FIRST CONFERENCE

OF

THE INDIAN INSTITUTE OF GEOMORPHOLOGISTS

28th to 30th October, 1988

SEMINAR ABSTRACTS

GEOGRAPHY DEPARTMENT, ANDHRA UNIVERSITY

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PREFACE

During the International Symposium on Geomorphology and Environmental Management held from 17th to 20th January 1987 at the University of Allahabad, Allahabad, an Indian Institute of Geomorphologists (IGI) was found at the Geography Department of the University. About 50 members joined as Life Members to start with.

This is the First Conference of the above Institute being held at the Geography Department of Andhra University, Visakhapatnam. A seminar is being held where about 30 papers in the field of geomorphology will be presented by geomorphologists from Government Organisations, Research Institutes and Universities from different parts of the country. This volume contains the **abstracts** of these papers.

The Executive Council of the Indian Institute of Geomorphologists and the Organising Committee of the Conference at the Geography Department, Andhra University, are particularly grateful to the authorities of the Andhra University for releasing funds for the conduct of the Conference and the Seminar from the Unassigned Grants of the University Grants Commission. The Conference and the Seminar will be held from 28th to 30th October 1988, followed by a Field Excursion on 31st October, 1988.

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CONTENTS

GEOMORPHOLOGICAL CHARACTERISTICS OF THE ALLUVIAL FANS OF THE RIVERS BALASON, RAKTI AND ROHINI IN THE FOOT-HILLS OF THE DARJEELING HIMALAYAS

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Rivers debouching from the Darjeeling Himalayas on to the wide-open plain of North Bengal have developed a number of alluvial fans. Between the 300 m contour in the north and the 75 m contour in the south, these alluvial fans coalesce to form a Piedmont zone. The fans between the rivers Balason and Rohini, bounded by the latitudes of 26°45'19" to 26°50'23" N and longitudes of 88°14'35" to 88°20'30" E were selected for detailed study. These are located on the right bank side of the river Tista in the District of Darjeeling, West Bengal and cover approximately 40 km^2.

The main purpose of the present study is to describe systematically the evolution and development of the alluvial fans together with their geomorphological characteristics. The methodology employed include quantitative determination of slope, examination of soils, analysis of the geomorphological processes involved in sculpturing the land surfaces together with the study of the nature of the existing landuse.

The geometry of the Balason-Rakti-Rohini fans of the piedmont zone in the District of Darjeeling have been closely controlled by local relief, climate, lithology, hydrology and channel forms since their formation out of the periglacial debris and the solifluction materials during the Pleistocene epoch. The fan materials are coarse-grained, poorly sorted and immature sediments. Usually gravels, cobbles and boulders predominate with subordinate amounts of sand, silt and some clay. Maximum size, thickness and roundness of coarse grains decrease rapidly towards the base of the alluvial fan deposits. Intermittent flash floods, stream action, stream floods and mass-movements are four notable modes of deposition of alluvial fans. The processes are essentially all contemporaneous, each one having

its own area of impact. In the upper part of the fans stratification is moderately developed, boulder and pebble beds alternate with sandy, silty and muddy beds rich in organic matter. But such stratification is not apparent in the lower reach of the fans.

The vertical profile of the fans consists of three well defined straight line segments (upper, middle and lower) having ap .oximately uniform slope. Each one of these segments has its own individual topographic characteristics and landuse. The upper fans spanning between 260 to 460 m have a general slope varying from 3.5° to 5°. Due to stream action the fan heads are deeply entrenched. Huge flash flood debris and mass-movement materials are often seen scattered all over the surface. The middle fan extends from 200 to 320 m having a general slope varying from 1.5° to 3°. The size of the deposits here is mostly smaller. Being away from the apex, the middle fan segment is rarely affected by the hazards of flash floods and mass-movements. But the stream action and floods often affect this region quite conspicuously. The outer most area, south of the limiting contour of 200 m, grades into the zone of coalescence of all the fans. Such a coalescence is due to the frequent flooding of the existing braided streams and the mingling of their flood-water together with flood-deposits. Here, the deposits are generally fine grained silts and sands. Overall slope varies from 1.5° to even less than 1°. Bank erosion and river migration are quite common in this part of the country.

Excessive deforestation, increasing arable farming as well as overgrazing have profound effects on the existing soil-cover of the fans. The removal of top-soil is so widespread that the present landuse is often being carried out on former sub-surface horizons. The degree of pedogenesis seems to be the maximum in the middle fan, moderate in the upper fan and the minimum in the lower fan segment.

The unplanned and unscientific use of the fans have set gyrating the vicious cycle of deforestation, soil-erosion, mass-movements and floods. Such a process begun by an ill-informed

and profiteering minority, has been drastically disturbing the local ecological balance. The forces of nature have thus been prevented from maintaining any equilibrium. On the contrary, constant cultural impositions by man have induced the natural forces to remain ever active. As such the morphology of the fans under study is also being gradually modified, and continuous vigil is necessary to reveal the personality of such a dynamic landform.

CATENARY SEQUENCES OF THE UPPER VINDHYAN FORMATIONS OF THE TRANS-YAMUNA REGION OF ALLAHABAD DISTRICT

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The Trans-Yamuna region of Allahabad district is located between 81°29' E to 82°30" E longitude and 25°25'40" N to 24°41'15"N latitude. The region exhibits the complex blending of sediments derived from the old Vindhyan formations of Upper Algonikan in the south and the mighty Himalayas of Tertiary in the north - creating patterns of complex series and varied members of catenary sequences developed over temporally and litho-spatially heterogenous platform like the Trans-Yamuna region of Allahabad district.

Main objectives of the present paper are the following:

i) Identification of developed catenary sequences as well as their member soils;

ii) Analysis of soil forming processes with special reference to the genetic evolution sequential development and destructive culmination of catenary sequences and its member soils.

Field work and micro-level study of the geological structures and pedogenesis through mineral analysis of rocks and chemical analysis of soil were carried out. Mechanical and chemical composition of the soil samples were determined by various methods like Pipers method for silicate analysis, organic carbon estimation by Walkley and Black's method, nitrogen estimation by Kjeldahl's method etc.

The study reveals three major divisions forming major catenas of the region (though micro-catenary variations are possible). These are (i) the Vindhyan scarps catena of the south, (ii) Catena of Central rocky terrain of Vindhyachal and

(iii) Northern alluvial plain catena. During the course of soil survey five typical profiles were selected which fully illustrate the entire soil development series of the region in a catenary sequence. Catenary sequence no. 1 represents Catena of Vindhyan scarps whereas Catenary sequence Nos. 2-3 and 4-5 represent central rock terrain and northern alluvial plain catenas respectively. Maximum depth of no. 1 sequence is 48 inches whereas maximum de th of no. 2-3 and 4-5 sequences are more than 72 inches. Presence of organic matter is highest in the A-horizon of no. 2 Catenary sequence. Major chemical constituents of all the sequences of catenas at varying depths are SiO_2, Al_2O_3, Fe_2O_3, P_2O_5, CaO, etc. (Oven dry soil below 2 mm). Base exchange capacity of sequence no. 5 is highest and it reduces from catenary sequence no. 5 (44.2 to 52.9 m.c. percent) to no. 1 (6.20 to 7.69 m.c. percent).

PEDOGEOMORPHIC PROCESSES AROUND MANGALAGIRI IN GUNTUR DISTRICT, ANDHRA PRADESH

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The hills around Mangalagiri are formed by the khondalites and quartzo-feldspathic gneisses. The hill slopes are compound-concavo-convex type. Climate is semi-arid and the vegetation is scarce. The intensity of weathering on slopes is not uniform. Some slopes show clay development, and others do not. Except for some weathered material on summits, the sites on crest- and mid-slopes are youthful. Colluvium with 2-3 m thickness is deposited over the foot-slope and below that residual soil formation is recorded. The alluvial toe-slope is characterised by the deposition of red-loamy soils with occasional pebble zone. $CaCO_3$ forms duricrust. Both colluvial foot-slope and alluvial toe-slopes are under extensive quarrying. The sorting of sediment from foot slope colluvium to alluvial toe-slope loamy soils has taken place within a 100 m distance. The soil forming factor equation for the foot-slope was $l,s,v,a = f(p)_{cl,r,t,o}$ and for transported soils $l,s,v,a = f(cl)_{r,t,o,p}$. The denudational balance is $A < S+M$ for crest- and mid-slopes and $A > S+M$ for foot-slope. Human factor alters the physical environment and results in the disruption of the soil profiles.

An attempt has been made to understand the pedogeomrophic processes around Mangalagiri, the effect of transporting agent on sorting and human impact on environment, mainly based on field observations.

