times for days together, the discharge of the Subansiri and its tributaries increase suddenly. This is accentuated by the melting of ice in the upper reaches. The heavy rain also led to the increase of landslide and rockslide which so often takes place in the outermost hill ranges. Thus the river receives large discharge with sediments and carries it through the hilly terrain. But as soon as it debauches in to the plain the gradient of the river bed falls abruptly and the sediment carrying capacity of the Subansiri river and its tributaries decline resulting

in deposition of sediments along their channels. The river starts meandering only a few kilometers away from the foothills. The increase in volume of water of the river spills out and inundate vast area. The situation becomes worst when there is also heavy rain in the plains. The remedy to this is the construction of embankments along the river banks. Sufficiently high and away from the bank so as to accommodate the increased volume of water and sediment during the flood. Regarding the bank line stability it may be stated that the large discharge and heavy sediment load cause the rivers to be extremely unstable and the channel consistently migrate laterally. But the Subansiri and its tributaries being mainly meandering rivers the changes and migration pattern are fairly predictable since the rivers cut on one bank and deposit on the opposite. It can be effectively controlled by timely construction of suitable dykes.

The river is floored with quaternary sediments ranging in size from boulder to clay which provide materials for the formation of good aquifers. Due to the absence of boreholes and geophysical data, the exact thickness of the deposited sediments and the bed rock topography are not known. This data is essential for an accurate quantitative estimation of ground water in the area.

Ground water in the area occurs under water table condition in the shallow aquifers. The gradient slope of the water table is from north to south. The hydraulic gradient is highest in the pediment plain and decreases progressively southward. The water table becomes almost flat near the Brahmaputra. Though nothing is known definitely about the deeper aquifers, the impersistent nature of the aquifers indicates that they are in hydraulic continuity with the shallow. From the water level data, it indicates that water table is deepest in February - March and the shallowest in the month of July - August.

From the environmental point of view, it can be summarised that the area suffers from extensive landslides affecting the road connection. In addition to this heavy soil erosion and submergence of large area under the flood water especially during the rainy season accelerated further degradation of environment in the entire region.

RECOMMENDATIONS ON ENVIRONMENTAL MANAGEMENT

After the detailed field study of the area it is noticed that the environmental degradation has been taking place to a great extent. Some of the important recommendations are given below for the proper and timely management of the environment as a whole, so that no further ecological imbalance is created in the region.

- (i) In the catchment area, to check vigorous soil erosion, large scale planned afforestation programme should be undertaken by the Forest Department, Govt. of Arunachal Pradesh.
- (ii) Ban on all constructional activities along the NH - 52 should be put to prevent initiation of landslides.
- (iii) Terrain characterisation should be made, based on geomorphic parameters to identify different landslide prone areas for rationalising landuse in the area.
- (iv) The landslide muck should not be dumped as it enhances silting problem in the basin area. Suitable schemes may be formulated to dispose off this muck.
- (v) Keeping in mind the seriousness of silting problems of the basin area the government agencies and NGOs should initiate a correct assessment of silting taking place over year and accordingly take the remedial measures to minimise the silting and the landslide problems.

