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INTRODUCTION

1.1. INTRODUCING THE AREA & ITS SPACE RELATIONS

The Chhatrapur Subdivision in the Ganjam District of Orissa lies between latitudes 19°16' N. and 19°51' N., and longitudes 84°42' E. and 85°11' E., covering a geographical area of 2142 km² inclusive of hills and prohibitive forested tracts. The Subdivision shares 17.09% of the total area of the Ganjam District (12,531 km²) in the State of Orissa in India (Fig.1.1). In terms of size, the Subdivision ranks fourth among the four subdivisions of the Ganjam District (Berhampur-2295.6 km², Bhanjanagar-4035.7 km² and Paralakhemundi-3764.9 km²). The Subdivision of Chhatrapur comprises of four tahasils (Chatrapur, Kodola, Khallikote and Purusottampur) and eight blocks.
INTRODUCING THE AREA

(Polosara, Kodola, Khallikote, Kavisuryanagar, Purusottampur, Ganjam, Hinjili and Chatrapur), 9 towns, 151 panchayats and 944 villages. It is bounded on the northeast by the Puri District, on the west-northwest by the Bhanjanagar Subdivision (formerly Ghumusur Subdivision), on the west-southwest by the Berhampur Subdivision, on the south and southeast by the Bay of Bengal and on the east by the southwestern portion of the Chilka lake. The maximum north-south extent is about 48.50 km and the maximum west-east width is about 39.10 km. The subdvisional area attains its maximum length along 19°39' North latitude and maximum width is along 84°55' E longitude. The study area has a coast line of about 30 km constituting the south and southeastern boundary. The coast line in the Chhatrapur Subdivision is remarkably smooth and straight and behind it there is a narrow beach providing ample evidences of coastal emergence. The eastern boundary of the Subdivision makes a series of irregular arcs of several circles in a vertically inclined row which have been extended above the high water line of the Chilka lake. The Chilka shore is remarkably indented into several inlets that are rimmed by the projections of several disjointed Khondalitic ridges of the Eastern Ghats. Among the streams of this lacustrine strip (Nitika jhor nadi for example) there appears to be a tendency to flow in the direction more or less at right angles to the rocky shores of the lake Chilka while the streams of the coastal strip (Rushikulya, Khari and Raja-Rani rivers) have
a tendency to flow in directions parallel to the coastline in their lower reaches and to unite into a single estuarine mouth.

The Subdivision has an average surface elevation of 442.25 metres above the mean sea-level but it ranges from less than 15.25 metres to 945.5 metres from the coastline to the hill top. The highest hills in the north are represented by Khundabola (945 m), Barani (618 m), Banamali (559 m), Dandimul (500 m), Khalladimal (495 m) and Chandikho (462 m). Besides these high hills the low altitude residual hills and bare rocky hilly outcrops scatter themselves all over the Subdivision in isolation. The Subdivision has a general slope from north to south with notable regional variations from northeast to southwest and northwest to southeast.

So far as the physical layout of the Chhatrapur Subdivision is concerned, the area exhibits quite contrasting physical characteristics and land-surface-forms owing to its complex litho-structural built, tropical weathering and typical geographical location amidst varying environmental specification layouts of the hills, plateaus, rivers, lake and sea. It may be observed (Fig.3.1) that the Subdivision divides itself easily into four broad regions from its north to south conforming to great regional physical inequalities. The north and northeastern frontiers bordering the Puri District and Bhanjanagar Subdivision consist of the northeast-southwest
trending disjointed and often rugged and dissected ridges of the massive eastern hills (Eastern Ghats) of India. These are forested while many of these ridges are stripped bare of soil and vegetation. Towards the centre it is a tableland which is a continuation of the Eastern Ghats presenting comparatively moderately sloping uplands and residual hills of plateau subduction with elaborate rugged patches. The continuity of these plateaus are often marked to be punctuated by high and low undulations and upland narrow plains. Both the northern hilly and central plateau landscapes present together a panorama of residual hills, dissected and subdued plateaus, relict weathered profiles, rugged slope faces, undulating plains, gullied surfaces, interfluvial ridges, colluvial slopes, erosional plains, truncated soil profiles and non-perennial south-flowing parallel valleys. On the other hand the south and southeastern portion is represented by extensive flat alluvial and planation surfaces dotted occasionally with low altitude residual hills, uplands, minor undulations, dunal ridges, swamps, saline flats, mud flats, beach lands and lacustrine rocky upland plains. The river Rushikulya displays an apparent transition between the two contrasting surface configurations and surface elevations of the north and north central, and south and southeast.

The river Rushikulya, with its narrow meanders (Fig. 4.1), flows from the west to east-southeast for about 58 km in the Subdivision. Its major left bank tributaries are Bhaguva,
Dhanei, Jagati and Kharkhari rivers. The river Ghodahad constitutes the right arm. These rivers are non-perennial and flood-prone. The eroded gullies and valley side uplands give high drainage texture (Ch.8, Figs. 8.1 & 8.2).

The geo-lithological-formations in the Chhatrapur Subdivision are older alluvium, blown sand, laterites, newer alluvium and Archaeans comprising igneous metamorphic rocks namely granite gneiss and Khondalites (Fig. 2.1) and metamorphic rocks and sands of sedimentary origin (Fig. 7.1), such as intrusive sandstones, feruginous metasands and rare sands consisting of Ilmenite, Sillimanite, Monazite, Zircon, Rutile and so on. The Khondalites form a very conspicuous feature of the regional geo-lithology of the area and occur as broad bands in the gneisses and as intrusive or injection granites. A large area of the Chhatrapur Subdivision is covered with irregular deposits of laterites at all altitudes. The coastal tracts contain deposits of riverine alluvium which contain older sediments occupying the higher grounds and recent alluvium of clay and fine sand. Blown sands resulting in ridges of coarse sand hills are found along the coast.