Overland flow is active on crest- and mid-slopes. On foot-slope, hydrolysis is responsible for the development of residual soils and frost heaving for extensive fracturing in quartzo-feldspathic gneisses. Here erosion is aided by the cumulative

effect of rain splash, sheet wash and troughflow. These processes have changed due to human impact in the form of quarrying. Sliding and erosion by sheet wash are operating. The sorting from colluvium to red-loamy soils within a distance of 100 m gives unequivocal evidence for the deposition of coastal red sediment from adjacent hill ranges by unconcentrated flow. The formation of $CaCO_3$ duricrust is related to pedogenic processes. The variation in intensity of weathering is due to slope angle.

Man is one of the most important geomorphic agents. Practically all accelerated soil erosion today is a result of man's interference. The universal soil loss equation fails to provide a place for human impact. Perhaps, there is an immediate need to include this.

MOISTURE LOSS - TEXTURE AND PERMEABILITY OF SOIL - AN ENQUIRY INTO THE RELATIONSHIP OF THESE VARIABLES

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Moisture content is one of the important parameters related to the soils, not only for the plant growth but also for the processes of weathering. The moisture content is greatly influenced by the texture and is related to the rate at which the water enters into the soil.

Present study attempts to find the rate of moisture loss in different soils collected from varied environmental conditions. Soil samples are collected from (1) high leaching environment over granite and non-Trappean rocks from South Konkan, (2) moderately leaching environment of the Ghat zone in Western Maharashtra (Pune district) and (3) the southernmost ranges of Satpuras with basalt rock as parent material.

The analysis of moisture loss is carried out with the help of infra-red moisture meter. The loss of moisture against time has been noted and curves representing the moisture loss are plotted. The moisture loss, textural properties and the value of permeability have been analysed for inter correlations and these are highlighted with some details.

GEOMORPHOLOGY OF BORRA (KARST) CAVES IN EASTERN GHATS IN VISAKHAPATNAM DISTRICT, ANDHRA PRADESH

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Karst caves are developed in crystalline limestones at Borra in the Eastern Ghats in Visakhapatnam District, Andhra Pradesh, due essentially to solution process.

Contour map has been prepared on a scale of 1:1000 with 1.5 m contour interval using Micoptic Alidade over plane table, and cave plan with geomorphic features was prepared by using theodolite, prismatic compass, Brunton compass and tape, on 1:200 scale. According to BCRA (British Cave Research Association), the nature of survey comes under grades of 4X for main cave and the remaining parts, 4b.

Aerial photographs on two scales (1:50,000 & 1:25,000) and Landsat (TM) imagery on two scales (1 : 250,000 & 1: 50,000) have been interpreted, besides fractures/lineaments and faults marked to get a regional picture.

Three levels of karst caves are recognised from above the river bed (base level) besides the one in the river bed itself, and all these are considered to be related to sea level changes. The development of caves along mostly the bedding planes and changes of phreatic to vadose zone have been studied. The collapsed material is seen at entrances of caves only.

Caves, gorges, natural bridges, dry valleys, dolines (sinkholes) with or without travertine deposits, stalactites, stalagmites and pillars are identified.

The following factors are considered to have contributed to the evolution of caves in this area :

i) Occurrence of crystalline limestones, with intrusives of pyroxenite and skarn veins, well jointed and thinly bedded.

ii) Favourable climate, classified as Humid-Mega thermal (Subra manyam, V.P.,1965).

iii) The richest canopy (dry evergreen deciduous forests) aids in the formation of particularly the acidic nature of humus in the soils, these contributing to solution activity.

iv) A major fault extending N 30° E - S 30° W and a number of small fractures that traverse through this limestone area aid seepage of water.

v) The existence of surface river in the valley and many karst springs flowing down to meet the river.

It is suggested that in the formation of caves here, there could be the influences of geological structure, base level changes and climate.

A STUDY OF KARST FEATURES IN THE VICINITY OF BAGESHWAR TOWN IN KUMAUN HIMALAYA

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The present paper is an attempt at the systematic study of karst features (landforms) developed in Kumaun Himalaya in India. The study area is covered in toposheet No 53 O/13 of S.O.I. and lies around Bageshwar town, Almora district, U.P. The area is drained by Sarju river and its tributaries. Karst landforms are developed mostly in carbonate rocks, namely limestones and dolomites. It has been found that karst features are not generally developed where insoluble material exceeds more than 30% in limestones, which is the case at Kanda village. The significance of geological structure like joints, fractures and bedding planes are seen in the solution process.

The climatic conditions of the area vary from subtropical to temperate and the annual rainfall exceeds 106.56 cm and is well scattered throughout the year. The annual temperature varies from freezing (2° C) point to more than 30° C. This climate is favourable for the growth of vegetation ranging from lichens and algae to chir-pine trees. The solution effect of carbonate rocks is generally more intensive in warm and humid climatic conditions (Lehman et al, 1963).

Water samples have been collected from different parts of the study area at two different periods (May 1985 and July 1986) analysed for estimation of pH values and concentration of anions and cations of different elements as suggested by Hens (1970). The values of pH shows that water samples are essentially basic and it has been observed that the concentration of Ca, Mg and CO_3 and HCO_3 ions are higher during summer than duringwinter seasons. This indicates that solution and precipitation processes are quite dominant here.

A number of karst features have been observed viz. solution notches, karren, sinkholes, different dimensions of caves, stalactites (straw, conical and curtain) and stalagmites. Stalactites are more common than stalagmites due to flow of cave streams on the floor with variable discharges.

STRUCTURAL LANDFORMS AND GEOMORPHIC PROCESSES OF KALIMACHAK RIVER BASIN (A SUB-BASIN OF NARMADA) IN M. P.

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The topographic characteristics of any area on the surface of the earth are largely controlled by structure and geomorphic processes acting on it. The Kalimachak river basin experienced massive tectonic movements in the past and offers numerous structural landforms for the study and these landforms are further modified by the present fluvial action. Hence it has been chosen as a study area. The study area consists of about 741 sq km stretching between N latitude of 21°54' and 22°12' and E longitudes of 76°40' and 77°11' .

The Kalimachak river basin lies in Narmada-Son line which is affected by faults. This basin comes under offshoots of Satpura range, consisting of thin soil, rocky topography and some regions of barren land. The southeastern portion of the basin is rugged, uneven and hilly. The middle portion of the basin is relatively gentle and even with scattered residual hills. The western side of the basin represents a well dissected topography. The general slope of the basin is from southeast to northwest.

OBJECTIVES & METHODOLOGY. The objectives of the study are (a) to identify the structurally controlled landforms, (b) to observe the structural control over fluvial pattern, (c) to identify the various types of lineaments; and (d) to analyse the important geomorphic processes.

Topographical sheets on 1:50,000 scale and the Panchromatic black & white aerial photographs on 1:25,000 scale of the study area were interpreted for the Geomorphic details. Lineaments resulting from faults, offsetting of streams, gullies, resistant

ridges, straight course of stream and a long narrow valley, etc., have been identified and mapped separately. Geomorphic map has been prepared to show the location of various structural and fluvial landforms.

RESULTS OBTAINED - RELATIONS ESTABLISHED. Structurally controlled landforms identified in the study area are faultscarp (fault line scarp), cuesta, mesa, butte, fault line valley, fault terrace and resistant ridges etc. The characteristics of each of these landforms are explained. Fault trellis, parallel, sub-parallel & dentritic patterns have been identified & studied which reflect a structural control. Other features of structural control in the study area are also recognised with the help of different types of lineaments such as topographic lineaments and vegetation lineaments. The causes for the termination of lineaments is also explained.

The important factors which affect the rate of weathering (of the region) are also explained, based on the study of soils. Mass-movements in the study area have also been recognised.

The fluvial process is the dominant geomorphic process in the basin. The different types of erosion such as soil erosion (rill, gully, sheet erosion), channel erosion (vertical & lateral) have been analysed. The constructional processes are also understood by studying the depositional landforms (delta bars & point bars). The location, size, shape and characteristics of the landforms which are produced by each process have been explained in detail and mapped accordingly.

CATTLE TRACKS OR TERRACETTES : A STUDY OF MICROFORM ALONG INCLINED SURFACES

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The small miniature step like structure often easily noticed particularly along the debris covered slopes have often been considered as cattle tracks. However such tracks are sometimes considered as valid forms of process of mass movement by some authors. The controversy remains still unresolved and there exists general agreement for the need of detailed analysis of this form.

An attempt has been made in this work to quantify various morphological aspects related to the terracettes. The variables considered include, besides the soil depth and inclination of surfaces, drop along terracettes - width of the terracette tops - amount of inclination - the pattern of terracettes vis-a-vis general direction of slope, soil texture and the intensity of formation of terracettes. The areas which show no sign of the formation of terracettes have also been considered and their properties related to soil and slope have been analysed.

