Land Systems : A Case Study in Applied Geomorophology in Trivandrum District, Kerala

Dissertation submitted to Jawaharlal Nehru University
in partial fulfilment of the requirements
for the award of the Degree of
MASTER OF PHILOSOPHY

GOPALAKRISHNAN S.

CENTRE FOR THE STUDY OF REGIONAL DEVELOPME
SCHOOL OF SOCIAL SCIENCES
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI - 110067

1989

जवाहरलाल नेहरु विश्वविद्यालय
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI - 110067

Centre for the Study of Regional Development

School of Social Sciences

D E C L A R A T I O N

Certified that the dissertation entitled "Land Systems: A case study of Applied Geomorphology in Trivandrum District, Kerala " submitted by Gopalakrishnan, S., is in partial fulfilment of the requirements for the award of the Degree of Master of Philosophy of this University. The dissertation has not been submitted for any other degree of this or any other University. This is his own work.

We recommend that this dissertation be placed before the examiners for valuation.

(Sanjay Kumar Chandra)
Supervisor

Kusum Chopra
(Kusum Chopra)
Chairperson
21.7.89

Dated: : July 1989

GRAM : JAYENU TEL. : 667676, 667557 TELEX : 031-73167 JNU IN

ACKNOWLEDGEMENT

I wish to place on record my heartfelt gratitude to my supervisor Dr.Sanjay Kumar Chandra for his constant guidance and encouragement.throughout the study. I feel greatly obliged to Dr. Padmaja for discussing my study and for all other help. I thank Dr. Sivasawmi for his valuable help and encouragement.

I wish to thank all the teachers of the Centre for their excellent course work and every other help. My thanks are also to the non teaching staff who were always ready to oblige me.

I wish to thank Dr. Ramakrishnan, Director, Centre for Earth Science Studies, Trivandrum for every facility extended to me. My immense gratitude to Dr Dr. Srikumar Chattopadhyay and Dr. Shravan Kumar for their active encouragement and help while at the above Centre. I wish also to thank Mr.Raju, Mr.Jayaprasad and all others who helped me while needed.

I thank Mr.Surendran, Deputy Conservator of Forests, Trivandrum, for granting permission to enter the Neyyar Wild Life Sanctuary.

I wish to thank Prof. Mr.Walter Rose, presently Head,oGeography Department, Government College Chittur for his encouragement lend to my academics and in general.

Further, I wish to thank my friends Mr.Saleel, Sreekesh, Mohanachandran, Somnath Bandopadhyay and to Miss. Sobha and Miss Meera, for all their encouragement.

My thanks are also to the various librarians of the libraries I visited during my study.

Last but not the least, my gratitude to my mummy and my younger brother Unnikrishnan, for their excellent understanding and sharing of my troubles.

Gopalakrishnan S.

15th June 1989
New Delhi.

(GOPALAKRISHNAN.S.)

Author

LIST OF PHOTO PLATES

Highland Region

Plate No.1	Wet Evergreen Forest with climbers and lianas
Plate No.2	Tribal Homes and subsistence farming
Plate No.3	Deforested depressions, seasonally occupied by the reservoir waters
Plate No.4	Mirror like surface of reservoir. Increased reflectivity and albedo rate
Plate No.5	Close up of degraded vegetation near banks. On the left a large fractured boulder is seen.
Plate No.6.	Pot holes above the present water level indicates the past erosion during pluvial periods.
Plate No.7.	Pot holes and a small stone arch. Muddy water collected in pot holes soon after rains indicates disturbance to the riperian system in the upstream areas.
Plate No.8	Amphithsatrical hollows on cliff face indicates shifting of the water-fall and the resultant gorge.
Plate No.9	River follows the inclined bed plane during normal runoff and lean periods (photograph taken before precipitation)
Plate No.10	River swell. Some water escapes the geomorphic threshold. (Photograph taken immediately after rainfall)

Midland Region

Plate No.1	A typical midland segment of the Neyyar river.
Plate No.2.	Construction of embankments. Severe erosion noticed along the base.
Plate No.3.	Thick vegetation of trees and crops grown on the bank above the embankment.

Lowland Region

Plate No.1. A general view of the coastal estuarine region

Plate No.2. Extensive backwaters extending into the estuary

Plate No.3 The typical natural vegetation along the backwaters consisting of coconut trees, shrubs and sedges

Plate No.4. A closer view of the vegetation along the banks. Cultivated reclaimed land portions extend into the backwater.

Plate No.5. A 'tor' like rock outcrop in the midst of the estuary.

Plate No.6. Fenced cultivation of Acacia and Eucalyptus. Failed attempts at estuary stabilization.

Plate No.7. An inland marine terrace is seen in the picture as a white linear deposit alongside the banks of the backwater.

Plate No.8. Observing estuarine fishing techniques

Plate No.9. Fisherboys at work, using long hammock shaped nets suited for harvesting fish from the breaking wave against the funnel shaped banks of the estuary.

C O N T E N T S

CHAPTER I

INTRODUCTION

Geomorphology - Evolution and Progress

The classification, measurement and description of landforms and the study of the history of the processes that have produced them (James, P.E. and Jones, C.E.19) no longer covers the entire scope of geomorphology. The subject has undergone a transformation from mere theoretical conjecture so that today it is a systematic applied science. It was a slow and steady change towards the establishment of geomorphology as a science with its own method of investigation. Generalities such as the theory of geomorphic cycles were replaced by more adequate concepts, and qualitiative, quantitative studies on processes and landform development under different climatic conditions. The strengthening of the subject has rendered it fit for application in its final evolution as an applied science. (Verstappen, H.Th. 1983).

Today geomorphologists are involved in the dynamic socio economic and political scenario of the present world. They have an important role to play in improving the quality of life everywhere, (Matley, 1966; Tricart, 1956; and Ehlrich, et.al. 1977).

It is difficult to draw a clear distinction between applied and pure geomorphology. In one setting a theory may have practicability but in an other, it may simply be confined to academic interest. (Brunsden, 1981; Derbyshire, and Sperling, 1981; Dixey, 1962, Jones, 1980; Sidorenko,1972). It would be more relevant to say that there is a symbiotic relationship among the two. Pure research forms the basis of applied science. Only well developed concepts yield reliable, practical conclusions. (Dury, 1972; Gellert, 1968; Joly 1977; Clamer 1965; Mensching 1979; Semmel 1979; Tricart, 1968).

Progress:

At present, there are four major interrelated aspects of applied geomorphology.

(i) Static Geomorphology:

This is concerned with actual landforms. The study of present landforms, disregarding the hypothetical shape of the land millions of years in the past or in the future, and leaving aside the positive processes of the past as well as the process operative at the moment is the purpose of static geomorphology. (Verstappen, 1963, 1968) "Morphometric" studies come under this class. The studies may encompass slope steepness, slope form and profile and in plan (concave, straight, convex), degree of dissection or valley density or relief

amplitude etc.,. Although a thorough knowledge of the physical properties of each unit and feature is essential to render the classification useful for practical purposes such as evaluation of the hydrological conditions, agricultural potential, and the engineering properties, it is evident that landform studies of this king must also be shouldered by investigations in other major aspects of geomorphology.

This aspect is synonymous with the concept of the permanance of landforms that prevailed in the early 18th century. Since it was believed that the present landforms were due to cataclysm in the past, only description could be given of a landform. There were a few contradictory ideas concerning changes in landforms, valleys being formed by rivers etc., like those of Greek and Roman scientists, the Arab scientists and of Leonardo da Vinci.

ii. Dynamic Geomorphology:

This is concerned with processes and the short term changes so caused in landforms. It was formerly referred to as physiological geomorphology. The emphasis is on active proceses of erosion, sedimentation, etc., and on the minor changes in the land caused by these processes in short periods of time. The human timescale

rather than the geological time scale is used as a term of reference. Landslide, volcanic eruptions or sudden changes in the course of rivers are catastrophic in nature. However, the less spectacular changes provoked by everyday changes of weathering and mass movement, the work of rivers and wind, which can only be demonstrated by careful observation and precise measurement are in the long run more effective than rare abrupt changes. Investigations concerning these processes and rapid changes in landforms have ample scope for applied geomorphological research.

Dynamic geomorphology had its origin in the early 18th century when the problem of soil erosion was recognised in Europe. Farmers saw processes such as sheet, rill and gully erosion as a threat to their land. Another contribution from the practical side from the engineers who, when constructed roads and bridges became aware of river work and of matters such as cliff recession due to wave action etc. An early (1884) example in this field is given by Lamblardie in a study in Normandy of cliff recession. These factual and functional studies demonstrated the applicability of geomorphological research.

Simultaneously the interest was also shown in processes such as glacial erosion and deposition as illustrated by the studies of De Saussure (1740-1799). It was the time when the doctrine of catastrophism and permanance of landforms was being replaced by the uniformitarianism concept. The names of Hutton (1726-1797), Playfair (1748-1899) and particularly Lyll (1797-1895) are associated with this concept.

iii. Genetic Geomorphology:

The long-term development of landforms requiring extrapolation in both past and future is treated in genetic geomorphology. The subject developed in the latter part of the 19th century. This sort of study seeking to establish a sequence of landform development covering millions of years is also called 'physiognomic geomorphology' (Verstappen 1983). At present genetic geomorphology is still an important branch of geomorphology supported by scientific framework and appropriate methods of ersearch. Earlier genetic geomorphology was based mainly on views of synthesised landscape under the influence of endogenic and exogenic factors advocated by W.M. Davis (1850-1934). It was only after the concept of the 'geomorphological cycles' had been replaced by the open system approach, with a defined input and output that geomorphology also became useful in

applied research. In modern genetic geomorphology detailed analysis of forms, processes, soils and sediments replaced the synthesised approach and hypothetical deductions of classical geomorphology.

(iv) Environmental Geomorphology.

Landscape ecological links of geomorphological phenomena are treated in environmental geomorphology. It is the newest major branch of geomorphology (Barch (ed.), 1979; Coates (ed.), 1979, 1972/4; Cooke and Doornkamp, 1974; Dawson and Doornkamp 1973; Flawn 1917; Hall 1974; Leser 1976; Morgan and Moss, 1965; Tank 1976; Tricart 1973; Tricart and Kilian, 1979;) . The relation between landforms and processes with land elements such as soils,ground and surface water, vegetation through the landscape ecological situations and even including man as an agent through the use of the land, has become studies of prime importance. This study was stimulated some years ago by the use and interpretation of aerial photogrpah, showing the landforms in their environmental context. It developed rapidly during the fifties.

METHODOLOGY

DATA BASE

Topographic Sheets | Aerial Photographs | Field Work

Block Diagrams | Morphology | Land Use | Terrain Photos | Field sketches

Land Units | Land Facets | Land Elements

APPLICATION OF THE SYSTEMS APPROACH

Highland region | Midland region | Lowland Region

Methodology

With the application of data from the Survey of India, Topographical sheets, Aerial Photographs and field observations along with the use of a systems approach, various terrain units within each land system (grid area) have been analysed, highlighting the pecularities of each of the major natural divisions.

At first the Neyyar river basin was delimited from the topographical sheet of the scale 1,50,000. The major natural divisions viz., the highland, the midlands and the lowlands were demarcated. These divisions correspond to the natural divisions that are represented throughout the State of Kerala. The Highlands are those areas lying above 75 mts., above sea-level. The Midlands occupy areas between 8mts and 75 mts., and the low land area covers the region lying below 8 mts. The western margin of the lowlands forms the coastline washed by the Arabian Sea (Lakshadweep Sea).

Through systematic sampling from the topographic sheets (1,50,000) three grids of size 10cmsX 10cms were chosen from each of the natural altitudinal divisions. The size of the grid was purely arbitrary, keeping in mind the need for raising block diagram for the

area, comprising the grid. These grids represented an area of five square kilometers on the ground. These grids were chosen so that they compound the main river with the river traversing approximately through the middle portion of the grid. The reason for choosing the grid from such a location was to correlate the dynamics of the river the single major denuding agent, to the landsystems produced by it.

The grids chosen from the three altitudinal zones along and across the river, have been subject to intensive study and portrayal. For ease of reference these grids and their respective block diagram have been designated as follows:

A : Highland region grid/Block

B : Midland Region grid/Block

C : Lowland region grid/Block

From the topographic sheets, (Nos.58H/2, 58H/3 and 58H/6,(restricted sheets) in the scale of 1:50,000, the contours at 20 mt. interval for the grid areas were traced. One point perspective block diagrams were drawn from the contours, after taking their profiles in suitable scale. The orientation of the blocks were not necessary, as they were viewed from the direction of mouth to source, and in itself offered the necessary

grading of terrain. The completed block diagram for each grid formed the land system, which formed the base for the applied aspect of system approach and landuse.

These land sysems connoted A, B and C were further subdivided to form land units or facets and still further to form the land elements. The 'land system' and its components in descending hierarchy were mapped and their characteristic features explained. The build-up of the land system and its components with the help taken from Aerial photograph interpretation and field work has succeeded to produce a clear identity for the terrain unit as a whole. This terrain unit or land system formed the basic framework for the application of the systems approach.

A preliminary reconnaissance survey of the aerial photographs covering the whole basin was conducted. The aerial photo pairs covering the selected grid areas were isolated for intensive study and mapping of morphology and landuse. The interpretation of the serial photographs were done using a German made mirror stereoscope of very good quality. Lateral ovrelap (60%) and verticla overlap (20%) were necessary so that the entire grid area could be covered. These

aerial photographs were in glossy black and white prints of the scale 1:60,000. The overall view of the geomorphic quality of the land helped in the choice of size for land units or facets and the land elements, which are entirely discretionary, based on the degree of clarity necessary for the study, and the purpose for which the study is made. The aerial photograph provided accurate and reliable landuse information. The landuse for each of the grids were prepared. This landuse map prepared of the grid area was superimposed on the block diagram of the respective grid, so as to bring out the relationship of the land system with the landuse.

The field work was conducted in three stages. Field work for Grid A, chosen in the upper catchment area of the river above the reservoir was conducted in a two day trip. Since this area comes under the Neyyar Wildlife Sanctuary, special permission was obtained from the Deputy Conservator of Forests, Trivandrum, Office of the Kerala Forest Department; Vazhuthacaud. The Forest Department, afforded us a boat journey to one of the extreme arms of the reservoir, from there we proceeded on foot for about six to seven kilometers till we reached the grid-A area. This study area was

identified on the ground using the 9 metre waterfall as the landmark. The heavy rain for a few hours hindered our work for the first day. Poor lighting prevented us from taking more than two photographs. The next day was clear and we made field sketches of the toposequence above the waterfall. Many more photographs of the terrain and forest cover were taken. Brief notes of the region was also made in the field diary. In the evening we returned to Trivandrum via Amburi.

The second stage of the field trip was conducted in the midle course of the river. After alighting at Neyyatinkara, (a town situated by the river) the river was traced flowing north-east of the town. Terrain photographs of the region were taken. Brief notes were also recorded. Since linear settlement stretch on either banks of the Neyyar river, permission was sought for trespassing private property to gain access to the river. Photographs were taken of the river training works, the natural vegetation and the river bed.

The third stage of the trip was conducted at the estuarine mouth of the Neyyar river at Poovar, near Vizhinjam. Although a high amount of light reflectivity was experienced, fairly good pictures could be taken using an SLR camera. Brief field observations were recorded and rough sketches were made in order to facilitate ana-

lysis in general and also to construct toposequence.

All the studies were finally combined to help in the analysis of the land systems. Further, a 'systems' approach was applied. This descriptive geomorphological study along with the systems approach provided a functional base with which deductions can be made. Thus a thorough understanding of the grid areas which are more or less representative and characteristic of the three natural divisins is attempted.

Data Base:

The topographic sheets produced by the Surveyor General of India (1968) bearing numbers 58H/2, 58H/3 and 58H/6 were the base source for the descriptive study of landforms. These topographic belonging to the costal region of India are 'Restricted' material. These were made available by the Centre for Earth Science Studies, Aukulam, Trivandrum, for use in their cartographic lab. These sheets in the scale 1:50,000 were used to prepare block diagrams in the areas selected for study. Systematic sampling was done to obtain these areas of study. The contour intervals of the map were of 20 meters.

Secondly, the aerial photographs in the scale 1:60,000 were made available of Trivamdrum District. Out of

these photographs that covered the area of the grids selected were studied and mapped. These serial photographs were in black and white and were taken by the secret Task Force No.1015 A, in 1978. These Aerial photographs are a highly 'Restricted' nature and was available for work and interpretation in the cartography lab. These aerial photographs were provided by the Centre for Earth Science Studies, Trivandrum. There were immensely useful in the geomorphic mapping and terrain unit identification.

A general reconnaisance study of the aerial photograhphs covering the Neyyar basin area was undertaken. The aerial photographs used for reconnaisance study were of the following numbers.

No.71 ; 1 to 7 ; No.72 1 to 10; No.73 1 to 1:
No.74 1 to 8; No.75 5 and 6; No.73 1 to 1:
No.78, 1 to 11: No.79 1 to 10
No.62, 1 to 31 : No.65 1 to 23 No.68 1 to 19
No.55 1 to 25 and No.58 1 to 23

For the interpretation of the Highland region's grid selected for study. Aerial Photographs under No.75 series are necessary. But in this series only No,75 series are necessary. But in this series only No.75 5 and 6

are available, with the centre for centre for Earth Scienc Studies, Trivandrum. These do not cover the grid area and hence the highland grid chosen could not be interpreted geomorphologically, using aerial photographs.

Finally, extensive field observation was done. Intensive field checks in all the grid areas taken for detailed land system mapping. This field check for ground truth is very essential for the accurate study of landforms. The need for field work, and the observation during field survey gains importance when the area chosen is of a smaller scale. This has been pointed out by Andrew Goudie.* 'The smaller thescale of investigation, the more field survey becomes inevitable and geomorphologists should beware of assuming that secondary data sources are adequate without field checking. (andrew Goudie, 1964).

---

* Andrew Goudie , 1964 "Geomorphological Techniques" p.28, Published by George Allen and Unwin, Sydney.

Scope and Objectives of the Study

This study takes a holistic approach to the origin, structure, process and stage of land forms. It reveals the other sub systems that have a close link in the purport and maintenance of the landforms under study. It studies the degree of linkage afforded by each of the controlling agents, whose individual or combined work has created, changed or modified the land form and have presented them in its present status. For suah a study the human impact on the landscape is also of prime importance. "Yet few tropical geomorphologists in their field traverses can fail to notice the geomorphologists in their field traverses can fail to notice the geomorphological problems that arise from man's impact on the landscape. As C.H. Leigh and K.S. Low (1976) point out:

Because of their limited interest in human impact on the environment, geomorphologists remained unreceptive

to, or disinclined to follow the leads suggested by naturalists, human geographers, or contemporaries in other disciplines.

Since most contributors to the literature on tropical landforms are still based in extra-tropical countries and are therefore guests in the nations where they carry out field work, the remotenses of many contemporary geomorphological investigators from the people of the host nations must surely be questioned. Both Tricard (1965) and Garner(1974) conclude their textbooks by commenting on man's impact on the environment and the problems which natural feedback mechanisms bring." *

Here, in this study the stress placed by the stress placed is on the identification of the land system and its composite units so as to make it as base, a frame work upon which other studies of practical development can be initiated. Such an exercise, after initial identification of the basic characteristics of the landforms, on the one hand runs itself into other sciences in search of systems that influence its form and present

---

*

Geomorphology : Present problems and future porspects" edited for The British geomorphological Research Group

Oxford University Press 1978.

By C Embleton, D. Brunsden and D.K.C. Jones.
Oxford University Press, 1978.

stage, and on the other, lends itself to the application of other systems so as to make a correct choice and usage of the land, minimising the amount of trial and error. A very conducive use of the land can thus be envisaged. The base of any such optimal landuse envisioned will be purely based the on land system characteristics which we have initially produced. Thus the correct identification of the characteristics of the land forms and its processes are a pre-requisite for reducing the margin of error in advocating the optimal land use. An optimal land use can only be advocated after a through study of the whole array of system linkages offered as well as afforded by the unit area of land under scrutiny. Much of the study of certain linkages may not seem necessary but has to be undertaken so as to present a data base of the land system for future reference. This is because proposed languages are not always permanent in nature. A further change in the initially proposed land use is a reality which we are facing today. For such further changes, it is of utmost importance to have an account of the history of the land system linkages once afforded by the land.

Here, after proposing a complex of landforms attempt has been made to establish the need for the study

of the system linkages as a two way system, which is of vital importance in advocating sound land use. This is the thrust area of applied aspect of geomorphology in this study.

(i) To provide a Land systems approach and classification so as to prepare a proper framework of the land aspect so that other models may be superimposed on it.

(ii) To provide a sequential break-up of landform based upon the altitudinal variations and also to identify the composite terrain units so as to assess their individual geomorphic disposition.

(iii) To provide a diagrammatic representation of the 'lie of land' using one point and two point perspective block diagrams thus enabling a clear and conjunctive appreciation of landform, processes and landuse.

(iv) To produce a general land-use diagram from the typographic sheets and serial photos and then superimposing such landuse upon the block diagram of the particular grid, thereby enabling to understand the geo-morphology Land Use relationship and

(v) To provide reasons for the typical geomorphic processes being initiated and taking place in these natural divisions.

Limitations of the Study

1. Materials that provided the data base, viz., topographic sheets (58 H/2, 58 h/3 and 58 H/6), published by the Survey of India, on scale 1:50,000 and serial photographs (secret Task force No.1015 A) cover the constal region of India and these are strictly 'restricted' in nature. These materials for study have been provided by the Centre for Earth Science Studies, Trivandrum, for use in the cartographic laboratory. Field trips of two or more months were necessary for use and reference of these study materials, at Trivandrum.

2. For interpreting the morphology and the land-use for the highland region, the required aerial photographs in the series No.75, were not available with the Centre for Earth Science Studies. Only plates 5 and 6 under this series were available, which does not encompass the study region.

3. Soil map for Trivandrum District, let alone the Neyyar basin area, were available with the All India Soil and Land Use Survey, Pusa Road, New Delhi, the reason being no 'priority survey' for the region had been done. The State Department of Agriculture 'Vikas Bhavan, Trivandrum, and the Soil Conservation Unit, under Department

of Agriculture have not produced a soil map even for the Trivandrum District as whole. The latter is working to produce a soil map at District level in the coming months.

4. The State Department of Mining and geology St. Joseph's Building, Trivandrum has not yet prepared a geological map for Trivandrum District.

Nevertheless, the staff of the above Departments helped in discussing the matter and was extremely useful in giving some ideas in the respective areas.

5. The Upper catchment area of the Neyyar river basin comes under the Neyyar Wildlife Sanctuary. Special permission from the Deputy Conservator of Forests, Trivandrum was necessary for conducting field survey in the area. Both trip was offered to extended arm of the reservoir. Although a boat journey offered by the Kerala Forest Department, was of great help, the rugged terrain, nearly four and half hours of trekking uphill was necessary to reach the study area. The heavy rain, and the sighting of a herd of elephants (numbering sixty two, reported by the forest officials) were the incidental limitations. A small herd of eight elephants, busy at foraging, (including

two sub-adults) were encountered by us on the return jouney.

6. The interpretation of the dense settlements in the low land region could not be done as the close-knit fronds of the coconut vegetation, obliterated the settlements.

LAND SYSTEMS SURVEY

Philosophy and Background :

"The Starting point for all land systems surveys is the recognition of regions with/each of which there is a specific assemblage of types. Each region is internally homogeneous with respect to its landforms but differs from neighbouring regions. Thus an area of sand dunes is distinctly different from one composed of dry lake floors, which is in turn distinct from an area of alluvial fans. The pattern of landformsin any one area is called a land system and this may vary in size from a few square kilometres to several hundred square kilometres." *

The reason for tracing a system for the study of terrain morphology is to abstract data from them of terrain information as applicable to various other study. Such an excercise leads to a coherent set of information regarding a particular terrain type.

---

* Brundsden and Jones" Urban Geomorphology in Dry Lands. Longmans London 1984.

The criteria for selecting a Drainage Basin as a unit of study for Land Systems Survey :

(i) The water divide constitutes a na ural physical boundary for examining the interdependence between land and water; forms and processes. All landforms are dependent upon the sub aereal processes, for their particularmorphological status and genesis. The river basin approach gains special relevance since the study of landforms is conjoined with the study of the single major sub aerial force, water; affecting its shape and size.

(ii) A river basin may be considered as an unit of functional ecosystem which includes the organisms of a natural community together with their environment. The major ecosystem components involved in a river basin when viewed as an ecological unit can be grouped into three different systems; physical, biological and human or socio-economic, each comprosing discrete but interacting and inter related environmental factors. Each part of the river basin affords

typologies of soil, moisture, vegetation, human occupance land use, slope, debris materials, ground water, and fauna due to its own immediate processes or as a resultant of processes elsewhere but within the drainage basin unit itself. The land system is affected by the ecosystems through the vegetation - soil link. The nature of the land system and its soil that is offered for vegetation growth determines the quality of the ecosystem and vice versa.

(iii) The Drainage basin is a susceptible and sensitive unit which markedly reflects the amount of human intervention thrust upon it. In certain cases, the whole river system is put into disarray and its processes deranged due to man-made construction of dams and consequent reservior flooding. Consequent to inundation of reservior areas, the land systems links are disturbed Stalling of fluvial process affects the status of landforms in the longrun. Accelerated erosion caused by deforestation and plantation agriculture or slash and burn causes hasty changes to land form structure and surface materials

(iv) The Drainage basin is useful for the identification of toposequences giving due importance to the surface water network. This is of great importance for proper landuse approach taking account both land and water reaources, of a particular region. In virgin land oovered by rich tropical wet evergreen forests, the construction of toposequences gives us a clear picture of the close link between a systematic assemblage of plant types in association with the surface water. Such a similar method of land use where in the crops requiring high quantity of water planted close to the surface water source and those requiring lesser dosage of water be planted away from water source would be a method of using the scarce water resource sparingly.