The study area has alluvial soils (loamy, sandy loam and loamy clay) in its south and southeastern parts while lateritic, sandy and heavy clay soils form extensive scattered patches all over the Subdivision. The natural vegetation in the eastern-central and northern frontiers consists of
thick forests with well-grown sal trees. These are of tropical moist deciduous type. The other important forest species found are asan, bija, teak and khair. These forests of the study area constitute only 7.96% (170.56 km²) of the total area during the recent times.

The climate of the Chhatrapur Subdivision is characterized by an equable temperature all through the year, particularly in the coastal regions and by high humidities. The cold season from December to February is followed by hot season from March to May. The period from June to September makes the season of the South-West Monsoon (Ch. 4). October and November constitute the post-monsoon transition. June is the hottest month (32.63°C). December is the coldest month (22.62°C). The average annual rainfall of the Subdivision is 1157.47 mm. The rainfall generally increases from the coast towards the interior hill tracts of the area (Fig.4.1). The Polosara block in the northwest has an annual total rainfall of 1382.17 mm and Chatrapur block on the coast gets nearly 875.21 mm. About more than 60% of the annual rainfall is received during the South-West Monsoon period. August is the rainiest month. The variation in the pattern of annual rainfall in the study area from year to year is not large. On an average the rainy days are between 60 to 70 days.

About 96.87% (20.74.90 km²) of the Subdivision area of Chhatrapur is rural. The Subdivision accounts for a total
population of 787,249 (1981) registering 368 persons per km$^2$. As against this general population density, its average rural population density is 323 persons per km$^2$. The sex ratio of the Subdivision indicates 1061 females to 1000 males (1981). The high sex ratio is still more conspicuous in the rural areas indicating the region's being devoted to traditional agricultural economy. The urban towns of Polosara, Kodola, Khallikote, Kavisuryanagar, Hinjili, Purosottampur, Chatrapur, Ganjam and Rambha constitute an urban area of 67.10 km$^2$ accounting for 3.13% of the total geographical area of the Chhatrapur Subdivision. The town of Chatrapur, acting as the district headquarters of Ganjam and Subdivision headquarters of the Chhatrapur Subdivision, is situated conveniently on the NH.5 and South Eastern Railways linking Madras in the south with Calcutta in the north.

Agriculture is the primary occupation of the people in the Subdivision. Nearly 95% of the total population is engaged in this occupation. Rest 4% depend upon non-agricultural services.

The agriculture in the study region is mostly rainfed and therefore practising predominantly monocropping. Besides the rivers and canals of the region, it is only during the late sixties that different types of irrigation means namely tube wells, dug wells, lift irrigation points,
energized dug wells, etc. were developed. Owing to hard Khondalitic rock basement, greater degree of surface undulations, high altitudes and ruggedness the digging of wells is not practicable over most of the Chhatrapur Subdivision excepting in parts of Hinjili, Purusottampur, Ganjam and Kavisuryanagar blocks. Under these adverse circumstances, construction of tanks in many places of the Subdivision during the recent years helped to store rain and run-off water for the purpose of irrigation. About 37.42% of the total panchayat area (172959.53 hectares) constituting 52.87% of the total cultivated area (122403.56 hectares) in the Subdivision is irrigated (1991). The main irrigation is concentrated only to kharif crops due to the late arrival of monsoon rains (Ch. 4). The intensity of rabi cropping is low in terms of area owing mostly to the scarcity of irrigation water over most of the Subdivision.

About 70.77% of the total panchayat area of the Subdivision is under direct agricultural use. The principal crops in order of dominance are paddy, ragi, mung, biri, til, groundnut and chillies, etc. During rabi season, mung and biri are grown in many parts while the groundnut is grown both during kharif and rabi seasons.

Among the economic minerals found in the Chatrapur Subdivision are the abrasive and grinding materials (Ch.7), e.g., zircon, monazite, sillimanite, etc. and building
materials. These grinding materials have been extracted from the beach sands in the Indian Rare Earth Industry located in the Kaliabali panchayat of the Chatrapur block. The Khondalites provide building materials and serve as raw material for the Karnataka State based granite polishing units. The other industries of the Study area consist of a chemical and many small scale non-agro-based industries including extensive common salt extraction. These industries serve as additional source of employment for the seasonal unemployed in the rural agricultural sector of the Chhatrapur Subdivision.

The Subdivision is served by a network of roads of all kinds (NH, SH, MDR and CVR) which is related to the fairly high density of rural settlements (SH, MDR and CVR). The roads are however, least developed in inaccessible hilly regions and littoral regions of tidal stress. The NH No.5 and southeastern railways linking Madras and Calcutta follow a longer route from the southwest of the study area to its northeast almost parallelly in an arc form.

Thus the Chhatrapur Subdivision, with its greater physical inequalities, agricultural economy and available socio-economic and cultural infrastructures provides a wide field for applied geomorphological studies taking into account the traditional evolution and historical appreciation of its agro-economic landscape and nevertheless the related socio-cultural situations of utmost exploratory significance.
1.2. **STATEMENT OF PROBLEMS OF THE AREA**

The discussion (1.1) reveals that the Chhatrapur Subdivision has great physical inequalities which have brought about strong inequalities in its intra-regional weather phenomena, natural vegetation, overland drainage, underground water, soil and soil profiles and the pattern of general and agricultural landuse and the degree of response and participation of its uniformly dense farm population.