It is observed that the development of the terracettes is confined to some areas with certain inclination and given soil depth (or depth of loose material, if it cannot be considered as soil in its strict sense of definition). In areas of very steep slopes over 30° inclination, the terracettes are rarely found, if any. The development of terracettes varies not only with the amount of inclination but also the depth of debris cover and the textural properties of soil.

SAND DUNES ALONG RIVER TAPI NEAR UBHAD (DIST: DHULIA) AN EOLIAN LANDFORM IN FLUVIAL SETUP

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Occurrence of sand dunes in hot deserts and along beaches is rather a common phenomenon. However when such features are found just along the channels of river they appear anamolous and need some explanation for their very existence. The invading sands from such dunes also cause considerable damage to the farm lands in the fertile tracks of flood plain and thus pose some environmental problems.

The existence of such dunes is reported from two locations such as Talkad near Mysore along River Kaveri and Ubhad near Prakasha (District Dhulia) along Tapi. The dunes in Dhulia district occupy an area of 3-4 sq.km. and are reported from 3 different locations within a distance of about 25 km, along river Tapi between Prakasha - and Taloda. It is observed that these are developed at locations wherever the gullys have cut the banks and make it possible to move the sand (mostly fine sand) beyond the limits of the bank. However these dunes appear to have been deveveloped at the same locations in different periods and it seems to be a recurring phenomenon. The present paper analyses the forms of sand dunes observed along Tapi channel and attempts to explain their development.

PALEOGEOMORPHOLOGY OF SUDDAPALLI AREA IN GUNTUR DISTRICT, ANDHRA PRADESH

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A column of sediment, varying in thickness from 1-6 m, is deposited in and around Suddapalli village. It occupies a linear zone, having 11 km length and 2 km average width. It is mainly composed of medium to coarse pebbles, which by weight constitutes 80 percent. This zone is overlain by a red sediment and underlain by the Upper Gondwana sandstones. Conglomerate is recorded in between sandstone and gravel bearing sediment. The gravel bearing sediment is characterised by the presence of large boulders / blocks, especially in the upper part.

The geomorphic evolution as well as the environment of deposition of the linear zone have been studied by means of field observations, textural, orientation, surface textures and shape and roundness of materials. Subsurface lithology is obtained from bore-hole observations.

The absence of fines, negative skewness and derived paleo-current velocities support the deposition of sediment in the linear zone under high energy environment, probably beach. The predominant percentage of sandstone pebbles in gravel bearing sediment indicate their derivation locally by reworking of underlying Upper Gondwana sandstones. The boulders/blocks of sandstones with NE-SW orientation, extensive burrowing action and carved surfaces also support beach environment. The development of crescentic impact scars and chink facets on quartzite pebbles and their well rounded and elliptical flat shape further suggest modification in beach environment. The absence of sandstone boulders/blocks in the northern part of linear belt and their abundance in the southern part suggest wave action from the southern side.

The alignment of the linear zone parallel to the present shoreline and its deposition and maritime influence suggests that the linear zone might have been deposited as a barrier island. The sea level during its development may be +16 m MSL, equal to the elevation of the study area. The significant horizontal variation in the sediment distribution of the region, perpendicular to the linear zone -- black clayey soils near Budampadu to gravel near Suddapalli, sandy soils near Sahgam Dairy and black clayey soils further, corroborates the idea of paleo-shoreline transgression. Chertification of chink facets and formation of chert pebbles indicate acid environment during the deposition of gravel bearing linear zone.

PALAEO-GEOMORPHOLOGY DURING BARAKAR PERIOD OF THE GONDWANA IN RAJMAHAL HILLS, BIHAR, INDIA

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The objective of the present study is to interpret the palaeo-geomorphology of the Barakar times of the Gondwana with the help of lithofacies analysis, heavy mineral, granulometric and petrographic studies.

The Barakar Formation of the Gondwana Supergroup, with its economically important coal seams, is exposed on the western flanks of the N-S trending Rajmahal hills, as five disconnected coal fields. In the northwestern part of the Rajmahal hills, the Barakar Formation is concealed under 60 m to 80 m thick alluvial cover. The Talchir Formation is confined to the southern coalfields only. In the northern coalfields Barakar Formation has a normal contact with the Archaean granite gneissic basement. The Gondwana sediments were deposited in a N-S trending morphotectonic of graben with faulted eastern margin. The metamorphic terrain in the west is dominantly of Amphibolite facies with 'Almandine' garnet as the dominant heavy mineral. The area in the south forms part of the Chota Nagpur plateau and consists predominantly of granite gneisses characterised by 'Pyrope' garnet. The Chota Nagpur plateau was the centre from which the Talchir glacial ice radiated. Palaeocurrent direction also suggests a mean northerly vector for sediment movement, during Barakar times. The incomplete fining upward sedimentary cycles in the Barakar Formation may suggest braided channels of deposition.

The C-M plots after Williams indicate a mixing of lower energy and higher energy fluvial environments. The lithofacies indicate a higher coal zone in association with coarser sediments near the proximal part of the Barakar basin. This area is also

characterised by the dominance of Feldspathic Wacke and Almandine garnet, whereas the distal parts are characterised by quartz wacke and Pyrope garnet. Since Feldspathic Wacke represents rapid erosion from a higher relief, and Almandine indicates an Amphibolite provenance, the mixing of the lower and higher energy environments can be explained by assuming a higher energy tributary system draining the Amphibolite country in the west and joining the lower energy braided fluvial regime flowing from south to north.

LATE QUATERNARY CLIMATIC CHANGES AND THEIR EFFECTS ON LANDFORM DEVELOPMENT IN KANGRA VALLEY

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The Kangra Valley is one of the most beautiful valleys of Himalaya in Himachal Pradesh lying between lat. 31°40' to 32°20' N and long. 75°40' to 77°5' E to the south of snow clad., Himalayan ranges of Dhauladhar which rise upto an elevation of 6200 m. The Siwalik ranges (1018 m) form the southern limit of the valley. The Chakki Khad and Beas River form its western and eastern boundaries respectively. The Kangra Valley encompases an area of about 5739 sq km.

The Dhauladhar ranges consisting of Sundar Nagar Formation and Chails abruptly rise in the northern part of valley forming a crown. The upper ranges of Dhauladhar remain snow clad throughout the year and a large number of small valley glaciers originate in these ranges. Towards south of Dhauladhar the Kangra Valley is dissected into many smaller valleys and are drained by a number of channels. These channels draining towards east and southwest ultimately form the river Beas, which is the master stream.

Distinct landforms are visible in various parts of the valley due to the presence of Murrees, Siwaliks and Quaternary sediments, distinct processes and asymmetric nature of Kangra valley. The drainage reflects structural and lithological controls. Just to the north of river Beas, mainly around Jwalamukhi and Dehra Gopipur, the channels generally follow the strike of folded Siwalik beds and show rectangular drainage. This rectangular drainage gradually leads to dendritic drainage due to ongoing neotectonic activity in the region. In the central part of the valley, which

Is mainly formed by the filling of glacial and glacio-fluvial deposits brought down by valley glaciers and channels originating from Dhauladhar and deposited on already eroded upper Siwaliks, is developed highly dissected rill and gully topography. The non-perennial channels originating from upper Siwalik in the southern-most part of valley, form highly dissected topography in the upper reaches and broad ephemeral channels are to be seen towards the down stream side. These broad ephemeral channels have distinct levels of sediment deposition brought from the Upper Siwaliks during high downpour of monsoon, commonly known as choe.

There are four distinct glacial records of advance and retreat. These records of climatic fluctuations are well preserved in the sediment exposed along the main channels. Erratic and morainic deposits are well observed along the central and northern part of the valley. These erratics and morains are derived from the Dhauladhar as they mainly consist of granites and gneisses of the Dhauladhar range.

In the higher reaches of Dhauladhar periglacial landforms are found. The fast weathering of granite and gneiss have facili-ated the process of pedogenesis Mass movement in the form of creep and slumping are quite common in the periglacial areas.

GEOMORPHIC ANALYSIS OF SELECTED MINERAL DEPOSITS USING REMOTE SENSING TECHNIQUES

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The morphological signatures of a few selected mineral deposits using satellite imagery and limited field checks were studied with a view to finding out whether there are any significant geomorphic controls/expressions/associations.

The Noamundi iron-ore deposit is on the northeastern corner of the iron-ore supergroup syncline of Singhbhum area and expresses itself as arcuate ridges on the false colour composite. Iron-ore areas appear as greyish black patches. Colour variations enable the recognition of different landforms like scarps, flat uplands, cuestas, etc., according to their lithology and slopes. Lineaments are concentrated on the eastern portion of the synclinal limb and many deposits are located here; hence it can be inferred that the deposits are structurally controlled.