(v) The landsystem/approach at Drainage basin level will help us to identify the various ways in whichthe land forms serve the ecosystem it sustains. The ridges along the perimeter of drainage basin are very sensitive areas along which animal movement takes place. These migration paths are wiped away with the

advancement of plantations to the crest of the hills. The vegetation along the ridges are easily spoilt by human intervention. They invariably being at high altitudes, the 'Habitat Corridors' may be provided by the dense growth along a river or stream (riparian strips) or ridge systems. Construction of roads, fireline boundary or plantation strips may severe the habitat corridor which leads species insularization and extinction. Seasonal movement of fauna through these corridors or pathways is important for for its sustenance in terms of goods requirements. They sojourn to adjucent river basins and return to their own territory after foraging.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

General

The State of Kerala occupies the extreme South-west part of india. It is flanked on the West by the Arabian Sea and to the East the State of Tamil nadu. Trivandrum, the State's capital is situated in the extreme south of the State. The present Trivandrum District was historically part of the erst-while Travancore State. They area of the district was considerably reduced since 1951 by the States Reorganisation Act 1956. Four Tamil speaking taluks viz., Vilavancode, Kalkulam, Thovala and Agastheeswaram which now form the Kanyakumari District was transferred to Madras State on Ist November 1956. Since reorganisation, there have been no major changes in the boundaries of the Dsitrict.

Situation:

Trivandrum, the southern most district of the state is situated between North latitudes 8@ 17' and 8*51' and east longitudes 76*41' and 77* 17'. It is bounded by Quilon District on the north and on the east by Tirunelveli District of Tamil Nadu, on the south by Kanyakumari District of Tamil Nadu and on the west by the Arabian sea.

Physiography:

The district covers an area of 2192 sq.Km., accounting for 5.67 per cent of the geographical aera of the State. (Devassy M.K. 1966). Trivandrum District is among the smaller districts of Kerala and is bigger only to Alleppy District. The District has a maximum length of 59 Km. from north to south and 56 Km. from east to west.

Based on the Physical features, three district natural divisions can be envisaged. Theya are the highlands, the midlands and thelow lands. These altitudinal zonations have been envisaged by the Public Works Department of the Government of Kerala. This divisioning have been followed by the Centre for Earth Science studies, Trivandrum for their research works. The altitudinal zones are as follows:

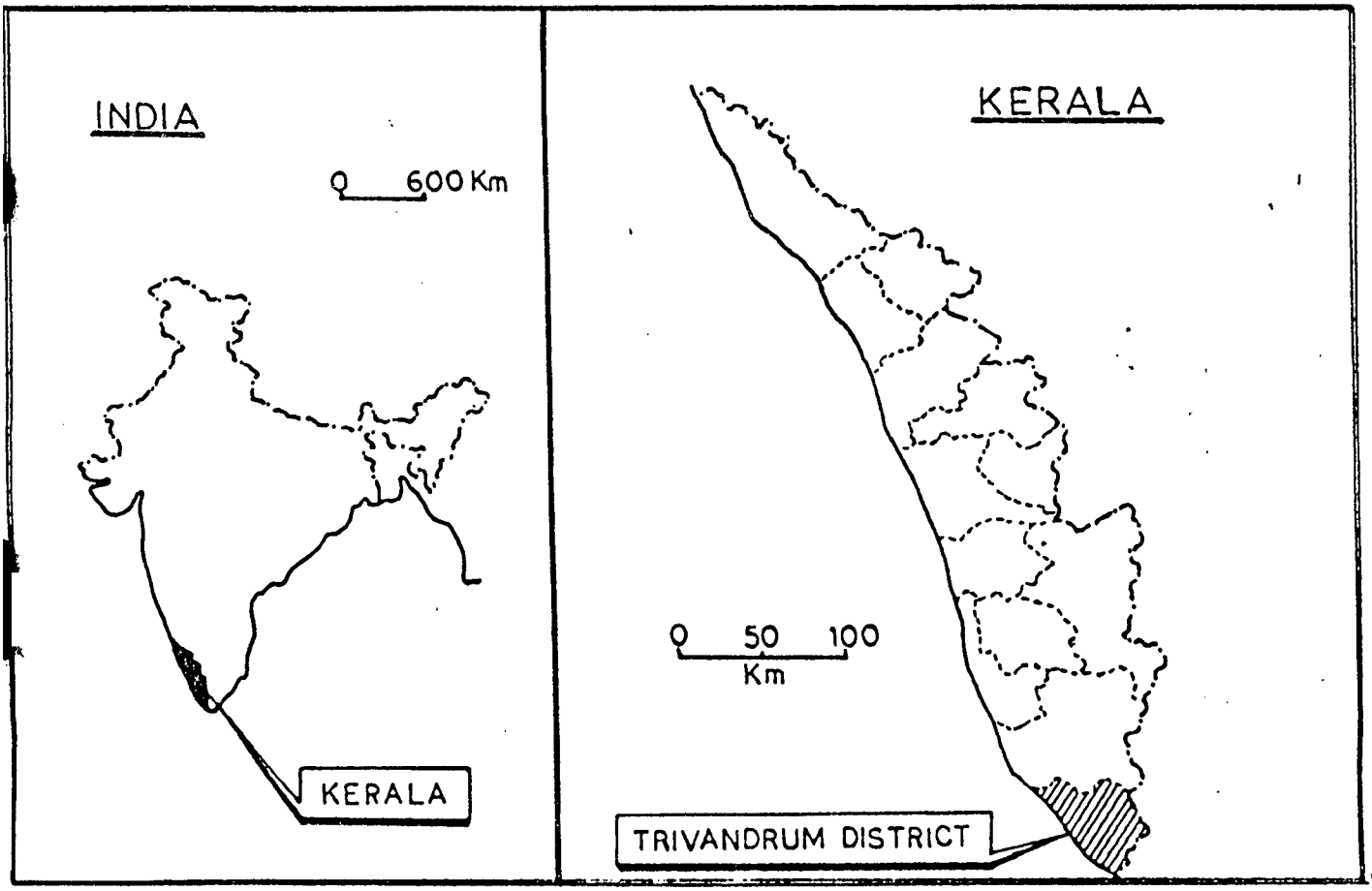
Highland : Greter than 75 m.
Midland : 8 to 75m
Lowland : Less than 8m.

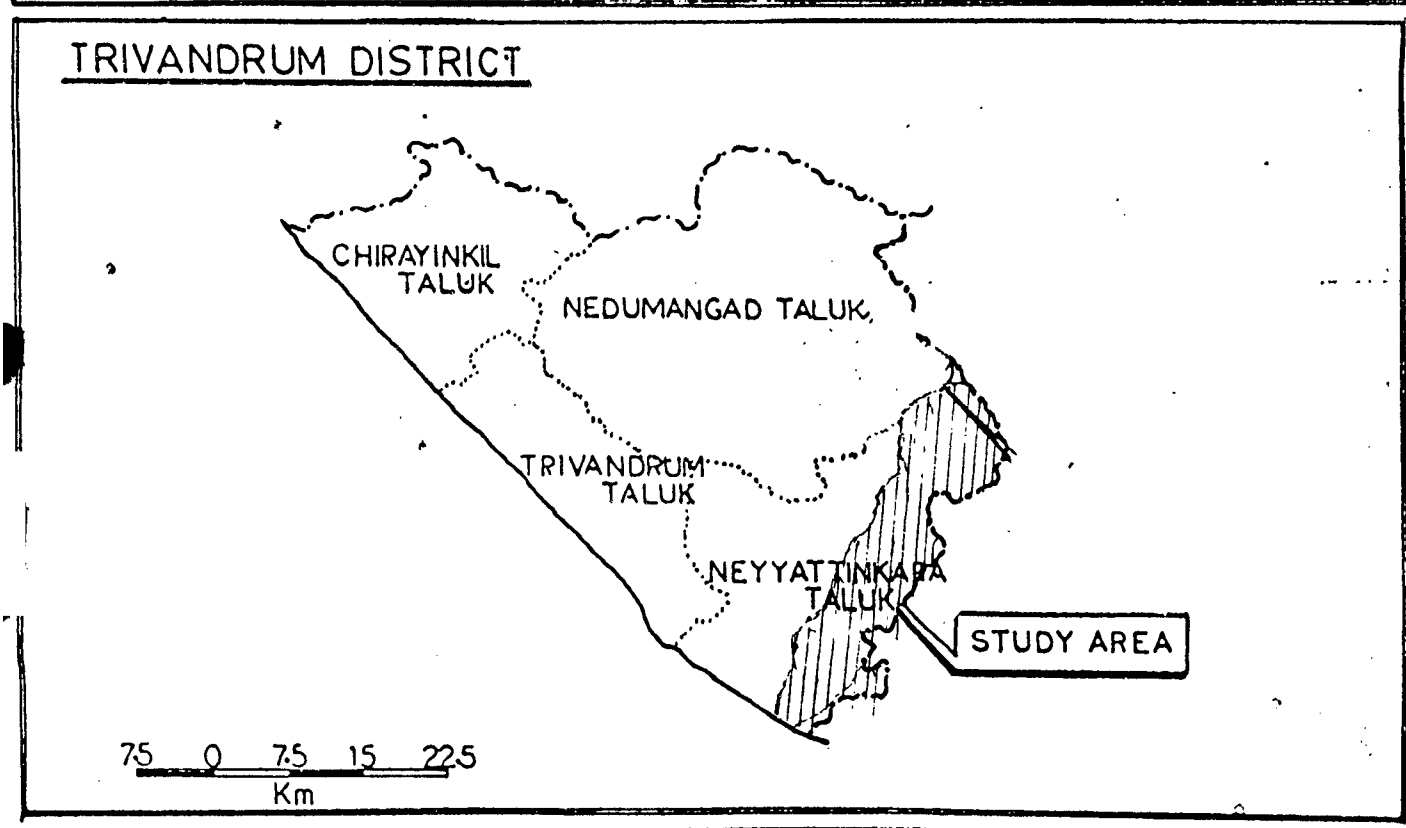
Drainage :

There are three important rivers in the district viz., Vamanapuram Karamana and Neyyar

The drainage net work of Kerala consists of fortyfour short and swift rivers. Out of these 41 flow westward and

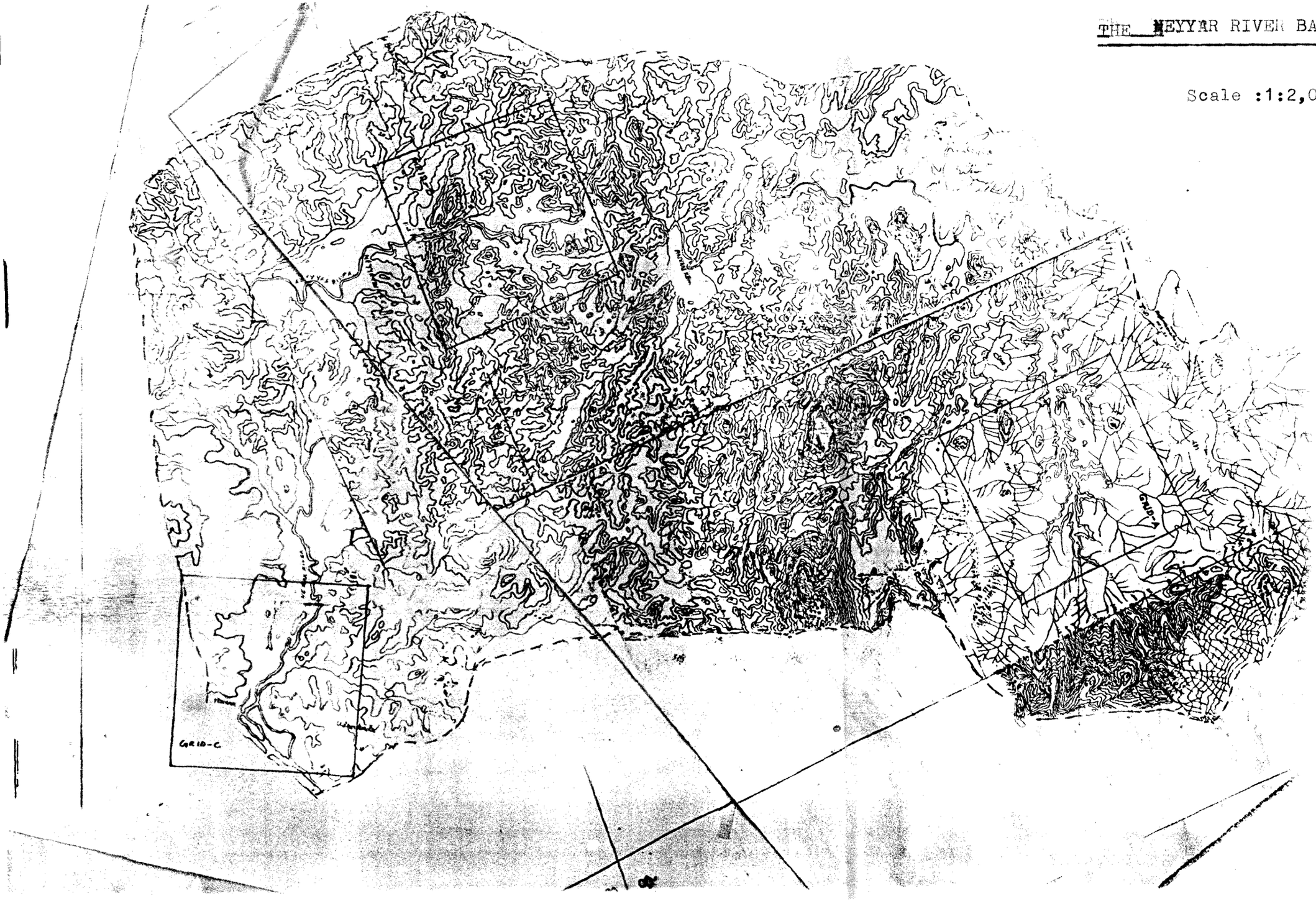
LOCATION MAP





THE NEYYAR RIVER BASIN

Scale :1:2,000000



three eastward. The four major rivers, viz., Periyar, Bharatpuzha, Pampa and Chaliyar, together drains about thirty five percent of the state.

In Trivandrum District there are three important rivers viz., Vamanapuram, Karamana and Neyyar. The Vamanapuram or Attingal river rises on the peak Chemmunji Motai situated in the Palode Reserve south of Ponmudi. It empties into the Anjengo estuary. This river has a total length of fifty miles. The drainage area of the river is 336 sq. miles with an annual estimated run off of 52,000 million cubic feet. Vammanapuram, Attingal and Chiraynakil are the important places on its banks.

Karamana, the second longest river in the district oritinates from the deep valleys of the high ranges of the Chemmunji peak and Aduxai Malai of the Western Ghats. It empties into the sea near Pachalur. The runoff of the river is estimated at 38,750 million cubic feet. Trivandrum., Nedumungad, and Aryanad are the chief places on the banks of this river. An imponding reservoir of 136 million gallon of net drawable capacity, formed by construction of a low overflow type of masonry dam across this river, was constructed at Aruvikkara for meeting the daily water requirements of the people of the capital.

The Neyyar, the southern most river of Kerala State is the area of the present study. It has its origin in the Agastya hills and descends rapidly until it reaches the foot of the hills. Kallar and Karavali Aar are the important tributaries of this river. It has a length of 35 miles with a catchment area of 191 square miles. Its annual run-off is estimated as 29,600 million cubic feet. Neyyatinkara and Balarampuram are the important towns on the banks of this river.

Geology:

Although the Kerala Circle of the Geological Survey of India has taken the work of carrying out the Systematic Geological mapping in the States, since 1962, so far, 26,000 sq.Km. has been covered by Systematic mapping out of the total area of 38,860 sq. Mt.

Geologically the region of Kerala is occupied by four major rock formations:

(i) Crystalline rocks of Archaen age
(ii) Sedimentary rocks of Tertiary age
(iii) Laterites caping the cyrstallines and the sedimentary rocks.
(iv) Recent to Sub-recent sediments forming the low lying areas and river valleys.

The Archaean Crystalline rocks are complex and are of igneous or of metamorphic origin. Some of the metamorphic rocks which have developed gneissic structure may be of igneous origin, while other matamorphic rocks, finely foliated and contorted, may be of sedimentary origin. These crystalline rocks comprise chiefly charnockites, the Khondalite suite of rocks, granites and granitic gneisses traversed by basic dykes.

The charnockites are the most prominent rock types among the cyrstalline rocks in the State and they are characterised by the presence of the mineral hypersthene, a rhombic pyroxene. They are bluish to dark coloured rocks, granulitic in texture and they constitute the high ranges of an Western Ghats.

The Khondalite suite of rocks are a group of light coloured, fine to medium grained, foliated and granulitic rocks and they comprise garnet-sillimanite gneiss with graphite, garnet-biotite gneiss, cordierite gneiss, garnet-quartz felspathic gneiss or granulite, calc granulites and quartzites. These Khondalite suite of rocks traversed by narrow zones and bands of charnockitic rocks make up the greater part of the country in south Kerala.

The regional strike of the crystalline rocks is roughly

NW-SE in the southern part of the State, while in the northern part, it locally swings to NE-SW strike of the Nilgiri range. These crystalline rocks are highly folded and isoclinal folding is the general structure in the region.

The Tertiary sediments (of Miocene age) consist chiefly of a series of variegated snadstones and clays with lenticular seams of lignite, known as Warkalli beds. The Tertiaries are flat beds with gentle dips towards the coast. They (mostly the Warkallis) extend in a narrow belt from Trivandrum to Kasargode with the intervening promontory promontory of the crystalline rocks in the region of Calicut and Tellicherry.

The term 'Laterite' was coined by Buchanan in 1800 'After a study of quarries near Angadipuram in the erstwhile Malabar, Buchanan in 1800 coined the term 'laterite.' General Cullan (1840-60) who discovered the existence of graphite in Travancore, was the earliest worker to study the sedimentary formations around Quilon. Laterite, at places associated with bauxite is found forming low flat topped ridges and hills covering the Tertiary sediments and the crystalline rocks between the foot hills of the

Western Ghats and the Arabian sea. The thickness of the laterite cappings varies from few metres to 50m at places. These laterite plateaus are indicative of different phases of uplift of the land in this region. Uplift is also indicated at several places by the presence of sediments much above the sea level. The presence of alluvial fill in some places within 60 m. contour between Trivandrum and Cape Comorin may indicate a recent uplift.

Sub-recent formation are seen in great thickness of sand with shell fagments, sticky black clays and peat bed mostly in low lying areas.

In addition to the sub-Recent marine and estuarine deposits surrounding the backwaters and low-lying areas and river alluvium along the major river valleys, there are coastal fringes of parallel sand bars and sandy flats alternating with marshy lagoonal clays and beach sand deposits. At places there are also raised sand beaches composed of fine-grained reddish sandy loam known as 'teris'.

THE NEYYAR RIVER BASIN

Introduction

The Neyyar river basin lies between 8° 15' and 8° 40' north latitudes and between 77° 0' east and 77° 20' east longitude. The basin area has an area of 492 Km^2 and the cumulative length of all stream orders of basin in 605.38 Km. The water resources of the basin is assessed as 229 Mm^3 "(Samsuddin M., 1980). The annual runoff is estimated at 29,600 million cu.feet." (Devassy,M.K. 1966) DCH.

The Neyyar river is the southern most river of Kerala State. It starts from Agasthya Hills at about 1860 mts. above the sea level. After its source in the Agasthya malai it descends rapidly until it reaches the foot hills, where the Neyyar Dam (103 m), is situated. It flows in a south westerly direction in the mountainous regions and there takes a westerly course upto Ottasekharamangalam, where it again turns west and from Valapallikonam traces a south-western course till it empties into the Arabian Sea. It empties into the Arabian sea at the estuary at Vizhinjam.

The important tributaries are the Kallar and the Karavalli Aar. There are in addition a few more streams in the basin. They empty their waters either into the Neyyar or into the sea independently. The msot important streams are (i) The Vandichira thodu (ii) The Kulathur Valiathodu (iii)

The Marathur thodu (iv) the Athiyanoor thodu, (v) the Thalayil thodu (vi) The Kottukal channel and (vii) the vengannur thodu. The length of the river is 56 Kms. During its course it passes through the villages of Ottasekharamangalam, Kulathummel, Marannaloor, Perumkadavila, Chenkal, and Kulathur. Neyyatinkara and Balaramapuram are the important towns on the banks of this river.

Geology:

The geology underlying the highland zone of the Neyyar river basin largely consist of crystalline rocks of the Archean group, mainly of charnockites and Khondalite gneisses capped by laterite. Pegmatites with large crystals of quartz and feldspar with accessory mica etc. occur as veins and lenses commonly in the leptynites and gneisses. All the belts are oriented more or less in a north-south direction. The general strike of the foliation is north-south direction. The general strike of the foliation is north-west and south-eact with high dips..

In the mid land region, the residual laterite occurs in a fairly broad zone west of the Archean crystalline rocks and is the resultant product of the 'in situ' alteration of the crystalline rock. Along the river course and in the flood plain region, alluvial deposits of great thickness

are seen in this region. Paleo-flood plains and sand deposits resulting from stream meandering have formed potential sites for extraction of construction material. Here most of the structural landforms have been found to bear thick deposits of weathered material both of immediate parentage and those brought down from upstream areas.

In the lowland region, the coastal belt has recent deposits which include marine, lacustrine and alluvial deposits. Economically, mineral resources wise this is the most important region of the basin and contains mineral sands such as ilmenite, monazite, zircon, sillilmanite, etc., The lacustrine beds contain vast deposits of fine quality China clay. A large quantity of fresh water mollusc are also found which is exploited for producing slaked lime. The marine deposit includes black sand which is the raw material for Titanium.

Climate:

Being placed in the tropics, the region has a typical tropical climate with high rainfall, heavy insolation and high humidity. At elevations of 1000-1500 mts., the climate is cool for most parts of the year. The typical climate is responsible for the mechanical and chemical weathering taking place within the basin. The claimate near the lowland,

the coastal zone is influenced by the heavy sea breeze and during the dry season, it resembles arid conditions. The humid cropical climate enables cultivation of a wide variety of crops including rice, coconut, rubber, pepper and spices. A heavy rainfall of around 300 cms is received in the region. The rainfall is distributed, is received under two spells, viz., the south west monsoon and the north east monsoon. The south west monsoon is from may to August, while the north east monsoon is from September to November. The coastal region and the highland region experience high windspeeds. The lowland vegetation consists of coconut trees, which [illegible] withstand the heavy winds. In the highlands, above 1500 mts, the trees are dwarf sized so as to withstand the high wind speeds.

Soils:

In the highland region, organically rich forest loam soils have been found. These soils provide the base for the humid tropical forests found in this region. They are dark reddish brown to black with loam to silty loam texture. Forest loams are the products of weathering of crystalline rocks under forest cover, and under high humidity conditions.

In the midland region the chief soils found are Lateritic

soil, brown hydromorphic soil river alluvium and red loam. Laterites are typical weathered products derived from gneissic and granitic rocks. The humid tropical conditions, mainly the high temperature and high rainfall are the chief conditions for the formationm of laterised material. The organic and mineral content of these soils are low. Extensive soil management practises and irrigation are necessary for the cultivation of crops. The chief crops found on lateritic soils are coconut, tapioca, rubber, arecanut and cashewnut. Borwn hydromorphic soils have been formed as a result of transportation and sedimentation of material from adjoioning hill slopes and also through deposition by rivers. The water table beneath these soils is high. Those soils therefore present characteristic hydromorphic features. River alluvium is seen in the mid land region as the river starts its depositional stage within the midland traverse itself. River alluvium is deposited on either banks and over flood plains. These are rich in plant nutrients and a variety of agricultural crops are grown in this region. The main crops include irrigated paddy, ragi, coconut, vegetables, pepper and spices. The red loams are found at the western margins of the midlands where it merges with the low land. The soil is highly permeable and are usually very deep and homogeneous. The red

colour of the soils have been suggested to be due to the presence of haematite. They are generally very poor soils.

The lowland consists of some riverine alluvium sediments and consists predominantly of coastal alluvium. These coastal alluvium soils are strictly halomorphic in nature and have been developed from recent marine deposits. They have hardly any organic content and are excessively drained. Only coconut thrives on this soil.

Physiography:

The highland region consists of rugged topography and the river is in its juvenile stage. Steep slopes, thick vegetation, a fine drainage net work, and a high rate of erosion are the chief features of this region. The high land rising at places above 1500 mts blocks the moisture laden winds causing high rainfall in the region. The high rainfall together with high humidity have acted on the terrain to produce typical tropical landforms.

The midland region has an undulating topography. The low rounded hills and the extensive flood plains are capped with great thickness of laterite. The river takes a meandering course within this region, resulting in depositional

features. Thick deposits of river alluvium are seen along the flood banks. The foot hill zone of the highlands, provide excellent drainage and a rich soil which are conducive for plantation agriculture.

The low land region consists of extensive coastal alluvium with low topography. Although the relief is low the soil is highly permeable and hence waterlogging is not extensive, It is however, is noticed along the banks of backwater areas. The backwaters locally known as 'Kayals' are a veritable feature of this region. Both marine and fuvial terraces are found in this region. Although of low relief, the excellent permeability of the soil and thereby the reduced risk of water logging has paved the way for dense setlement in this region. The kayal beds have vast deposits of Kaollinitic clay, river alluvium and lime shell.

Natural Vegetation:

The highland region, comprising the upper catchment area of the Neyyar river has an extensive cover of tropical forest vegetation. The humid tropical forests include forest types : described below : Tropical Wet Evergreen, Decicuous, Semi-deciduous, Shola, and fire degraded secondary

forests, These contain many species of plants and organisms yet to be discovered. It symbolises a natrual gene pool which is as yet not fully studied. The increasing interference of man is tending to upset the ecosystem and its control over the land system maintenance and the delicate balance that exists in nature.

The midland has been an area of extensive human control over the land, and vegetation and hence much of the natural vegetation in disappearing fast. The midland regions formerly consisted of forested lands, shrub and grass cover. These have been extensively removed to provide space for agriculture, grazing, and settlement.