The presence of steeply sloping and other undulating uplands are subjected to extensive soil erosion making agricultural landuse difficult in many parts of the Chhatrapur Subdivision. High elevation and high gradients have encouraged fast surface run-off making the streams ephemeral and depressions empty of water during the summer season. The non-porous nature of the garnetiferous gneissic rocks further accelerated the problems of water-logging and underground water non-availability for the cultivable space in the Subdivision. The undulating topography in many parts has limited irrigation to favoured tracts only. The rugged surfaces, salinity of soil and water, migratory dunal ridges, mudflats, salt pans and saline water swamps of the coastal and lacustrine belts render the Subdivision a problem region of the Ganjam District. Annual floods of the rivers of the Rushikulya, Ghodahad, Dhanei, Bhaguva and Kharkhari are an additional menace against the stability
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of crop-use in the favoured tracts of the Subdivision. Un-
scientific tillage, passive dependence upon agriculture and
overcrowding of agricultural land are some of the physico-socio-
cultural and economic problems in the Chhatrapur Subdivision.
Agriculturally the Subdivision is lagging much behind its
neighbouring subdivisions of the Ganjam District.

1.3. MAIN OBJECTIVES

The physical features in the Chhatrapur Subdivision appear
to pose many constraints for the potential agricultural land
utilization in the area. But it is at the same time interesting to note that the Ganjam District ranks second after
Cuttack in Orissa with regard to agriculture and it is the
largest producer of pulses in the State. The Chhatrapur Sub-
division which is a part of Ganjam is lagging far behind although the other three subdivisions of Ganjam do not have
far greater physical potentialities in terms of agricultural
utilization. The main objectives of the author have been, therefore, to see whether the backwardness of the Subdivision
is really related only to physical constraints or there are
other stresses and strains prevailing in the area. Such
objectives can be achieved only when the area is evaluated
properly; and if the area is found to have positive physical
potentialities to a great extent, it must be planned properly
to get maximum returns from the land. For this purpose the
evaluation of terrains of the Subdivision is necessitated, the validity of which is discussed under the conceptual aspects.

1.4. CONCEPTUAL ASPECTS

1.4.1. TERRAIN:

Terrain which has become popular with geographers very recently is a generic term coined from an assemblage of phenomena on space having distinctive characteristics in common. It is a term of multiple connotation and varying use unlimited in kind, class or sort of events through time. Therefore, the term in sense is a neutral term having variation, however not absolutely, in connotation and demarcation depending on the user's need.

The term terrain is an obsolete synonym of terrane and it is a derivative of terra, a Latin word meaning thereby 'earth'. In its derivative adjective form the term terrenus (Latin) or terrenum (French) or terrene means 'earthen' or 'earthly' or 'terrestrial'. Now the term 'terrain' or 'terrane' is frequently used in noun form. In the Oxford Dictionary this term connotes an implication of a 'standing ground' or position. It also refers to a tract or region of the earth's surface considered as a physical feature, an ecologic environment, or a site of some planned activity of man, e.g., an agricultural location or an engineering point. Further, the word 'terrain' has been taken in the Oxford Dictionary to
mean a tract of country considered with regard to its natural features, configurations, etc. As regards its historical familiarity with military operations, the word 'terrain' appears as an appropriate technical substitute for 'a battle ground' or 'a region suited for defence, fortifications, etc.

In the Webster Comprehensive Dictionary (Encyclopaedic Edition, 1977, p.1295), the word terrain means 'a piece of land or plot of ground, a region or territory viewed with regard to its suitability for some particular purpose'. In Mill's lexicon, the term lays stress upon a district or tract of land considered with reference to its fitness or use for a special purpose.

In Geology, the term 'terrain' indicates a name applied to a rock or a group of rocks and to the area in which they crop out with reference to its system, formation and stratigraphic subdivision. In the words of Fairbridge (Encyclopaedia of Geomorphology, 1968) the word terrain therefore refers to 'any tract or region of the earth's surface, considered, as a purely physical feature, an ecologic environment, a geologic setting or as a site of some applied activity of man — an engineering location, an architectural setting or a landscape analysed in terms of military science'.

The usage with regard to the word terrain both in military and geology has become obsolescent during the recent times in respect of any purpose under geographical consideration. A geographer's, particularly a geomorphologist's concept of
terrain and its conditions are far more adequate that those of the military specialists or other geologists for that meaning (Thornbury, 1954,p.582). In geography, particularly in geomorphology the term holds identical meaning with a more pragmatic stand on the purposeful particularity combined with territorial or regional suitability. The term is never used to limit the signification of the noun terrain. The term, as a geographer uses it, appears to mean a tract or facet or 'a part of the landscape, usually with simple form, or a particular rock or superficial deposit, and with soil and water regime that are either uniform over the whole of the facet or if not, vary in a simple and consistent way' (Webster and Beckett, 1970, p.54). Each facet is considered to be sufficiently homogeneous to be planned uniformly for most purposes in general and, for the purpose under consideration in particular. The terrain, a facet of land with more or less homogeneous or uniform properties, uniform not only in relief, but also in slope morphology, soil characteristics, drainage condition, vegetation cover and other natural features. In this sense the term may be used to denote a 'region' with uniform properties of natural features and configuration. In other words, the terrain is an expression of the geologic character, the soil and the surface geometry of the earth's crust (Mitchell, 1977, p.13) and therefore terrain studies are natural studies usually with an emphasis
on relief, soil, vegetation, and drainage (Stamp, 1968, p.451).

The designation of study of a facet with uniform properties of natural features, not one but many and specific or particular purpose has come about as a result of dissatisfaction with many other seemingly similar terms, e.g., topography, relief, landforms, land surfaceform (Hammond, 1964), physiography and physical environment, etc., on the following logistics of each of these terms:

(i) **Topography** means the general configuration of a land-surface, including its relief and the position of its natural and man-made features, the essence of which indicates no any surface with definite purpose.