In the Bailadila area of the Bastar district of Madhya Pradesh, the satellite picture shows two long ridges running north-south with a fault-valley in between. The ridges are cuestas and there is a considerable slope asymmetry between the western and eastern slopes. The ridges widen in the south and again meet in the form of a spindle. Several deposits of banded hematite quartzite are located all along the ridges which form a part of major folds in the area.

The signatures of the Sukinda chromites of Orissa on the false colour composite are small arcuate black bands on a dirty white patch indicating folds in the valley portion, surrounded by ridges on either side of the valley. The colour varies according to the lithology and slopes. There are two parallel faultscarps between which the Sukinda valley has been formed.

The Garividi-Garbham manganese areas of Andhra Pradesh on Thematic mapper false colour composite show as badland topography with small mounds and ridges as red patches; there are also depressions filled with water that show as black patches. The manganese deposits are restricted to the small mounds and depressions. The quarries under exploitation appear as dirty white patches. The lineament analysis shows the dominant strike of the area as NW-SE.

The above study reveals that the geomorphic data may provide important clues to the mineral occurrences.

GEOMORPHOLOGY OF GULF OF MANNAR OFF MANAPPAD TO VAIPAR IN SOUTH INDIA

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The coast of Gulf of Mannar in the area is smooth, low lying, fringed with palmyra/coconut trees and sandy. There are many rock exposures in the offshore evidenced by rock or stone bottoms on the latest navigational chart (1984) published by Naval Hydrographic Office, Dehra Dun, the prime agency to hold bathymetric data and producing navigational charts for Indian Ocean/Indian Waters. The surface currents along the coast generally set with the wind at rates between 1 to 2 knots and run along the coast. During lulls in the monsoon the current sets into instead of across the Gulf of Mannar. There are three major rivers pouring sediments into the sea in the area. Sediments which are either seaborne or river borne are carried from south to northward striking at the port of Tuticorin being a protruded coast, causing maximum deposition in Tuticorin Harbour. This has also created siltation problem in the harbour. Heavy siltation is evidenced by the seaward buldge of 5 m depth contour as far north as off Vaipar. Numerous shoals are created endangering safety of ships approaching the ports. The rock exposures overlain by sediments have turned into submarine hillocks.

The area is divided into continental shelf, continental slope and continental rise. The continental shelf portrays very rugged topography along its coastward limit where lie the ports and harbours. The shelf itself has specific areas of gentle slope with rugged topography, steep slope and gentle slope with comparatively smooth submarine terrain merging with the coastward limit of continental slope. Highwater islands/rocks, submarine

ridges and hallows, pearl banks, are common features of the shelf. Pearl banks being the well known features of Gulf of Mannar are marked by specific legends on the chart. The continental slope Off Manappad to Tiruchchendur is wall like. It starts even with the 30 metres depth contour as its coastward limit while northward it is comparatively moderate in slope. The most striking features of this area are a few submarine valleys which are extrapolated for the first time by the author. However more data for their exact delineation into submarine canyons or valleys is lacking. The continental rise is an extremely gentle sloping area without much variation. The 500 metres depth contour marks its coastward limit with a maximum depth recorded to date as 1800 metres in the area of study. The Continental Rise on the east merges with the seaward limit of continental slope, continental shelf and coast of Sri Lanka in ascending order, so is the case northward as the northern part of the Gulf of Mannar is blocked by southeast coast of India including Pamban Island and Adam's bridge.

SILTATION IN TUTICORIN HARBOUR - A MORPHOLOGICAL ANALYSIS

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Hydrographic surveys as old as 18th, 19th century and those of latest origin held in the archives of naval hydrographic department of Ministry of Defence have been utilised in consultation with navigational charts to describe the bathymetry and physiography of the submarine terrain off Tuticorin.

Various sandspits have developed along the coast changing their shape and increase in their extent, from time to time. A shoal charted as Middle Bank in 1879 has developed into a narrow drying spit (during low tide) and charted as such in 1955 which is further charted in 1977 as a broad elongated drying feature. Navigational chart of 1984 shows various shoals, drying features and seaward shifting of depth contours of 5 and 10 metres. Two different islands viz., Paundian (Hare) and Punnayuddee separated from each other by a narrow channel in 1796 were charted as a single high water feature in 1960 retaining names of the two islands and chart of 1977 referred this feature as Pandiyan Island only. A deep channel with 5 m water, west of earlier Punnayuddee island, was also silted up in 1933. The geomorphic studies, seaward shift of bathymetric contours and increase in size of submarine and drying spits are indicative of fast siltation trend in the area which is further evidenced by sinking of various shifts/crafts due to uncertain nature of bottom configuration with change of time.

Development of shoals in the approach channels to Tuticorin Port has made it unfit to handle present shipping and necessitated the development of New Port of Tuticorin as a major port by the construction of two break-waters in order to protect the

approach from siltation. However the silting still continues. The depth contours of 5 and 10 metres are shifting seaward pressing hard the port authorities for regular dredging in order to keep the harbour open for use. Shoals are developing and enlarging endangering the safety of navigation.

The paper is concluded explaining the utility of marine geomorphology and the concept of Submarine Terrain Evaluation in harbour engineering and high level planning proposing solutions to this siltation problem.

PROGRADATION AS EVIDENCED AROUND A SUBMERGED ANCIENT PORT PERIAPATNAM, TAMIL NADU, INDIA

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During the course of field work in connection with coastal geomorphological studies, a distinct spit formation has been noticed in a place near Periapatnam village, which was a popular Pandya's port in 13th and 14th centuries, in Ramnad district, Tamilnadu.

In order to evaluate the growth of that spit in a place where there is no present day drainage, and its probable role in the closure of the ancient port, Admirality charts from the year 1596 to 1986, the Satellite imagery of 1979 and Aerial photographs of 1972 have been utilised. The same have been supplemented with sufficient ground truths and have also been verified with the latest imagery available.

The comparison of Admiralty charts of 1919 to 1972 has clearly shown the difference in hook formation from young to mature. The presence of beach ridges with alternate swales in this coast, indicates appreciable amount of progradation. Satellite imagery clearly depict the palaeo-coastline with cut-off water tank, which is considered to be the part of the earlier navigational channel.

The progradation has been attributed to the river Vaigai (1) because of the close linearity existing between the stream closeby the Periapatnam tank and palaeo-channels of that river, demarcated earlier in the imagery and (2) the strong northerly longshore currents which are intersected by the configuration of the coast.

The fast change in the bathymetry of the Palk Strait has supplemented the possibility of sediment accumulation in this part. From the rate at which the spit is growing, it is contemplated that another cut-off tank may emerge in the next 35 years, in this place.

GEOMORPHOLOGY OF ANDAMAN AND NICOBAR ISLANDS USING SATELLITE IMAGERY

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The Andaman and Nicobar group of islands in the northeastern Indian Ocean forms an arcuate chain that extends for about 850 km in a nearly N-S trending arc between the latitudes 6°45' N and 13°45' N, and longitudes 92°15' E and 94°00' E, separating the Bay of Bengal from the Andaman Sea. Orographically, Andaman and Nicobar islands are the projections above sea level of parts of submarine ridges, continuous with the Arkan Yoma and Patkoi Ranges to the north and Mentawai group of islands to the south. This orographic belt constitutes the outer non-volcanic arc of the East Indian Orogen, circumcontinental in nature, around the Sunda shield. The islands are in two groups, the Andamans and the Nicobars with the ten degree channel separating the two.

OBJECTIVES : Though geological mapping in Andaman and Nicobar islands has been carried out by many geologists, yet geomorphological mapping was not attempted. In the present study, it is aimed to use Landsat Thematic Mapper (TM) data, and all the islands are to be mapped geomorphologically to get an overall idea of the various geomorphic units present in the island and their evolution.

METHODOLOGY : To prepare the geomorphological maps, visual interpretation of TM Band 4 (infra red) and FCC prints of 1986-87 data on 1:250,000 scale has been carried out, following the image element (tone, texture, pattern, size, shape, etc.) and terrain element (Landform, drainage, erosion, vegetation, etc.) analysis. Limited field checks have been done at doubtful areas. Finally geomorphological data are transferred to a base map on 1:250,000 scale prepared from SOI toposheets, incorporating the changes

taken from the latest Satellite data.

RESULTS : Information pertaining to inaccessible 'Jarhwa areas' are now known by virture of the present satellite remote sensing studies. For the first time geomorphic maps of the entire islands are prepared. The islands are mostly hilly, densely forested and dissected by numerous narrow valleys. The coastline is highly indented by bays and creeks which are frequently marshy and choked with luxuriant growth of mangroves.