The low land vegetation consists of some plants resistant to the halomorphic conditions of the soil. These include some varieties of cactii, coconut. The existing natural vegetation consisting of coconut cover has been maintained since its usufructs are of dietary and economic value.

The Geographical identity of the basin area:

The catchment area of the Neyyar basin is the lofty Western Ghata that flank the eastern portion of Kerala.

"The mountain range of the Western Ghats runs parallel to the west coast of India from the river Tapti in the north to the Kanyakumari in the south. The Ghats descend steeply to coastal plains on the west, but merge rather gently through a series of hills with the Deccan plateau. Geologically the Ghats fall into two sectins; north of the river Kali is the Deccan trap country of relatively fragile rocks and flat hill tops. The hills do not rise much beyond 1500 m in this tract. South of Kali is the region of precambrian archean crystalline rocks which are much harder. The hills tend to be rounded and rise to 2000 m or more:*

Physiographically, Loebeck in his work 'Geomorphology' describes Western Ghats as 'It is a mature part of a plateau side which physiographically serves the purpose of a mountain. The backwasting of slopes has led to give shape to piedmont slopes and alluvial fans. * [2]

---

1. 'Integrated Mountain Development', Edt. by Tej Vir Singh and Jagadish Kaur. Published by Himalayan Books, New Delhi 19)

2. Lobeck (A.K) 'Gemorphology : "An introduction to the Study of landscapes (1939) Published by McGrow Hill Book Co. Inc. New York and London.

The South-West monsoon from June-September, and North-East monsoon in October and November bring rain to this region, and the annual rainfall varies at different places from 89 cm to 625.7 cms.

The Neyyar river takes its source from the Agasthyamalai peak. The agastyamalai peak is also locally known as 'Pothikaimudi' and 'Agasthyarkudam' (1868 m). With the given altitudinal position, aspect, and area, it presents a whole spectrum of the vegetation found throughout the Western Ghats. "Since the ecosystem diversity in quite high, almost all vegetation types known from the Western Ghats occur in this region depending on the altitudinal zonation, such as Southern tropical thorn forest, Southern tropical dry deciduous forest, Grasslands, at slow altitudes Southern tropical wet evergreen forest/ Subtropical montane forest and Grassy swards at high altitudes. " *

For this reason the Agastyamalai and its environs had been suggested as a potential area for a Biosphere Reserve. (A.N. Henry, M. Chandrabose, M.S.Swaminathan and N.C.Nair) 1982).

---

* Bombay Natural History Society Journal (1982) 'Agastyamalai and its environs: A potential area for a Biosphere Reserve.' by A.N. Henry, M.Chandrabose, M.S.Swaminathan and N..C.Nair.

The singularity of the region as regards its position, altitudinal range, vegetation characteristics geomorphological status, and prevailing landuse gives a specific identity to the basin area.

The rich tropical wet evergreen forest biome is typified by a multitude of vegetational forms. Typical layered canopy is found in the area which denoted the good quality of the tropical wet evergreen forest present. Some of the species have reached their dead end of evolution eg. Cycad palm, which points to the high degree of climatic stability, providing for climatic climaxes and the virtual non-interference of man in some of these patches of virgin forests.

The climate in the region is especially favourable for rapid growth of vegetation, with an annual rainfall of about 250 cms, and a dry period of about four months.

The slash and burn type of agriculture was practised by the 'Kanis' the hill tribe occupying the area. This system was highly successful for the past hundreds of decades.

This system involves the use of pristine forest land for agriculture for five to six years after burning

the forest cover. When yields decreased, the tribes moved to another area, and the previous cleared land is left fallow and enough time ensures for regeneration of vegetation. This system thrived for hundreds of years mainly because their numbers were small and they had the whole of the forest land for themselves. But now with the construction of large dams much of their forest lands have been flooded and they have been forced to move further upsrtream. These areas being more steeper in nature, their methods of agriculture could not enable them to cultivate on such steep slopes. Their attempts of farming at the susbistence level, led to great disasters like flash floods, sheet wash, gully erosion, land slips and slides, and total loss of crops and exposure of bed rock, hitherto unknown to them. To add to this spatial marginilazation, the development and rehabilitation projects of the "Government forced them to settle in colonies, resulting in building up heavy pressure on the remaining forest land around them for requirements of fodder and food. This is an important as a forced change in landuse pattern followed by the tribes. Here the natural interaction between man and environment has been disturbed and irrevocably altered.

The lower reaches of the highlands has been under

threat from plantation agriculturists. In the Neyyar basin, rubber (hevea Brasiliensis) and Pepper.are the main contenders as plantation crops. The extension of area under plantation means a reduction in forest cover. These plantation crops need land with moderate slope for needs of eficient drainage. Hence adjoining forest cover is under attack by plantation agriculturalists.

In the middle region, the mid land area, much of the land is under garden crops, and the valleys and flood plains are under paddy cultiation. The low isolated hills poroviding sufficient gradient for drainage is occupied by plantation crops mainly rubber. Most intensive agricultural practice in the whole of the basin area is noticed in the midland regin.Tapicca (cassava) is another important crop of the midland region. "The haphazard form of cultivation of tapioca and other garden crops on the slope of the river banks and streams have contributed to heavy soil erosion reducing flood carrying capacity of thewWater channels." (PWD Govt.of Kerala,1963).

The low land region occupies a narrow portion of land along the coast. This area supports the highest density of population in the entire basin.

As is the case with most of the other rivers of Kerala, the Neyyar river also enters the sea at Poovar (near Vizhinjam) through an estuary. During monsoon the sand bar separating the mouth of the river from the sea is artifically broken to prevent floods in the lowlying areas, which are of dense human settlement. The main land use is coconut cultivation and fishing along the coasts is a prime occupation. The halomorphic alkaline soils and the salty sea breeze does not allow much of other varieties of crtops to be grown in this area. Due to the open nature of the coastline, a number of marine terraces and fluvial terraces can be noticed in this region. The presence of marine terarce, located much inland refers to an emergent coast line.

With all these varied altitudinal range, vegetation, and landuse, the Neyyar river basin offers a unique synthesis of land form; from the coastal sand bars and dunes to the lofty peaks of Agastya Malai and Klamalai.

---

*Government of Kerala, Public Works Department, Irrigation Branch, Trivandrum 1963. "Long range outline plan for flood control in Kerala" Part II Vol.I.

CHAPTER III

APPLICATIONS OF THE SYSTEMS APPROACH

"The definition and examination of systems, more or less simplified for study purpose more or less simplified for study purpose, enables the complexities of the real, observed world to be considered in an orderly manner. We can see more clearly the interrelationships between the components of a system and the flows of energy and matter which take place within it. We simplify to see how the system is structuerd and to consider how the components may be further studied and measured. simplifications involve subjective actions. It is important to define the limits of the study and to specify the systems and sub-systems under consideration. In practice, field measurements and analysis are required to establish casual relationships between vegetation forms and the environmental variables selected for study"* (Richard P.W. 1972.)

"Understanding the form, behaviour and historical content of landscapes is crucial to understand the ecosystems on several temporal and spatial scales.

---

* Richard P.W.: The Tropical Rain Forest (1972) Cambridge University Press, Cambridge.

Landforms such as flood plains and alluvial fans, and geomorphic process such as stream erosion and deposition, are important parts of the setting in which ecosystem develop and material and energy flows take place. Over a long term geomorphic process create landforms, over a shorter term landforms are boundary conditions controlling the spatial arrangement and rates of geomorphic processes. [1] (Swanson F.J., Kratz T.K. ,Caine N and Woodmansee R.G. 1988) .

This study aims to bring together the two way balance between the dynamics of ecosystems controlling the geomorphic process, as well as the landforms controlling the toposequence and thereby the ecosystems.

'Ecosystems respond to both landforms and geomorphic processes. The history of geomorphic processes may be expressed directly in the composition and structure of vegetation, where geomorphic events and vegetation develop together. Geomprohic processes operating before the establishment of existing vegetation, or those subtly co-existing with the vegetation, may have their greatest influence on vegetation through controlling patterns of soil properties across a landscape, as in toposequences.

(Hack and Goodlett 1960)* (Swanson F.J., Kratz T.K., Caine N and Woodmansee R.G. 1988).

The ecosystem and in a limited sense the natural vegetation, bears a direct relation with the landform, the situation or spatial location of the landform and its altitudinal disposition. Such major characteristics of the land determines the density, quantity and quality of the natural vegetation afforded by it. "Natural vegetation offers the best indicator of the combined effect of surface features, soils and climate on the appearance on the landscape, just as present day vegetation in many areas reflects the impact of man on nature and the extent of the resulting change..... Implicit in our terms and clearly defined by plant geography is the impact of man and the cultural change he has irrevocably introduced in the natural landscape.

---

1 & 2 'Bioscience' (Journal) Published by the American Institute of Biological Sciences. Vol.38, No.2, February 1988 pp 92-98. "Landform Effects on Ecosystem Patterns and Proceses": By Swanson F.J., Kratz, T.K., Caine N. & Woodmansee R.G.

3. 'Geography and the American Environment; (Voice of America Forum Lectuers) Edited by Saul B.Cohen, p.300.

W.B. Morgan and R.P. Moss (1976) have successfully illustrated the idea of ecosystem-land and man-land relationship as a two way function. He describes this as "Thus it is clear that the essential relationship between living and non-living matter, between biological and physical phenomena exist in operation of the biosphere and in its processes. The biosphere may be viewed as a series of distinct ecosystems or biogeocenosis, concepts which provide a convenient and useful tool for study of the biosphere from the point of view of the geographer, since each is clearly concerned with space relationships and the delimitation of aereal units. Into these units man comes both as a component and as a factor. As a component, he fills a number of different niches : and here lies the justification for considering human population and their activities as communities, rather than as societies, despite their non-specific character. As a factor, man is a profound modifier of natural balances, a source of energy and a final detriment in interspecific competition, both of plants and of animals." *

---

* Annals of the Association of American Geographers. Vol.55, pp 339-350. 1976
'Geography and Ecology': The concept of community and its relationship to environment.' ByW.B.Morgan and R.P. Moss.

In the systems approach we have chosen to expose the existing linkages between systems and sub-systems that interact to give the terrain features its character and size. The disturbance offered to these systems by human interference is in need of special treatment since it has been in proportion to his numbers and technological development. However, a systems approach enables us initially to isolate human components and consider in turn other relevant variables of the atmosphere, hydrosphere, lithosphere and biosphere.

The Vegetation System

The natural vegetation of an area depends upon the altitude, amount of rainfall received, amount and duration of sunlight, soil character, humidity, moisture retention capacity of the soil and the degree of slope of the area under study. The nature of the vegetation in the catchment area of a river basin is vital in the regulation of hydrologic and morphogenic process at work within the basin area. The hydrologic and morphogenic processes tend to work in closeunison to produce a temporary balance or quazi-equilibrium to the land system and hydrologic regime.

Although combinations of external influences are significant, we deal with them separately. Firstly let us deter-

mine the intrinsic qualities of a vegetation cover as it affects land morphogenesis. Since the starting point of vegetation - land influence is at the supply of nutrients from the soil; our examination of the vegetation-land linkage should be from the vegetation-soil system linkage. The nature of vegetation in the upper reaches of the Neyyar river basin is essentially of varying qualities of forest cover. These forest types which occupy the upper region are mainly of the following types ; (i) Moist Deciduous (ii) Semi-Evergreen (iii) Dry deciduous (iv) Wet Evergreen.

These constitute the typical tropical forest varieties since the region comes under the influence of the tropical climatic regime.

Within these forest ecosystems, no single physical or biotic factor operates in complete independence; every component of the system is related to another and thus there are a large number of variables. Our effort is to isolate the variables that seem most important or that most influences the soil system which in turn is related to the land system.

The bontiful availability and storage of nutrients within the forest biome has a direct influence upon the soil. The deep litter cover often associated with the foerst biome and the rapid plant-soil nutrient cycling lends the soils under forest cover rich in nutrient and organic humus content. Under humid tropical forest cover chemical weathering of surface and bed rocks is of greatest magnitude when compared to other vegetation covers. This is due the combined effects of humidity and heat. The released nutrient from bedrock either enters the plant system or is lost through the drainage system, on surfacing. Such supply of nutrient from bed rock and regolith is the vital source of the nutrient content of the plant-soil system and consequently the development of the plant forms. Since the Neyyar river basin comes under a high rainfall region, the nutrients released from solution are also temproarily 'stored' in plants. These are released as plant litter which enriches the soil and gives it a high degree of mosture holding capacity.Such soils rich in nutrients and soil moisture storage are a target for human interference in the region. Much of the plantations are on areas once occupied by rich forest biomes.

The uneven nature of rainfall distribution in

the upper catchment of the Neyyar river basin, combined with attributes of soil, slope, prevalence of forest fire, time lag for rejuvenation etc., have produced the existence of semi deciduous and dry deciduous forest types. These forest cover do not have much of the layered structure that is noticed in the humid tropical rain forest. Forests of the deciduous semi and dry type have a seasonal nature of growth related to the availability of rains. During dry periods the trees shed their leaves and remains almost dormant. This lends a 'Seasonal' character to the forest and determines accessibility conditions. Accessibility is easy during dry periods than during rainly periods due to the near absence of ground cover. Only marginal foliage remains on the tree tops, which makes lumbering easy. Large scale removal of tree cover during the dry period leaves the soil bare of vegetation in the ensuing rainy season. This leads to accelerated erosion of the soil and leaching of its minerals and nutrient content. On steep sopes where the mantle of soil is thin sheet erosion results, which continues till the bed rock is exposed. On gentler sopes small rills give way to larger gullies which act as efficient conduits of rain water, giving little time for percolation

and groundwater recharge. The reduced tree cover points to a reduced natural mulch for the ground since litter is virtually absent, thus diminishing the moisture retentive capacity of the soil. "Altering the forest canopy over a large areas could interrupt longitudinal profiles of precipitable atmospheric water with consequences for the hydrological regime of the hinterland."* (Jean Paul Mallingreau and Compton J. Tucker, 1988). The most dominant tree found among the deciduous tree cover in the Neyyar basin ara is the dediduous teak (Tectona grandis).

Out of the external variables that influence the growth of natural vegetation cover radiant energy from the sun is the most important, since photosynthesis depends to a large extent on the light intensity and the radiated heat energy gives the necessary temperatures for photosynthetic process. The variation in ilumination is an important factor in the development of forest communities. The production of leaf litter has a seasonal accent which is related to the 'flushing' activity,

---

* "AMBIO" - (A journal of the Human Environment) Vol.XVII. No.1, 1988, published by the Royal Swedish Academy of sciences/Pergamon Press.
REPORT : 'Large-scale Deforestation in the South-Eastern Amazon Basin of Brazil.' By Jean -Paul Mallingreau and Compton. J. Tucker.

a photosynthetic peak and a decline. 'Flushing' activity sets in with the breaking of buds allowing a rapid growth of leaf or stem. Rapid growth for a few months results in a peak of photosynthetic activity or efficiency. This stage having reached there is a gradual decline in growth and finally ends in leaf shedding. While viewing at tropical forst crowns from a ridgeor a peak, onemay find that not all the forest 'flush' at the same time. This is due to the floral characteristics that is entirely different from species to species. Here the system of leaf production and subsequent leaf fall occurs thoroughout the entire period of an year due to the fact that the forest trees are a complex of different floristic typologies. This accounts for a continuous ground cover of dead and decaying litter and thereby an important influence on soil erodability. Thus the energy exchanges at the crown which is an active level far above the ground has an evident relation with the soil dynamics within a tropical biome.

Another important aspect of climate is rainfall. Although the rainfall is often heavy, the crowns of trees and other vegetation intercept much of it. Splash

erosion is reduced to almost nil. Although a quarter of the interceptd water from the crowns evaporates, a third penetrates the canopy, most of which reaches the ground through stem flow and leaf drip. The evaporation rates are low especially near the ground, for the air is often still, in the lower, sheltered part of the forest. But the soil is able to sustain a regulated throughflow with the help of the humus content which is always at a high level. Sustained through flow in all periods of the year helps in maintaining a constant influx of water into the stream channel.

Apart from the influence of climate on the forest floor litter, enriching the humus content of the soil that helps to maintain large quantities of water within the soil profile helps the maintenance of the hydrological regime, it also nevertheless have other effects on the soil.

The climate under a tropical rainforest cover is rich in organic content and micro organisms that help fast re-cycling of the nutrients within the ecosystem, before being leached out by severe rainfall. This maintains the edaphic quality of the soil, thereby helping in the upkeep of the ecosystem.

Trophical rainforests occur over a wide range of physical landscapes; and although the ridges, spurs and valleys which they cover may owe their main features to former tectonic movements, and to past as well as present climates, the forests affect both weathering and mass movements. We can identify typical macro and micro landforms associated with forest vegetation and with the hot humid conditions in which it flourishes.* (Richard P.W. 1979).

The rate of pedogenesis is accentuated along forest margins, and areas of forest clearance. With high heat and soil moisture content, deep beneath the weathering at the sub-aeral level, chemical weathering takes place within the regolith. This chemical weathering disjoints boulders from compact rock mass and is known as basal weathering.This is a typical feature of weathering found solely within the tropical rainforests. The rate of weathering beneath the normal or exposed weathering zone depends upon the typical conditions offered within a tropical forest cover. The work of streams remove a large part of the regolith, exposing these fragmented rocks termed 'core stones' from which further

---

* The Tropical Rain Forest, - P.W. Richards. (1979)/ p.32. Longmans London.

disintegration takes place. Such weathering also depends upon the structure of the rocks beneath. A well joined bed rock allows such weathering to penetrate it. This deep weathering front where chemical weathering takes place is the initial phase in pedogenesis. Schists and shales weather to form an impermeable clay which favours overland flow. Sometimes during turbulent period of high precipitation discharges, the clay is tranported along with yellow mud and is deposited in the flood plains. The consequences of chemical weathering in humid tropical environments and its crucial role in the initiation of weathering process is highlighted in the study by Ruxton and Berry. "The chemical rotting of granite in Hong Kong has been studied by Ruxton and Berry (1957); their conclusions are broadly applicable to the weathering of crystalline rocks in many tropical humid environments. Initially rainwater penetrates, joints, micro fissures and crystal boundaries, selectively attacking rock minerals. Biotite and plagioclase feldspar are decayed quite rapidly; when the plagioclase is partly decomposed, weathering of the orthoclase feldspar begins and the rock starts to break into a mass of tiny plate-like fragments or 'gruss'. At any early stage the semi-decomposed granite will display original structures (such as quartz banding and joints), but as the other orthoclase is increasingly rotted the

gruss will crumble into a structureless mixture of clay, silt and sand referred to as 'residual debris'. The weathering of the granite will not be uniform. Large joint-bounded blocks will be detached from bedrock and slowly weathered inwards; these will then'float' in the regolith as rounded core-stones. As the regllith progressively thickens leaching and eluviation will become important."* (Clark M J and Small R S - 1987)

Ruxton and Berry suggest that a fully developed regolith will comprise four 'Weathering zones'. The diagram of the dissected granitic weathering zones was also provided. "Zone I (the uppermost will consist of residual debris - stable quartz sand and clay minerals such as kaolinite and sericite - containing no unweathered rock masses. It will vary in thickness from 1 to 25 m. Zone II comprises residual debris and gruss, together with rounded core-stones which occupy upto 50% of the zone (thickness upto 60 m). Zone III is made up of gruss and large numbers of rectangular core-stones, which although detached from bedrock reflect

---

* Slopes and Weathering: Clark (M.J.) and Small (R.J.) Editors: Alan R.H. Baker, and Ecolin Evans. Published by Cambridge University Press, Cambridge 1982.

Third printing 1987.

the joint structure of the granite (thickness 7-17m). Zone IV (the lowermost) is partically weathered granite, resulting from initial penetration and opening up of joints."* (Clark R.J.and Small R.J. 1987). Thus the vast output of rock detritus materials as a result of basal weathering has an important role in soil formation, slope system and thereby on the landsystem.

Another prime external variable that influences vegetation cover is man's increasing pressure on the forest. With the increase in poulation and the advancement of technology new visions of development are sought, leaving at stake the vegetation cover, especially the rich tropical forest cover. Agricultural use of land by the tribals is of the slash and burn type, known also by other names like jhum and milpa. These have only a temporary effect of destruction on the forest cover, since sufficient years of fallow period were affordable by the tribal population which was small in number.Also because of the fact that only subsistence farming was practised and only small areas were put under slash and burn taking into account the meagre population.

Richard J. Chorley's view of the anthropogenic influence on vegetation in himid areas (tropical rain-forest regions gives emphais of human interference as of even more magnitude than that caused by climatic fluctuation. He is of the view that : "In more humid regions, fluctuations in climate are not usually of sufficient magnitude to destroy vegetation through aridity. The role of man, through clearing the vegetation for cultivation has therefore been relatively greater. Experiments have shown that greater the rainfall, the thicker the natural vegetationm cover (up to a point), the greter will be the acceleratiion of erosion consequent on stripping the vegetation."* (Chorley, Richard 1967).

Man's interference with forests includes the encroachment of plantation crops into adjacent forest lands, spraying of pesticides expecially aerosols, and unnatural efforts at afforestation on degraded forest lands using 'exotic' species such as Eucalyptus and Albizzia. Large scale forest clearance for plantation and timber requirements 'swamp drainage' executed to promote cultivation of tree crops in waterlogged areas have created widespread repurcussion on the ecology

---

* 'Water Earth and Man': Chorley (Richard.J.). p.257 (1967) Published by Mamethuen and Co. London.,New York.

of the region and on the land unit under attack.

These are the main external variables that act upon the vegetation cover and thereby on the landd system or land pattern.

Soil . Systems:

Since our study is towards identifying the links within a System, the land system, we proceed to analyse its sub-system among which soil is an important sub-system. We should not only identify the soils and its spatial occurrence, but also trace its edaphic character inorder to substantiate its link with the natural vegetation it offers; which to a great extent controls the degree of erosion characteristics which lend shape to landforms.

The two basic concepts of the soil which have evolved over the years have to be taken into consideration - that of the pedologist and that of the edphologist. Nyle.G. Bady defines these as:

""Pedology considers the soil as a natural body and does not focus primarily on the soil's immediate practical utilization." A pedologist studies, examines, and classifies soils as they occur in their natural environment. (Brady Nyle C 1984).

On edaphology he says "It considers the various properties of soils as they relate to plant production. The edaphologist is practical, having the production of food and fiber as an ultimate goal." * (Brandy Nyle C.1984).

While we may make a conjunctive picture of the soil matrix as from a pedological and from an edaphological point of view, it is of importance to consider the soil formation in a geomorphic environment.

"Development of the landforms takes place in a climatic set up and in a definite tectonic backdrop which together control the topographic relief and consequently the total energy in the geomorphic system as well as the post formational sequence of events involving weathering process including pedogenesis, erosion and deposition.Climate alongwith tectonics also determines the soil-water-ground-water environment which has

---

* Brady (Nyle C.) : "The Nature and Properties of Soils" 9th Edition. (Cornell University and United Sttes Agency for International Development) Eurasia Publishing House (P) Ltd., New Delhi,1984.

a strong control over the soil-forming porocess* Niyogi D, 1980).

In effect the sub-aereal agents of weathering instigate a set of geomorphic process to work, thereby denuding the land form through weathering, giving rise to soil, and later transportation and deposition, obliterating old landforms and creating new depositional landforms.

The soil body acquires a characteristic form as it undergoes the process of development. The soil forming factors of the environment, viz., climate, parent material. topography, geological structure, vegetation and time in varying combination play a vital role in the evolution of the soil.

Being formed from various parent source material and having undergone various stages of disintegration, and weathering, the soi matrix holds typical characteristics within one group. Often a particular soil body or class is found in combination with other group of classes. depending upon their granular size, properties of permeability and cohesiveness, these soils bear different attitudes to the processes of erosion.

---

* Indian Journal of Earth Sciences : Vol.15 No.3, August 1980, Published by Indian Society of Earth Sciences, Calcutta, India.

"Photogeomorphic and Photopedologic mapping of Quarternary formations around Kalna Town. Diostrict barddhaman, West Bengal,. By Niyogi D. (Department of Geology and Geophysics, IIT, Kharagpur, India).

Many of the geomorphic features and surfces is in one way or the other a result of soil movement, soil formation, soil deposition or soil degradation. The quality and nature of soils thus offer themselves as controls of topography formation. The major external force in the transport of soil within the Neyyar drainage basin is water. Atmospheric water when it reaches the ground, it starts displacing soil particles. With the added advantage of gradient offered by the topography, water takes up the major work of transforming the landscape mainly through material transport, and erosion.Thus landscape formation, the designing of land elements, land facets and land units are dependent upon the quantity of the soils that compose it. Water acts with the help of the slope factor, the length of the slope and the internal properties of the soil it acts upon.

Another important function of soils is that it gives a clear idea of the recent geomorphic processes that gave the soils its present position and sequence. Soil properties vary laterally with topography. Topography or local relief, controls much of the distribution of soils in the landscape, to such an extent tht soils of markedly contrasting morphologies and properties

can merge laterally with one another and yet be in equilibrium under existing local conditions. Four most important determinants of soil distribution are (i) Parent rock, (ii) Agents of weathering and (iii) Agents of transport, (iv) Topography or slope orientation.

"Milne proposed the term 'catena' to describe this lateral variability on a hill slope and emphasized that each soil along a slope bears a distinct relationship to the soils above and below it, for a variety of geomorphological and pedologic reasons. These are also called 'toposequences'* (Birke. and Peter.W. 19 82).

With the wide variety of slope forms, relief and the presence of even climatogenic soils (laterites), the Neyyar basin area study will benefit a great deal with the study of toposequences in each of its chief natural divisions. This study has been undertaken separately with the help of terrain photographs under the sub heading 'Toposequences'.