(ii) **Relief** is too exclusively geometric quantification of the vertical difference in elevation between the summits and the low lands of a given region. The expressions like 'high relief of a rough country' and 'low relief of a flat country' do not comprehend earth materials of structure for a purposeful study of an economic use of land.

(iii) The word 'landform' itself is becoming very much debatable day by day in the present sphere of geographical knowledge (Singh, 1974, p.1) as it is one of the multitudinous features that taken together make up the surface of
the earth. It does not include the materials of the earth which are significant for a purposeful investigation.

(iv) 'Physiography is an older term which includes not only surface form and geology but also climatology, meteorology and oceanography and indeed natural phenomena in general' (Mitchell, 1977, p.4). This kind of usage has now become synonymous with the theme of Physical geography and not terrain in the strict sense of the term.

(v) Physical environment is too general to comprehend discussions with particular purpose. 'Landscape or land are perhaps the closest equivalents, but both are somewhat wider concepts than terrain and the former rather too strongly connotes the visual and artistic aspects' (Mitchell, 1977, p.4).

The author, rather than continuing the practice previously common in this field of restricting several terms to the theoretical discussions of the landform only, has laid an emphasis on the purposeful meaning of the term terrain while dealing with the analysis and investigation of terrain of the Chhatrapur Subdivision for the purpose of planning the terrain use relating to agricultural landuser's need. According to him the word terrain conforms more to a homogeneous
inventory unit of potential landuse assessment. Since his specific purpose is related to agricultural landuse, emphasis has been given not on one but on a complex of many physical bases of the terrain under his investigation. Therefore the significance of the meaning of terrain in this regard emphasizes upon an intellectual and scientific exercise of terrain classification with an exclusive view to interpret the terrain of the Chhatrapur Subdivision with all its general and specific physical bases such as geology, surface elevation and forms, climate, drainage, natural vegetation, lithology, drainage texture and water resource, relief composition, slope morphology and the characteristics and potential agricultural value of soil texture and so on, besides other natural and man-made features of agricultural operation. Thus the author's study would begin with the concept of user's need in his investigation and evaluation of the terrain of the Chhatrapur Subdivision for agricultural land utilisation.

1.4.2. **TERRAIN EVALUATION**

The term 'evaluation' in this context refers to ascertain the extent of landuse in numerical form or estimation of land quality. In other words an objective of terrain evaluation is to judge the value of a tract of land for the purpose under consideration, e.g., whether a use of land, for instance agricultural landuse, is physically possible
and economically and socially relevant, and whether there is a possibility of sustained production. Therefore the basic feature of a purposeful terrain evaluation of the Chhatrapur Subdivision would involve a comparison of the requirements of agricultural land use with the basic resources offered by the capability of the terrain. The potential interference of man in changing the land quality of the terrain, upgrading or degrading is subject to fluctuations on space through time, while the natural potentialities of a terrain remain more or less the same on a firm foundation of the physical bases of the terrain (Ch. 1.4.1). Therefore the purpose of terrain evaluation as a process involves an analysis of the categorical measures of the physical components (Ch. 1.4.1) of surface geometry, surface processes and surface material that constitute the terrain. Thereafter the pattern of terrain use would evolve as a result of the action and interaction of various factors such as the physical constitution, characteristics and/or potential capability of the terrain on the one hand, and the institutional and human factors on the other hand.

1.4.3. AGRICULTURAL LAND UTILIZATION

Sometimes an attempt to draw a distinction between land utilization and land use is made, but the author has used these words 'interchangeably' (Stamp, 1968, p. 290). The agricultural land use is one of the major constituents of the
general pattern of landuse in an area especially where agriculture is the mainstay of the regional economy. The term landuse, be it general or particular, has been literally defined as the use which is made by man of the surface of the land that may or may not be directly used by him (Stamp, 1968, p.290). In other words, the word landuse stands for a complex of land cover and land utilisation which includes agriculture, forestry, pasture lands, settlement sites, communication lines and so on. The landuse of an area is the ultimate outcome of the interaction of economic forces with the natural environment and the historical/traditional values of society. The geographical maps denoting landuse exhibit the distribution pattern of landuses and their spatial relationship. When prepared at regular intervals these maps may also show changes in landuse. The area, for which data on the landuse classification are available, is known as the 'reporting area'. The areas for which no statistics are available are called 'non-reporting area'.

In a work of the present type which emphasizes upon the agricultural landuse only, it is neither possible on the part of the author nor necessary to go into too much detail regarding the general landuse. The author is sure, however, that the present work contains sufficient material in respect of general landuse as well, which can profitably be utilised for local use in the Chhatrapur Subdivision.
The main purpose of the author is to show the distribution of the existing agricultural use of the land in detail and how a particular piece of land can be potentially utilized in the Chhatrapur Subdivision. Agriculture is the science and practice of farming, using the word in its broadest sense (Zimmermann, E.W., 1951, p.148). Therefore the land cover connected with the science and practice of farming, or the area of the land utilized for cultivation, including arable, improved or unimproved grass land and other pasture, covering those productive efforts, by which man has been settled on the land constitute the agricultural landuse. More so, the agricultural landuse data will be used by the author at the time of planning the terrain use for evaluating the possibilities of their further development in adjustment with the terrain capabilities with a view to direct the expansion of intensive agricultural landuse into potential areas, and to check undesirable trends of the irrational use of land in the Subdivision of Chhatrapur.

1.5. PREVIOUS STUDY

The present study entitling 'Terrain Evaluation For Agricultural Land Utilisation In The Chhatrapur Subdivision - A Study in Applied Geomorphology' is new and an honest contribution to the sphere of current research in applied geomorphology all over India. In actuality no separate work on the various aspects of applied geomorphology in the Subdivision
of Chhatrapur was done previously. But some general ideas can be abstracted from the books, theses and research articles, etc., dealing with the methodology and with the Eastern Ghat highlands and east coastal plains of India, of which the terrain of the Chhatrapur Subdivision is an integral part.