Geomorphologically the Andaman and Nicobar islands do not exhibit a variety of landforms. This is due to the fact that the terrain is immature and the areal extent of the islands is so limited. Streams debouching from the hills immediately meet the sea so that no alluvial plain is formed. Development of mainly hills and valleys, are controlled by the underlying lithology and structure. The various geomorphic units as mapped are classified under coastal units and hilly units. Coastal geomorphic units include offshore/sub-marine terrace, beach, mangroves, bays, mudflats and raised beaches. Hilly units include structural hills, linear ridges, denudational hills, dissected upland, volcanic cone, gently undulating plain and infilled valleys.

The various geomorphic units developed in the entire islands are evolved during different phases of sedimentation and tectonism, subsequently exposed for sub-aerial denudation.

URBAN GEOMORPHOLOGY OF JAIPUR

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Geomorphological mapping was carried out on 1:50,000 topographical maps with detailed field investigations of Jaipur and its surrounding areas to identify geomorphological problems which have been encountered in the process of urbanisation of this biggest city of Rajasthan. The major geomorphological problems identified are drainage-flooding, silting on roads, gullying, deforestation and silt-load, reactivation/destabilization of fossilized dunes, accelerated runoff, reduction in infiltration, falling ground water table, mining and quarrying and slope instability. Geomorphologically, Jaipur has a mosaic of hills, pediments, stabilized sand dunes of more than one generation, terraces and flood plains of the Dhund and its tributaries.

Originally, the city of Jaipur was planned in 1727 on a sandy triangular plain in harmony with all city elements, which proved to be a sustainable habitat for over 200 years. But after Independence the population of Jaipur increased to 10 lakhs in 1981, and as a result of this and for lack of appreciation of geomorphological problems, the 'Pink City' environmentally is now becoming a 'Stink City'. The unprecedented rainfall of July 1981 caused serious soil erosion, landslides in hilly areas and widespread flooding. Over a thousand people were killed, hundreds of houses along the channels and other buildings were ruined, the lives of thousands of people in sprawling Jaipur were disrupted and the resources of the Government had to be mobilized to cope with the emergency and rehabilitation of the region. The study reveals that the dominant environmental processes responsible for this crisis - soil erosion, landslides and flooding were geomorphological problems - problems relating to the land surface and the forces that acted upon it.

The land use changes between 1971-83 of the city and environs are traced from the maps obtained from Town and Country Planning Department, Jaipur. The Master-Plan of the city is evaluated in the light of geomorphological problems. The paper also attempts to suggest some possible solutions for these geomorphological problems and for an overall development of the Jaipur urban agglomeration.

IMPACT OF FLOOD HAZARD ON AGRICULTURAL OCCUPANCE OF A PART OF THE MIDDLE GANGA PLAIN

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&

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Floods are an indirect response to changing terrain conditions in any geomorphic unit. A study of the geological background and human occupation of the Ganga plain reveals the impact of flood hazards on agricultural occupance and various other socio-economic activities. The river throughout its meandering course, along with a few terraces, natural levees, steep bank, sandy bed, channel islands and vast depressions, indicates the stages in its earlier evolution and the present stage due to human occupance. Floods, in this part, are usually dangerous hazards for the kharif crops but in the course of their distruction they do provide certain benefits through rich fertile siltation, though not without spatial variations. The effect is usually reflected in enhanced yield of the crop grown in the succeeding season. The duration, frequency, magnitude and the level of floods have their impacts separately as well as jointly. The 1978 flood has been remarkable in all respects. Field size and shapes exhibit spatial differences. In most vulnerable villages the narrow strips of elongated plots indicate continuous fall of elevation with the recession of floods, i.e., the average area of silt covered land is shared by almost each occupant of the village.

The sample study reveals the average size of fields in Ranipur to be 0.80 acres while in Firozpur and Khairabari it is 1.70 and 1.50 acres respectively. In more vulnerable villages like Firozpur under uncertain physiographic and edaphic conditions the land use pattern is never static. The area, location and shape of newly silted land depends upon the nature and character of floods as depicted through the present study in detail. Thus, the agricultural occupance also responds to a variety of conditions created due to flood hazards.

HYDRO-DYNAMICS AND ENVIRONMENTAL EVALUATION OF FLOODS IN TRANS-YAMUNA REGION OF ALLAHABAD DISTRICT

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The pulsating arteries of the northern Indian Plain, the Ganga and the Yamuna forming the northern boundary of the Trans-Yamuna region of Allahabad district and the river Tons bisecting the region into two halves, render the region prone to frequent ravages of floods having devastating discharge and ample kinetic energy. In the present paper complexities of flood dynamics of the study region have been explained through the systematic and analytical discussion of the themes like causes, dynamics of floods, fluctuation of kinetic energy, frequency and spatial pattern, hazards of floods and its management.

The study of various aspects of riverine floods reveal that floods of the present study region are of three types in genetic frame-work, viz. (i) discharge pushed valley - overflowing floods, (ii) runoff pushed valley - overflowing floods, and (iii) ponding backfloods. Besides, the meander loops of Belan, Sapari, Tundiary and Seoti rivers are also affected by flashfloods for very short duration. The analysis shows that the beds of Ganga and Yamuna valley are slowly but gradually rising with the result the recurrence, magnitude, spatial extent and flood duration are gradually increasing. The flood water spilled over the bunds (along the Allahabad city) during 1978 and 1980 floods and submerged the lowlying localities of the city. Now the bunds have been raised to meet the threat of very high floods up to 90 m level. The present study reveals that peaks of maximum discharge of the Ganga and Yamuna have never synchronized in past history.

The study of hydrographs of various rivers reveal that during periods 1971 to 1979, floods having very high magnitude occurred in 1971, 1973 and 1978. The recurrence period of the highest

flood in Ganga and Yamuna are eleven years and ten years respectively. Discharge relationship curve of the river Yamuna shows that the rate of increase of gauge is not as high as is the rate of increase of discharge, though gauge is a function of discharge. The study reveals that in 1971 the floods of Trans-Yamuna region of Allahabad district were of "runoff pushed; bankful stage" type and in 1978 floods of the study region were "discharge - pushed valley overflowing" type. Computed kinetic energy of the river Yamuna shows that in 1971 it soared to the highest ever maximum of 1960 x 10^9 million joules capable of drowning and tearing apart the whole of the northern Trans-Yamuna region of Allahabad district.

STUDY OF EROSIONAL IMPACT ON GADARWARA CITY AND AROUND IN NARSINGHPUR DISTRICT, M.P. THROUGH REMOTE SENSING TECHNIQUES

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The present paper traces the effect of erosion on features in Gadarwara city and around since the last 30 years. The area is between lat. 22°46' to 22°58' N and long. 78°45' to 78°56' E, about 483 sq.km. This is located on and around the banks of Sakkar river, a tributary of Narmada river. Moreover the area is entirely agricultural and has thick alluvium of Narmada, which gets eroded rapidly. Apart from these, in the extreme southern part of the area on Satpura hill range Archean quartzite, Gondwana sandstone and Deccan basalt occur.

Landsat multi-spectral scanner and thematic mapper data on 1:250,000 and 1:50,000 scales were used for the preparation of maps on related themes. Geological, geomorphological and land use maps were correlated with each other for the study of rate of erosional impact. The maps were compared with earlier physiographic maps of S.O.I. sheets on 1:250,000 and 1:50,000 scales for the recognition of differences in erosional features with time. Based on this it is possible to arrive at a rough estimate of the future rate of erosion and the areas likely to be affected in the city and its environs.

To reduce the erosional rate, to identify areas of erosion and deposition, to localise the possible future settlement areas from potential areas of erosion, various methods are suggested. Particular botanical species and plants which would be most suitable for this purpose are also suggested for plantation.

HYDROGEOMORPHOLOGICAL INVESTIGATION FOR THE EFFICIENT DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES IN A PART OF JHALAWAD AREA, RAJASTHAN, INDIA, BY USING REMOTE SENSING TECHNIQUES

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The present paper deals with the efficacy of remotely sensed data in geological and geomorphological mapping with a view to delineate the potential zones of groundwater occurrence.

The study area lies between lat. 24°16' to 24°55' N and long. 76°0' to 76°45' E covering an area of approx. of 5240 sq.km in Jhalawar area forming part of Proterozoic cratonic Vindhyan basin of Rajasthan. Landsat multispectral scanner & Thematic mapper false colour composites and black & white and thermal data on 1:250,000 scale were visually interpreted to map various geological, hydromorphological and structural units. Geologically, the area is occupied with the rocks of Upper Vindhyans in the north and Deccan basaltic rock in the south, showing distinct geomorphic and structural variations. Basaltic rock invariably forms a plateau while Vindhyans show distinct cuestas and hogbacks related to structure. Adjacent anticlinal and synclinal structures are well depicted with the axial planes trending NW-SE in this area. An attempt has been made to relate hydrological conditions existing to different geomorphic forms. All the lineaments are plotted classifying them into three categories depending on their groundwater potentiality. In general, lineaments are seen predominantly trending NW-SE, NNW-SSE and NNE-SSW, intersecting one another and the intersection point forms good site for groundwater discharge. Amongst these the latter two sets are mostly expressed as wide open master fractures with vegetation almost filling them, while the other lineaments are observed as thin vegetation liners.