Thus study of soil distribution, apart from the help in identification of land facets and elements also

---

* Birkeland (Peter.W.) : "Soils and Geomorphology " 1982- Oliver and Boyd, New York, London, Sydney.

help in the construction of the 'toposequence' whereby it islinked to the vegetation and the slope. Here since we are concerned with topographic relief of only a few meters in depth, we may link the soil forming processes with the regional climate which with respect to nature geomorphological weathering invoked in the region can be considered a constant.

Thus the linkage of the soil factor in the formation of land system is of prime importance. The study of soil is imperative for the understanding of the processes and resultant forms of the landscape.

The Geology System:

Geology alongwith structural landforms has a decisive control over the topography and soil matrix of a region. The lineaments offered bythe geological formations control the surface flow pattern of rivers. The river water ususally follow lineaments due to its immediate gradient offered without the need for erosive work of the basic kind like rilling and gullying, and also for the fact that lineaments provide definite paths or 'confines' for the river. Thus the river takes the route within the confinement offered by the lineaments.

Geological formations control the ground water depth with the presence of the layer of impervious rocks, underlying permeable rocks, "The water that occurs below the water tables within the zone of saturation is known as the ground water. Above the watertable and below the surface of the earth, the pore spaces and openings are only partially filled with water that percolates through them. This zone is, therefore, described as the zone of aeration and the water occuring in this zone as Vadose water."* (Mukherjee P.K. 1986).

Therefore, the geological formatins control the physical limits of the water table and the vadose water that are important components in the hydrological equation of a basin area. The quantum of vadose water is an essential component of water balance studies. Geology thus affects the hydrological status of river basins. At certain places along the stream course, the structural landforms dip towards the stream and the ground water thus enters the stream and provides discharge during lean flow periods. Geological formations of lens shaped impervious rocks situated in the zone

---

* "A Textbook of Geology" :Mukerjee (P.K.) 1986 Published by the World Press Pvt. Ltd., Calcutta. PP 146-147.

of aeration, provides for a small amount of ground water storage. This is described as a preached water table, and has local influence as it has enhanced capillary reach towards the surface layers as a result of its virtue of being placed comaratively near the earth's surface.

The Climate System:

While describing the external variables that effect the nature and distribution of vegetation; climatic effects on vegetatin cover and weathering have been discussed. A heavy annual rainfall, a warm humid atmosphere and a more or less uniform temperature throughout the year are some of the important characteristic features of the climate in the Neyyar river basin.

The heavy rainfall is well distributed throughout the year. It is this well distributed rainfall throughout the year that is conducive to the growth of tropical rainforests, which harbour the wet evergreen species. The normal range of temperature 22° C - 35.6 °C.provides for high evapotansiration rates and a high level of himidity in the region. The main types of climate induced rock weathering found in the basin area are spheroidal weathering, resulting in lens shaped fragments, granular disintegration and chemical weathering. The thick vegetation growth over boulder strewn areas provides

for root wedging along rock cleavages. The climate with its high humidity and heavy rainfall has also played a key role in pedogenesis. As has been described under 'soils', 'laterite' is a true examle of a climatogenic soil. the laterite soil is formed by weathering mainly of acidic rocks under alternate wet and dry tropical conditions. This soil is porous and well drained and has poor retentive capacity, and fertility. In the midland region laterites of 'residual' nature are found. These soils may once have been forest loams and as a result of forest clearing, been transported and deposited at its present position. The influence of climate has thenceforth changed the soil qualities to lateritic. Laterites have a typical character of its own which afects the topographic features and natural vegetation that it can sustain. It may even point to a newly emergent land use, like brick making. Laterites are highly well drained woils and respond well to management practices.

Thus climate is an important control in defining the nature and distribution of vegetation. It is an important element in weathering and soil formation. The rainfall regimen, and thereby the magnitude of erosive

work by fluvial action is dependent upon the climate. Thus the climate is closely linked and has dominant control over the rate of processes acting upon a landscape.

The climate of the Neyyar river basin is in effect a climate of the tropics, since it lies not only within the tropical latitudes, but also exhibit the wet evergreen foersts which is tyical of the tropical climatic climax vegetation. The amount of insolation and precipitation received in the region is the mainspring from which this climate controlled vegetation arise. Both the South-West monsoons and the north east monsoons are experienced in this region. Like other parts of the State, this basin experiences the four seasons, the dry weather from December to February, hot weather from March to May, South-West monsoon from June to September and retreating or noth-east monsoon from June to September and retreating or north-east monsoons from October to November. The monsoons are clearly defined by S.P. Khromov, as quoted by G.G. Tarakanov."The monsoon is macro-scale patern of airflows over a considerable part of the earth's surface, which is notorious for high frequency of a single prevailing wind during a season, either winter or summer, with this direction

changing to the opposites, or close to it, in coming from one season to the other."* (Tarakanov G.G. 1982).

While the differential heating of the land and the sea is the basic mechanics of the moinsoons, conditions of orography. which may be in the present context be interpreted to mean the configuration of the landsystem as affecting the aircirculation and thereby the rainfall, has an important influence on the monsoons. This has been illustated by G.G. Tarakanov as ": "The clasic theory of monsoons puts the thermal conditions into the forefront as being of major importance for their genesis. The most general features of monsoon circulation can more or less satisfactorily be explained in this framework. However, monsoons do not develop equally everywhere. Their development is influenced by the shape of the continents, orography, and the conditions for circulation in the upper troposphere. (Tarakanov G.G.1982)

From these it is clear that the altitude, position and the

---

* Tarakanov G.G. " "Tropical Meteorology". 'monsoon'. pp.133- Published by Mir Publishers, Moscow, 1982.

* Ibid.

aspect of various units of the land systems have an important influence on the precipitation received in the region. The altitudinal range within the land system determines wind diversion and air cirulcation.They also serve as barriers against which moisture laden winds are deflected upwards, into rarer air space and condenses to provide precipitation on the onward side. The Neyyar river basin occupies the onward side of the Western Ghats during the South-west monsoons and this brings plenty of rains during this season. This orographic rainfall thus depends both upon the climate and the land system for its occurence.The land system is therefore partly responsible for the climate experienced in the region.

CHAPTER - IV

RESULTS AND DISCUSSION

The Highland Region

I. LOCATION:

The highest peak in this region is Agasthya Malai which is situated at 1868 mts above sea level. It is the source area for the Neyyar river.

II. PHYSIOGRAPHY:

The physiography of the highland consists of topography in its young stage. Much of the hills slopes are experiencing a high rate of erosion. The tropical humid climate and associated vegetation, has induced the formation of typical tropical landforms in the regions. The highlands has a high range of altitudinal variation, extending from above 75 metres to above 1800 metres. The Neyyar river takes a rapid descend from its sourcin the Agasthya malai (1868 mts.) upto Erinja Malai (300 mts.). After traversing Erinja-malai, it bed slope is reduced considerably. Soon the river starts its deposition in the midland region itself. In the highlands the valley width is small and deep. This feature, together with the gradient ensures rapid drainage and high velocity.

The abrupt rise in elevation of the highlands, helps in modulating the occurrence of orographic rainfall. The moisture laden south-west monsoons are rapidly trained

up the mountain side and on condensation, produces heavy prepipitation. The lee-ward side occupied by Tamil Nadu, remains a rain shadow region.

III. GEOLOGY

The geology of the highland region is composed largely of Charnockites and Khondalites. "The Charnockites (or the charnockite series), named after Job Charnock are younger in age than the peninsular granites. They range in composition from acid to ultra basic and are characterised by the presence of a variety of pyroxene, known as hypersthene. Bluish grey grains of quartz occur commonly within the acid rocks belonging to the charnockite series. The charnockites posses characteristics of both igneous and metamorphic rocks. They exhibit intrusive relationship with the country-rocks and are at the same time, distinctly foliated. The Charnockites are widely distributed in the Peninsula and form a portion of the Nilgiris and the Eastern and the Western Ghat ranged. There is much of controversy regarding the possible mode of origin of the charnockites. According to T.H. Holland R.A. Howie, and W.A. Groves, the Charnockites are of igneous origin, while P.K. Ghosh, H. Ramberg, F.J. Turner and B. Ram Rao suggest that such rocks might have been formed due to metamorphism of pre-existing sedimentary rocks under deep-seated conditions".*

---

* "A Textbook of Geology", by Mukerjee. P.K. Chapter VII 'Stratigraphy of India', p.312. Published by The World Press Private Limited, Calcutta. 1986.

These charnockites and khondalite group of rocks comes under the Archaean Crystalline rock complexes. The Charnochites are predominant over the Khondalite suite of rocks. The crystalline rocks of Archean system include leptynites and charnockites, hornblende and biotite gneisses, schists and granulites. The general strike of the foliation is north-west and south-east with high dips.

IV. SOILS:

The soils of this region come under forest loam. The soil has a dominant role in the vegetation cover over the area. Forest loams are rich in minerals, and have a thick humus layer with plenty of decayed organic matter (DOM) which helps in the efficient recycling of nutrients within the ecosystem.

V. NATURAL VEGETATION:

The region is covered mostly by semi-deciduous, deciduous and wet Evergreen forest cover. The wet evergreen forest cover found in this region has the distinctive layerification typically found in tropical rain forests. It is chracterised by presence of a tangled vegetation consisting of lianas and climbers, as illustrated in the photo plate No.1. The tropical forest cover found in this region has a highly complex yet fragile ecosystem. It is one of the small remaining patches of the Indo-Australian belt of

tropical forest. Tropical forest ecosystems thrive only in very limited areas of the earth, where it seeks and successfully upholds its life sustaining threshold levels in altitude, soil, climate, slope, aspect, geology, hydrology and eco-tones. Even minor changes in any of these factors affect the Tropical forest ecosystem's threshold limits thus hindering its growth and development. The degradation of an existing forest biome have telling influence in the accelerated and associated degradation of the land system components also due to negative feedbacks in erosion proneness.

The tendency towards maintenance of these threshold limits is seen as a ubiquitious phenomenon in natural environments, undisturbed by man. These threshold limits function as a sequence and may act within varying time periods. The intervention of man may result in altering the thresholds levels. Human influence may either accelerate or decelerate the threshold functions per unit time.

Marie Morizawa classified geomorphic thresholds into two types : the extrinsic thresholds and the intrinsic thresholds. She describes them as follows : "Extrinsic thresholds are those conditions external in nature that alters or plays a role in facetting the landscape. These are mainly

the forces of storm, rainsplash, intensity and angle of rainfall upon the geomorphic unit in question. These act directly on the face of the earth, wiping away completely, dislocating the granular and particulate weathered artefacts that have been remaining within the 'intrinsic threshold'. So those weathered elements which were within the intrinsic threshold have been markedly dislocated by the particular element controlling the extrinsic threshold, namely a rain-storm or gale. The weathered particles remain for a considerable time 'insitu' after initial dislodgement due to weathering. These in the normal course or cycle remain as long as the intrinsic threshold is reached.

Incidentally, 'intrinsic threshold' needs explanation. The multitude of organisms, (plant and animal) the micro relief, slope aspects weathering trend, geology and parent material, the manner of juxtaposition, all determine the placement of the particular mud block or rock as regards its pre-disposal to weathering. Although these may itself designate a level of threshold the repose or immediate positioning of the weathered material and the amount of such material that can be contained in that perch perhaps gives a larger meaning to the term 'intrinsic threshold'"*.

Marie Morizawa, 1974.

---

* Marie Morizawa (Edt.), "Fluvial Geomorphology", 'Geomorphic thresholds and comples response of drainage system'. Longmans, London.

On the frequent field trips to the basin area, it has been observed that the eco-tones at the tropical forest margins determines whether the actual forest line is receding, advancing, quasi-stable or stable. The eco-tones invariably act as the buffer zone between human encroachment and the dwindling tropical forest region. The eco-tones usually are seen to have either shrub and tall grass cover or have a fire - degraded vegetation, often seen regenerating towards a secondary forest ecosystem. Some fire resistant species (deciduous) will be seen interspersed among tall grass and large boulders. The land under degraded forests have an increased proneness to erosion and soil leaching. Changes in the internal qualities of the soils, like friability after fire, decreased water premeability, soil, moisture content, etc., influence the intrinsic properties of soils and prepare it for easy dislodgement and transportation.

VI. HUMAN INTERVENTION:

Along with the rock debris found as transported material, appreciable quantities of drift wood is also seen. Some of the drift wood are seen to have burnt ends. This is evidence to the human interference in the region. The pilgrims to 'Agasthya Malai' the abode of Agastya Muni, a Hindu Saint, have set up camping fires through out their journey through the forest. Although the movement of pilgrins

is seasonal, the burnt fuel wood used for camping are seen throughout the year as driftwood. At many instances huge logs are burnt and a lot of wood is cut down for fuel needs. In anticipation of the needs of the next pilgrim season, whole trees are cut down, so as to get dried and ready for the next season. Most of such clearing are found close to the river, for the additional advantage of a nearby water source. Much of these fires are not properly extinguished before the pilgrim proceed on their journey. The live cinders that are left unheeded pave the way for numerous devastating forest fires. Thus camping areas are particularly noticeable as areas with cleared or charred vegetation due to such accidental fires. These fires have an immediate effect although local it may be, on the vegetation in creating open patches within the thick forest cover. Since the pilgrimage is usually during summer, the scope for the spread of accidental fires is even more since the ground cover offers plenty of dry leaves, and grass. Such ground fires may often stretch upto the canopy level, and create total disaster in the region. The soil organisms gets killed along with ground inhabitants like snakes and rodents. Much of the seeds are burnt and the soil turns friable with lowered moisture retention capacity. With the loss of vegetation and root matting much of the soil is eroded and is lost in the river. The whole system in the region is altered drastically. Many months have to elapse before the rains bring a scope for regeneration of the vegetation.

To a limited extent, the occurence of natural fires is also a part of the ecosystem dynamics. It is the high frequency of fires as when initiated by human interference wantonly or accidentally that tend to degrade the ecosystem. Wanton firing of vegetation has been taken as an easy and cheap method of vegetation removal either for agriculture or for setting up communication facilities with a view to developing the region. Accidental fires are initiated mainly by non-extinguished camp fires or as a result of lighted beedi stubs discarded carelessly by pilgrims or unskilled labourers employed for lumbering.

Forest fires caused by natural agents such as lightning or friction between bamboo stalks may certainly have devasting effects soon after the incidence of fire. But, since natural fires never occur at the same place repeatedly, nature allows for re-growth and, re-furbicating a typical forest over a considerable period of time. The gap created by the fire is bridged by a succession of plant communities that give way to trees and the whole ecosystem is regenerated. Such a time lag between two consecutive forest fires is not present for man induced fires. The exposed land units under go rapid changes in its morphology.

Even a devastating calamity such as a fire cannot degrade the ecosystem for long, if the fire is from a natural cause. Forest fires due to human intervention have a decisive

influence upon the vegetation cover and thereby the erodability of the land. Forest cover removal leads to sudden changes in erosion rates. With the occurrence of precipitation, heavy erosivitiy results in largescale sediment load entertainment which has important influences upon the landscape both at the point of erosion and downstream. Soon after a heavy rainfall, the clear river turns yellowish brown in colour due to the high increase of sediment load. Due to high discharge rates during heavy precipitation, the water turns turbulent and has greater power to remove larger material in quality and quantity.

The Kerala Forest Department, has put up sign boards along the one-foot pathways inside the forests. These wooden signboards are fastened onto tree trunks. It is written in the local language, Malayalam, spoken throughout the state. Although the literacy among tribals is almost nil, the sign boards are very useful in reminding the pilgrims of the careless use of fire. The message of the signboards my be translated as :

"Forests are the source of our drinking water"
"Take case so that it does not dry up due to fires".

An important result of human interference was the construction on the dam. Large areas of the forest had to be removed to give way for the reservoir. The extensive area cleared

for containing the impounded water not only comprises the area presently under water but also include large arms of depressed areas which come under occupation by the reservoir during the monsoons. The margins of the reservoir exposed due to removal of vegetation, and due to natural control by the seasonally fluctuating water level shows the slope of the land units, which is otherwise indiscernible due to the thick vegetation cover. The reservoir being a flat mirror like surface leads to increased reflectivity, there by creating an increase in albedo. This may be another reason for the lack of plant succession leading to the water front.

VII. LAND USE:

The highlands are covered by thick growth of tropical forests. The landuse consists of timber extraction, collection of forest produce by co-operatives, and private individuals, and the local use of the land by tribals. The use of the land by tribals does not come under the definition of landuse. A.P.A. Vink (1975), argues the point as follows : Land use is any kind of permanent or cyclic or human intervention to satisfy human needs, either material or spiritual or both, from the complex of natural and artifactial resources which together are called 'land'. In this sense, true nomads with no fixed habitat do not practice land use; they do not systematically apply their energies to any specific tract of land, and they themselves are a natural part of an ecosystem, as are other living organisms.

Their use of the land is not systematic or scientific. Also intensive methods of use are also absent. They do not spoil the ecosystem beyond redeem. They clear only a small patch of forest at a time, keeping in mind the natural demands of low slope, and a land of easy tillage for their indigenous tools. The shifting nature of their cultivation, gives enough time for regeneration of the plants in the region.

From the system of shifting cultivation, the use of land by the Kani tribes who occupy the rain forest regions of the highlands have evolved into a system which can be termed as 'rudimentary sedentary cultivation'. This change to this type of system my be attributed to the reduced areas available to them to practice shifting cultivation. Formerly the whole of the forests were theirs, and they enjoyed a living by merging with the natures' laws. But with the construction of a reservoir, and its boundaries being earmarked for reservoir swells, have reduced the availability of moderately sloped lands. The tribals are now re-settled in government parcelled lands, and those tribals unheeding to live in the government alloted pieces of land, were forced to shift further towards the crest of the mountain. These are invariably areas of high steep slopes, thin soil and rapid surface runoff including overland flow, due to thin soil, and heavy rate of precipitation. Their practice

of crop cultivation on these steep slopes have gravely increased the amount of 'surface loading' due to tillage on these steep slopes. The high rate of precipitation, induces mass removal of the topsoil, eventually exposing the bare rock. This is evidenced by the muddy colour of the river soon after a fairly moderate to heavy rainfall.

Jordan (Terry G) and Rowntree (Lester), (1986), describes the attributes of 'rudimentary sedentary cultivation' : Another traditional form of tropical agriculture is 'rudimentary sedentary cultivation'. Farmers use this system mainly in the highlands and mountain valleys of the tropics, as well as in some river plains. Rudimentary sedentary cultivation differs from shifting cultivation in numerous ways. Fields are fixed and permanent. Farmers keep more livestock, and they rely more heavily on farming, instead of hunting or fishing for their food supply. Although many shifting cultivators are women, rudimentary sedentary farmers are generally men. Jordan Terry (G) and Rowntree Lester (1986).

The land use of the grid A, consists of rich forest cover, which comes under the area of Neyyar Wild-life sanctuary.

Jordan (Terry G.) and Rowntree (Lester) : "The Humn Mosaic" : A thematic introduction to cultural Geography. Horper and Row Publishes, NY 1986.

There are no tribal settlements of the 'kani' tribe nearby. The area is almost wholly undisturbed natural forest cover, at margins of the river, expecially at the base and immediately above the waterfall, human interventions is noticed. The pilgrims to 'Agasthya Malai' use this as suitable camping spot.

VIII. GEOMORPHOLOGY:

Apart from the geology, soil and vegetation cover, the dynamics of open water flow within deeply incised channels is a marked pecularity of this region. The highland region is characterised by steep slopes which produce numerous rapids and waterfalls in the tributaries and main river of Neyyar. The upper course of the stream in this region is strewn with boulders and rocks. The river may be said to be juvenile at this part of its course. The river concentrates on down cutting and is swift and deep at various places. The structural control offered by the exposed bare rock is evident on observing the erosion features. The pot-holes situated on rocks higher than the present water-level indicates pluvial periods of the past. These are evidence of high water level and the river's work in the geomorphic past. Heavy downcutting is noticed in regions of bends forced by the presence of rock faces. These rock faces dip slightly towards the streams but near vertical walls created by rock faces are also seen. This down cutting

is due to the effect of helicoidal flow, experienced at the bends. As the rock face is comparatively more resistent than the stream bed, greater amount of erosion occurs at the bed level. The deep scouring of the bed leads to more voluminous flow at this region as a result of narrow confinement and the application of the law of hydraulics. The upper course is characterized by boulder, sub angular rock fragments and pebble deposits all along the stream beds. The exposed boulders wear a black colour due to growth of fungus and lichen, as a result of the high humidity in the area. Much of the boulders are sub angular to rounded. The sub angular nature points to the presence of their parent material closeby, in other worlds, they are not likely to have trvelled far from their place of initial dislodgement. Along the banks of the Neyyar, large boulders and striated rocks faces are seen. These striations on the rock wall presents to us the past high level flow of water. The dynamic nature of the fluvial action is well depicted by the numerous pot-holes, arches, caverns and amphitheatrical hollows carved out in the rock.

The water-fall takes its 9 metres plunge on to a faulted, and highly jointed bed rock. The structural control of the base rock is seen in the river following the major fault slope. The amphitheatre shaped howlows to the left

of the present water fall shows the former plunge face carved out in the near vertical rock. Presently the river is seen to have shifted from the left (former plunge cavern) to the right, its present course.

The highly jointed bed planes having a dip of about 30 degrees which controls and conducts the waters. During peak runoff after the rains, the large quantity of water overcomes the geomorphic threshold and is seen to cascade like rapids over the jointed step like base rock.

These pot holes invariably contain gravel, coarse sand, and pelletted but fairly rounded stones. The circular flow within the pot holes along with the action of rock pieces acting as grinding material have eventually led to an opening towards the direction of flow at a portion of the pot hole. These have in course of time widened to form armchair shaped rocks.

The presence of large quantities of unassorted material found along the banks of the river and in the visible portion of the stream bed points to high energy variations in the flow regime. The lack of assortment also points to the juvenile nature of the stream.

Plate No.1.

Wet Evergreen Forest
with climbers and lianas

Plate No.2. Tribal homes and subsistence farming.

Plate No.3. Deforestedidepressions, seasonally occupied by the reservoir waters

Plate No.4. Mirror-like surface of reservoir Increased reflectivity and albedo rate

Plate No.5. Close up of degraded vegetation near the banks. On the lefta a large fractured boulder is seen

Plate No.6. Pot holes above the present water level indicates the past basal erosion during pluvial periods.

Plate No.7. Pot holes and small stone arch. Muddy water collected in pot holes soon after rains indicates disturbance to the riperian system in the upstream areas.

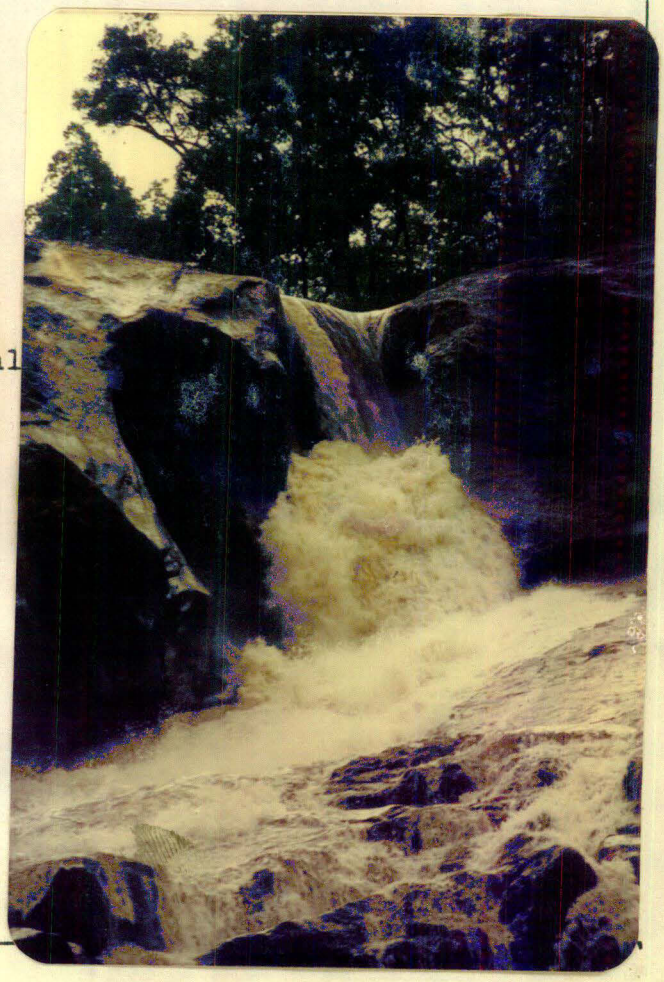


Plate No.8. Amphitheatrical hollows on cliff face indicates shifting of the water-fall and the resultant gorge.

