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GEO - ENVIRONMENTS AND MANAGEMENT

CONCEPT AND APPROACH

The geological environments of the area are governed by the exogenic and endogenic processes. The endogenic processes operating beneath the ground, determine tectonic status of the area. The processes include occurrence of earthquakes, volcanism etc. The interaction of surface exposure of the geological formations with the prevailing climatic conditions gives rise to a set of geological environment which include floods, inundation, erosion, deposition, salinity, cyclones etc. Human activity considerably modifies the natural pattern of the geological environments. Various environmental parameters of the area related to the three major activities are given in Table VI.1.

Table VI.1 Geo-environmental activities and parameters in the study area.

Activities	Environmental Parameters
I Endogenic	1. Seismicity
II Exogenic	1. Floods and inundation 2. Erosion and deposition 3. Salinity of land and water 4. Cyclones and storms
III Human	5. Agricultural practices 6. Industry and Urbanisation

The three major activities and seven related parameters i dentified are relevent to the study area are briefly discussed here.

ENDOGENIC ACTIVITIES

These activities are attributed to the neotectonic movement in the area and studied as seismicity. Other endogenic activities like volcanism etc. are of no relevence to the area.

Seismicity

It is manifested by the occurrence of earthquakes. It is seen that tectonically the study area forms a part of Cambay graben, and the sinking block of the graben itself is subjected to a system of several minor facults. The entire sedimentary basin therefore represents an unstable block repeatedly experiencing earthquakes, readjustment of land segments and thereby energy is getting released. This seismic activity in the present times is determined by evaluating the neotectonic status of the area. Based on the data from IS (1975) Rao, et al (1986), Balasundaram (1970), Gupta et al (1972), Arora, et al (1970), Rama Kalaiah, et al (1970) etc. A seismic status map is complied as given in Fig. II.1. The eastern limit of the Cambay graben is marked by the N 350 trending basinal fault that divide the area into two parts. The eastern part is more stable compared to the central and western parts. Of course, the Narmada lineament east of this limiting fault is also considered to be relatively vulnerable, but the seismic activity along this lineament is relatively of much lower order compared to the graben block. It could be seen from the Fig.II.1. that the entire study area is included into the Seismic Zone III of India. However, the north-eastern part realtively has less number of earthquake epicentres.

In the Narmada rift valley several earthquakes have been reported and perhaps attributable to the fault breaks in the Narmada Son lineaments. Of these, three earthquakes viz. Narmada 1846, Khandwa (Satpura) 1938, and Broach 1970 are the prominent ones. The magnitude of these earthquakes is said to be between 5.4 to 6.5. The epicentre of the Broach earthquake perhaps originated at the junction of ENE-WSW Narmada fault lineament and the NNW-SSE Cambay right graben.

The Broach earthquake of 23rd March 1970 was of tectonic origin having depth of focus at 10 to 21 km, magnitude 5.4 on Ritchers Scale and intensity VII on MM Scale. (Gupta et.al 1972).

EXOGENIC ACTIVITIES

The complex framework of lithostructural and geomorphic characteristics of the terrain and wide range of variations in the climatic factors viz precipitation, temperature, humidity, winds, solar radiation, etc. have produced a compound pattern of surficial dynamical energy distribution. This has given rise to a set of parameters that control the processes of geological environments. The major parameters relevent to the area include floods, inundation, erosion, deposition, salinity and cyclones.

Floods and Inundation

The rivers of Mahi and Narmada have extensive catchments in the upstreams. The bank zones of these rivers in the study area are prone to flood hazards. Mistry (1989) has reviewed the flood situations in Gujarat and observed that in the Mahi-Narmada area 25% of the years of record have experienced floods. i.e.on an average, one out of four, is an year of flood. During the period of last 65 years Narmada crossed the flood mark at Broach for 17 times.

The Narmada and Mahi rivers aremajor flood threats to the study area. Extensive area along the banks of these rivers get affected to the recurrent floods. Flow exceeding 30,000 cumecs. is considered as flood for the Narmada river.In 1968 the maximum flow was 60,000 cumecs which was the highest recorded flood. Similarly, in 1973 Mahi recorded maximum flood flow of 33,000 cumecs. These floods cause heavy damages in the downstream areas. The gentle gradient and series of meanders aggrevate the flood effects on the bank areas. (Plate VI -1). Dhadhar river having limited carrying capacity of its channel causes flash floods with significant damage.

The land below 13m elevation in the western part is liable to conditions of inundation and water logging. This mainly due to general flatness, lack of sufficient drainage and presence of several lowlying depressions. The low permeability of the top soils also contributes to this hazard. In the days of heavy rainfall, the surface runoff fills the depressions on the ground and then spilling over runs down in irregular sheets, called overflow, increasing in volume and velocity as more and more rain water is added. The inundation is an annual feature for these areas. Many a times the approach roads gets submerged and the nearby villages become unaccessible. Extensive land in the parts of Jambusar, Amod, Vagra and Bharuch talukas are generally subjected to monsoon inundation.