Furthermore, when all these informations are correlated and integrated with selected ground data, it is possible to get an in-sight into the factors controlling the movement & occurrence of the groundwater. Apart from this, these maps also suggest suitable sites where smaller check dams can be constructed for storage of surface-water, which will not only release pressure on groundwater but also facilitate augmentation of groundwater.

A QUANTITATIVE ASSESSMENT OF RECENT CHANGES IN CHANNEL GEOMETRY : KOSI RIVER, NORTH BIHAR

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Alluvial channels are controlled by processes of erosion and deposition of sediment in response to variations in amount of discharge of water and sediment-load which channels receive from their upstreams. When the above factors are operational the components of channel geometry like width of the channel, hydraulic depth, hydraulic radius, slope, channel planform change. Channel hydrology in terms of channel flow, velocity, discharge of water and sediment affect the most. The study area is a narrow strip (embanked rivet from two sides east and west, and barrage to the north) constricted in space through which the entire energy of the mountain Kosi has to be dissipated. In this portion the river builds up its plain by dividing itself into several channels spread over a width varying from 6 to 18 km and a longitudinal distance of 100 km.

Repeated datum levels taken by Kosi Project Authority is available which is surveyed every year after flood season at an interval of 600 m apart, along definite cross-sections. Where the river bed changes its elevation considerably, the reduced levels are taken at 150 m interval. By assuming water level height, area at selected cross-sections is computed using the trapegoidal and Simpson rule. The area-matrix table and the width of water surface being known, the other channel parameters like hydraulic radius and hydraulic depth are computed. In the present paper, the above procedure of computing the necessary parameters of channel geometry is also repeated on yearwise data of selected cross-sections. The new set of data, thus obtained is subjected to the analysis of identifying the reaches with silting/aggradation or scouring/degradation.

The present study shows that the parameters of channel geometry change over from one cross-section to another, and it is also evident over the years. Whenever the peak discharge has risen up more in a particular year over another, the abrupt change in channel geometry is conspicuous. This happens due mainly to two factors, scouring in the river bed at the peak discharge period and again filling when discharge diminishes. Sometimes these factors lead for the creation of completely new channel on one hand and complete filling or abandoning the other which further means the oscillation of channel over the years within the Kosi embanked area.

INTRASEASONAL VARIATIONS AND HYDRAULIC GEOMETRY OF RIVER CROSS-SECTION

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Hydraulic geometry is a major aspect of fluvial geomorphology which mainly deals with the study of stream cross-section and its characteristics, which is the effect of interrelationship between the independent variable discharge and the other three variables - depth, width of the stream section and velocity of flow. The discharge which forms the independent variable is the main factor which causes the variations in the other three variables such as width - depth - velocity. The study deals with the changes that occur in the three dependent variables as discharge varies.

The aim of the present paper is to analyse the impact of intraseasonal variations in the rainfall on the shape of the channel. For this purpose Dukanwad site on Karli river in the South Konkan was selected. The scatter plots, the b-f-m triangular diagram and theory of minimum variance are discussed in some detail in the paper. The data related to the Q, W, D and V for a period of 5 monsoon seasons (1983-87) have been used.

The results of the analysis of variance applied confirms the original assumption of the effect on these parameters due to intraseasonal variations in rainfall.

STREAM POWER, BEDFORM AND GRAIN SIZE RELATIONSHIPS IN RIVERS : A CASE STUDY FROM THE BRAHMAPUTRA RIVER, ASSAM

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The transport rate of sediments is the product of the weight times the mean forward velocity of the grains. It is expressed as the immersed weight of sediments passing in a unit time over a unit width of the bed and is measurable in terms of work rate or stream power. The stream power is the product of velocity of flow and shear stress on the channel boundary. Grain size of sediments and available stream power are related to the size of bed forms and their associated flow regimes. Similarly flow depth and velocity correlate with the phases of the bed.

For the Brahmaputra river at Pandu (Assam), stream power is calculated based on limited field data and subsequently, its relationship with various bedforms and grain-sizes is examined. The estimated value of the stream power for a high flow (July 31, 1977) places the Brahmaputra in the neighbourhood of antidune, plane bed region for the lowest grain size i.e., 0.1 mm. If a moderate depth of 5 m and a flow velocity of 0.5 m/sec are assumed for the average low flow in the river, then the stream power drops low enough to place the river in the vicinity of the upper limit of large scale ripples. Although this discussion is clearly not definitive, the various empirical analyses included herein suggest that the bed configuration of the Brahmaputra may be in antidune or plane bed phase during peak flows and in dune phase at relatively lower stages. The stage-discharge relations in the river also appear to be related to the bedforms.

INFLUENCE OF CLIMATE ON THE MORPHOMETRIC ATTRIBUTES OF DRAINAGE BASINS IN SOME SELECTED AREAS IN INDIA

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The data on the morphometric attributes of several drainage basins of six areas and five regions, experiencing different climates and situated in the northwestern, southwestern and southeastern parts of India, were analysed. The areas are Bombay Island in the northern part of the West Coast, Khandala plateau on the northern part of the Western Ghats range, Brahmapuri in the central part of India, the Shevaroy plateau in south India, Ajmer in northwestern India and Sagar in the central part of India. The bigger regions are : Tamil Nadu Coast, Kerala Coast, both in south India, the Kathiawar peninsula in the western part, the Tapti river basin in the central part of India and the southern part of the Deccan volcanic province. The bifurcation ratios, the mean length ratios, the mean area ratios, the mean slope ratios and the hypsometric integrals are tabulated below.

Area/Region	B.R.	L.R.	A.R.	S.R.	H.I.
1. AREAS:					
1. Bombay island	4.18	0.56	0.22	-	17.70
2. Khandala plateau	5.58	2.26	2.13	-	52.00
3. Brahmapuri	2.98	1.67	3.40	-	17.20
4. Shevaroy plateau	3.98	5.95	7.29	2.43	22.50
5. Ajmer	4.08	2.30	3.62	2.03	18.89
6. Sagar	3.90	1.80	4.07	1.78	38.00

contd.....

II. REGIONS					
1. Tamilnadu coast	4.05	4.58	5.71	-	33.75
2. Kerala coast	4.02	2.08	4.95	-	9.75
3. Kathiawar	4.25	5.76	6.25	1.85	25.36
4. Tapti basin	4.42	2.01	5.19	2.82	25.30
5. Deccan volcanic province, southern part	4.69	2.27	5.61	-	15.10

The geology of the Bombay, the Khandala and, to a large extent the Sagar areas is the same and so is the case with the regions Nos. 3, 4, and 5. The considerable variations that are observed in the morphometry attributes of the drainage basins thus appear to have been effected mainly by the variations in the climatic parameters. The values of the daily mean temperature and mean annual precipitation for these areas and regions are given below.

Area/Region	Daily mean Temperature (°C)	Mean annual precipitation (mm)
I. AREAS		
1. Bombay Island	26.8	1805
2. Khandala plateau	24.0	4400
3. Brahmapuri	27.1	1267
4. Shevaroy Plateau	27.5	955
5. Ajmer	24.8	520
6. Sagar	25.0	1229
II. REGIONS		
1. Tamilnadu coast	28.0	1037
2. Kerala coast	26.0	2881
3. Kathiawar	26.5	590
4. Tapti basin	27.0	886
5. Southern part of DVP	26.0	1455

APPLIED GEOMORPHOLOGY AND MORPHOLOGICAL EVOLUTION OF CUMBUM WATERSHED, MADURAI DISTRICT, TAMIL NADU

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The Cumbum watershed covering an area of about 2,200 km^2 lies in the Uttampayalam, Periyakulam and Kodaikanal hills of Madurai district. The terrain analysis of the watershed revealed that there are four tentative denudational levels, namely > 1500 metres, 900 to 1500 metres, 600 - 900 metres and 300 - 600 metres. The morphometric analysis of the watershed revealed that the drainage density ranges from 1.28 to 1.90 km/km^2 and bifurcation ratio varies from 3.46 to 3.77. The circularity ratio varies from 0.40 to 0.80 and elongation ratio 0.70 to 1.0. The studies revealed that the drainage texture is coarse, and drainage pattern is not much influenced by various geological formations because the watershed comprises unclassified granitic gneisses. The ruggedness number varies from 0.2931 to 0.7056. The high elongation ratio and low circularity ratio of the watershed revealed that it is moderately compact and elongated.