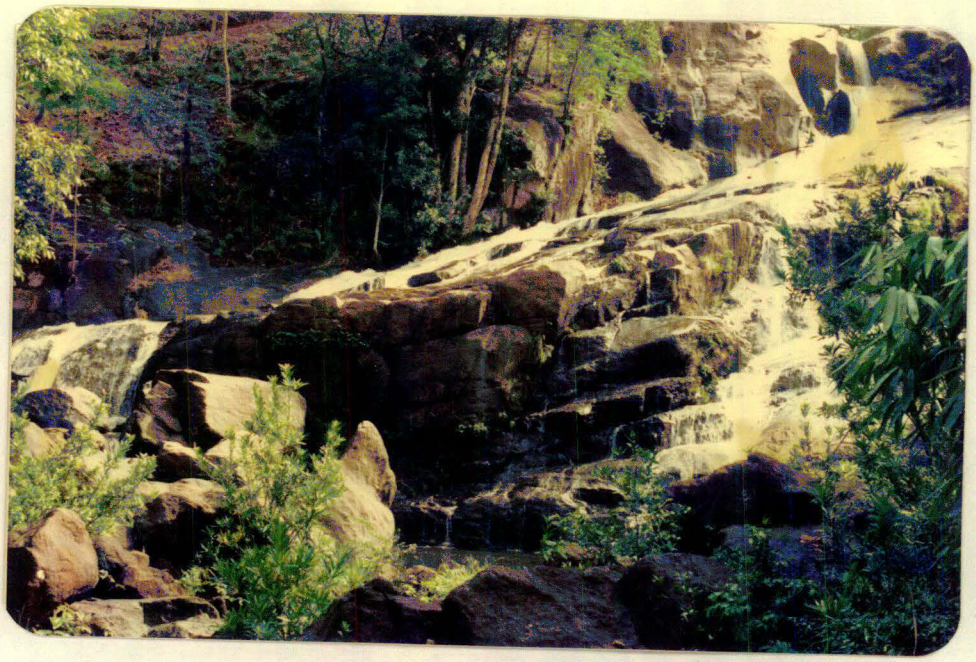
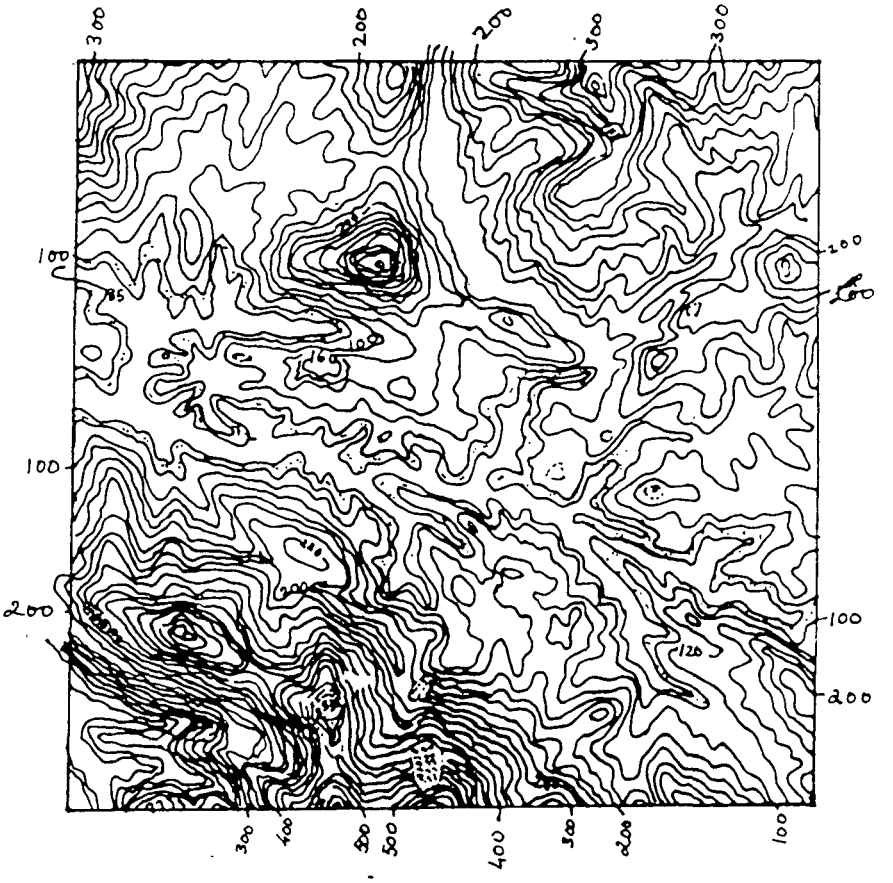


Plate No.9. River follows the inclined bed plane during normal runoff and lean periods(Photograph taken before precipitation)

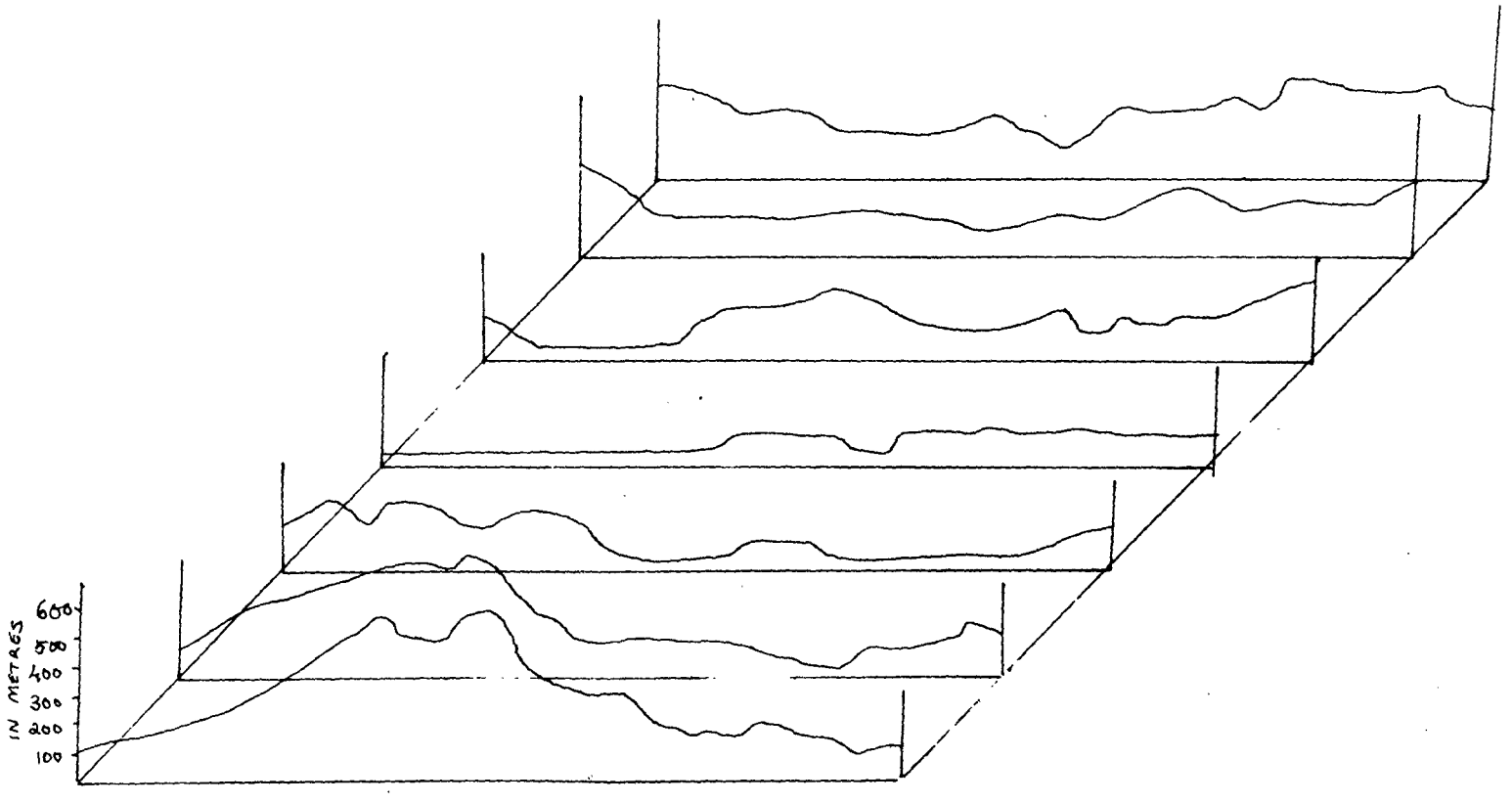
Plate No.10. River swell. Some water escapes the geomorphic threshold (photograph taken immediately after rainfall)

CONTOUR MAP - GRID 'A'



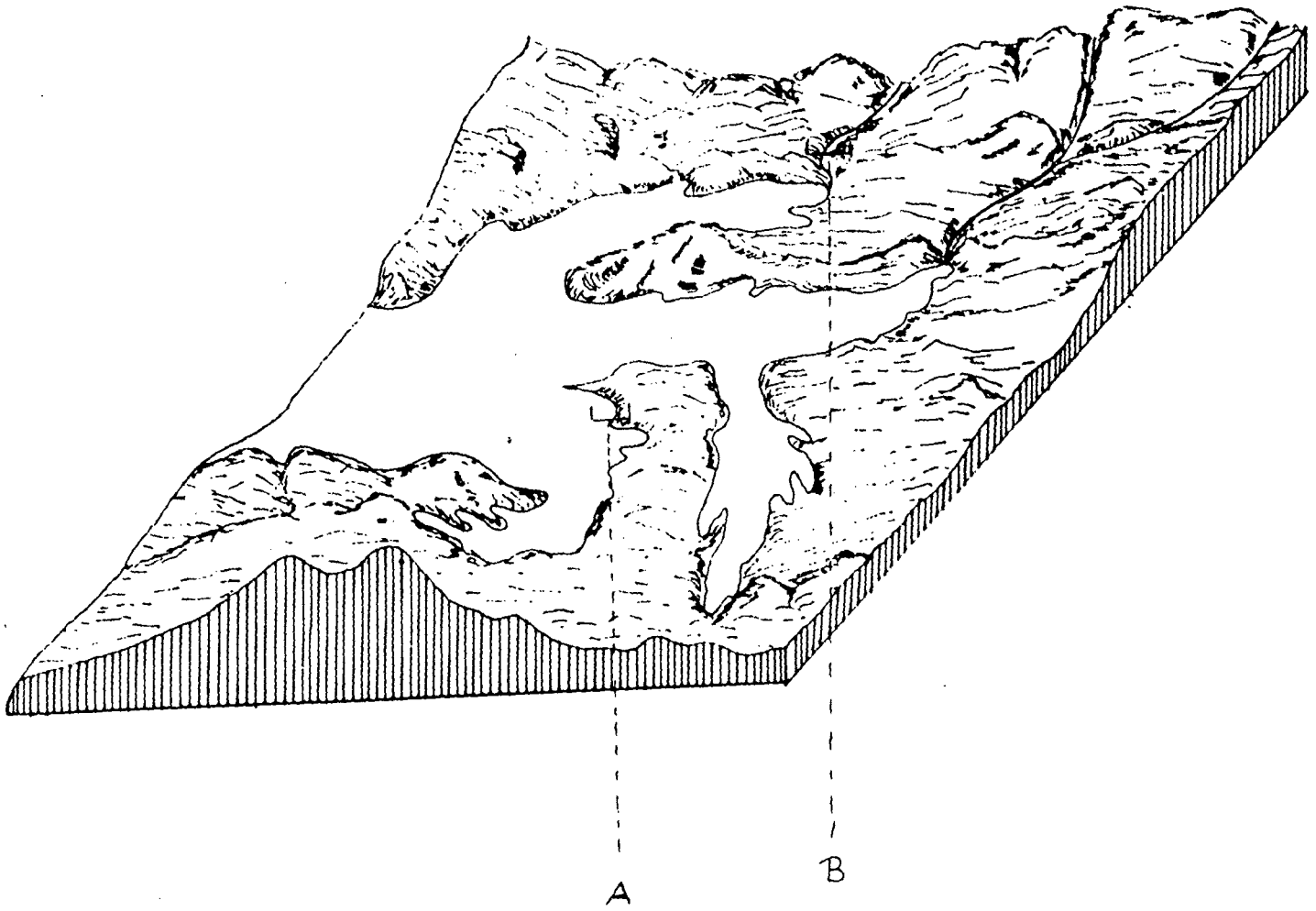
Contour Interval - 100mts.

PROFILES FROM CONTOURS - GRID 'A'

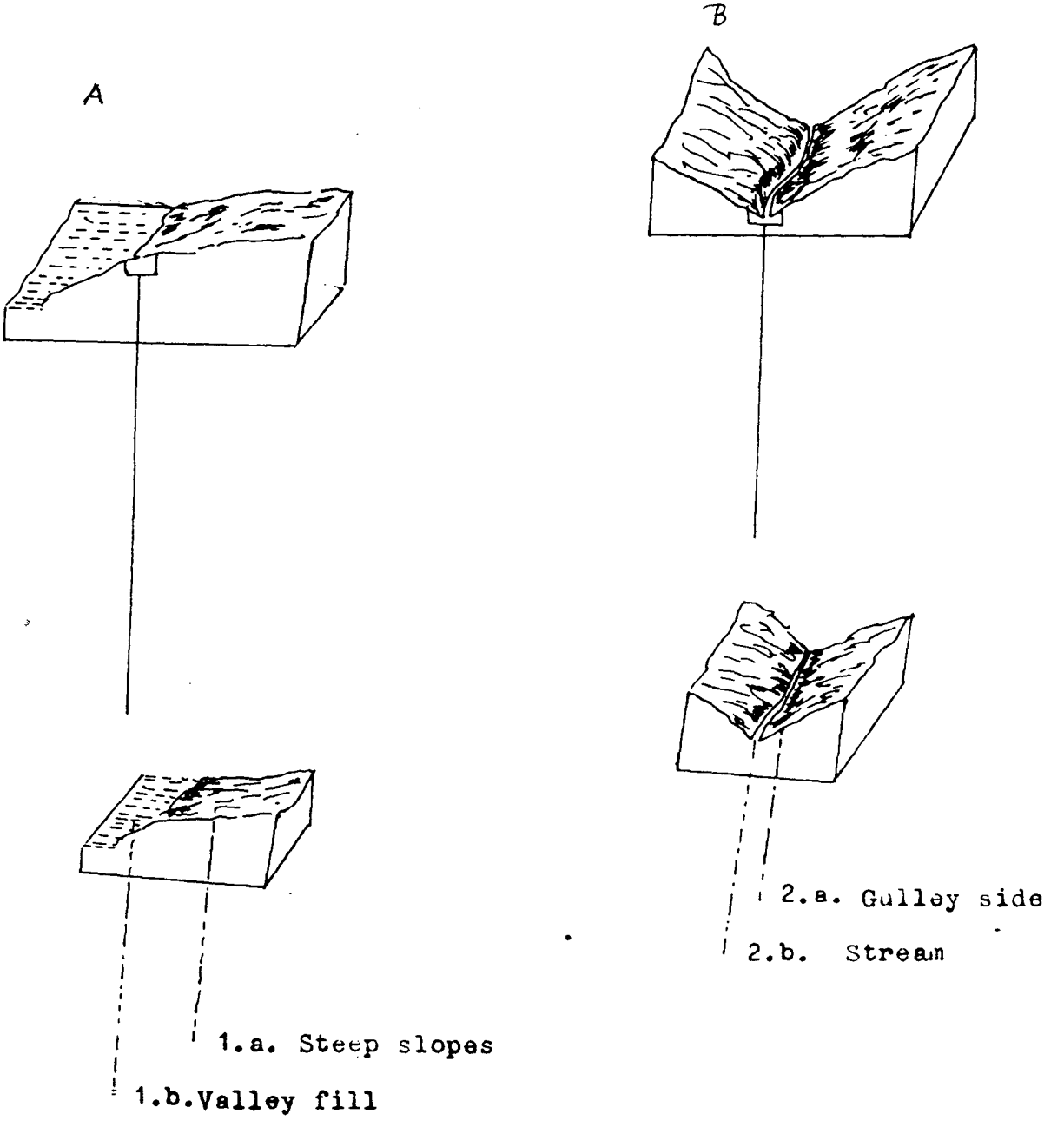


BLOCK DIAGRAM SHOWING THE LAND SYSTEM

GRID - 'A'



LAND FACETS AND LAND ELEMENTS



THE MIDLAND REGION

Location:

To the west it is bounded by the low land region of land lying below 8mts. and towards the east, it is bounded by the highland region composing land at elevations above 75 mts. Thus to the east the midland region joins the high land region at its foot hill zone.

II. Physiography

The physiography of the region consists of gently undulating hills and extensive flood plains. The low undulating hills provide sufficient drainage for a variety of crops. On well drained soils the chief cultivated crops are rubber, pepper, cashewnut, tapioca and cotton. Most of the low hills also afford ideal condition for settlements. Many individual settlements are seen enconsed within the plantations. An active peneplanation process is seen in progress which has led to low hills with gradual slopes and wide extensive flood plains found betwixt them.These flood plains found juxtaposed among the haze of low hills are formed by the active work of river deposition, as well as a result of heavy deposition as a resuslt of hill slope erosion process. A typical view of river in the midland region

is given in the Photograph (Plate No.1). The river banks are seen to be densely vegetated. The vegetation consists of useful trees planted by private land owners. The river is obviously in lean flow period and only a part of the river bed is now occupied by the river.

III Soils:

The soils capping the low hills are mostly laterite. Laterites are in general poor in available nitrogen, phospherous, and postash and are also low in available bases. The organic matter content is also low. These lateritic soils are not fertile but is responsive to proper land management practises. The lateritic soil on lower slopes are sometimes seen worked away so as to provide a flat surface for housing. Lateritic soils are used for making bricks which has risen to the status of a large scale commercial activity, employing a large number of people. Only the midland lateritic region offers the scope for brick making. laterite is a semi consolidated mass like structure with plenty of vesicular spaces and is highly permeable. These bricks made out of laterite using wooden frames are sun dried and on exposure to weather, they harden and grow more resistant disintegration. Laterites

are typical weathering products of gneissic and granatic rocks, developed under humid tropical conditions.

Heavy rainfall and a high temperature which is characteristic of the humid tropics are the typical conditions favourable for laterisation to take place. 'Insitu' laterites have been formed by intense leaching and removal of silicate minerals and silica from the original parent rock leaving a high proportion of oxides of iron and aluminium. Laterites come under oxisols and are the most highly weathered in the classification system. The clay content of these soils is very high, but the clays are of the non-sticky type. The depth of weathering is high in Oxisols and laterites are found upto a depth of 16 mts. or more at places. Their most important diagnostic feature is the presence of deep 'oxic' sub surface horizon - a horizon fenerally very high in clay-size particles dominated by hydrous oxides of iron and aluminium. The surface soils are mostly reddish brown to yellowish red in colour. The texture of surface soils ranges mostly from gravelley loam to gravelly clay loam. Laterites cover a vast portion of the midland region and extends upwards till the foot-hill zone.

In the valleys between the low undulating hills are found crescent shaped sand bars and flood plains. These flood plains consists of alluvial soils brought by the river. The flood plains invariably being areas of low drainage, water-logging is a frequent phenomenon specially during the monsoons. These flood plains are the chief areas for the cultivation of paddy. Both indegeneous and hybrid varieties are grown. At many places where proper land-levelling, or agriculture had not been commenced, the flood plains with their inherent quality of unsatisfactory drainage, has developed marshy stretches overgrown with weeds such as parthenium, and water hyacinth. Due to negligence or non-use of such lands, their condition have been deteriorating in the context of human use for agricutlture. Land levelling works, drainage works and continued land care may prove very expensive. Such areas are in some places being infilled for housing purposes.

In addition to this brown hydromorphic soils are also found in the midland region. Being a poorly drained soil, crops that needs excess moisture, or those that can withstand stagnant water conditions are planted in this soil. These include fodder crops and also

vegetables grown on small ridges made with rills on either side to drain away the excess water. These soils are of great practical importance in local areas, being the most productive especially fo vegetable crops and horticulture. Although horticulture is a farming which gives high returns, its potential has not been realised in this region. These soils are formed in a water saturated environment. These soils are from organic (plant) deposits alternated with sand deposits in depressions while there was more of water. Later, with added deposits of sand and clay, and greater evaporation, the water component got drastically reduced, exposing the dark-brown or black coloured organic soils. The first physical characteristic of cultivated organic soil, is the colour which is dark brown or intensely black. The second outstanding characteristic is the light weight of the representative organic soil whend dry. This isbecause usually these soils have more than 20% decayed organic matter (DOM). The third important property of organic soil is its high water holding capacity on a weight basis. These soils are mostly confined to the valley bottoms between the undulating topography of the mid land region. These are formed by the combined action of both river deposition and

hill erosion towards the valley, in various forms like soil creep, slumping or sheet erosion. In addition , to these, a large quantity of plant life is also trapped in the sedimentation process of this soil. Thus the soil profile contains large quantities, of over 20%, of organic matter in decayed or semi-decomposed form. Therefore, these soils, exhibit characteristic hydromorphic features like gley horizon, presence of mottings, streaks, dead organic matter (DOM), hard plans, iron-manganese concretions etc.,. The black clay is used for pottery. The spatial location in the soil catena, of the region, impeded drainage conditions, topography of the surrounding areas, and fluctuations in the water-table seem to be the major contributors to the aquic condition of the soil.

Red loam soils are also found in the midland region. They are chiefly found in the southern region of Nayyattinkara Taluk. The deep red colour of these soils is mainly due to hacunatite or any hydrous ferric oxide. The majority of red soils are loams of some kind. These red loams are deficient in organic matter and low in all the major plant foods and lime. But they are seen to respond well to good agronomic practises

because of their favourable loamy texture. The reaction is acidic. Under careful management, coconut, tapioca, banana and some vegetables are seen grown in this soil. But the yield from coconuts grown in red loams are poor. This is mainly because organic matter has been leached out of the soil. In order to improve the fertility of such soils, the growth of leguminous plants as an undergrowth to the main crop is a ubiquitious phenomenon noticed in the crop management in this region.

Red loam soils in Kerala, are of localised occurrence and are found mainly in the southern parts of Trivandrum District. These soils occur in a catenary along with laterites and are found mainly as deposits by colluviation in foot hills and small hillocks. The depression where these soils are found are relatively large areas compared to hill tops, and hence only negligible amounts of water are brought in from the slopes. The sponge-like nature of the red loam with plenty of vesicular cavities and large pore space makes it a highly permeable soil. The rapid permeability of surface soils also has been responsible for the characteristic development of the loamy soils which are very deep and homogeneous and without much expressiosn of horizon.The

soils have a red colour with the intensity of the hue increasing with depth. The red colour has been attributed to the presence of haematite.

The next important soil group that exhibit itself in the midland region are the riverine alluvium. These occur on either banks of the river and are also seen deposited in the flood plains regions. These have varying physico-chemical properties depending obviously on the nature of the alluvium that has been deposited. These sedimentary layers of soils have their source from all parts of the drainage basin. This is in appreciation of the fact that even gully, rivulets and tributaries add to the sediment load carried by the main river. Alluvial soils lack horizon, but distinct layers of sediments of roughly homogeneous granular size are noticed in the soil profile which indicates the annual nature of the floods which bring in coarser grains. In the long run the pluvial periods also bringing such coarser material give distinct layers and these can easily be identified through the study of lithogenesis. The riverine alluvium are deep soils with their surface texture varying from sandy loam to clay loam.

IV. Natural Vegetation

Much of the regions natural vegetation has been removed now due to the accute pressure for agricultural land. Even bare,open lands have been managed to produce crops like tapioca, which thrive in even the most infertile soils. The pressure of grazing on the left over patches of natural vegetation is also an important reason for the disappearance of natural vegetation. While livestock and agriculture compete for the land resources, the spread of towns like Neyyatinkara, and Balaramapuram, have placed increasing areas under occupation.

Since the natural vegetation in the midland region has been highly altered by human intervention mainly through agriculture, and settlement, the natural rate of erosion has also eventually been highly altered. The resulting altered conditions of topography has altered the characteristics of the denuding agents also, mainly the fluvial action. The geologic parent material has through pedognesis at its exposed surface given rise to vast quantities of soil and debris material. These freshly formed soils, together with other disintegrated material, are easily transported to the valley bottoms,

due to the lack of vegetal cover, and root binding. From there, further transportation is poor since the gradient of the river bed has been altered due to the changed hydrological conditions. Although of low relief, the rounded hills provide requisite kinetic energy for movement of materials to be base of the valley. Here it accumulates as the river bed has been altered and the Neyyar river is having a sluggish sinuous course, even its middle course. This accounts for its deposition activity starting from the middle course itself. No further material is entrained and the flow is sinuous till it reaches the estuarine mouth at Poovar. Thus there is a marked difference between the erosivity and river load conditions in the midland region as when compared to the highland region. Even during precipitation, not all the deposits in the bed stream of the midland region is carried away by the river. The presence of clay enhances soil compaction and flash flood results, rather than excess sediments being carried downstream.

V. Land Use :

The mid land region has a complex landuse of both agriculture and settlement. The right and left

bank canals mainly supply water to this region, for agricultural purposes. The crops grown in this region include rice, (oriza sativium), Coconut, tapioca also known as manihot or casava (Manihot Esculanta), pepper and cashew nut. A variety of yams are grown in the flood plain areas. The elephant foot yam grows to a large size in the flood plain region. A variety of spices which need delicate management practises are grown in this region. They include pepper, cinnamon, cardomon, ginger, cloves , nutmeg and a new hybrid variety popularly known as 'all spice'. Although great care is necessary for the crops to withstand the vegiries of the cimate, the high returns from spices crop is an important factor that allures cultivators. The foothill zones and steeper sloped regions are terraced along the contours for the use in plantation agriculture.

The midland region provides the agricultural hinterland for the Neyyattinkara town and Balarampuram situated in the midland regin and for Trivandrum District, the State capital situated in the low land region. Chief crops produced are paddy, ragi, tapioca, coconut, arecanut, rubber, pepper, cashewnut and pulses. Tapioca

is also known by other names such as cassava or Manioc (Manihot Esculanta). The bush can provide a harvestable yield even when the soil is virtually exhausted of all nutrients and hence is the last crop that is planted before a field is abandoned. The plant is so reliable, in fact, that it is commonly grown as an insurance against famine. It is a drought tolerant crop and can be harvested any time from six months to three years. Tapioca, given its characteristics of root enlargement actually a levering agent for the soil and is never a proper vegetation cover, when thought of as a soil cover. The enlarging roots, loosens the soil and rain splash and sheet erosion can take place with added advantage. It leads to rapid soll erosion when planted on steep slopes.

Since the low lands have a very dense settlement, and the highlands have too steep a slope surface, the midlands are a favoured site for settlements. This is evidence by the observation of even peat bogs being reclaimed to as to form sites for houses. The presence of a good irrigation system from the canals, attracts cultivators. While scope for development of transportation facilities in the highland is scarce in view of its rugged topography, the midlands ample scope for accommodating the expansion of settlements and agriculture.

