CHAPTER - III

GEOENVIRONMENTAL FACTORS AND PARAMETERS

GENERAL CONSIDERATION

The study area as already stated in the earlier chapter provides a very good example of landscape diversity and is divisible into very well defined smaller terrain units each characterised by its own geoenvironmental features. In order to fully understand and evaluate the diagnostic and distinctive terrain features of the area, the present author, identified the various factors and parameters which could be taken into account. For describing each geoenvironmentally distinct units, following four major factors have been taken into account:

(i) Terrain attributes

(ii)Climatic diversity

(iii)Surface and sub-surface water regime

(iv) Anthropogenic impact and interference.

TERRAIN ATTRIBUTES

This factor includes the overall landscape and geological framework of the area and systematic description and analysis of various terrain attributes comprises an in-depth study of two main aspects: (i) **Landscape** and (ii) **Geology.** The former includes various landforms which collectively comprise the physiography of the area. Physiographic diversity is an important factor which in turn, is a reflection of geology and climate. It however, represents an independent and important element of geoenvironment. Topographic features and slopes very significantly influence the behaviour of surface runoff including rivers and streams. Geology and groundslope together control the drainage of an area. Rivers and streams though follow the slope and behave differently in rock types of different lithology and hardness. In many cases however stream courses ideally reveal strong structural control, flowing along fracture lineaments (shear zones, faults, joints etc.), synclinal troughs etc.

LANDSCAPE

In landscape, aspects of topography, drainage, slope and soils are studied. The factor of **topography** comprises the overall features of the surface and the landforms. An important aspect of topographic analysis pertains to the a evolutionary history especially whether the various landforms are aggradational/degradational or are controlled by tectonic features like folds, faults etc. Several land features may be typical of igneous activities like batholiths, plugs, dykes, lava flows etc. The role of tectonism in landscape evolution is also very important, and it is quite vital to fully recognize a topography in which folding, faulting or joints, at various scales, have played their due roles. The aspect of **Drainage** is mainly manifested in the form of streams. Essentially a synonym for paths of running water, a stream could be of varying dimensions in terms of channel length, width and depth. Drainage of an area represented by streams of various orders may form a complete basin or it may form a part of the total river basin. The stream may be of any order ranging from a first order to the higher order of the main river (trunk). The pattern of streams again may reflect slope control or they may be following various sets of joints. Running water erodes as well as deposits, depending upon the load that it carries and its flow energy. Generally the low order streams cause erosion, but quite often depending on the breaks in the slope provide sites of local flood plains and deposition. A precise evaluation of the drainage characteristics therefore is very important in any geoenvironmental study.

Slope constitutes another important feature of landscape. Obviously, it is a product of geology (lithology and structure), processes of erosion and deposition caused by marine, fluvial and aeolian agencies, and climatic conditions. The factor of slope has to be viewed at variable scales in a larger context. The entire area under investigation shows a regional westerly slope; within such a slope configuration, smaller topographic features show diversity of slope characteristics at all scales. A slope could be gentle, moderate or steep. Slopes are expressed either in degree values or in gradient scales. For the purposes of general description, slope can be divided into seven categories viz. (i) Horizontal (ii)Very gentle (iii)Gentle (iv) Moderate (v) Moderately steep (vi) Steep (vii)Vertical.

The **Soils** also form an important component of the landscape, and they are vital from the point of view of geoenvrionmental diversity. Soils could be insitu or transported; they may be totally absent or may form a cover of variable thickness, very thin to deep. The soils are important from the point of view of natural and human induced eco-systems. To a major extent soils form an important base for agriculture. A soil cover might have escaped pedogenic changes or might provide a good mature soil profile. Soils are investigated from various angles and studied by geologists, botanists, agriculturists and engineers. As a result, enormous data on soils are available. Of course, the information is categorized into well defined use base.

GEOLOGY

No geoenvironmental study can be complete in the absence of a thorough and complete understanding of the factor of geology because it is an important controlling element in the evolution of landscape. Rock types, their disposition and lithology are very vital in carving out landscape and physiography. Igneous and metamorphic rocks each provide their own district responses to sub-aerial and sub-terrainean processes. An important aspect of geology is that of tectonism and structure. Folding and faulting of rocks, presence or absence of joints, faults and fault-related features like vertical and lateral movements, crushed zones etc., all these comprise features that significantly control landscape.

It may be mentioned that the influence of geology on landscape is not exclusively confined to the surface exposures but very often the sub-surface features also play vital role in producing surfaces, configuration of the land.

CLIMATIC DIVERSITY

The factor of climate also forms a very important component of geoenvironment, especially in its interaction with the land surface. It may be emphasized that temperature and rainfall would interact differently with geology and topography. Very often the complexity of the combinations of terrain attributes vis-a -vis climate produce interestingly distinct geoenvironmental conditions. An area could lie within a climatic zone marked by a uniformity in **temperature** variation and **rainfall;** on the other hand the area might show significant variations in the temperature in its different parts and also experience varying intensity of rainfall. Obviously, in the two cases cited above the response of the rocks of the area to these two important components of climate would be very different. As a result the terrain conditions, and water regimes would be quite different. Apart from rainfall and temperature changes, the two other elements of climate are those of **wind** and **humidity**. Areas prone to strong winds coming from one or other direction bring about striking changes in the landscape; the winds erode, transport and deposit, resulting into degradational and aggradational landforms. The role of wind is very much conspicuous in the coastal area where it controls sea water movement and beach morphology, and in deserts where winds are responsible for aeolian landscape. The factor of humidity which is more or less related to either periods of high rainfall or nearness to coastline, is also one of the causes that influence terrain conditions. The increased humidity tends to stabilize loose sediments and also under appropriate temperature conditions provides environment for soil formation. Humidity varies from area to area and season to season. The above discussed factors which characterise climatic conditions and their influence on the landscape are described in terms of quantified values so that the phenomena concerned are more precisely described.