Erosion And Deposition

Land erosion along the banks of the rivers is a serious environmental problem (Plate VI.1). Especially the courses of

PLATE VI.1 A view of Narmada bank erosion and protection wall been constructed Loc. Sinor

PLATE VI.2 Gully erosion on Narmada bank, Loc. near Gadashwar bridge N.H.8

Mahi and Narmada have cut deep channels through their own alluvial flood deposits. The local drains meeting the main rivers generally erode the deposits and extensive development of gullies and ravines have been formed through the unconsolidated sediments (Plate VI.2). The deposits have a blending of aeolian sediments which are generally prove to high rate of erosion. Dhruvanarayana and Rambabu (1983) have estimated soil erosion in India. According to them ravine land covers about 4000 km2 at an annual rate of soil loss 3320 tons per sq km. Sharma et al (1981) have made riverwise estimation of gulley erosion. The three rivers of study area showing distribution of affected land is as under :

	River	Area in ha	
1.	Mahi	61,888	
2.	Narmada	58,142	
3.	Dhadhar	12,086	
	Total	1,33,116	i.e. 1331 sq.km.

This 1,33,116 ha revine area share 12% of the total study area and also accounts for 46% of the total ravine land of Gujarat state.

The gullies have varying dimension; depth 3 to 12 m, bed width 5 to 15 m, side slopes steep to vertical and length 100 m to more than 1000 m. The important factors affecting gully erosion include sediment types, climate, topography vegetation human activity etc. Sharma et. al. (1981) have considered predominant role of vegetation and human actvities in the development of ravine land. Haigh M.J.(1984) has reviewed origin and evolution of India's revines and observed predominant role of neotectonism and human activities. The author considers the uniform particle size of sediments subjected to neotectonic activities to be the major cases of gully development.

The present day active sites of depositions are restricted to river beds, flood banks, estuaries, and intertidal zones along the coast. The two major rivers of Narmada and Mahi having extensive catchment are in the upstream bring enormous quantity of sediments which partly gets deposited in the area. Dhruvanarayan and Rambabu(1983) have studied relationship between average annual erosion and sediment loads for river basins. Accordingly, the basin characteristics of the two rivers are given in Table VI-2.

Thus at an average rate of 400 Tons/ha erosion,total 83.47 M Tons of sediments are brought by the two rivers every year and get distributed over different parts. The river mouth bars and estuarine mudflats progressively grow in their size receiving this high rate deposotion.

Table VI-2 : Basin characteristics and sediment load of Mahi and Narmada rivers.

Basin characters	Unit	Narmada	Mahi & Dhadhar	Total
1. Catchment area	M ha	9.88	3.76	13.64
2. Av. Ann. runoff	M ham	4.01	1.18	5.19
3. Av. Ann. Percipitation	mm	9.88	3.76	13.64
4. Av. Ann Corosion rate	Tons/ha	508	372	440
5. Av. Ann. Sediment load	M Tons	61.37	22.10	83.47

Salinity of Land and Water :

Salinity is one of the major environmental hazard to the study area. The area is affected by two kinds of salinity problems; viz. soil salinity and groundwater salinity. The presence of salinity in the soils can be regarded as combined result of primary and secondary processes as under.

Primary : Inherent soil salinity imparted during the deposition.

Secondary : i) Surface and subsurface ingress of sea water through tidal creeks, and estuaries.

ii) Inundation conditions of land due to poor out fall and inadequate drainage.

iii) Irrigation with brackish water.

iv) Wind borne salts.

About 600 km^2 land along the coast is under the influence of surface ingress and about 1400 km^2 lowlying open land in the western part of Jambusar, Vagra, Broach and Amod talukas shows salinity problem. Thus total 2000 km2 i.e. about 33% land of the study area suffers from salinity hazard. An Expert Committee of the State Government studied the salinity problem along the Mainland Gujarat in depth., The physico-chemical properties of soils related to salinity characteristics as determined by the committee(1984) are given in the Table VI-3.

Table VI-3 - Physico-Chemical Properties of Saline Soils.

S.No.	Property	Value
1.	Moisture holding capacity	28.3 to 57.5%
2.	Infiltration rate	0.12 to 2.90 cm/hr
3.	Permeability	Impervious to 0.57 cm/hr
4.	Salinity (E.h.C)	1 to 15 Millimhos/cm
5.	pH	7.1 to 9.6
6.	Cation Exchange Capacity	8.3 to 51.6 meq/100 gm
7.	Exchangeable Sodium	0.18 to 13.8%

The soils in general are very deep (90 cm) medium to fine textured and 'Heavy montmorillonic clayey' type. The clayey layer has thickness of 7 to 15 m and it is underlained by a sand layer. Depth to water level varies between 3 to 13 m Salinity of the groundwater in terms of TDS ranges from 2000 ppm to 25000 ppm and chloride range from 1000ppm to 6600 ppm.