VI. Human Influence:

Although not much sediments are carried away by the stream, the voluminuous flow during the monsoons have necessitated the construction of embankments along the middle coyrse at various places. These embankments consist of grantie and cement walls. Some places where there is human settlement nearby, steps leading to the river are also constructed for the purpose of using the river for domestic purposes like bathing and for livestock care (see photo plate No.2) . Helicoidal flow at the bends of the river have eroded the granite walls from beneath, leaving large cavities in the base of the walls. those embankments designed with long steps leading to the river are seen less damaged by erosion (as observed in plates 3 and 4). During the monsoons boats ply across the river to transport men and materials across to the other bank. But during the summer season, the water will be only knee deep and allows easy crossing to the opposite bank. All along the river coure, the banks are thickly settled and a variety of tree crops like coconuts, arecanut, coca, and banana are grown. Photo Plate 3). A luxiuriant vegetation is noticed along thebanks which consists of fine alluvium deposits which ae very fertile. While granite walls, and mud banks are constructed for combating floods, a lot of flood routing of the river water is done through both the canals, on its right and left bank. With the increased

sedimentation in the river bed, the need for raising the height of the embankments is on the increase year after year. During the dry season, the summer, the lean period flow in the river, exposes much of the alluvial deposits of the bed steram, and the bed is worked for agricultural crops mainly vegetables and spinach which take three to four months of growth. They are harvested soon after the first monsoon spells, since the water level rise rapidly.

VII. Gemorphology

The midland region has an undulating terrain. Most of the slopes end up in vast flood plains. The soil in the flood plains is not purely the alluvial soils brought down by the river. The hill slope process operating in the surrounding hills bring in large quantities of soil and unassorted material. For the setting up of new cultivable areas, the removal of the unassorted materials pose a great problem. At many places, sheet erosion send unscientific use of steep areas for cultivation has led to massive rates of erosion and sheet rock has been exposed in many areas. The important types of erosion found affecting the midland region are rock slide, slumping, debris slide and in

periods of high precipitation, debris flow. Much of the midland region is composed of laterites and is of considerable thickness. Thomas (1974) aptly describes the situation of erosion in lateritic soils as follows: The highly permeable laterite admits much.,..rainfall, leading to the developoment of underground cahnnels beneath the duricrust and to an increase in pore-water pressurte within the regolith. Cambering and collapse of the laterite occurs widely and regolith periodically suffers shear failures resulting in slumping and earth-flows.

Rotational slips are common on longer and gentler slopes within the midlands. The interference of man and animals (grazing) lead to acelerated geo-morpholgoical changes. The accelerated erosion due to grazing and trampling by cattle hooves it perhaps the turning point for soil degradation and considerable soil loss. Although geomorphological processes like soil creep are slow various other mass movements like debris flow and mud flow assume alarming proportions espe-cially after severe monsoons.

The unassorted materials described earlier that hinder agricultural activities, may consist of

stone lines as its take its source from Stone Lines. Stone lines have been defined briefly by Faniran A., and Jeje L.K. (1983) as : Stone lines are soil horizons with a greater proportion of stones than the material above and below them.

Stone lines are found in both temperate and tropical areas, but according to young (1976) they are more ubiquiotus particularly in the tropics. They have been recognized all over tropical Africa (Folster, 1969; Bruckner, 1955, Rhodenburg, 1969; Burke and Durotype (1971); Moss, 1965, Ollier, 1959; Ruhe, 1956; Thomas 1974; de Villiers, 1965) in Tropical Australila (Williams, 1969; Mulcahy, 1960;) in Hong Kong (Benry and Ruxton, 1959), and in venezeula (Garner, 1968).

While duricrusts (laterites) and duricrust profiles almost invariably occur on tops of hills and plateau while their truncated forms (mottled, pallid and country-cock zones) tend to outcrop mostly along the valley occupying the interfleuves between the rounded hills of the midland region. These laterites are particularly well preserved on the flat-topped low hills as cappings and also occupy interflueves as a result of slope wash. More of laterite deposits is found in the main interfleuve occupying the major local or sub drainage basins.

Plate No.1. A Typical midland segment of the Neyyar river

Plate No.2. Construction of embankments Severe erosion noticed along its base.

Plate No.3. Thick vegetation of trees and crops grown on the bank above the embankment.

Results of the Aerial Photo Interpretation :

Geomorphology :

The midland region offers extensive flood plains along both banks of the river, extending much inland. These flood plains are very rich tracts of alluvial riverine deposits, and are areas of intensive paddy cropping. These flood plains are benefited from extensive irrigation from both the right bank and left bank cahals. The river follows a meandering course and has arrived at its depositional stage which can be discerned by the presence of numerous sand deposits within the channel. Many of these deposits are partly under water and may not be sensitive to the photograph. Regions of raised relief are seen leading to rounded hills. These rounded hills have a moderate vegetation cover. They are capped by laterite. Laterite occurs as a very thick capping in the midland region.

Raised relief areas offer considerable slope for enabling moderate drainage. These are extensively cultivated with proper land management practises. The laterite capped rounded hills, provided lot of eroded material during high precipitation, to the low

lying flood plain areas.

The isolated hills are found mostly adjoining the flood plain and rise abruptly from the flood plain These isolated hills are also crested by laterite material. These hills are usually settled and provide only for cultivation of tapioca, since the soil is of leached nature and very poor.

Fluvial terraces are also present in the region. These fluvial terraces afford fairly rich soil and are cultivated with crops. These fluvial terraces have been built by the work of stream in their shifting to new channels. These fluvial terraces occurs in relatively raised position and their position denotes the former paleo coursex of the river.

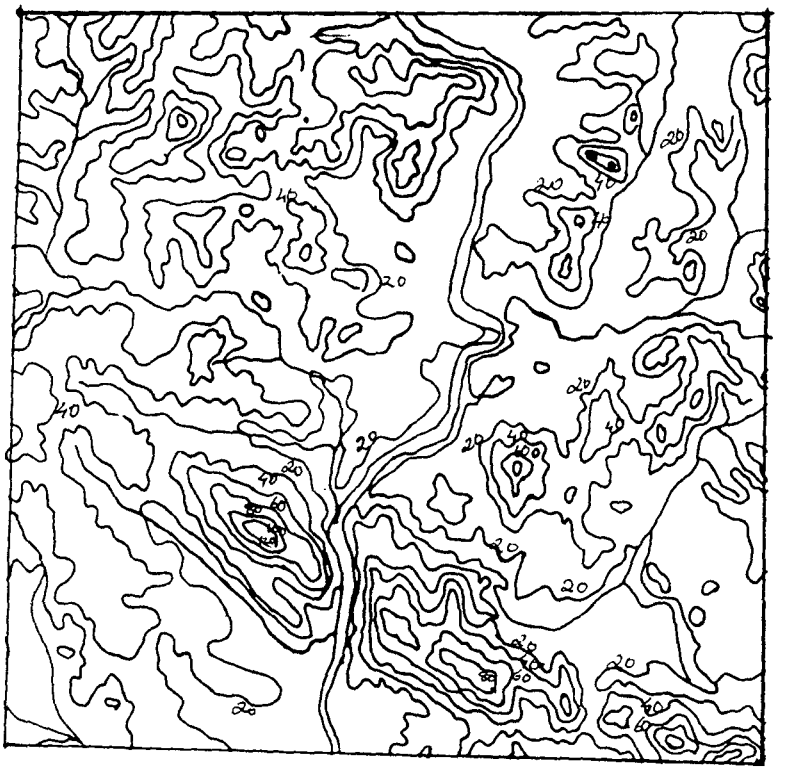
Land Use :

Extensive paddy cultivation is seen along either banks of the river, which contain extensive deposits of riverine alluvium and silt. These areas, on field observation was found to have crops like ragi and vegetables also. Banana is also cultivated in these flood plains, on slightly raised ridges. Scattered settlements are found in fairly raised relief areas which provides for adequate drainage. Concentra-

Concentrated settlements are also found in many places The railway line of the Southern Railway pass through this region. It is part of the Trivandrum-Kanyakumari (Cape Comorin) line, that passes through this region The area is an agricultural hinterland for the coastal lowlands, which have a dense population, and a low variety of crops and cropped area. The areas seen as dense vegetation could be areas of tree crops as well. Mango (Mangifera Indica) is mainlyy grown as a garden crops in this region. Also of importance are cashewnut cultivation. Areacanut and pepper are the other main produce in this region.

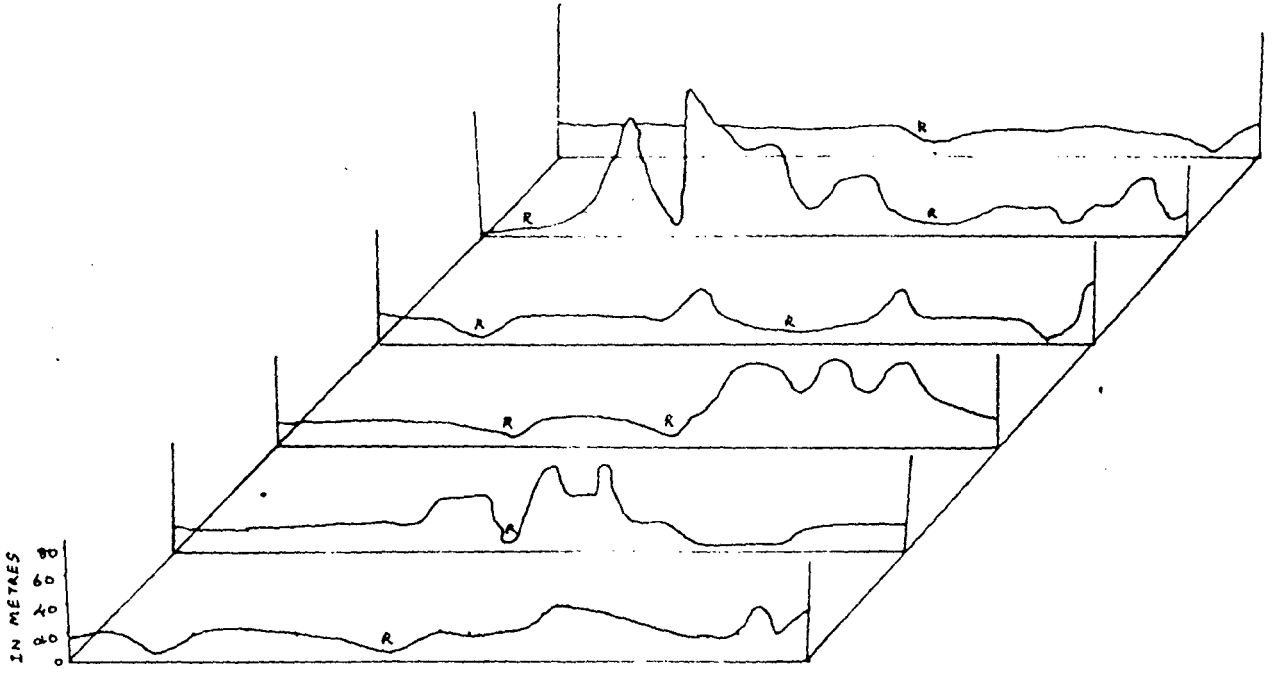
The immediate banks of the river are densely settled, mainly with house owners who own further stretches of agricultural land in the region. Tapioca is seen extensively grown in this region. Scattered vegetation is often found near areas of concentrated settlements. The scattered vegetation may consist of the natural vegetation of drought resistant species. These areas may be infertile and have thus lent itself to settlement agglomerations.

CONTOUR MAP - GRID 'B'



Contour Interval - 20 mts.

PROFILES FROM CONTOURS GRID - B



Super imposition of the land use on the land system
Discussion

Throughout the length of the river on its either sides of the flood plains, are seen cultivated under paddy crop. The availability of water for waterlogging the paddy corp. and the natural replenishment of the flood plain due to silt deposits are the main land conditions of this area that attracts such a landuse. At this margins along the paddy fields, vegetable farming is also observed. The undulating hills are planted with tapioca and fruit crops. Much of the Paddy fields along the river banks have been infilled to form housing plots.

The area is well connected with roads. These are the main arteries for the transportation of agricultural produce and domestic travel.

Some small hillocks are seen to have a dense vegetation. This may either be natural vegetation or planted tree crops. This could not be clearly identified from the aerial photographs. Some scattered vegetation are found at many places adjacent to the topioca crops.

Scattered settlements are seen fairly well distributed settlement throughoutt the region.

Explanation of Land Systems :

The land system coming under grid 'B', midland region includes a variety of geomorphological features, of both erosional and depositional features. The erosional features include sheet wash plains, low gentle slopes, round shaped hill crests and broad gentle valleys. The facts have been designated alphabetic for easy identification. The valley sides have erosion features like gullies and smaller features like rills and micro scale slumping. Gully sides are seen almost vertical and is seen as bluffs (2.B), along the valley sides.

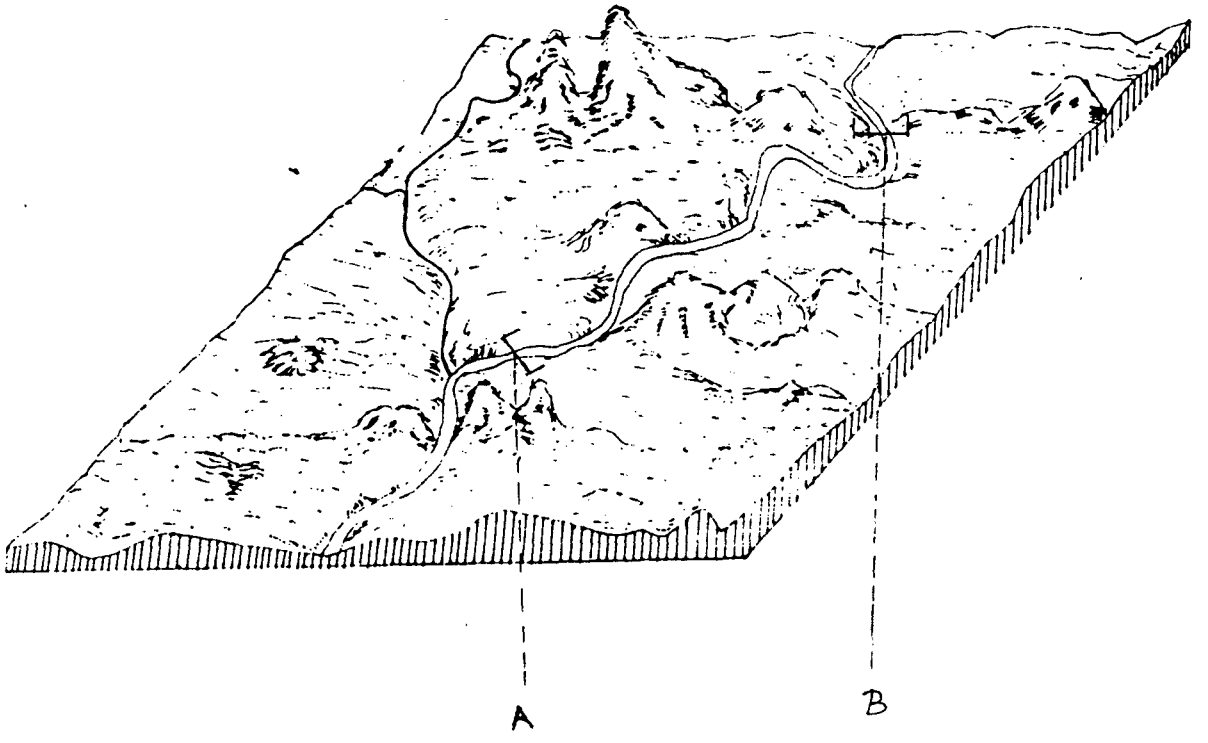
The depositional features include flood plains and a wide gully floor (2.C). The meandering stream course deposits large quantities of sand and silt on either banks of the river.

In the systematic method of analysis, we can

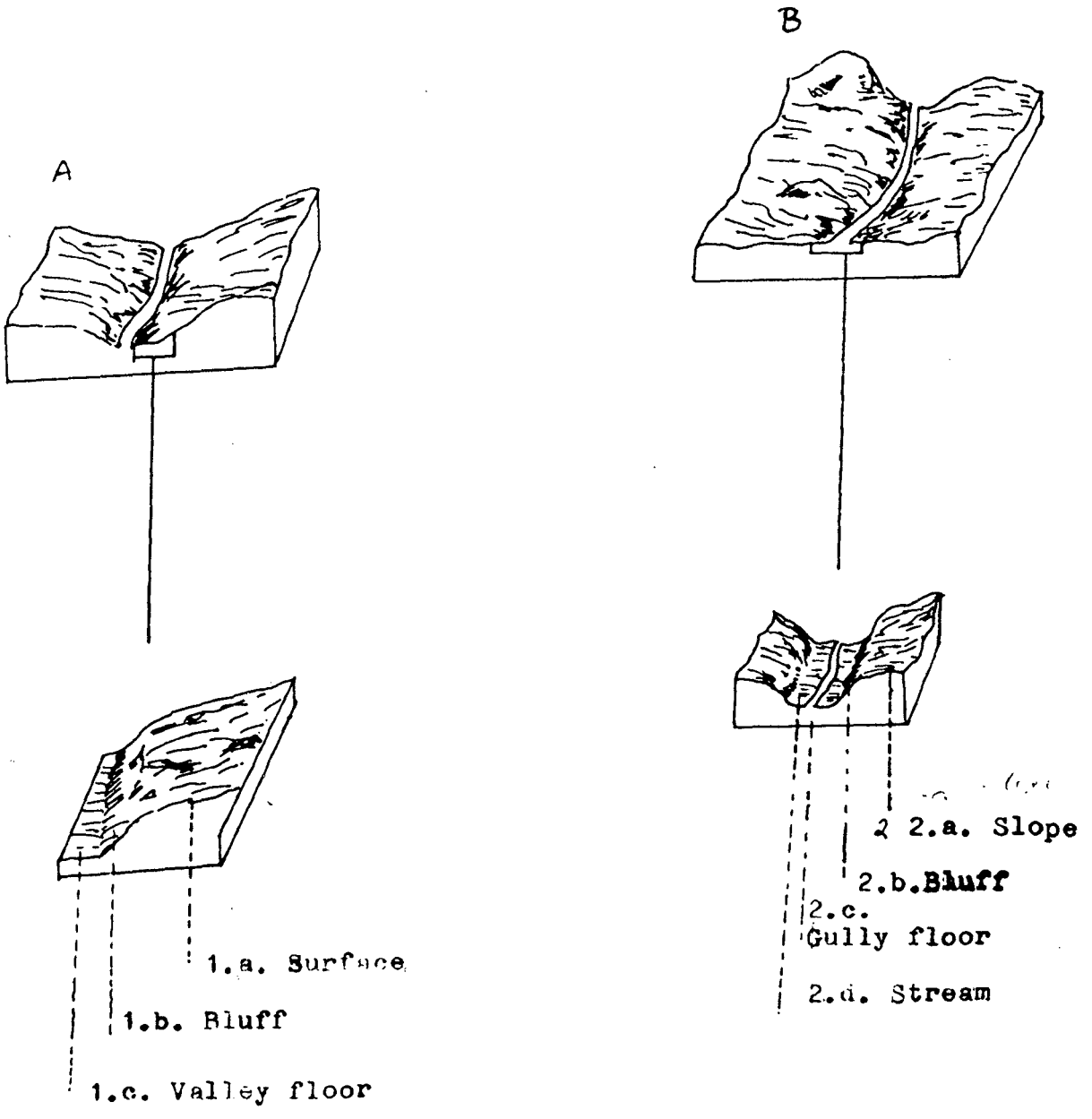
relate the relief features as forming a chain or heirarchy of component elements which are interdependent regarding process and stage. The features of the region exhibiting a variety of both erosional and depositional features. The crest of the hills and the slopes seen affected by severe erosion, at places where the land is left barren. On cultivated areas, although the slopes are loaded with disintegrated materials and fine soils, the fairly good quality of the land management practises have helped in the maintenance of the topsoil at some places. However in areas of mono crop. cultivation, the degree of erodibility is more due to the lack of proper root hold upon the soil. The soil along the river banks are loose and are easily cultivated under paddy or other crops. The gently undulating hill crests are capped by laterites. During the rainy season the laterits get leached since it is highly porous. The high permeability permits rapid percolation and large quantities of water reached the stream as interflow. The flood plains created by the stream contains deposits of both the lateritic hill wash sediments brought down from the soil catena, on either sides of the valley, and those that are brought down by river action from elsewhere. The transportation

of the soils further from this point is comparatively a very slow process. This is due to the low gradient and the presence of unassorted material that comes down from the slopes. The land facet 'B' is having greater relief variation than the land facet denoted as 'A'. The crest of the rounded hills consisting of leached laterites are usually cultivated under tapioca. The bluff slopes are usually seen stabilized with granitic wall, to prevent bank erosion. These low undulating terrain is used for the cultivation of a variety of crops and settlements. At the crest of the lateritic h ills the soils are so infertile that they are left unused, covered with scrub and cactii.

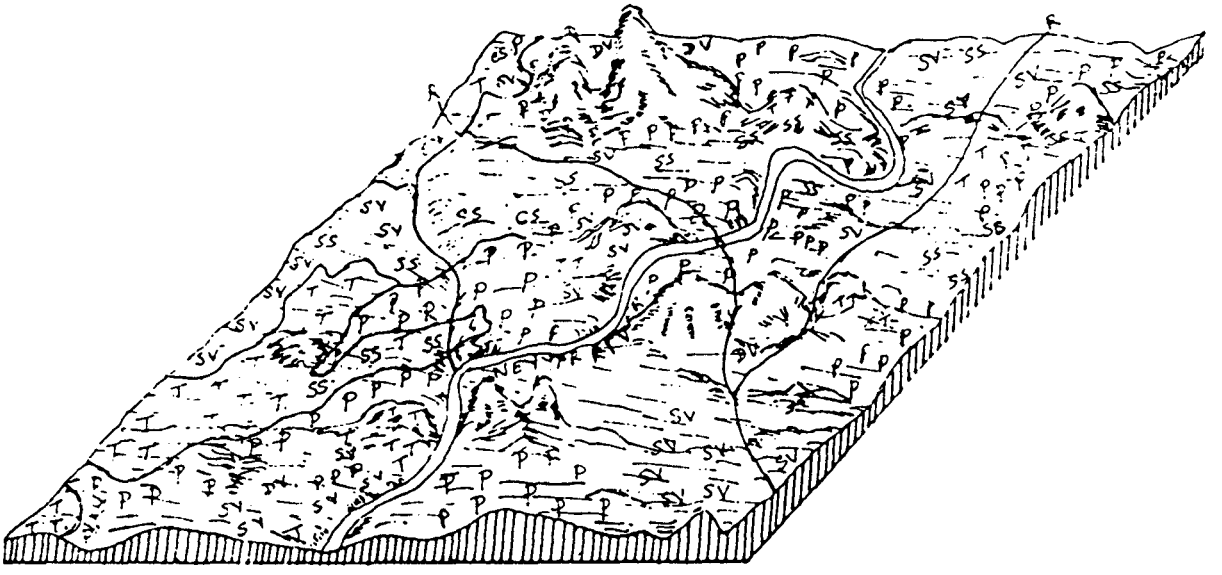
LAND SYSTEM : GRID 'B'



LAND FACETS AND LAND ELEMENTS



SUPERIMPOSITION OF THE LANDUSE ON THE LAND SYSTEM, GRID 'B'

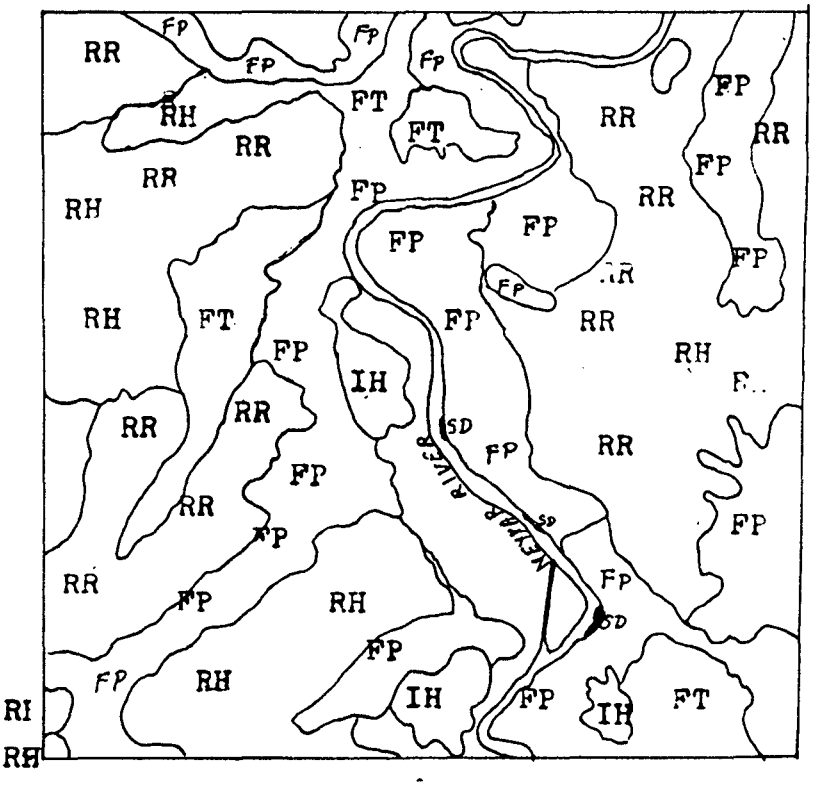


Index :

P	Paddy
DV	Dense Vegetation
SV	Scattered Vegetation
SS	Scattered Settlements
T	Tapioca
CS	Concentrated Settlements

GEOMORPHOLOGY - GRID : B

MIDLANDS



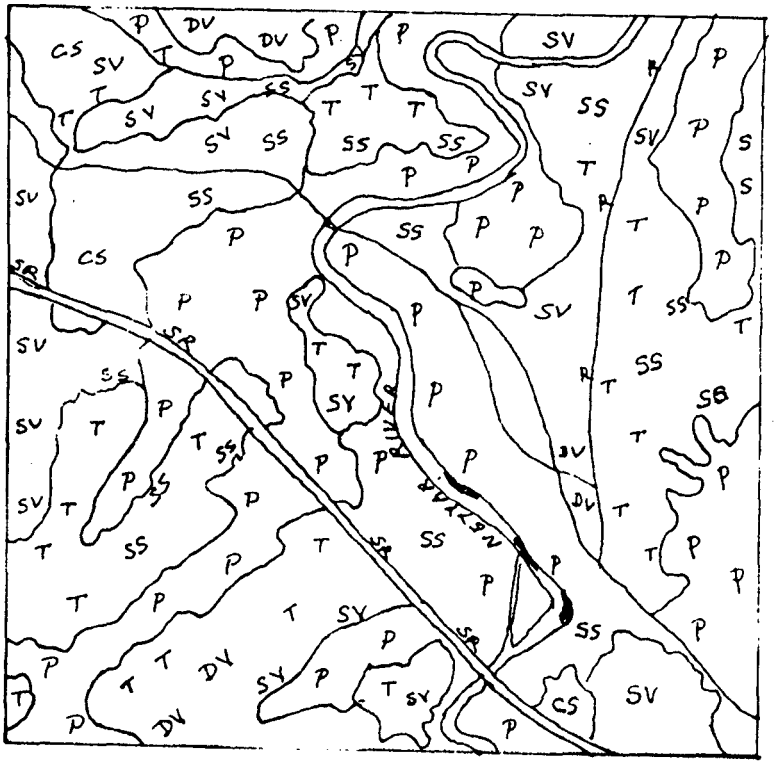
Scale 1: 60,000

INDEX

FP	Flood Plain
RR	Raised Relief
RH	Rounded Hills
FT	Fluvial Terrace
IH	Isolated Hill
SD	Sand Deposits

LAND USE AND LAND COVER : GRID :B

MIDLANDS



INDEX

Scale 1:60,000

CS	Concentrated Settlements
SS	Scattered Settlements
P	Paddy Cultivation
T	Tapioca Cultivation
SV	Scattered Vegetation
R	Roads
SR	Southern Railway Line
DV	Dense Vegetation

THE LOWLAND REGION

)CATION:

The lowland region lies adjacent to the sea-)ast, parallel to it and extends eastwards till it :aches the western margin of the midlands. It encompa-)es the land that lies below 8 mts (28 ft.) The coast-ine, like the rest of Kerala coastline is almost straight. ne coastline of Kerala is almost straight, but broken t a few places by estuarine interfaces with the sea. he sea of Lakshadweep washes the coast line.

hysiography:

Physiograhically the region is of very low elief fluctuations. I - The low relief fluctuations, and the juxtaposition of the backwater parallel to the coastline, the vast coastal alluvium deposits are all seen in this photograph showing the general features of the lowland. In the foreground lies the deposits of coastal alluvium. At the rear the tall continuous stretch of coconut vegetation is silhoutted against the horizon. (Plate No. 1 A general view of the low land). Marginal variations are noticed due to the persence of sand bars and low dunes. Backwaters or 'Kayals', as they are locally known are a ubiquitous feature

throughout the coastal region of Kerala. The coastal segment of the Neyyar river, where it enters into the sea is also waylaid by the presence of a backwater. The photograah shows the portion on the backwaters which have been slightly modified in its configuration and has been extended over a wider area, extending to the sea. The almost lake like expanse of the water provides high surface reflectivity of heat and insolation. Tidal bores are seen moving towards this backwater region, through the esturine mouth. The Neyyar river enters the backwater before reaching the sea. The backwaters are found parallel to the coastline. Due to changes in sea level during the geological periods, marine terraces can be observed in this region. Low sand dunes, sand bars and sand spits are found in this region.