Climatic description of any area is generally presented in the following style :

1. Rainfall : a) Average annual rainfall
b) Number of rainy days
c) Rainfall extremes
d) Dependability
e) Rainfall intensity

2. Temperature : a) Mean annual temperatures
b) Mean maximum and Minimum
c) Temperature extremes

3. Wind : a) Direction (summer, winter and monsoon)
b) Velocity (Seasonal)
c) Average annual velocity

4. Humidity : a) Relative humidity (seasonal)
b) Change in relative humidity based on nearness to sea or desert.

In addition to the above discussed parameters which define the climatic conditions, there are a few climatic phenomena which have to be considered, namely storms, depressions and cloudy skies. These are difficult to fit into the routine climatic framework of an area because they are not the elements that could be monitored year to year. Skies could become cloudy once in a while every year or once in several years and these could cause appropriate impact on the then prevailing climate. Similarly, stormy conditions marked by high velocity winds with or without heavy rainfall, though in-frequent, are potential agents of bringing out marked changes in landscape and water regime. The various manifestations of climate, quantified temporally as well as spatially, are considered in totality and expressed in terms of **Aridity Index**. It indicates sustained potential water depicit when P.E. (Potential Evapotranspiration) out-weighs precipitation.

WATER REGIME

Water regime of the area constitutes an important facet of geoenvironment. It is divisible into (i) **Surface water and (ii) Subsurface water (groundwater).** The former includes rivers, and streams, reservoirs lakes and ponds, and the latter mostly comprises groundwater under phreatic and piezometric conditions.

SURFACE WATER

Running water in the form of **streams and rivers** is the most important source of water availability. As course, occurrence of rivers of various orders, is not universal. Some areas are endowed with numerous rivers and streams while others have none. Similarly, the groundwater resource can also be erratic. In some areas, it may be a dominant source while in others, it is scarce. The water regime of an area has therefore to be categorized on the basis of the surface water and groundwater availability, and as water forms the backbone of all human activity, the nature, mode of occurrence, availability and utilization pattern of water constitutes a very important geoenvironmental element. Rivers can be of any size and dimension, may carry water in varying abundance, may be perennial or ephemeral, all these aspects have to be very thoroughly investigated and quantified. As the behaviour of rivers and streams is intertwined with rainfall, bedrock characteristics, gradient etc., a proper evaluation of flowing water resource, therefore cannot be done in isolation. Thus the drainage pattern of an area which in turn manifests the nature of the rivers and streams is an important feature that requires in-depth investigations.

The surface water regime for the purpose of quantified appraisal is described in terms of rainfall -runoff relationship. **Surface storages** (stagnant water bodies) viz. reservoirs, lakes and ponds, also constitutes an important constituent of water regime. Big natural lakes can be sources of water supply for purpose of domestic use, irrigation, industry, etc. Man-made reservoirs by damming rivers, also simulate lakes to considerable extent. On the other hand, natural ponds though holding comparatively small quantities of impounded water very often assume considerable significance. Small impounded water bodies, sometime natural but very often man-made are almost invariably associated with most villages, and form an integral part of village economy, providing domestic requirements and limited irrigated needs. In fact, most of village ponds represent bunded shallow channels and form sites of rainwater storage, providing an ideal example of village level rainwater harvesting as practised by our forefathers. These ponds not only are the direct sources of water but they also act as agents of recharging shallow groundwater dug wells located on the periphery of ponds.

GROUNDWATER

Groundwater always constitutes an important source of water for all human activities. Its occurrence and availability in terms of quantity and quality depends on a number of surface and subsurface terrain attributes and climate mainly rainfall. An essential factor that controls groundwater behaviour is geology. The rock types of an area depending on their lithology and structural features comprise the major component because on this attribute of the terrain depends the storage conditions of groundwater. Together with the surface features like topography, slope and soil cover the geological conditions play their due role. The groundwater occurring at variable depths below the surface is restricted to well defined levels and forms water bearing zones or aquifers. The groundwater occurs in confined or unconfined aquifers, and in the case of former it may at times occur under artesian pressure. Studies on unconfined aquifers can be easily carried out because they represent replenisable resource, mostly represented by open dug wells; the water availability is directly proportional to the periodic recharge of the aquifer storage through direct precipitation or lateral migration along impervious layers. But in the case of confined groundwater the problem of recharging of aquifers happens to be somewhat complex. In most cases the recharge zones happen to be located at long distances, and the water tends to occur under hydraulic pressure. Many a times, the confined aquifer marked by artesian conditions, represents reasonably deep-seated "fossil" accumulation of water.

In such cases there are little chances of replenishment, and once the supply is exhausted the aquifers get depleted more or less permanently.

The **quality** of groundwater is also an important aspect and its chemical composition as well as contamination by pollutants significantly affect the utility of this resource. Inherent salinity or high fluoride and nitrate contamination could be due to various reasons, natural as well as human-induced. Natural causes for increased salinity have been found to be either the inherent salt content of aquifer sediments or nearness of sea.

Judicious groundwater utilization not only depends on the quantity and quality, but also on the level and degree of exploitation. Any scheme for the development and exploitation of groundwater resource has to take into account the parameters of (i)potential,(ii)recharge, (iii)draft, (iv)utilitiblity, and (v) level of development. Unless an appropriate balance is maintained between the replenishment and exploitation, the groundwater regime tends to gradually deplete and deteriorate. An understanding of this aspect of the geoenvironment of an area, is very vital.