The landforms of the watershed are classified into denudational, fluviodenudational, fluvial and aeolian based on geomorphic processes and agents involved in their formation and their geographical location parallel to hilly terrain or river. The lineament analysis in the watershed revealed that the major trend is NNE-SSW and conforms with structural trends of the watershed. The sediment deposit depth studies revealed that the thickness exceed 50 metres on the southern side and gradually recede to less than 5 metres on the northeastern side around Andipatti. Based on the disposition of landforms, terrain and morphometric characteristic, lineament and structural trend analysis the evolution of the Cumbum watershed and valley are dealt-with.

Based on terrain and morphological characteristics the land evaluation of the watershed has been attempted. About seven classes of land are identified. Based on geohydrological characteristics seven classes of hydrogeomorphic units are also delineated. The erosion and intensity of soil removal has been worked out applying Flaxman's (1971) sediment yield predictive index. The intensity of soil removal varies from 5 to 45 m^3/ha/year. It is less than 5 m^3/ha/year in the valley proper. The analysis of rate of sedimentation revealed that during the northeast monsoon period the average rate of siltation in the Vaigai reservoir is about 8,663.04 m^3. Finally, based on spatial distribution of rate of erosion, intensity of soil removal and rate of sedimentation in the Vaigai reservoir, a few suggestions are made for better management and conservation of soils in the catchment area of the Cumbum valley.

TERRAIN ANALYSIS THROUGH AUTOMATION

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Terrain analysis as a process involves a set of activities leading to the compilation of complex terrain "characteristics". Core of the information needed for terrain analysis includes its external features in terms of height, relief and slope. Analysis of Terrain involves three basic phases - (1) acquiring existing information/data about the Terrain, (2) classification and storing of data for its actual and potential users and (3) retrieval of data for analysis in a comprehensive manner. Thus Terrain Analysis involves both theory and practice of data acquisition, storage, processing and analysing.

The present paper highlights the importance of computer application in Terrain Analysis. Gorali and Phul Nadi basin in Bastar district of Madhya Pradesh has been chosen as the unit of the study area. The Basin has a dendritic drainage pattern and the two major streams are perennial. The topography is semi-rugged with the altitude ranging between 200 to 7[illegible] m. The landscape, marked with elongated hills, is heavily dissected by numerous streams.

A grid-cell based geo-reference information system has been evolved. Data has been extracted from three topographic maps overlaid with grid cells, spaced at 2 cm^2 interval. The height data at every grid intersection point helps in forming the data matrix which provides a basis for Terrain Analysis. The data matrix thus formed has been analysed with the help of Fortran and other computer softwares. The output has been obtained in the form of distribution of average slopes and maximum slopes, basic topographic shapes, list of terrain parameters for each grid intersection point, symbolic slope maps, three dimensional blocks with different angles of tilt etc. Finally a comparison has been made between the computer analysis and empirical interpretation of topographical sheets.

The concept of collection of inventories and processing of data has undergone considerable change. The foremost change has come about with the use of Landsat data and aerial photographs which have become an integral tool available for Terrain Analysis. Multimedia approach and computerisation of techniques have brought in efficiency in terms of time and accuracy.

DEVELOPMENT OF GEOMORPHIC DATA BASE - A CASE STUDY AROUND TIRUPATI

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A geomorphic data base is a computer-based Geographic Information System which deals with geomorphic and terrain related data. The aim in developing a geomorphic data base is to computerise the methodology of geomorphic analysis, to evolve methods of storing qualitative geomorphic data and to produce thematic geomorphic maps for specific purposes.

The development of the geomorphic data base involves three phases : (i) data acquisition, (ii) data storing and (iii) data retrieval. Geomorphic and terrain related data were collected from various media available. In designing the data base, care was taken so that the data base can meet the requirements of various geomorphic analyses.

PC based dBASE(III) package was used to develop the data base. As most of the geomorphic data collected were qualitative, different codes were assigned wherever it was necessary for the purpose of storing. In the case of quantitative data, the actual values were stored. Codes developed are independent of the area and are adaptable to any other area. Manual digitizing methods were used with a raster data model for coding purposes.

An area of approximately 490 sq.km around Tirupati and Chandragiri of Chittoor district of Andhra Pradesh was selected for this purpose. The whole area was divided into pixels of 15" x 15" with a corresponding ground resolution of 420 metres.

Properties of different entities were stored for every pixel. Each of these pixels was addressed by unique row and column number.

Data were retrieved with simple conditions and superimposition of the data was achieved by retrieving the data with multiple conditions. Fortran programs were developed for producing different types of maps and data inputs for all these programs were taken from the data base. Morphometric analyses, slope analyses (areal aspects), and landform analyses using CSIRO methodology were successfully computerised. Thematic maps like Erosion hazard zoning map, Mass movement hazard zoning map and Land resource evaluation map were prepared.

DIGITAL ANALYSIS OF GEOMORPHOLOGICAL FEATURES IN COASTAL ORISSA (INDIA) USING T.M. DATA

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Use of high resolution satellite data for digital analysis of coastal landform is presented. The method is designed to suit present state of art of remote sensing in India. It describes digitally classified landform units using VAX 11/780 image analysis computer system. TM data of Landsat 5 was used. A method adopted for analysis has been the classification of various landforms with grey level classes of different bands. Maximum likelihood algorithm has been used to classify different geomorphic units. Use of different indices such as greenness index, brightness index, and wetness index has also been made for identification and analysis purposes.

The geomorphic units identified are coastal plains varying in age, nature of sediments and hydromorphic conditions. Tidal flats have also been separated on the basis of their age. Mud flats, sand bars, coastal wet lands and beach ridges could be separated with great accuracy due to the typical reflectance characteristics. The results show that a proper combination of methods and materials can provide the reliable information which can be used to monitor dynamic land systems such as coastal areas.

THE USE OF DRAINAGE AND RELIEF PARAMETERS IN RECOGNITION OF LAND SUB-SYSTEMS : A CASE STUDY

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The problem of comparison of different land sub-systems in a tropical monsoon region is approached by the simple method of showing their relative positions in scattergrams-binary variation diagrams. The parameters used are drainage density, stream frequency, node frequency and relative relief. Values of these parameters are derived for an area forming a part of Western Ghats of Kerala and adjoining Cumbum valley of Tamilnadu. A grid reference system (1' x 1' on 1:50,000 topographic map) based on geographic coordinates is preferred due to its easy integration with other Resource Data Bases, if necessary. Relative relief of each grid is plotted against its abovesaid drainage parameters in three different diagrams.

In general, points falling in lower left of the diagrams (lesser values of parameters) represent grids for an erosion surface: a sub-system of rolling divides and wide intermontane valleys at an altitude of 1000 to 1100 metres. Points representing grids of steep scarp overlooking Cumbum valley with numerous first order streams fall in the upper right corner of these diagrams. The first cluster represents an area where the present landform is an end product of an erosion cycle and the second one represents a young-topography. Lanform sub-systems with intermediate degrees of ruggedness are represented by a widely distributed scatter between these two.

Depositional surfaces such as river flood plains and deltas from elsewhere give the least values for the above parameters. Position of upraised lake floors and river terraces in the diagram will change, possibly independent of relative relief with the development of drainage pattern. However, the structural landforms

In the study area do not identify themselves on these diagrams with a separate cluster.

An attempt is made to demarcate different fields showing the possible range in ruggedness for each land sub-system. These diagrams may be helpful in pixel based Resource Data Bases and in land capability studies for delineating areas with identical and/or different degrees of ruggedness.

LANDSAT IMAGE ANALYSIS FOR GEOMORPHOLOGICAL MAPPING IN A FLAT TERRAIN : A CASE STUDY IN PARTS OF THE GANGES DELTA

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Image analysis is primarily attempted for reconnaissance level survey to delineate broad terrain units by using various methods of identification - key, analogues and deductive reasoning. The elements for identification like shadow effect, grey tone, lineation, texture and tint pattern provide important clues for geomorphological mapping.

However, the same set of principles cannot be used while mapping in the flat terrain like delta plains. Absence of relief and low diversity in land cover hinder the identification of units. This problem can be successfully overcome by using multi-band and multi-seasonal images as has been demonstrated in the present case study.

The study area covers the eastern part of the Ganges delta around the Megna estuary and adjoining plain. Landsat image of band 5 and band 7 for the months of December 1973 and March 1975 have been used for identifying different geomorphic units. Tonal variations, tint pattern, lineation and locational aspects, both singularly and in association help to identify geomorphic units/features. The physiographic map of the area has been consulted to ascertain locational aspects.

Based on depositional character, three broad units - old alluvium (river terraces), new alluvium (flood plain) and fluvio-tidal alluvium (tidal flats) - have been separated. The tract with new alluvium or flood plain has further been classified into

three systems, namely, the Padma-Megna system, the Lakha-Megna system and the Jamuna system, on the basis of the dominant role played by the respective rivers as expressed in the sediment transport pattern.