Photographs of Lower Subansiri Basin



Plate :1.1

Clearing of Hill Slopes for Jhum Cultivation



Plate :1.2

Steep unstable road side exposure



PLATE: 3.1

Collection of sand and gravels for commercial purpose from the river banks



PLATE: 3.2

Collection of sand and gravels for commercial purpose from the river bank



PLATE: 4.1

Favourable compact rock mass for road side cut



PLATE: 4.2

Unfavourable friable weathered rock mass for road side cut



Plate : 5.1

Jointed rock mass Landslide prone zones along road cuts



Plate : 5.2

Jointed rock mass Landslide prone zones along road cuts



Plate : 6.1

River bank erosion



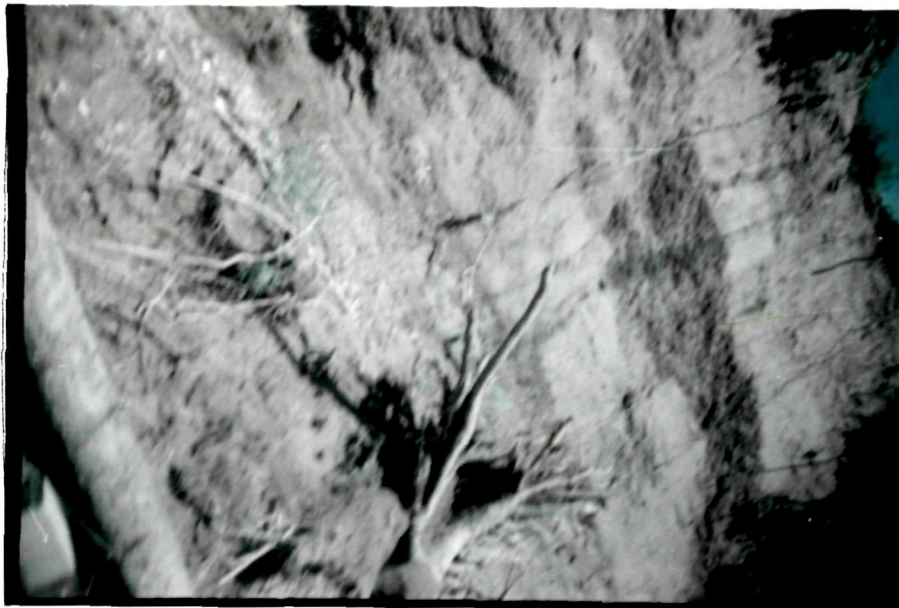
Plate : 6.2

River bank erosion

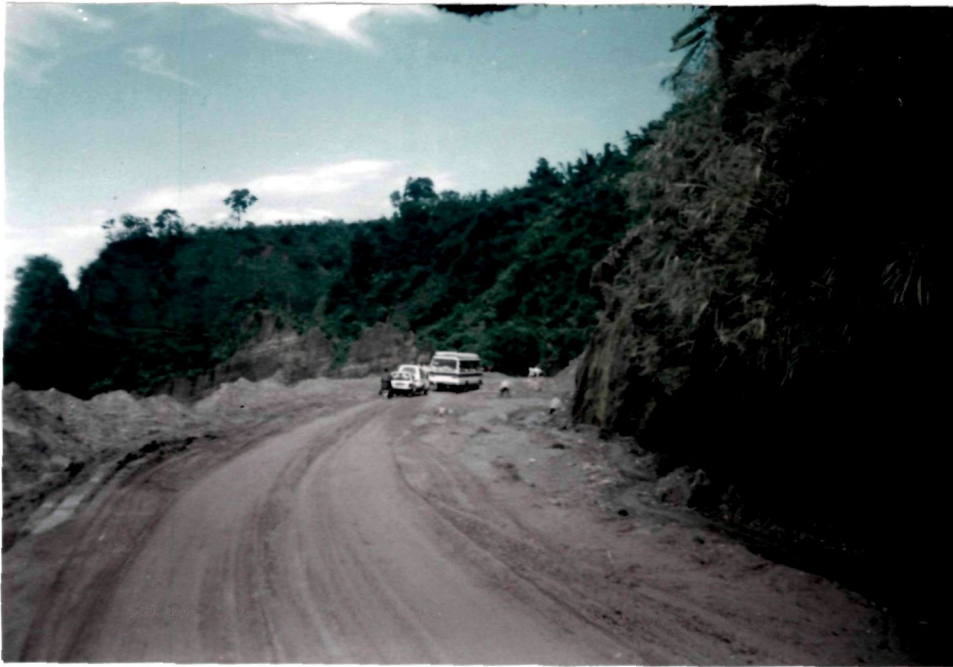


Plate :6.1

Gully erosion along the river (road Side)



Gully erosion



Detariorating road condition due to landslides



Plate : 7-1

Detoriatng road condition due to landslide



Plate : 8.1

A typical westland in the Lakhimpur district



Plate : 8.2

Bifurcation and channel mid bar of Subansiri River



Plate : 9.1

River bank erosion



Plate : 9.2

A typical water and Channel mid bar



Plate : 10.1

Landslides due to cloudburst



Plate : 10.2

Landslide due to cloudburst

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