ANTHROPOGENIC IMPACT AND INTERFERENCE

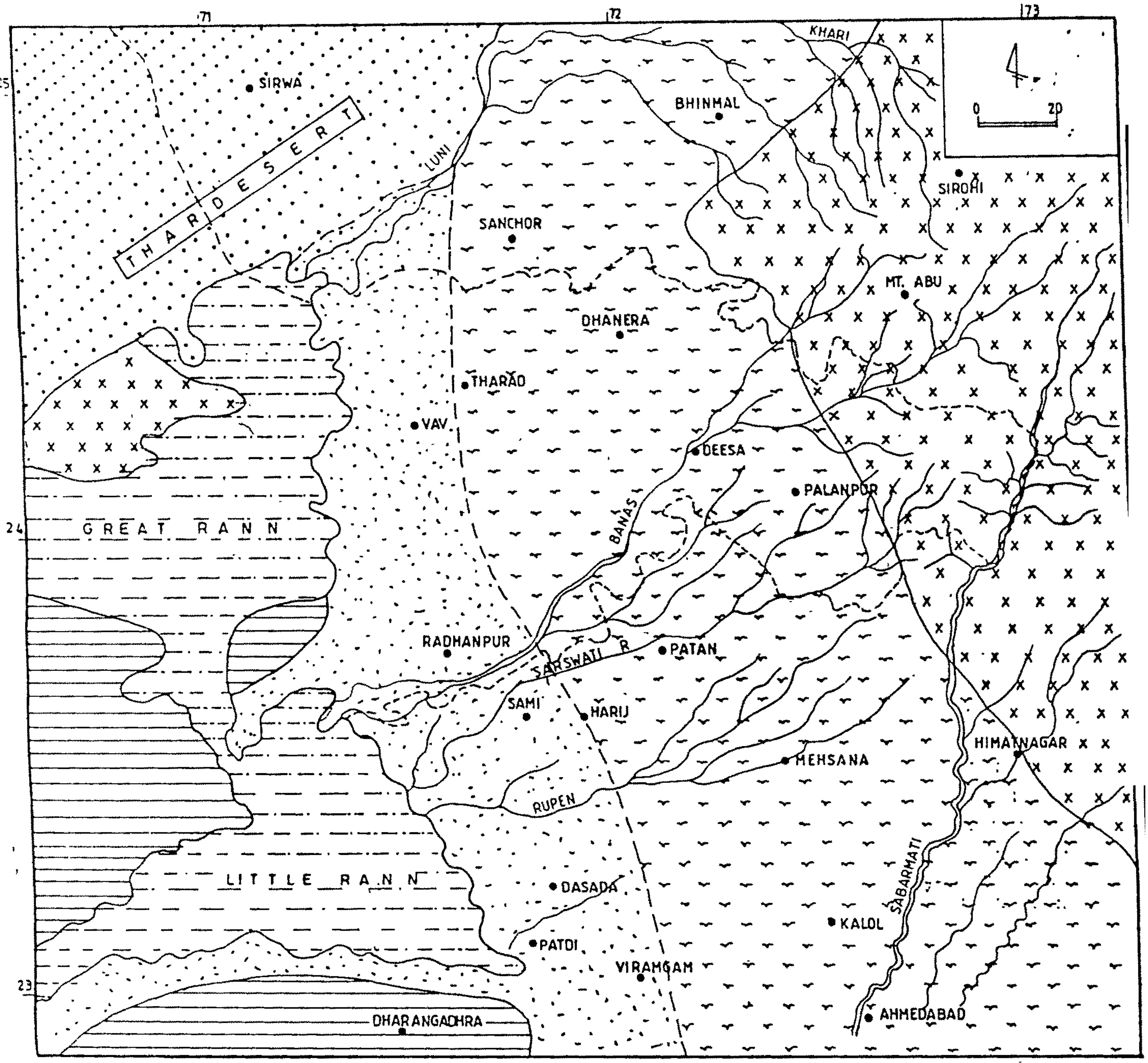
The various development activities which in combination with the other discussed factors, play an important role in modifying the overall geoenvironment, both for the better or the worse. As is welknown, landscape of an area keeps on changing with increasing human activity; whether it is for agriculture or for urban and \or industrial development. Construction of new roads, leveling of hilly terrains, designed and planned landscape changes for various human activities, these all, bring about very significant changes in the topography, slope characteristics and drainage pattern. Mining of rocks and minerals by quarrying also is responsible for bringing about landscape changes.

Another field where human interferes with environment is that of water regime. The increased tempo of developmental activities in economically backward areas (paradoxically where the geoenvironment shows its original natural preservation) is one of the major causes of environmental degradation especially in respect of water regime. Construction of reservoirs, dams, canals etc. vitally affect the natural surface water behaviour by interfering with the natural drainage system. Similarly, exploitation of groundwater also in most cases causes much damage to the subsurface water regime both in terms of quality and quantity of water.

Industrialization with accompanying unplanned disposal of toxic waste, indiscriminate application of pesticides in agricultural practice and overdraft of the groundwater are the most common and vital hazards to the environment. It is not to say that the development activities need to be completely stopped but it is most essential that all human activities have to take into account the various facets of the prevailing natural geoenvironmental components of an area and work out a sustainable strategy such that a happy balance exists between development and environment.