Climate :

The coastal region receives heavy insolation almost throughout the year. The high wind speeds along the beach pick up and transport sand particles further inland. Although the rainfall decreases from the high lands to the plains, the coastal lowlands receives heavy rainfall during the south-east monsoons. The high degree

of premiability of the coarse sand grains prevents flooding in the low lying regions, especially along the banks of the backwaters. Since the low land region has little altitudinal variation to provide for drainage, the presence of a premeable soil stratum is a blessing for the human settlements in the region. During the dry season, the hot air picks up speed while passing over the flat terrain, resulting in high evaporation rates and mirage is produced, increasing the reflectivity over the sand terrain.

Geology:

The geology in the lowland region consists chiefly sand, sandstone and lignite. At a few places gneiss outcrops are also seen. Sand stone is a sedimentary rock and is caused due years of deposition. A study of the facies analysis on this region would throw valuable light on the geomorphological history of ther egions belonging to the midland and highland region.

Soils:

Coastal alluvium is the major soil found over this region. It occupies vast stretches of the beach area, and extends to the margins of the backwaters.

Riverine alluvium is seen deposited in the bed of the back waters. Also considerable amounts of Kaolinitic clay is seen deposited along with the reiverine alluvium. Thus the esturaine portionof the 'Kayals' or backwaters have formed themselves as storehouses of construction materials. Towards the margins of the lowland, where it meets the midland region, small hillocks with laterite cappings are also seen.

Natural Vegetation:

The natural vegetation in this region mainly consists of coconut palms, a variety of shrubs, cactii and sedges. Many of the coconut palms are of natural wild strains and are left without any use. Cultivated coconut palms of selected, and hybrid strains are seen cultivated close to settlements. A large of water loving plants and grasses are seen along the border of backwaters., whichrich deposits of mud and silt.The photograph (plate 3) shows the typical natural vegetation present in the lower course of the river. The photograph is taken where the river joins the backwater. While the inner portions of the banks are occupied by coconut trees, and settlements beneath their shade (which is not visible),

the margins of the land at the water front is vegetated by a variety of shrubs, coconut sproutings from transported coconuts, and sedges and certian species of hydrohytic polants which are semi immersed in the water.

A closer view of the vegetation adjoining the banks of the backwater is give in Plate 4, Much of the land along the backwaters are being progressively being reclaimed for coconut crops. Initially coconuts are grown on raised ridges and progressively the channels between them is filled up in courase of time. The land thus reclaimed may even be used for building huts. A finger shaped sand deposit is seen extending from the right handside of the photograph towards the middle. Avifauna specific to the estuarine environment are seen homing the sand bar.

Land Use

The region has a high density of human settlements. The brazing sea breeze, string sunshine , and nearness to the sea, which is the main source of employment 'fishing' practised by most of the people in this region. The strong sea breeze provides a healthy atmosphere and fine ventilation in the closely packed settlements.

The strong sunshine helps in the curing and drying of fish, the natural method of fish preservation in this hot humid region. while the men are engaged in the process of bringing ashore the fish, and undertaking the repairs of boats and nets, the women looks after the transport and trade of fish.

The dense coconut vegetation in the region, provide the raw material for coir production. The presence of backwaters provides ample supplies of fresh water necessary for the retting of coconut husks for fibre extraction. Mostly women are negaged in the various processes of coir extraction and spinning. The cool shade offered by the dense coconut fronds is a great advantage for women who mostly work outdoors, near the backwater areas.

The presence of vast deposits of river alluvium beneath the estuarine portion of the backwaters have opened up the use of these deposits. Labourers collect the deposits from the floor of the backwaters, onto woodden boats and later it is punted to the shores to be offloaded and is sold.

Geomorphology:

Like most of the other rivers of Kerala,

the Neyyar river also empties itself into a backwater, locally known as 'kayal' and is connected to the sea through an estuary. The estuary is a funnel shaped exit. usully carved by the river on its way to discharge into the sea. The low relief, reduced energy of the river, and the presence of a backwater parallel to the coastline, and affecting the normal discharge of the river, all contribute to the spectcular dynamics in operation at the estuarine part of the Neyyar river.

The marine transgression into the land is specially marked during the monsoons. The sea carves into the land every year and monsoons are period of accelerated marine erosion. Since settlements are situated fairly close to the sea-front, at certain places hardly 40 to 50 feet from the sea, these are easy targets of marine erosion. The coarse sand deposits on the beach is easily carved away and the sea steadily overcomes the land. Even after facing the onslaught of the amrine erosion,during the monsoons, the fishing community prefers to re-settle close to the sea front from where they had to evacuate. Such a re-course is chosen for two reasons. Firstly, it is dueto thehigh competition for land in thedensely populated region.

Secondly, due to the estrangement from their livelihood (Fishing) that may occur, if they move further inland.

The Neyyar river in its lower course, has a meandering habit and in its course in this region, the shifting of its course is a marked feature. The river deposits large quantities of fine and moderately sized sand both on thebanks as well as bed deposits. Rocks are virtually absent in the region except at one or two places. A rock outcrop is seen emerging in the central portion of the backwater region. This can be seen clearly in the photograph (Plate No.5) This core remain of Tor like outcrop must be of must be of composed of highly resistant rock type, which has withstood weathering by both estuarine dynamics and marine transgression.

Across the backwaters to the south and to the north of the easury there are locks. These wooden locks were formerly used to control navigation along the backwaters, but now they are in a state of disintegration due to non use nad old age.

During the monsoons, when the water brought

in by the river is enhanced, it creates chances of flooding the banks and the edges of the backwaters. In order to reudce the risk of floods along the lower portion of the river and the banks of thebackwaters, which are regions of dense settlements, the sandspit blocking the estuarine mouth with the sea is cut open artificially by human labour. The peak discharges during the monsoons thus escapes into the sea. The shifting ofthe river mouth, is due to the differences in discharge rates and therefore the differences in energy of the river. Another possible reason for the shifting is because of human interference in trying to control or confine the estuary. The vegetation coastal alluvial deposit, so as to create a state of permanence for the esturism mouth has been trid many times. The photograph (PLATE NO,6) shows the sand bar near the present estuary being fenced and trees like eucalyputs and alibizzia were planted by the State Govt. As these species are exotic to the region, and for the reason that they do not withstand the halomorphic soil these attempts have failed. Only the columnar granite supprts and barbed wires remain.

If thearea was underlain by soft sedimentary

rocks, the funnel-shaped estuary would have been scoured into a state of almost geomorphological permanence. But here in the case of the Neyyar estuary, the region is occupied purely by coastal alluvium. The characteristic shifting of the estuarine mouth is occuring due to the absence of structural control in the area. The coastal alluvium is easily trnasported and gives little scope for etching.

A deposit of coastal alluvium is seen on the far side of the backwater. In the photograph pesented (Plate No,7), the white coloured deposit is of marine deposition formed during the geological periods of sea-level changes.

The shifting nature of the river mouth has let the potential zone of shifting without human occupance nor cultivation of coconut crop. Here the estuary is flooded by the marine water and the tides have played a key role inmaintaining than actually creating its shape.

The mixing of the river water (lotic ecosystem and the backwates (lentic ecosystem), together with saline water incursions have produced a singular ecosystem which is not portrayed elsewhere. In the region,

particular varities of sedges, crabs and a typical avifauna is observed. The aquatic life in this region consists of a typical kind of life forms that can survive at the geographically controlled mixing of fresh and saline water. When we consider the quality of the mixed water in which the particular type of lifeform exsits, we should also take into account the ill proportionately mixed water, organic sea weed intrusion and its decay, foraminifera and plankton influx and sediment exchanges. A typical kind of fishing using a long hammock shaped net is done at the mouth of the eastuary. When the wage rises against the funnels shaped edge of the estuary, the net is held in position so as to capture the fish carried along with the current. The two Photo plates (Shows the author watching the fishing technique. Phot Plate No.(8) shows the technique of fishing being observed, while at field work. The photo plate No.(9) shows the wave rise against the edge of the estuary. This wave is seived through the net and fishes get trapped. The incessant work of the wave against the edge of the estuarine inlet leads to rapid erosion.

Plate No.1. A General view of the coastal estuarine region

Plate No.2. Extensive backwaters extending to the estuary.

Plate No.3. The typical Natural vegetation along the backwaters consisting of coconut trees, shrubs and sedges.

Plate No.4. A closer view of the vegetation along the banks. Cultivated reclaimed land portions extend into the backwater.

Plate 5. A 'Tor' like rock outcrop in the midst of the estuary.

Plate.6. Fenced cultivation of Acacia and Eucalyptus. Failed attempts at estuary stabilization

Plate No.7. An inland marine terrace is seen in the picture as a white linear deposit alongside the banks of the backwater.

Plate No.8. Observing estuarine fishing techniques

Results of Aerial Photo interpretation :

Geomorphology :

Although the general geomorphology of the region had been discussed earlier, the more specific and accurate interpretation was done using aerial photographs of Task force No. 1015, Series No.79, sets 4 and 5. These photographs were taken in 1978.

The Neyyar river basin at its final lap, enters the sea through a backwater. The estuarine mouth is blocked from the sea during the dry periods by a sand spit produced by marine action. During the monsoons, the rain season, the mouth of the estuary is notched open by human labour, to drain away the excess water collected within the estuary. The estuary mouth 'E' has been marked on the map after field trip to the area. The river runs a very sluggish course and alluvial deposits are seen through out its lower extremity. Sand bars and delta shaped sand deposits have been created by the combined action of river and the sea.

A linear stretch of coastal alluvial deposit is seen along the sea coast, which may be defined as the berm. To the north west, a small extension of the coastal alluvial deposit is seen extending almost upto

the paleo channel. Older deposits of the coastal alluvium deposits having a low relief are seen to be vegetated, showing its geomorphic age, compared with the new alluvium. Flood plains containing fairly deep deposits of riverine alluvium are seen occupying extensive areas.

Fluvial terraces 'marked 'FT' and marine terraces marked 'MT' have been identified with the help of aerial photographs. The fluvial terraces are gently sloping surfaces having heavy deposits of coarse alluvium. A marine terrace was identified between two fluvial terraces. This terrace was the work of marine deposition in the geologic past, associated with the changing sea-level.

A paleo channel was identified on the right bank of the Neyyar river. The mouth of the paleo channel joining with the back water is seen inundated. Further to its right relief of low variations are noticed. A few isolated sand dunes and sand hills are seen in the region. The sand dunes occur in almost straight line, denoting the influence of wind. To the lower portion of the river, on the left bank, a

fairly large rock outcrop is seen. Rock outcrops are rare in this region, which chiefly consists of sedimentary deposits.

The backwaters stretch along the coast of Kerala almost throughout its entire length and accounts for regulating the estuarine mouth of many rivers that first debouch into it before entering the sea. Large portions of the backwaters adjoining settled areas are seen infilled with available materials and the hydromorphic conditions have given rise to marshy areas and mud flats. Much of the river's alluvial deposits are deposited in the bed of the backwaters. Calcic deposits of lime shells are also found in the bed deposits. These are excavated in large quantities for use as construction material. Small sand hills having laterite cappings also contribute by way of finer indurated materials to the matrix of these deposits beneath the backwaters.

Land Use and Land Cover.

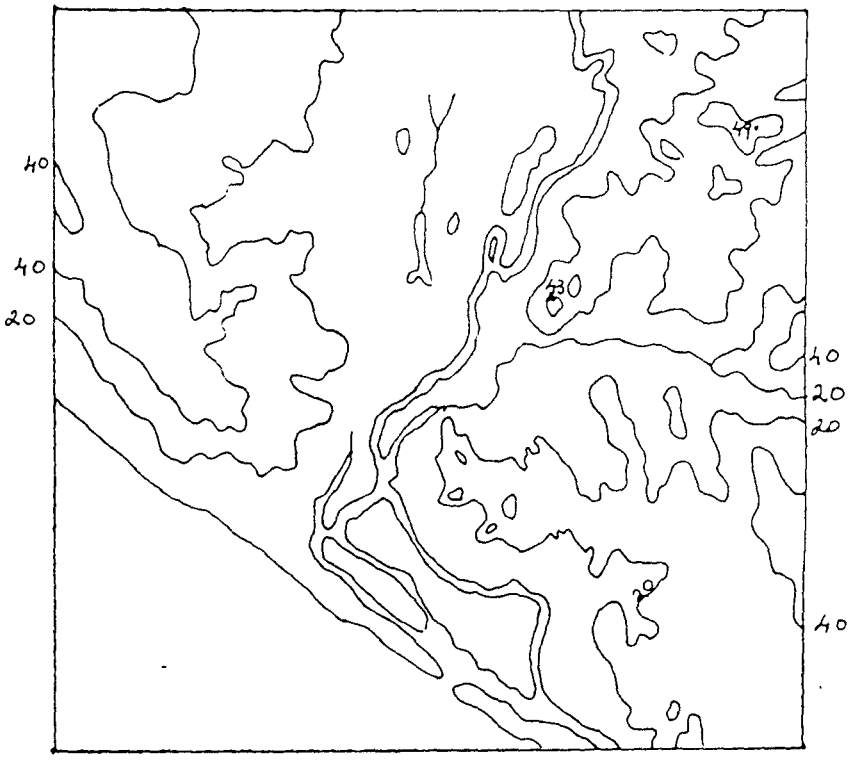
The coastal alluvium along the sea front remains a barren land due to the constant shifting of the sand. The interior occurrences of the coastal

alluvium are stable in nature which is indicated by the presence of vegetation, chiefly of coconut trees. The region is characterised by dense vegetation at various places. Some paddy fields are also seen on the far left bank of the stream. Most of the hill areas of low relief of about six to ten matres. The hills are usually driver than the rest of the region. Scattered and barren vegetation are found on these low hills.

The area is accommodating a dense population. With the presence of a thick canopy of coconut fronds, the view of the settlements have been obliterated. Hence they couldnot be mapped. But from field observation, it has been observed that areas vegetated with coconut trees invariably are areas of dense settlements. Some scattered settlements are observed on the slopes of low hills.

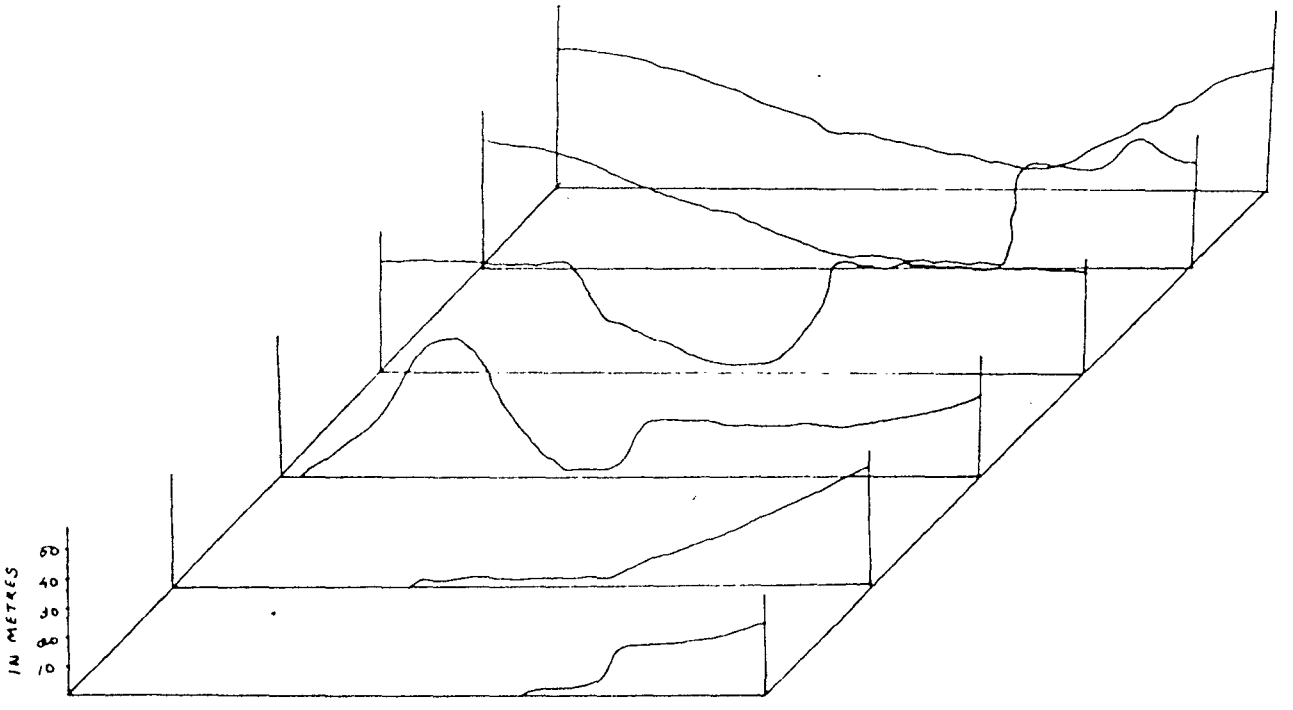
Certain portions of the lowlying paddy fields are seen infilled, and these reclaimed lands are used for purposes of housing. The natural vegetation cover includes some stretches of scrublands which contain cactii and other xerophytic species.

CONTOUR MAP - GRID 'C'



Contour Interval - 20 mts.

PROFILES FROM CONTOURS OF GRID 'C'



Explanation of the Land System :

The low land block diagram showing the land system clearly brings out the nature of the subtle interlinkage existing between its components. The land facet 'A' depicts a gradually sloping land with a sand dune to its left. The sand hill may have been formed due to the action of wind. The area of low relief consists of coarse alluvium brought out by the river. Because of the coarse nature such lands although of low relief rarely get inundated and hence bear concentrated settlements.

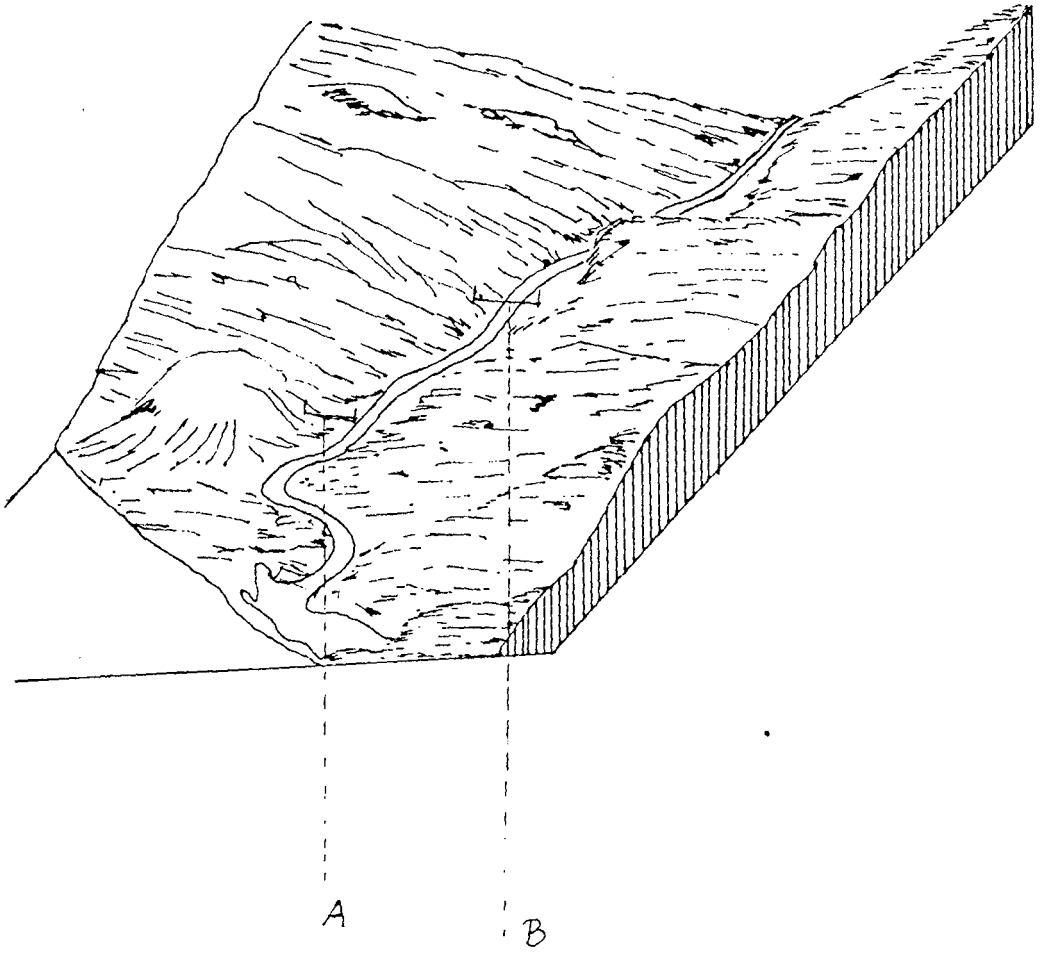
The land facet 'B' shows the broad river as it reaches the estuary. The river widens out and has a lot of meander channels of paleo origin. The land is gently sloping, and offers the bare necessary gradient for drainage.

The stream has innumerous deposits of sand deposits both submerged and emergent ones. These deposits are collected for construction purposes. The gentle relief extends on both sides of the river valley with hills of low relief.