Land units such as the back swamps, levees, tidal flats and filled up ox-bows (former river channels) have been identified. The former river courses are arranged in the order of succession. It is observed that all four imagery are required to bringout this geomorphological map. While most of the land informations can be deduced from Band 5 image of December 1973, delineation of back swamps, levees and tidal flats is made possible by using March 1975 image of both 5 and 7 bands. The water features are easily mapped from Band 7, December 1973 image.

This paper attempts to highlight that multi-season and multi-band images need to be used for mapping geomorphic details in a flat deltaic region. Use of single image can possibly lead to many an error. It is also noteworthy that by using landsat images it is possible to determine comparative age of the terrain units in any flood plain.

GEOMORPHIC CLASSIFICATION SYSTEM USING SATELLITE IMAGERY

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Geomorphological studies are indispensable in various resource surveys like land, water, environment and for planning, development and utilisation of renewable and non-renewable resources. In the past, geomorphological mapping was being carried out mainly by conventional ground surveys using topographic maps. Gradually, the aerial photographs with stereocapability have been found to be of great advantage in geomorphological studies. For the past nearly one and half decades satellite remote sensing has provided an opportunity for better observation and more systematic analysis of various geomorphic units/landforms. Due to its synoptic view, multispectral nature and repetitive coverage, remote sensing has made it possible to map on different scales various landforms commensurate with their size and complexity besides understanding their dynamic changes.

In view of the growing importance of satellite imagery in geomorphological mapping, it is necessary to evolve a suitable classification system, wherein various geomorphic units can be identified mainly based on their photocharacteristics supported by selective ground checks in the representative areas. The classification systems and geomorphic nomenclature that are being currently used are overlapping, difficult to understand and often confusing to the user. Several terms are used synonymously and sometimes with different meanings and connotation. The regional and detailed maps prepared for the same areas sometimes show contradictory nomenclature. Hence, to make the geomorphic classification simpler, easier and more meaningful, an attempt has been made in this paper to present a generalised classification system adopting appropriate standard terminology

for discussion. Wherever required the existing terminology is suitably modified to suit the Indian conditions.

A three tier system of classification with level-I showing geomorphic provinces, level-II showing geomorphic units and level-III showing landforms is presented for further discussion. Depending on the scale of satellite imagery, the level/levels of classification may be selected. Scope is provided for further detailed analysis of landforms into smaller subdivisions (level-IV) based on detailed ground surveys or by interpreting large scale aerial photographs with sufficient ground information. At level-I classification emphasis is given for the morphography and morphostructures, at level-IImorphography, morphostructures and morphogenesis are given due weightage and at level-III weightage is given to the morphometry and parent material also besides the other factors referred to above.

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LATE ABSTRACTS

FLOODS IN THE RIVER YAMUNA AND FLOOD MANAGEMENT WITHIN THE UNION TERRITORY OF DELHI.

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Floods in the river yamuna are caused by intense rainfall in its upper catchment, in association with the passage of depressions in the month of August and September. Some times the floods in the Yamuna coincide with the rise in the water level in the rivers from the Vindhyas. Such occurrences are, fortunately, not very frequent. But whenever they occur, the damages caused by floods are both extensive and considerable. Much efforts have gone in for the management of floods in the river Yamuna.

The paper describes the frequency of occurrence of floods in the river Yamuna and analyses the causes of some floods. In order to manage such floods within the Union Territory of Delhi, elaborate arrangements have been made over the past two decades. They include conventional methods like embankments and comprehensive method like flood forecasting, warning and evacuation. With the close co- ordination among different government departments, the damages due to the floods have considerably reduced. This paper evaluates, with case studies, the methods adopted in flood managements within the Union Territory of Delhi.

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BATHYMETRY OF THE KARWAR BAY

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Karwar is geographically situated approximately in the centre of long coast line on the West Coast of India, lying on the east coast of Karwar Bay. Karwar Bay is a gentle sloping part of the Arabian Sea, which is prtotected by Kurmagad I., on the north and Karwar Head on its southern end. Oyster rocks devide its western approaches into northwest and southwest channels. The rocky bottom of the bay appears to have been covered by a thin layer of landborn sediments brought by the Sadasivgad River. The river joins the Bay on its north-eastern flank. Ideal location of the Bay has provided favourable conditions to develop a naval base at Karwar which provides protection to Indian naval ships busy in their vegilence duties on our territorial sea. Hydrographic Surveys carried out during the last hundered years in the Bay offers data in estimating sealevel variation through bathymetric information.

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TRIANGULATION SURVEY OF BARA SHIGRI GLACIER AREA OF LAHUL HIMALYA.

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Triangulation survey in and around the snout of the Bara Shigri Glacier of Lahul Himalaya was conducted by the author with a group of mountaineers and geographers during several years in order to detect the rate of advnce/ retreat of the glacier. Also observations were made of major glaciological features like crevasses, moulins etc. and minor features like Suncups, icieles etc. as well as phenomena lide avalanches, ice-bursts etc. Moraines were studied in order to detect the age of formations, environmental processes like glacial, periglacial, fluvio - glacial and fluvial were observed and the change in macro and micro landform produced by them were noted.

The glacier once advanced down to the Chandra river and even beyond it, although at present it is in retreating phase. Successire heaps of moraine indicate several static phases of the glacier during the 18th century.

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MORPHOMETRIC ANALYSIS OF LANDFORMS OF THE GAMBHIR BASIN (RAJASTHAN)

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The Gambhir river which drains an area of about 8,000 Sq Kms. in the districts of Bharatpur, Sawai Madhopur of Rajasthan state and Agra of Uttar Pradesh state flows over a length of about 350 Kms and join Yamuna in Bah tehsil of Agra district. The study is aimed at to bring out the development and the evolution of various landforms and features and interpret the morphometric characteristics of the Gambhir River Basin. The region under study is a complex jargon of older Aravallis and newer Vindhyans and coupled with bordering plains interspersed with hillocks of moderate relief. 1: 50,000 toposheets and aerial photos are the chief tools used for the study. The study of landsat imageries have also given a new bearing to the problem. The study and interpretation of above materials are supplemented and corroborated by ground checks and data.

The methods of study are described as follows:

- The relative relief map has been computed and analysed.
- North-east to south-west and north-west to south-east diagonal profiles have been prepared and the morphometric characterics of drainage and other topographic features have been highlighted.
- Hypsometric curves are drawn to analyse the form and erosional surfaces and the stage of development of the fluvial system.
- Altimetric frequency histogram and slope histogram have also been prepared.
- An analysis of drainage shows that the sample basins belonging to the Vindhyan Super Group formations witness the mature stage of topography while the basins located in pre-Aravalli formations signifies the late youth to early maturity.
- Drainage analysis of the basin indicates that it is mostly controlled by the structure of the rocks and the basin is highly dissected, ravined and faulted in nature.

APPLICATION OF REMOTE SENSING TECHNOLOGY IN GEOMORPHOLOGICAL STUDIES

A CASE STUDY OF SAMBHAR GAP

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The newly emerging Remote Sensing Technology is being used widely in undertaking geomorphological studies. The Sambhar gap area has been chosen for the present study.

METHODOLOGY

For change detection study two approaches were used, Firstly, the visual interpretation of analysed scene of 1987 TM Data with Topomaps surveyed in 1969-70 and also the FCC of 1975 and MSS Data was done.

Secondly image processing of 2nd May, 1977 and 5th May, 1987 MSS data and image subtraction to detect the amount of change over decade was analysed and presented in the tabular statement and image form. An area of 1325 Sq. km. of Sambhar Gap CCT's of 2nd May, 1977 and 5th May, 1987 MSS Data was selected and used and the image registration and rectification were performed. Then soil brightness index was carried out on both the scenes using supervised classification separately in four sand terrain classes.

RESULTS AND DISCUSSIONS

The over all change in four classes combined was of the order of +6.60 to -6.62% over the decade. The first two classes namely, (1) active sand dune and (2) active sand sheet were shown in terms of area unchanged, increased and decreased over the decade.

The study had also revealed that in the category of (1) active sand dunes, there was an increase of 375.46% over 1977 and also 66.08% area remained unchanged over 1977, where as 1987 has reported 33.92% area decreased under active sand dunes over 1977. In the category of active sand sheet there is an increase of 144.36% over 1977 whereas 14.87% area of 1977 remained unchanged and 85.12% area decreased over 1977. In absolute terms the net increase in active Sand dune and active sand sheet area was 3.35% and 3.25% over 1977 respectively.

CONCLUSION

Digital Analysis carried out at different steps had clearly identified the latest sand drift features.