GEOENVRIONMENTAL OVERVIEW OF THE STUDY AREA

The district has a very unique geoenvironmental setup. It is located at the junction of several environmentally diverse regions (Fig 3.1), and within itself also shows much variation. Its north-eastern hilly part forms the southwestern extremity of the Aravalli mountain of Rajasthan. To the west, as it abuts against the Ranns of Kachchh, the western part more or less comprises a saline wasteland. The median portion, the aeo-fluvial area, forms the northern extension of the Central Gujarat plains. To the north, these plains, merge into the Thar desert. On the basis of geoenvironmental diversity, the district is divisible into following units :



REFERENCE

SYMBOL	GEO-ENVIROUMENTAL UNIT	ELEVATION RANGE (m)	CLIMATE	GEOLOGIC AGE
	SALT ENCRUSTED RANN SEDIMENTS	5 – 15	ARID	HOLOCENE
	DESERT DUNES – AEOLIAN SAND	20 – 300	ARID	HOLOCENE
	PALAEO-MUDFLATS – SALINE WASTE	20 – 50	ARID TO SEMIARID	LATE QUATERNARY
	ALLUVIAL PLAIN (AEO-FLUVIAL)	50 – 200	SEMIARID TO ARID	QUATERNARY
	ROCK OUTCROPS (SEDIMETRIES & TRAP)	20 – 200	ARID TO SEMI ARID	TERTIARY TO MESOZOIC
	ROCK OUTCROPS (CRYSTALLINES)	200 – 1000	SEMI ARID	PRECAMBRIAN

FIG-3.1 REGIONAL GEOENVIRONMENTAL SETUP OF BANASKANTHA DIST.

1) Eastern Rocky Highland (ERH)

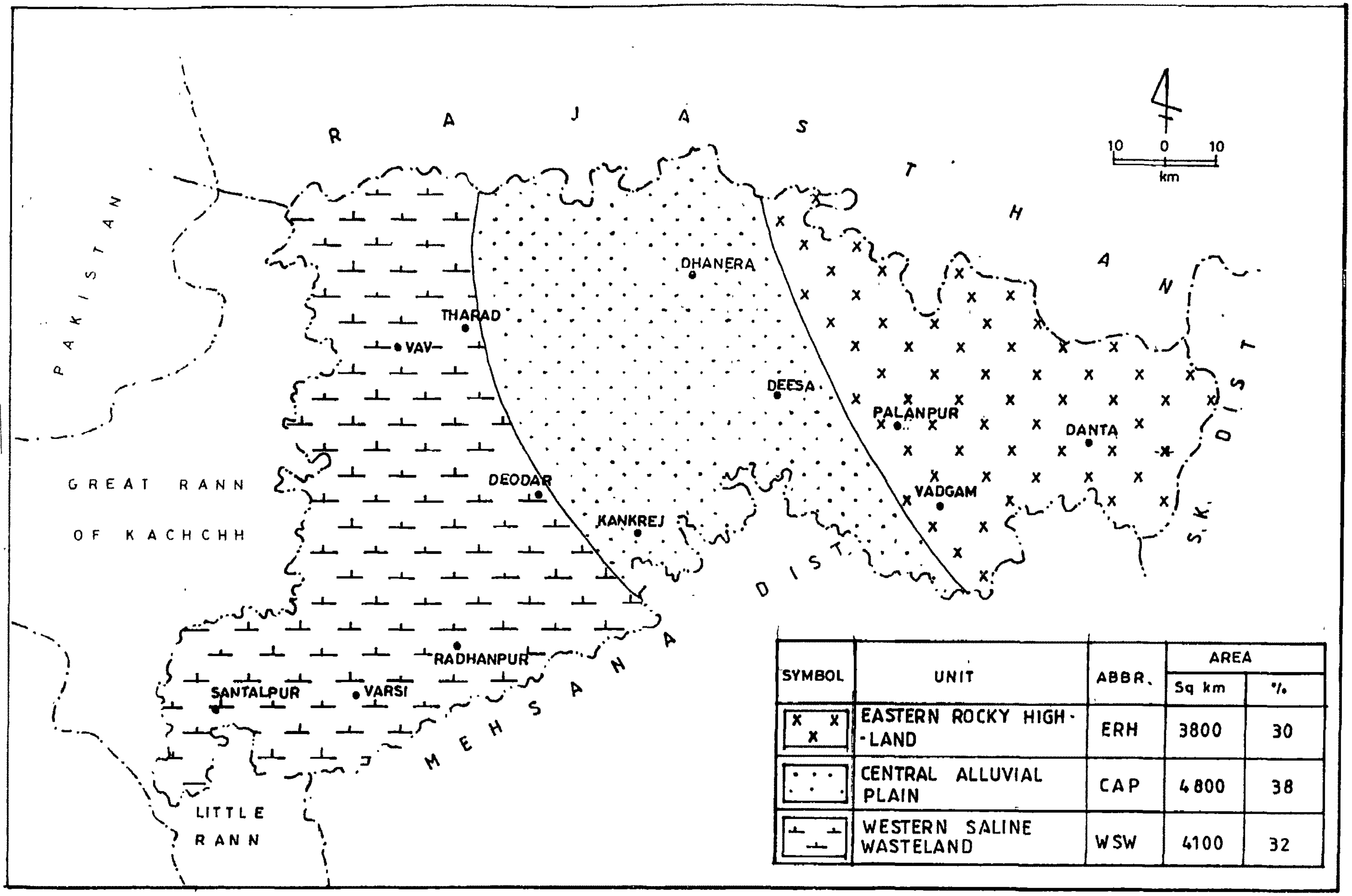
2) Central Alluvial Plain (CAP)

3) Western Saline Wast land (WSW)

The three geoenvironmentally distinct units (Fig 3.2) of the district have their own physiography, geology and surface and subsurface water regimes. Climatically too, the district shows a marked change from east to west and north to south. The Luni river in the north separates the semi-arid Banaskantha alluvial plains go beneath desertic sands. The Banas and Saraswati broadly delineate the North Gujarat plains from those of Central Gujarat.