Pascoe (1963), Krishnan (1960) and Wadia (1961) have presented excellent literatures of the progress of the Geological Survey of India. These literatures have been treated as the general geologic appreciation of the landscape of Orissa to which the study area belongs.

What is most important is the actual work dealing with parts of the terrain of the Chhatrapur Subdivision. A brief discussion of such works is presented as follows:

P.K. Chatterjee (1960, p.65), in the Annotated Index of Indian Mineral Occurrences, Part-I (A-E) of the Memoirs of the G.S.I., outlined the material use of the Ganjam Khondalites, Charnokites and granite gneisses. The analytical presentation of various rock groups by Chatterjee has been treated as fundamentals of geological and lithological descriptions for research work of such type.

M.S. Jain (1960-61, p.173), in the Memoirs of the GSI was the first to examine the site for a composite dam across the Bhaguva river of the Rushikulya system where he stated that the alignment of the dam runs of a nearly featureless terrain
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composed of the Khondalitic suite overlain by recent alluvium and slope-wash. In page 173 of this Memoirs Jain also investigated the site for a composite storage dam across the Dhanei river of the Rushikulya system where he mentioned that the alignment traverses garnetiferous granite gneisses. Jain has, no doubt, presented a good deal of the geo-lithological informations on one or two small parts of the northern hilly and upland regions of the Chhatrapur Subdivision which are made use of in the relevant chapters of the present work.

P.G. Adyalkar (1959, p.111), in the records of the GSI investigated an area of about 6000 sq.miles of Balasore, Cuttack, Ganjam, Mayurbhanj and Puri with a view to locate gravel of suitable quality for tube well shrouding. In p.112 he mentioned that after two bore-hole operations, the camp was shifted from the Ganjam agency of which the present study area is a part, owing to unworkable resistance provided by the underlying rock basement.

R.L. Singh (1971), without bothering about the evolution of landscape in the Subdivision, has dealt with the physical and regional account of Orissa Highland Region (pp. 754-774) and East Coastal Plains (pp.932-966), of which the study area is a part.

B.N.Sinha (1971) in his book 'Geography of Orissa' had given a broad outline of Ganjam District without focussing
his critical attention on this most problematic and complex environmentally designed Chhatrapur Subdivision owing to the limitations of the scope of his modest contribution.

E. Ahmad (1972), in his Coastal Geomorphology of India has confidently surfaced the evidences of coastal emergence of the Ganjam coast. In this work, Ahmad also mentioned about the sterility of the surface material upon the Khondalitic hills bordering the rocky shores of the southwestern Chilka lake, which incidentally constitutes an integral part of the Chhatrapur Subdivision.

Maya Das (1990, pp.174-175) in her paper 'Resources of the Chilka, the largest estuarine lake of India' had a brief touch of the present study area where she mentioned that the lake is being narrower, shallower, because the canal between the Chilka and the Rushikulya river has been bounded up to take sea waters to the salt pans of Humma. A similar mention of Chilka lake was also discussed by Niyogi (1967).

B.K.Sahu (1981) in his doctoral thesis entitled 'Geochemical Studies On Beach Sands Of Some Coastal Parts Of Orissa State' categorically mentioned in p-6 that the Eastern Ghats consisting of Khondalitic series of rocks serve as the source material of rare sand which upon weathering releases ilmenite, zircon, rutile, garnet, sillimanite and other accessory minerals into the sea by the rapid flowing river systems of the Rushikulya.
Apart from all these, some of the concise reports of the Indian Rare Earth Journals (Newsletter) also spelt out many features of coastal characteristics and their bearings on the extraction of beach sands along the Chhatrapur coast.

So far as the methods of terrain studies in general are concerned, a few works have been done in some Indian and foreign universities (Ollier-1978, Mitchell-1977, Verstappen-1983, Desai-1968, Kulkarni & Sinha-1968, Bose-1968, Kayerker & Wadhawan-1968, Singh-1974, Singh & Singh-1979, Mahato-1985, Chatterjee-1987, Jha & Hazra-1990). All these works are distinctly different from each other in treatment and purpose under investigation. A few of these works have considered geology, lithology and forestry, etc., in addition to other relevant physical components in studying the terrain. In conclusion, it may be said that most of these methods seemed to have been based upon limited number of natural components and least field observations.

Thus in summing up, it may be said that although many authors, experts and researchers are keen to spell out the results of their macro regional studies either at district, state or national level, no effort has previously been made to study the terrain of the Chhatrapur Subdivision for such a practical purpose.
1.6. SOURCES OF INFORMATION

Since the Chhatrapur Subdivision has not been studied geomorphologically as an individual unit previously, the sources of information are very limited. Even other types of study has not been conducted. The Survey of India topographical maps (74-A/10, A/11, A/13, A/14, A/15, 74-E/1, E/2, E/3) on inch and metric scales (1:63360 & 1:50,000) have been the basic sources and therefore have been used to prepare the geomorphological maps showing quantification of data on forms, processes, etc., and their effects in precise spatial situations and interrelations. The source for functional informations constitutes the published materials like census data, landuse data, meteorological informations, informations on irrigation and crop-use, etc. The primary source of both these factual and functional data consists of the author's intensive field-work in the study area and his paper work of the file informations in different block headquarters, official organisations and on-spot interviews.