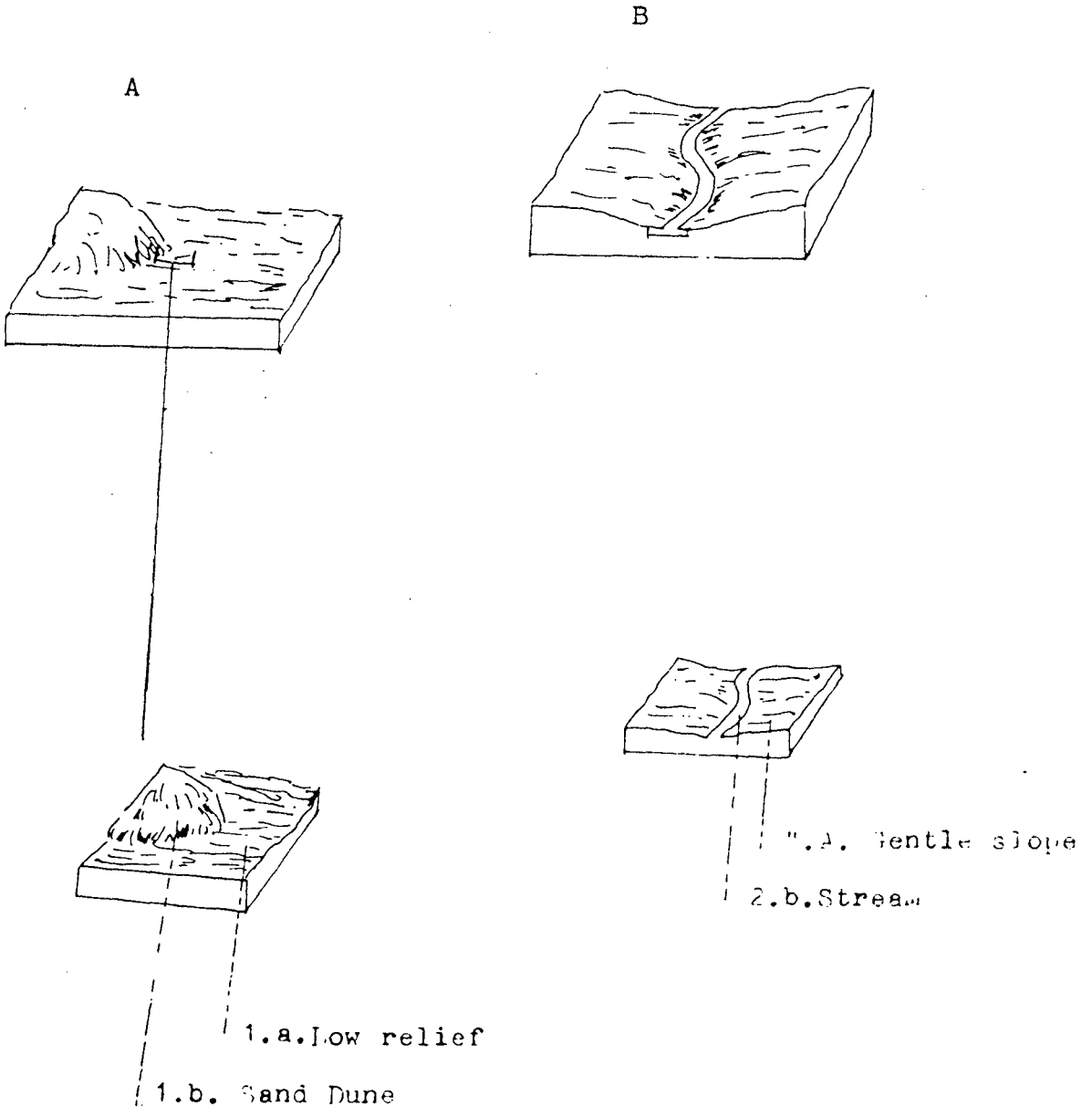
Much of the coastal alluvium is in constant change of configuration. The river alluvium gets depositsed at the bottom of the estuarine and some of them reaches the sea level. The region has a high dnesity of populatmon and the communications are easy due to the low topography.

LAND SYSTEM : GRID : C

LOWLAND REGION

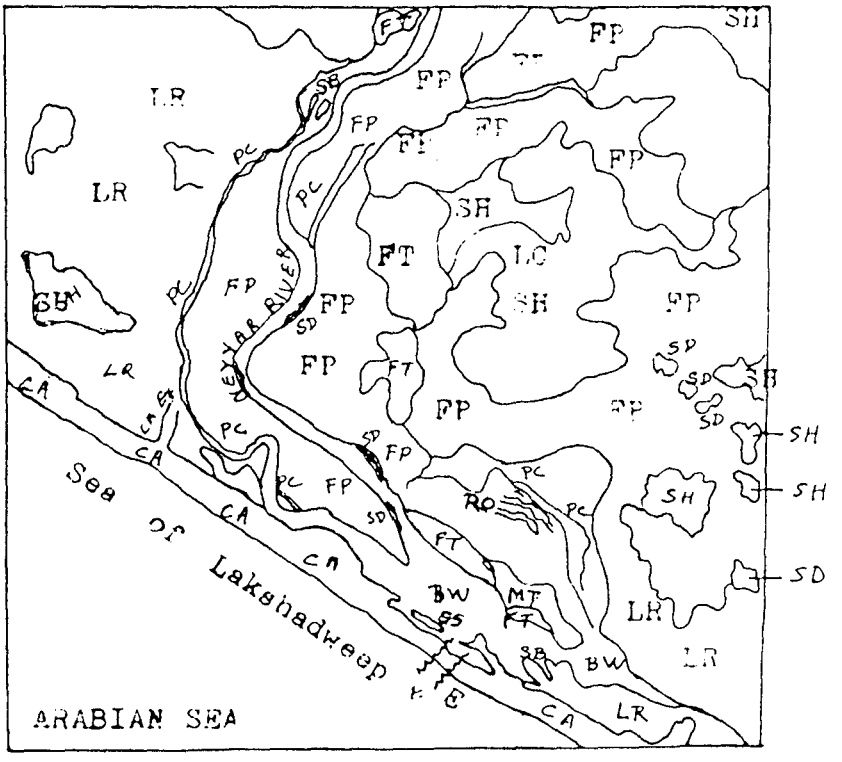


LAND FACETS AND LAND ELEMENTS



GEOMORPHOLOGY - GRID :C.

LOWLANDS



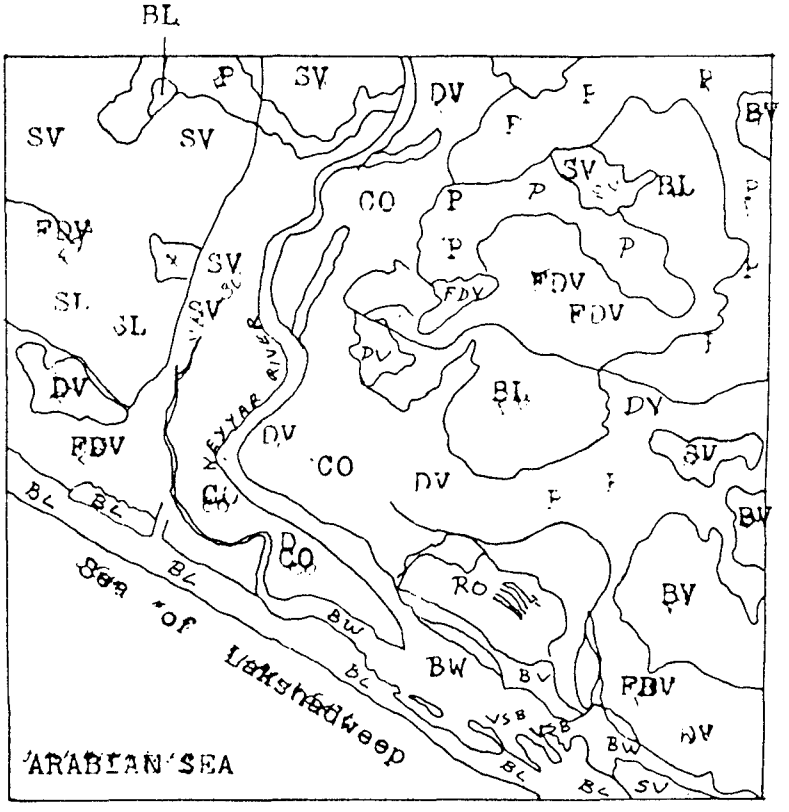
Scale 1 : 60,000

INDEX

SD	Sand Dune	SS	Sand Spit
SH	Sand Hill	SB	Sand Bar
FP	Flood Plain	LR	Lo Relief
MT	Marine Terrace	LC	Laterite Capping
FT	Fluvial Terrace	PC	Paleo Channel
CA	Coastal Alluvium	E	Estuary
BW	Back Water	SD	SAND DEPOSIT

LAND USE AND LAND COVER

GRID - C LOWLAND



INDEX

Scale 1:60,000.

P	Paddy
Co	Coconut
SV	Scattered Vegetation
SL	Scrub Land
DV	Dense Vegetation
BL	Barren Land
FDV	Fairly Dense Vegetation

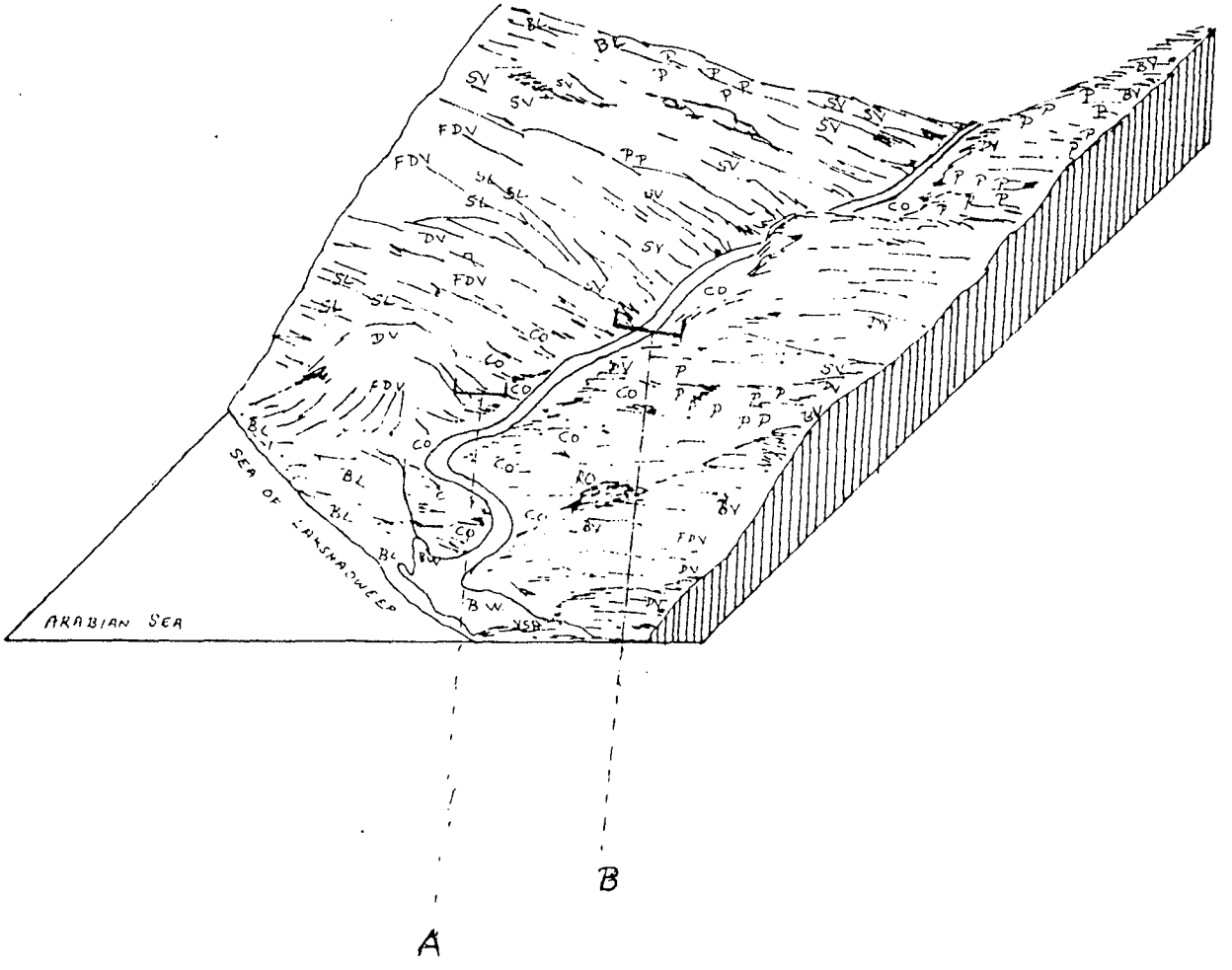
RO	Rock Outcrop
BW	Back Waters
VSB	Vegetated - Sand Bar.

Superimposition of the Land Use on the Land System :

Much of the region is under coconut cover. The thick fronds of coconut has disabled the identification of settlements. Scattered vegetation occurs at many places within the grid area. Fairly dense vegetation are found in the higher slopes. Dense vegetation patches are found at the crest of hills. These may have a definite stabilizing influence on the sand dune or hill. Paddy cultivation is noticed near the left bank of the stream. This cultivation could have been made possible by considerable deposition of alluvium in the area.

Barren land is noticed along the river mouth shifting zone near the estuary. Besides the backwaters, some vegetated sand banks are also observed. Some barren land is also seen on moderately sloped land.

SUPERIMPOSITION OF LANDUSE ON THE LAND SYSTEM, GRID 'C'



CHAPTER V

CONCLUSION

Within this study of the land systems of the Neyyar river basin, the land components typifying each of the natural divisions, the highlands, midlands, and lowlands, have been discussed separately. The basin approach has been made use of to inculcate the work of the major denuding agent river erosion in this case, to have played the major role in the formation of the landforms.

The making up of the land system was done with the help of the topographic sheet and also from serial photographs. The results pooint to a specific assemblage of landform, which are at various stages of its degradation. The study of the highland region, grid 'A', helped to bring to light the various landforms which are typical of tropical weathering. The heavy rainfall and the dense vegetation cover, comprising of mostly of tropical forest types, give high humidity conditions within the region, elading to rapid disintegration of surfaces materials. A highd egree of ehat is also preserved within the forests, with the closed canopy acting as a barrier to re-radiation of energy from the land surface. Thus an almost green house effect is created The steep slopes and the

aspect of the highlands in facing the moisture laden winds, bring heavy rainfall to the region, which is a result experiencing heavy erosion rates. Almost the entire sediment produced in the neighbourhood of the river channel, which gets entertained in the river, gets transported to the lower reaches, due to the rapid descent of theriver almost upto the 300 contour value.

The midlands region, which has been providing the functions of a hinterland for the densely populated coastal region, is an area which has been fully occupied by systematic landuse. Almost the entire land are in this region is cultivated, excepting certain hill crests offering excessive drainage, and poor and thin soils. With the help of irrigation, multiple crops of paddy are grown in the flood plains each year. The undulating topography of the region, with some of the cultiated areas lying fallow during the monsoons, provide extensive eroded material through soil creep, debris flow and mud flow. These get deposited in the flood plains. Since the Neyyar river, starts its depositional stage in the midlands itself, these materailas do not get transported. The boulder and debris movement some times reach such proportions, that the flood plains has to be seived of these materials

before ploughting. The identification of land components lead to the conclusion that although the region has comparatively gentler slopes than the highlands, fairly moderate to high erosion rates are prevalent in the region, leading to rilling and gulleying. The cultivation, of tapioca in the crest of hills, often with thin soil, leads to leavening of the soil, because of its root expansion for food storage. Tapioca thrives without proper land care, and hence is planted without due recognition of the slope or contouring needs.

The lowlands are regions of heavy density of population. The low relief of the region does not inhibit settlements because the soil of coarse material and of hardly any clay element, offers excellent drainage due to porosity. The highly perkeable soils thus overcome the disadvantage caused by the lack of surface drainage. Some of the low hills are sen capped with rasidual laterite brought down from the midland region. Tapioca is cultivated on such cappings. Much of the lowland vegetation consists of coconutvegetation, which grows to provide an almost ininterrupt canopy. Hock outcrops are rare

although it is observed at one or two places. Of specific interest in the single rock outcrop that rises in the midst of estuary. A few fluvial teraces and a marine terrace is noticed in the region. This has been identified with the help of aerial photographs, which would otherwise would not be possible. The backwaters, although not for navigation now, is used for the retting of coconut fibre for making ropes. Large quantities of fresh water is necessary for this work. The estuarine bed deposits of river alaluvium and lime shell are being collected on a large scale for use as construction material. This large-scale removal of material from close to the land with moderate slope may lead to slumping. Granite is also seen quarried from some of the outcrops.

The study of the geomorphology using serial photo-graphs helped in analysing in detailed and securately the particular grid areas. From the reconnsisance survey, a general idea of the basin features have been assimilated. The land use obtained from the serial photographs have been linked with the land systems of the region.Although the highland serial photographs requied was not available, the landuse of the grid 'A' consists almost wholly of tropical forests. The region has the least of human

interference excepting some seasonal pilgrims and illegal trespassers. The region is most suitable, for inclusion in the 'National Biosphere Reserve'. Such a move would help to preserve the evolution of teh ecosystem in the area, which have definite impact on the land system as well.

The midland region is found to be cultivated for almost the entire region, excepting settlement areas and some remains of scrub land vegetation. The cultivation of paddy in the flood plain and the cultivation of tree crops in the gently undulating hill slopes are perhaps proper land use. The cultiation of tapioca on steep slopes should be avoided to prevent mass wasting and heavy removal of top soil.

The systematic approach analyses the various systems that act upon the landscape in each of these grid araas, keeping in the view the information revealed through the study of serial photographs, and the block diagrams. Considerable advantage have beeng ained from on the spot observation and detailed work on the specific landform assemblages, their processes and responses. The field observations and work invovled the collection of photo-

graphs which helps to make the regional singularity more explicit.

Although it is not intended to draw generalisations, it is hoped that this study of appliled geomorphology will prove a useful base and a framework of land system upon which other closely related studies can progress or benefit.

B I B L I O G R A P H Y

Adam, J.A, and Walker, T.N; (1975), "Some Proporties of a Chrono - Troposequence of Soils from granite in Newzeland", Geoderma 13 - 1, PP 44 - 52.

Agarwal Anil, (Ed), (1982), "The State of India's Environment - First Citizens Report" PP.99.

Aufrere, L (1932), "La Signification de la Laterite dans L' evalution elimatique de la guinee", Bull. Ass. Georgr, Fr., 60 PP 95 - 97 and 457 - 58.

Aufrere, L (1936), "La Geographic de la laterite", C.R. Soc. Biogeography, France, 13 - 1, 3 - 11.

Abraham, A.D. (Ed), (1986), "Hill slpe processes", Allan and unwin - Boston.

Barsch, D (1979), "The Geomophological approach to enviromment", Geo. journal 3(4) PP 329 - 416.

Biswas, T.D. Etal, (1966), "Characteristics of catenary soils or granite gneiss parent rock in Kurnool district of Andhra Pradesh", I. Indian Soc. Soil Sei., 14: PP. 183 - 195.

Bruce King, R. (1975), Geographic and soil correlation analysis of land systems in Northern and Zanpula provinces of Zambia", Trans Inst. Br. Geogr. 64 : PP 67 - 76.

Brod, R. (1979), " Generalisation - a fundamental process in cartography", Bull. Illinois Geog. Soci. 21(1): PP 24 - 29.

Brunsden, D. (1981), "Geography in practice" Geomorphological Magazine, 53(8) PP 531 - 533.

Buringh, D. (1954), "The Analysis and Interpretation of Aerial Photographs in soil survey and land clasification", Neth. II Agri. Sci. 2(1) : PP 16 - 26.

Buringh, D, and Vivk, (APA) (1965), "The importance of geology in air photo interpretation for soil Mapping", ITC Publ. PP 333 - 24.

Carpenter, A. Richard,(1983), " Assessing Tropical Forest Lands (their suitability for sustainable uses"), Natural Resources and the Envt. Series Vol. 3 (Nataraj Publishers - Dehradun).

Chambers, R. (1974), "Water Management and paddy production in the dry zone of Sri Lanka", ARTI, Colombo.

Chorley, R.J. (1969), " Water, earth and man : A Synthesis of hydrology, Geomorphology and Socio Economic Geography", Mathun and Co., London.

Chorley, R.J. and Kennedy, B.A. (1971), "Physical Geography - A System Approach", Prentice Hall India, London P 370.

Coates, D. (Edt.) (1971), "Environmental Geomorphology", Proc. Symp. State Univ. New York, Birghampton.

Coates, D. (edt.) (1972-74),"Emironmental Geomorphology and landscape conservation", Hutchinson and Rose Inc. Bench Mark papers in geology, 3 Vols. 1 - 485, 1 - 454, 1 - 487.

Cooke, R.K. and Doornkamp, J.C. (1974), "Geomorphology in environmental management", Oxford University press P. 413.

Cooke, R. and Doornkanp, J.C (1974), " Geomorphylogy in Envirnomental Management, Clarendan Press, Oxford 1 - 143.

Cooke, R.U. Brunsden; Doornkamp, J.C, and Jones, DKC (1982), " Urban Geomorphology in Dry Lands" published on behalf of the United Nation University by Oxford University Press.

Corzier (Michael.J.), (1986), "Landslides; Causes consequences and Environment", Published by Croom Helm, London.

Davis, W.M.,(1954), "Geographical Essays", (Edt. D.W. Johnson) Dower Publication, New York.

Derbyshire, E. and Sperling (CHB) (1981), "Geomorphology in Practice", Geographic Magazine, 537 : 467.

Devassy, M.K. (1966), "District Census Handbook - 9, Trivandrum", Census 1961, Kerala State.

Dixey, F. (1962), "Applied Geomorphology South Africa", Geographic Journal 44 : 3 - 24.

Dury, G.H. (Ed.) , "Essays in Geomorphology", Heinemann, London, 121 - 38.

Ehrlich, P.R. et. al., (1977), "Ecoscience : Population Resources, environment", Freeman, Sanfransisco.

Faniran, A.S. Jeje, J.K. (1983), "Humid Tropical Gromorphology, Longman,London.

Fitzpatric, E.A. (1980), "Soils : Their formation clasification and distribution", Longman, London and New York.

Flawn, R. (1970), " Environmental Geology, Conservation, Lond use Planning and resources", Harper and Row New York, Evanston, London, 1 - 313.

Garner, H.F. (1974), "The Origin of landscape : a synthesis of geomorphology", Oxford University Press, New York, PP.734.

Goudie, A. (1981), "The Human Impact - Man's Role in Environmental Change, Basil Blackwell Publications, Oxford.

Holdridge, L.R., (1959), "Ecological Indications of the Need for a new approach to Tropical Landuse, Economic Botany, Journal 13; 271 - 280.

Kapoor Neena and Jayaraj, M. (Complied)," Kerala - A select Bibliography 1971 - 80 .

Kenworthy, J.B. (1971), "Water and nutrient Cycling in a tropical rain forest", Univ. Hull Dept. Geogr. Misc. Ser. 11, 49 - 65.

Lobeck, A.K., (1939), "Geomorphology", McGrowhill Book Co. New York.

Krynine, P.D., (1936), "Geomorphology and Sedimentation in the humid tropics", Am. J. Sci. 232, 297 - 306.

Langbien, W.B. (1947), "Topographic Characteristics of Drainage Basins, U.S.G.S., Water Supply Paper 968 - C.

Leopold, L.B. Wolman, M.G and Miller (1964), "Fluvial Processes in Geomorphology", Freeman and Co., New York.

Lobeck, A.K. and Tellington, W.J. (1944), " Military maps and aerial Photographs : their use and interpretation, McGraw Hill, New York, London, 253P.

Mabbutt, J. and Stuwart, G.A., (1963), " The application of geomorphology in resources surveys in Australia and New Guinea, Rev. Geomorph. dyn. 14 - 97 - 109.

McFarlane, M.J. (1976), " Laterite and Landscape Academic Press, London, New York.

Mitchell, B. (1979), " Geography and Resource Analysis", Longman Ltd., London 1 - 399.

Mohr, E.C.J and Von Baren, F.A. (1954), "Tropical Soils", Van Hoeve : the Hague.

Monkhouse, F,J and Wilkinson, H.R. (1963), "Maps and Diagrams", B.I. Publications, New Delhi.

Morgam, W.B. and Moss, R.P. (1965), "Geography and Ecology : the concept of the community and its relation to the environment", Am. Assoc. Amer. Geogr. 55(2) 339 - 350.

Pillai, U.R., and Panicker, P.G.K. (1965), "Land Reclamation in Kerala", Kerala University Economic Series, Asia Publication House, Bombay.

Pofali, R.M. and Sitaram, "Importance of Remote Sensing Technique for Geomorphological Mapping, - A case study of Western Ghats (Maharashtra), The Deccan Geographer vol. XXIII July - Sept. 1985 No.2.

Ruhe , Robert, V. "Gromorphology : Geomorphic Processes and Surficial Giology, Published by Houghton Mifflin and Co., U.S.A.

Russel, R.J. (1949), " Geographical Geomorphology", Ann. Assoc. Amer. Geogr. 39 : 1 - 11.

Ryabchikov, A.M. (1964), " On the interaction of Geographical Sciences", Soviet Geogr. 5(10) 45 - 60.

Samsuddin, M. (1980), "Quantitative Geomorphological studies of the Neyyar river basin, Trivandrum District, Kerala, CESS, Trivandrum, Prof. Paper No.9.

Selby, M.J. (1982), "Hill Slope Materials and Processes, Oxford Univ. Press Oxford .

Sinha Roy, S. (1979), " Laterite Profiles in relation to Geomorphology in parts of Trivandrum District, Kerala, CESS, Trivandrum, GSD, Prof. Paper No,3.

Stoddart, D.R (1969), "Climatic Geomorphology;: review and reassessment, Progr. Geogr. 159 - 222.

Strahler, A.N. (1952), "Dynamic Basin Morphology," Bullettin of the Geol. Soc. of America.

Tank, R. (1976), "Focus on Environmental Geomorphology", 2nd Edn. , Oxford University Press, New York.

Thomas, W.L. (Edt.), (1956), " Man's Role in Changing the Face of the Earth"- II Vols.

Twidale, C.R. (1976), "The Analysis of Landforms", Wiley, London.

Verstappen, H. (1963), "The role of aerial survey in applied Geomorphology", Rev. Deom. Dyn. 10,237-52.

Verstappen, H. Th. (1968), "Geomorphology and Environment", Inaugural Address, Waltman, Delft. 1-23.

Verstappen, H. Th. (1977), "Remote Sensing in Geomorphology", Elsevier Sci. Publ. Co., Amstordam, London, New York 1 - 214.

Verstappen, H. Th. (1983), "Applied Geomorphology", Geomorphological surveys for Environmental Development, Elsevier, Amsterdam, Oxford, N 7.