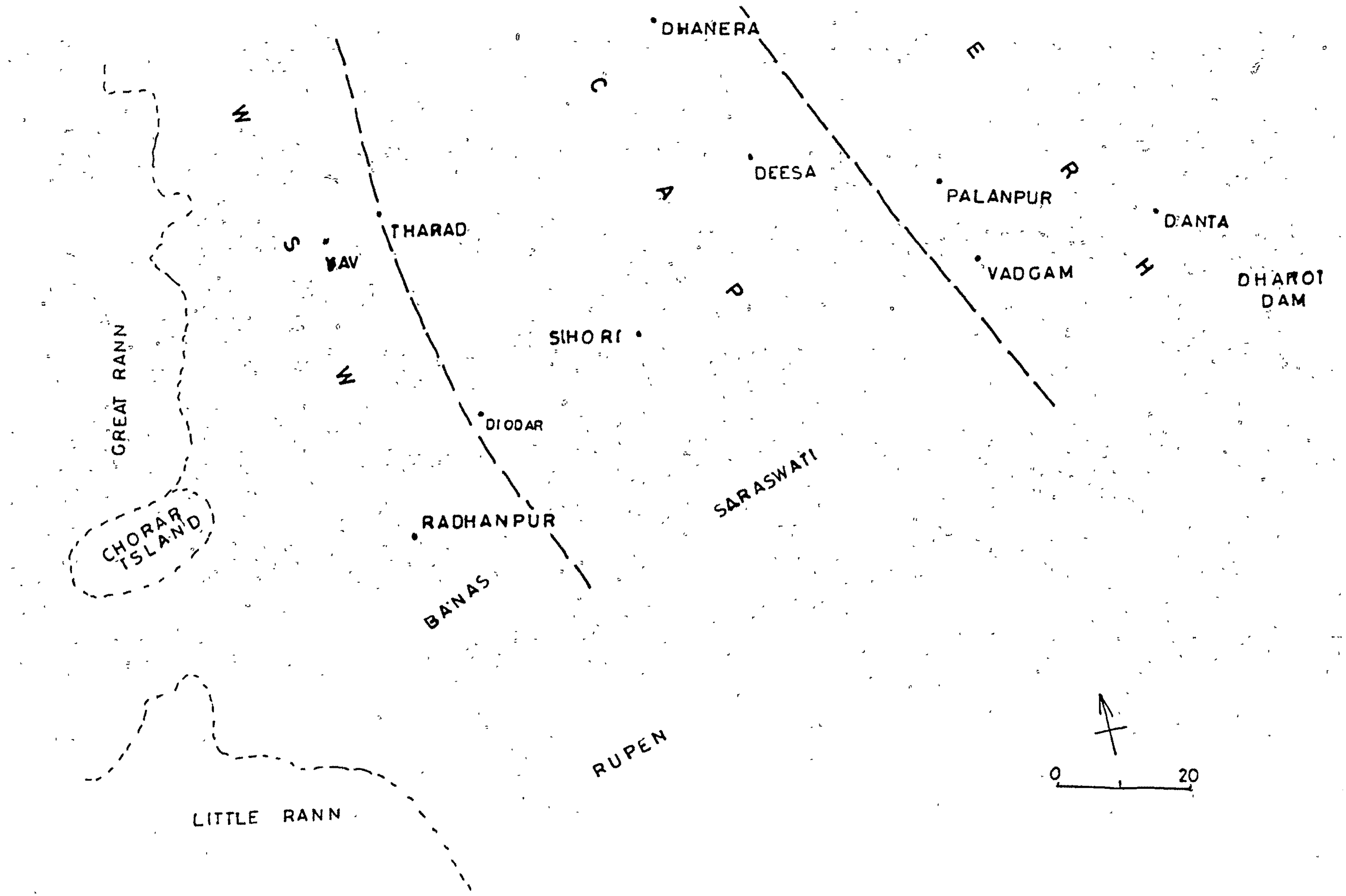
ERH typically represents Precambrian terrain, made up of folded metasediments and intrusive granite. The CAP Shows mixed characteristics of aeolian and fluvial sediments. The WSW typically comprises a barren and somewhat sandy and saline area (Plates 3.1 and 3.2).

Detailed descriptions and discussions of the above factors and parameters of the three geoenvironment units are given separately in the following chapters. However, in the background of the theoretical perspective of the geoenvirons given in the present chapter a comparative statistical profile of the three units is provided here (Table 3.1). This gives a geoenvironmental overview of the district as a whole and its internal diversity. The tabulated abstract information will serve as a good guide for understanding the implications at unit scale with the district in totally.



SYMBOL	UNIT	ABBR.	AREA	
			Sq km	%
x x x	EASTERN ROCKY HIGH-LAND	ERH	3800	30
· · ·	CENTRAL ALLUVIAL PLAIN	CAP	4800	38
⊥ ⊥	WESTERN SALINE WASTELAND	WSW	4100	32

FIG-3·2 GEOENVIRONMENTAL UNITS OF THE BANASKANTHA DISTRICT


DHANERA
DEESA
PALANPUR
DANTA
VADGAM
DHAROI DAM
THARAD
VAV
SIHORI
DIODAR
RADHANPUR
SARASWATI
BANAS
RUPEN
GREAT RANN
CHORAR ISLAND
LITTLE RANN
0
20