The main sources of investigation and information collection have, however, been extensive walk across the study region and field-work, because there was a general lack of information regarding the various aspects of terrain of the Chhatrapur Subdivision including its landuse especially relating to agriculture. The more or less difficult terrain in the northern half of the Subdivision and lack of communication
lines in the littoral southeast have led the region more or less to obscurity. Most of the published and/or under-published or unpublished data have therefore failed to justify the significance of distributional phenomena of some economic, social and spatial attributes of greater research importance. Casual but significant informations are however found in numerous Geological Survey of India (GSI) Memoirs, settlement records, mini-watershed management and soil conservation reports, crop-calendars and the GSI manuals. The administrative records including the restricted toposheets preserved in various civil and engineering and survey departments have disallowed the author's ready access to both reference and to purchase on some pretext or other. It is to the author's surprise that neither the Central Groundwater Survey Division nor the State Groundwater Board (Orissa) have ever attempted any groundwater survey operation in any part of the Subdivision since 1959 on the ground of geo-lithological constraints. After two bore holes the operation was discontinued in the year 1959 (Adyalkar, 1959, p.112) on the preceding grounds. Therefore the author had to incorporate the groundwater data in the relevant chapters (Chs.12,13,14,15,16 & 17) of the present work by personally measuring the groundwater level, once in summer and once in winter, of more than four hundred wells distributed more or less evenly in the five major terrain units, (Hilly, Rugged, Moderately sloping upland, Nearly level low upland and level low land), littoral and lacustrine tracts of the Chhatrapur
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Subdivision. Other details of sources of information have been given while discussing methods and approaches.

1.7. METHODS AND APPROACHES

We have mentioned that the present study aims at evaluating the terrains of the Chhatrapur Subdivision for the maximum and proper utilization of terrains. This requires a detailed analysis of phenomena, which must have a base of works by different disciplines. But the area under study has very limited previous literature in this regard. Therefore, the author had only option to do his best at his won basing upon the limited resources already available and his own intensive field study. He had also to extract numerous data from the topographical maps to facilitate maximum accuracy and cross-checking. He also knocked at the doors of officials and organisations for collecting data whatever available. Thus the present study is a complex attempt involving two most vital aspects of formality and functionality. Both these aspects are complementary to each other. The formal aspects of terrain investigation takes into account the procurement of topographical maps of the study area to prepare the required base maps for model work, and an intensive field study. The functional model work lies in intermediate position between these two formal aspects.

The author firstly made an attempt to procure the relevant large scale topographical maps of the Chhatrapur Subdivision
(74-A/10, A/11, A/13, A/14, A/15, E/1, E/2 and E/3) on inch and metric scales prepared by the Survey of India with a view to prepare the base maps and for incorporating official and worked out informations relating to relief, geology, lithology, surface elevation, soil, drainage, slope and underground water and so on. As all of these eight toposheets have been declared as restricted, the author has been denied the procurement of such relevant maps on purchase in spite of adopting official paraphernalia. Therefore the author, justifying his integrity in the interest of the national defence and in using these maps strictly for academic investigation, pursued tracing work of such maps under the strict vigilance of the Superintendent Engineers, Major and Minor Irrigation Division, Southern Range, Orissa; Soil Conservation Officer, Berhampur and Deputy Director, Mining and Geology, Ganjam, Orissa. As some sheets of the new metric series were yet to be published, the adoption of incomplete metric series maps on 1:50,000 scale had to be given up. When the traced out one inch toposheets were made ready, an alternative device has however been found to restore the metric system upon the 1:63,360 S.O.1. maps in view of our subsequent employment of geomorphic techniques at ease. For representing the same area in kilometres, each 5-inch division of a line on the million sheet representing 5 miles on the ground has been divided into 8 equal parts each measuring 0.63 cm on the map and 1 km on the ground. This method of metric conversion seemed quite appreciable. The present map
on metric scale has been graphically reduced by half times on the new scale of 0.625 cm to 2 km linearly to prepare the square kilometre grids for a graphical transfer of corresponding informations from the large sized map of the Chhatrapur Subdivision. Thus in the initial stages of terrain investigation these base maps prepared with the related toposheets provided the invaluable basis to incorporate the results of necessary analytical geomorphic techniques that were employed in view of working out a geographical synthesis of the purpose under study. Where the incorporation needed officially recorded information with regard to geology, lithology, underground water and soil, etc., due obligation in this regard has been extended in the present work. In case no such official information was available for a part or whole of the study area, the work is supplemented by detailed field collection of such informations. Thus in the present study — 'Terrain Evaluation for agricultural land utilisation in the Chhatrapur Subdivision, Orissa - A study in applied geomorphology', a judicious combination of unbiased, honest and rigorous field work and model works on base maps have been made to work out the present purpose in its appropriate spatial relationship. The merit in this kind of integration lies in the formulation of tentative hypotheses of geographic interrelationships fairly scientifically and systematically with regard to agricultural land utilisation vis-a-vis terrain classification and evaluation. Therefore each method of terrain investigation that was
employed on the base maps needs be highlighted in brief in the following paragraphs:

Field studies play a vital role in nearly all geomorphological investigations (Prasad, 1979, p. 23). The author therefore made a detailed field work in his study area—travelling on foot over more than 1600 kilometres in three phases. This study involved keen observation, skillful recording of informations particularly of those aspects which were not available in the form of previous literature, collection of rock specimens, other informations relating to agricultural land utilisation and interpretation. The author had taken all the following materials in appropriate relevance to the purpose under investigation in the field:

(i) Note books; outline maps of the field under report; field-sketch diary; photograph, rock and groundwater level measurement reference recording note books.

(ii) Pencil, pen, chalk, white paint and brush and erasers.

(iii) Protractor, drilled scale, spirit level, nails, hammer, axe, polythene bags and rubber bands.

(iv) Measuring tape, rope, etc.