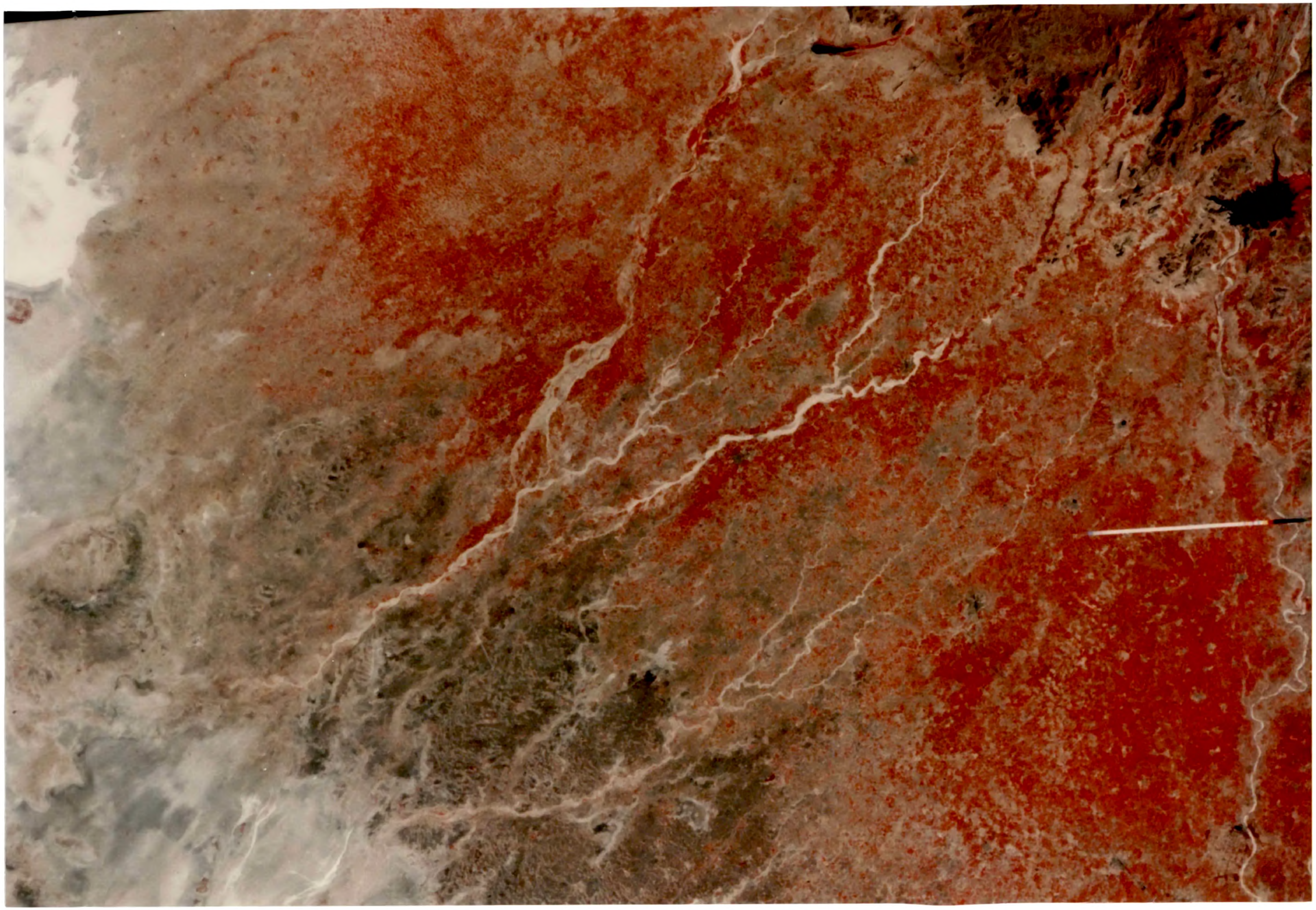
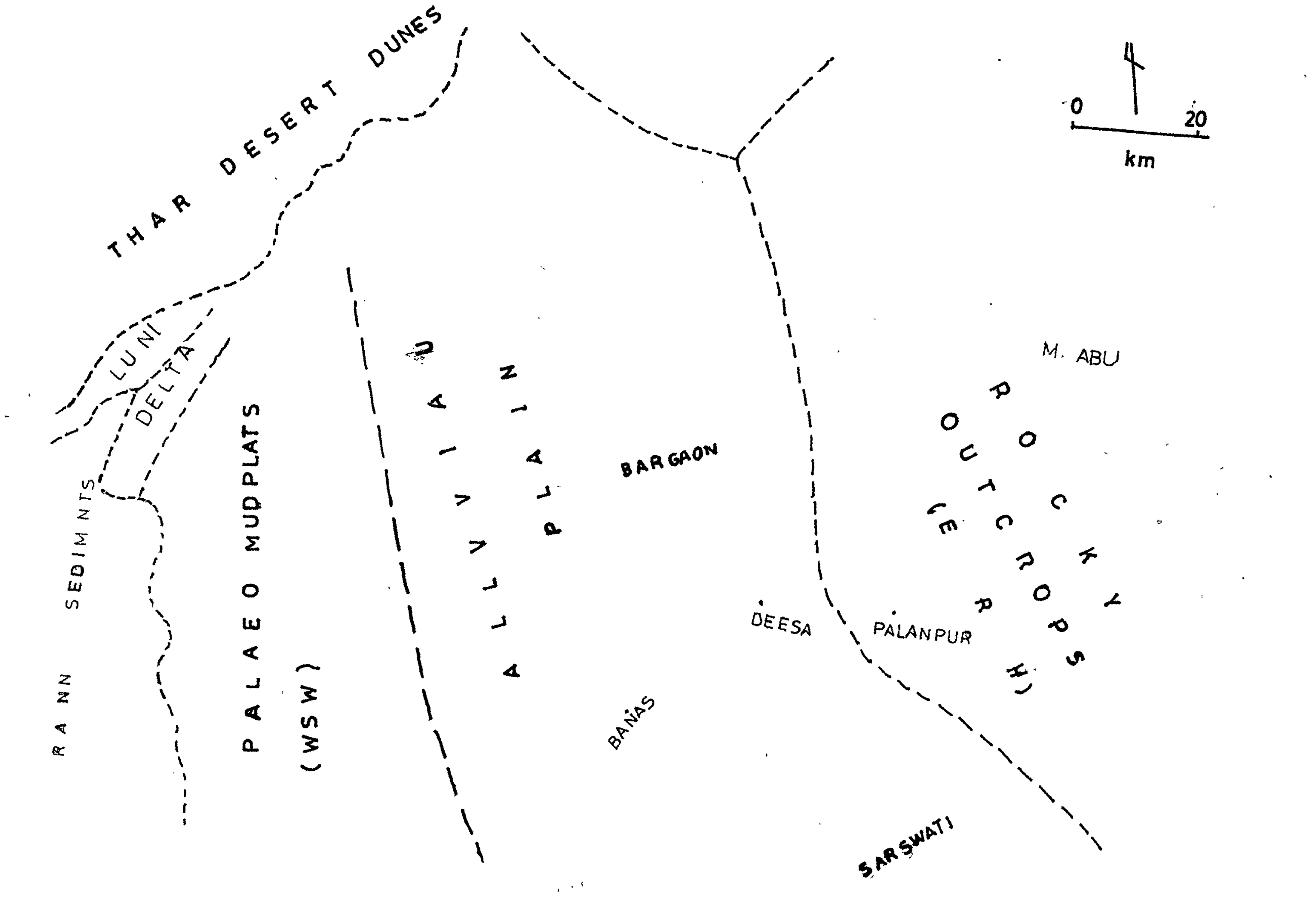


PLATE 3.1 SATELLITE VIEW SHOWING TERRAIN FEATURES OF THE 3 GEOENVIRONMENTAL UNITS


THAR DESERT DUNES
LUNI DELTA
SEDIMNTS
RANN
PALAEO MUDPLATS (WSW)
ALLUVIAL PLAIN
BARGAON
BAÑAS
DEESA
PALANPUR
SARSWATI
M. ABU
ROCKY OUTCROPS (ERH)
0
20
km

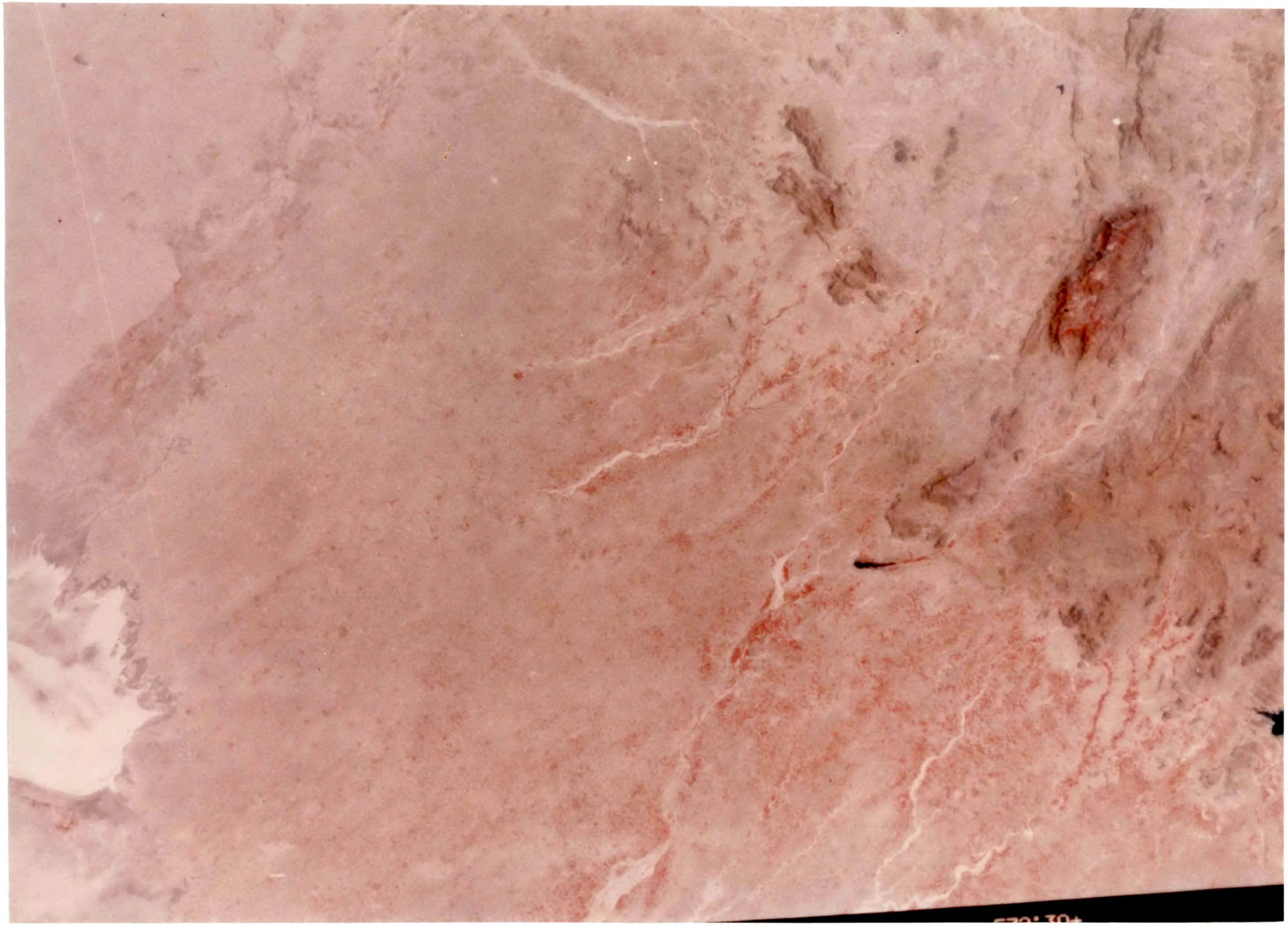


PLATE 3.2 SATELLITE VIEW OF THE NORTHERN EXTENTION OF BANASKANTHA SHOWING TERRAIN FEATURES

Table 3.1 Summarised informations of geoenvironmental units of the district.