(v) Camera and other essential things of personal field use.
CHHATRAPUR SUBDIVISION

REFERENCE:
- Dist. Boundary
- Subn. Boundary
- Block Boundary
- Panchayat Boundary
- Subn. Hqrs.
- Block Hqrs.

POLOSARA BLOCK
KAVISURYANAGAR BLOCK
PURUSOTTAMPUR BLOCK
HINJILI BLOCK
KODOLA BLOCK
KHALLIKOTE BLOCK
GANJAM BLOCK

REFERENCE:
- Hills
- River

FIG. 1.2
Besides recording field informations and collection of field samples, the field work is supplemented by pictures illustrating specific landscapes and/or landuse or other relevant details pertaining to the field enquiry and/or laboratory interpretation of geomorphic techniques, terrain mapping and manuscript preparation. In this manner the author tried to give a wealth of valid field details in all Chapters of the present work.

On the basis of various pre-field and post-field laboratory compilation of maps the terrain of the Chhatrapur Subdivision was classified and evaluated form planning the terrain use especially relating to agricultural landuse in a manner as follows:

(1) Owing to no recorded geological information in detail in respect of the study area either in the Geological Survey Manuals and Memoirs the author had to collect the rock samples from almost all over the Subdivision. Such samples have been presented to the office of the Deputy Director, Mining and Geology, Berhampur, Ganjam District, for identification. The nomenclatures of these rock samples have been incorporated in the panchayat map prepared on the scale of the base map(Fig.1.2) i.e., 0.625 cm to 2 km (Fig. 2.1, Ch.2) and a choropleth map was prepared to serve as one of the bases of terrain classification.
(2) The reduced contour map of the study area has been prepared on the basis of the S.O.I. topographical maps to discuss the pattern of distribution of surface forms and elevation above sea-level (Ch.3 and Fig.3.1) and has been field-checked.

(3) The official informations relating to the climatic elements have been gathered from the eight block headquarters of the Subdivision as well as from the Indian Meteorological Department and the Bureau of Statistics, Bhubaneswar, Orissa. These informations have been shown against each block headquarters and isopleth maps were prepared (Figs.4.1 to 4.5) at suitable intervals.

(4) A drainage map (Fig.5.1) showing the spatial distribution of all major and minor streams of the study area has been prepared in the laboratory on the basis of the S.O.I. toposheets.

(5) Owing to the non-availability of forest data the author has computed the area under forest in all blocks of the Subdivision for two periods, i.e., 1935 and 1977 on the basis of the S.O.I. toposheets and critical field observations of relevant natural phenomena relating to the present afforestation and age-long forest depletion (Tables 6.1 and 6.2).

(6) On the basis of the rock samples collected in the field and their characteristic field manifestations in surface processes,
forms and materials, a lithological map (Fig. 7.1) has been prepared. A large number of lithological units have been identified and nomenclatured on the basis of theoretical correlation between the proportion and degree of decomposition of minerals that are present in a rock specimen and the pattern of their surface expression. This work has been supplemented by the basic natural principles that are laid down in the Soil Survey Manuals, Geological Survey Manuals and common text books and geological glossary.

(7) Maps depicting the relative spacing of streams and their length per unit area have been prepared (Figs. 8.1 & 8.2) on the basis of the S.O.I. toposheets. The number of stream segments per unit square grid of the base map has been counted and incorporated in each unit grid. Thereafter the isopleths have been drawn at suitable intervals to prepare a stream frequency map of the Chhatrapur Subdivision (Fig. 8.1). Further, the length of each stream segment of a unit grid has been measured with the help of Rotameter adjusted to the map scale. The cumulative lengths of the number of stream segments in kilometres per each square kilometre grid have been plotted and isopleths of suitable intervals have been drawn to prepare a drainage density map (Fig. 8.2).

(8) Different relief measures have been adopted and mapped on the basis of the contours and drainage informations of the
METHODS

S.O.I. toposheets. Such measures consist of the indices of absolute relief (maximum height per km² grid of the base map), relative relief (value of difference between maximum and minimum height in each km² grid), average relief \( \frac{\text{maximum height} + \text{minimum height}}{2} \) per each km² grid), dissection \( \frac{\text{relative relief}}{\text{absolute relief}} \) per each unit square grid) and ruggedness \( \frac{\text{relative relief} \times \text{drainage density}}{1000} \) per each km² grid). On the basis of the formulations the values of each relief measure have been plotted separately on the base maps. Then isopleths of observed intervals have been drawn to prepare absolute relief (Fig.9.1), relative relief (Fig.9.2), average relief (Fig.9.3), dissection index (Fig.9.4) and ruggedness index (Fig.9.5) maps of the Chhatrapur Subdivision.

(9) For slope analysis of the study area, the author preferred Raisz and Henry method of slope determination in its usual procedure of categorising the uniform spacing of contours of S.O.I. toposheets. A choropleth map at suitable intervals have been prepared to show different categories of slope (Fig.10.1) in the Subdivision.

(10) As regards the techniques relating to soil, the different choropleth maps (Figs.11.1 to 11.8) have been prepared on the available village and/or panchayatwise soil informations from the Soil Chemist, Berhampur, at suitable class intervals. A soil fertility map was prepared on the basis of synthesized
qualitative numerical scoring of available nitrogen, phosphorus and potassium (Fig. 8.9). This exercise would have been more minute if the author had various other data relating to soil profile, soil conductivity, salinity, etc. To compensate the deficit, a more forceful soil potential tabulation (Tables 12.2 and 12.3) and tabulation of water resource were prepared in addition to the maps depicting the general and specific physical bases of the terrain. The soil potentiality tables 12.2 and 12.3 are based upon a synthetic index which is but an aggregation of the values awarded to each category of different physical properties of soil including soil texture (Table 12.1) and permeability (Table 12.1). The consideration of water resource for its significance for plant growth has been made basing upon a vivid mental assessment of approximation of microscopically perfect field observation and map reading of the details of natural conditions such as precipitation effectiveness (Ch. 5), ground water retention of a given soil texture (Table 11.1), soil depth (Table 11.2), permeability (Table 11.3), surface runoff (Chs. 4 & 7), frequency of rills (Ch. 4), brooks (Ch. 4), gullies (Ch. 2) and a host of other micro-moisture conditions. The possibility of irrigation (Ch. 15) is not absolutely kept out of consideration at the time of terrain classification exercise.

(11) As regards the terrain classification of the study area the author has adopted both parametric and landscape methods
(Ch.12) more objectively. The initial stages of terrain classification involved grading of the major physical components (Ch.2 to Ch.11). In other words, the author thought it better firstly to divide each of the components in major categories. Thereafter Maull's girdle method (Mitchell, 1977, p.25) has been adopted and the maps of different sets have been superimposed at different stages and the terrain was classified (Table 12.4 and Fig.12.1). It is unfortunate that the author could not make access to aerial photographs to give a more minute touch to the present exercise owing to the lack of institutional training in this regard.

(12) It is noted that the appraisal (Ch.13) of the terrains of the Chhatrapur Subdivision has been made only on the basis of their natural potentialities. The author has selected some eleven components such as surface elevation and forms (Table 3.1), stream frequency (Table 8.1), drainage density (Table 8.2), absolute relief, relative relief, dissection index and ruggedness index (Table 9.1), slope (Table 10.1), soil potential and water resource (Ch.12). All these components, except the classes of soil potential, have been graded through numerical score values (Table 13.1) similar to the procedure followed in the soil potential determination. Thereafter these graded maps have been superimposed to determine the mean capability classes of each terrain unit (Table 13.2 & Fig.13.1) for terrain evaluation for agricultural land utilisation.
(13) Keeping in view the land potentials of the different terrain units of the study area the pattern of general use irrigation use and agricultural use of a terrain unit have been computed and studied with the help of the Census Handbooks-1951, 1961, 1971 and 1981 and official file informations on such aspects for the year 1991 (Chs.14, 15 and 16) which are procured from their related quarters stationed at Chatrapur, Berhampur, Cuttack, Bhubaneswar and at all block headquarters.

On finding a gap between the available terrain potential and the extent and pattern of potential land utilisation in general and the agricultural land utilisation in particular, the terrain planning for agriculture was made in respect of the Subdivision (Ch.17) and of all blocks (Ch.18) in their proper regional geographical perspective on field and laboratory assessments.

Finally an abridged report of our findings on terrain investigation, terrain assessment and terrain planning for agricultural land utilisation has been presented (Ch.19) in respect of the Chhatrapur Subdivision.

The present study necessitated the test of several popular morphometric approaches some of which have been merely attempted, some accepted and some of them have been rejected on the ground of the extent of their relevance to the purpose of investigation and the pattern of the terrain configuration. The accepted
approaches in the present work consisted of some geomorphological, statistical and land utilization techniques which have been applied to the study of the terrain of the Chhatrapur Subdivision with a view to describe the structure and distribution of its various facets and their inherent land potentiality for agricultural land utilization.

These techniques in their notable singularity or in their integration helped the author to determine the distributional pattern of terrain capability units and agricultural land use in both absolute and relative terms. These techniques at various stages of terrain investigation yielded results which are quantitatively comparable, precise and correct in respect of the description of an agriculturally conditioned landscape unit of the terrain in the Chhatrapur Subdivision. While preparing an inventory of the terrain classification and evaluation, an emphasis has, however, been laid upon the significance of purpose, enquiry and approach. These have been briefly summarised in the ensuing paragraphs.

As a whole the study involves the following four-phased approach to the methodical analysis of the problem under investigation:

1. The procurement of the Survey of India topographical maps and other records relating to geology, natural vegetation, soil characteristics and their conservation and degradation,
irrigation, water conservation and water loss, geo-hydrology, weather phenomena, different aspects of the users and of agricultural landuse and land degradation. The historical records relating to the traditional bindings upon the practice of farming, farm community and its composition, attitude towards and general aptitude for landuse development have also been procured to investigate the spatial structure of agricultural phenomena resulting from man and land interaction.

(2) Mapping of the selected general and specific physical components has been undertaken to prepare the relevant base maps for terrain classification. Simultaneously a voracious journal work in different libraries and extensive discussions with the supervisory expert of the present work, other experts and fellow researchers in the field of applied geomorphology and technical experts of various geological, hydrological, pedological and agricultural concerns have been made as a necessary prelude to both formal and functional terrain classification and evaluation.

(3) An extensive field-work has been undertaken for a close field-observation of an already mapped phenomena, field measurement of relevant features, water level and size and shape of agricultural plots and collection of field informations relating to agricultural landuse from the village level agricultural workers (VAW), farmers, Sarpanchs and other
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responsible and reliable personnels. Field collection of rock, soil and water samples has also been made for their subsequent analyses in related laboratories for the necessary incorporation of their laboratory informations in the study of terrain evaluation. Finally the photographs of some specific and important field details have been adopted for subsequent field reference at the time of interpretation of the problem under study.

(4) The ultimate phase of terrain investigation involved final drawing of maps and diagrams, analyses and discussions of the data processed from printed, mapped and field-observational informations; interpretation and justification of the final findings, and finally compilation of the present work in the shape of a presentable thesis.

In brief, the methods and approaches have been simple as well as popular. Quantification and statistical analyses have been attempted in the present work wherever necessary. An all-too-greater emphasis has however been laid on the field-study approach to the terrain evaluation of the terrain in the Chhatrapur Subdivision for agricultural land utilisation.
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