Characters	Unit	Eastern Rocky Highland (ERH)	Central Alluvial Plain (CAP)	Western Saline Wasteland (WSW)	District Total \Average
GENERAL INFORMATION					
Area	Sq. km (%)	3800 (30)	4800 (38)	4100 (32)	12703 (100)
Talukas	-	Danta, Vadgam and parts of Dhanera and Palanpur	Deesa and parts of Dhanera, Deodar, Kankrej and Tharad.	Vav, Santalpur and parts of Tharad and Radhanpur	11 Nos.
Population (1991)	Lakh (%)	8.9 (41)	7.3 (34)	5.4 ('25)	21.6 (100)
Density (rural)	person/ sq. km	195	202	107	211
Total villages	No. (%)	609 (45)	377 (27)	382 (28)	1368 (100)
Density	vill. /100 sq.km	16	8	9	11
Towns	Nos.	03	02	03	08
TERRAIN - ATTRIBUTE					
Landscape					
Elevation range	m	1000 to 200	200 to 50	50 to 20	1000 to 20
Average elevation	m	300 to 500	100 to 150	20 t0 30	20-300
Landforms	Type (%)	Erosional 80 Depositional 20	Erosional 20 Depositional 80	Erosional 10 Depositional 90	Erosional 40 Depositional 60

Contd

Drainage density	-	Very high to Moderate	Very low	Very low	Very high to very low
Ground slope	Gradient	:2 to 1:200	1:100 to 1:1000	1:1000 to 1:5000	1:1000
GEOLOGY					
Stratigraphy					
Exposed	-	Metasedimentaries of Delhi Supergroup and Post-Delhi intrusives and fluvial Quaternary	Gujarat Alluvium of Quaternary period	Mudflats and recent sands of Quaternary sedimentaries of Tertiary and Mesozoic.	Precambrian Tertiary, Mesozoic and Quaternary.
Subsurface	-	-	Precambrians and Mesozoics	Wagad sst, of Mesozoic and sedimentaries of Tertiary	Precambrian, Mesozoic Trap and Tertiary.
Structure & Tectonics	-	Folds of 3 generations Delhi-Aravalli orogeny (NE-SW faults), (Delhi strike) and (E-W Post Delhi).	Sanchor-Patan block of Cambay basin and Neotectonism.	Eastern part of Kachchh basin and Neotectonism	Precambrian Orogeny, Mesozoic rifting and neotectonism.
CLIMATE					
Aridity Index	%	15 to 25	20 to 30	30-40	20-30
Temperature					
Annual Mean	°C	26	28	33	24
Maximum	°C	34	44	46.5	46
Minimum	°C	20	19.5	15	15
Extremes					

[2] Contd

Maximum	°C	44	46 (1958)	48 (1886)	48
Minimum	°C	4	2.9 (1954)	1.1 (1929)	1.1
Relative Humidity	%	29	49	50	40
Rainfall					
Average Annual	mm	704	526	462	555
Annual Maximum	mm	1688	1358	1177	1688
Annual Minimum	mm	160	125	21	21
Heaviest in 24 hrs.	mm	409 (1893)	532 (1960)	307 (1905)	532
Rainy days	Nos.	31	23	20	24
Dependability	(%)	50-60	40-50	< 50	40-60
Wind speed	km\hr	5 to 10	11.4	12.1	7.0
WATER REGIME					
Surface Water					
Rivers	-	Banas, Sipu, Saraswati	Banas	Banas	Banas
Runoff	mm	121	62	62	79
Ponds	No.	55	374	391	820
Area	ha	150	913	2117	3240
Storage	ha-m	146	804	2057	3007
Groundwater					
Occurrence	-	Hard rock	Alluvium	Alluvium	Quaternary Alluvium,
Aquifer		Unconfined	Unconfined &	Unconfined & Confined	Mesozoic

[1] Contd

Recharge Index Quality	(%) Of rainfall TDS ppm	12 300-500	Confined 15 500-2000	(artesian) 13 2000-4000	sedimentary. 13 300-4000
SOILS		Inceptisols and Entisols	Inceptisols and Entisols	Aridsols, Entisols and Inceptisols	Inceptisols, Entisols and Aridisols
NATURAL HAZARDS		Land Erosion	Flood, drought, duststorms, Gully erosion	drought, flood, inundations and duststorms, seismicity zone vi & v	-Easternpart prone to erosion, central part by flood and western part by drought.
ANTHROPOGENIC IMPACT		Mining and Deforestation	Overexploitation of groundwater and Intensive Agriculture	Salinity spread and Duststorms	Deforestation, Mining in eastern part, Groundwater mining and Intensive Agriculture in Central part and Desertification in Westernpart
NATURAL RESOURCES		Forests, Mineral deposits and surface water	Soil and groundwater	Pasture	Forest, Minerals, Soils and Water resources.