The groundwater salinity problem is related to the aquifer conditions with respect to nearness of sea and depth below the ground. Total Dissolved Soilds (TDS) show progressive increase as traced towards the coast. Increasing depth of aquifer show progressive increase in TDS content. Distribution of salinity directly reflects the depositional environments of sediments as fluvial/marine and fluctuations in sea level. In the central part of the area the aquifers below 100 m depth have saline waters. Towards the coastal area the saline ground water is met within 5 to lom depth. Many a times brackish water is used for irrigation which degrades the soil fertility. Salinity map showing iso-TDS in study area is given in Fig. V-10 It is seen that TDS content increases progressively from 500 ppm in the east to more than 20,000 ppm towards coast. The area to the west of the line joining Sarod-Jambusar-Vagra Broach covering about 2000 km^2 has saline ground water, unsuitable for drinking, irrigation or industry. Maps showing ground water quality and level of contamination are given in Fig.VI.l.

Cyclones and Storms

The gulf of Khambhat is characterised by strong influence of tides rising as high as 12m. Tracks of tropical cyclones (normalised) in Bay of Bengal, Arabian sea and Indian subcontinent as worked out by Koteshwaram (1974) are shown in Fig.VI-2 Compared to other parts of Indian coast line, the Gulf of Khambhat is less cyclone prone. Saha et al (1984) have worked out 1% frequency of cyclone landfalling for this area.

GROUND WATER CONTAMINATION MAP

FIG VI-1

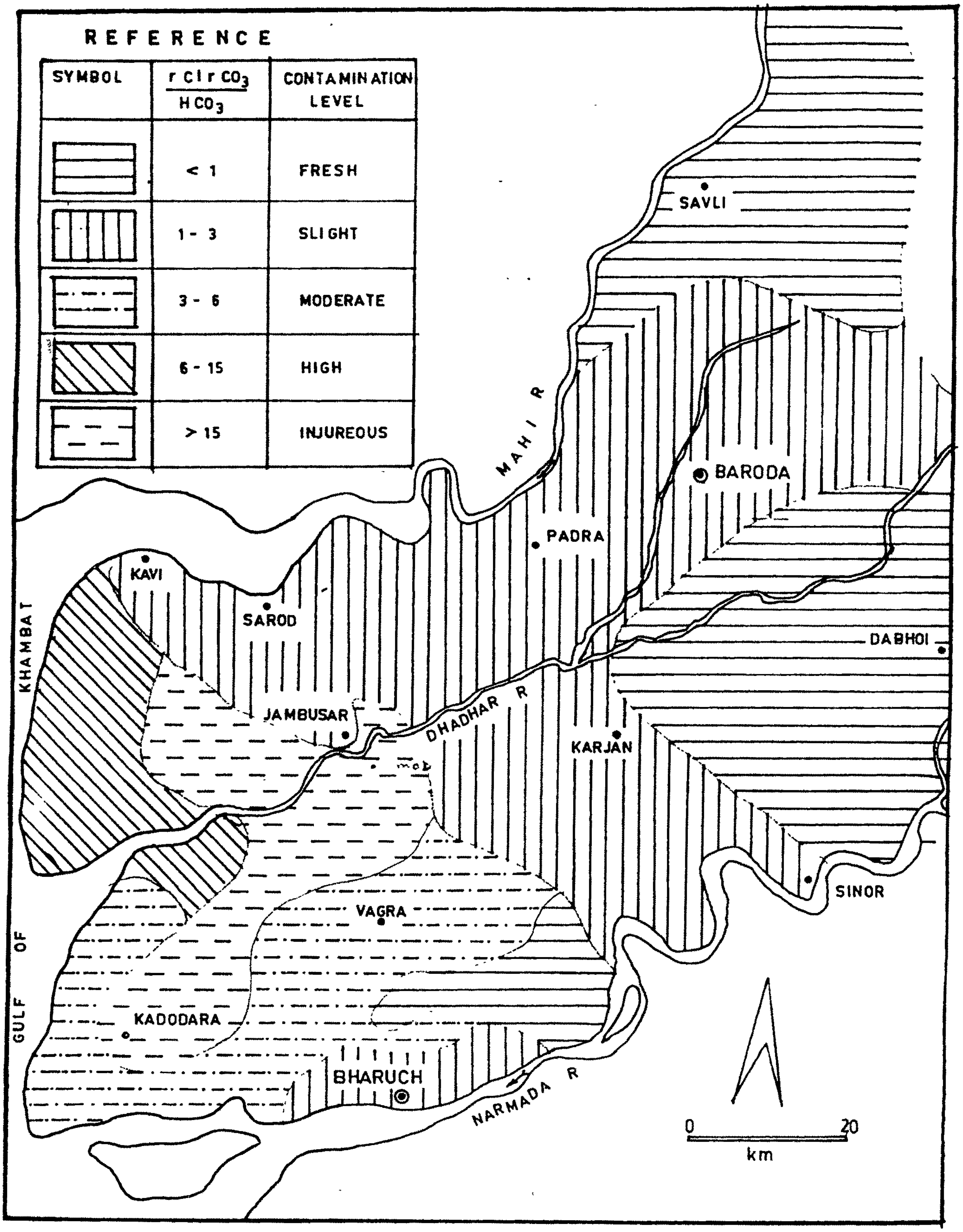
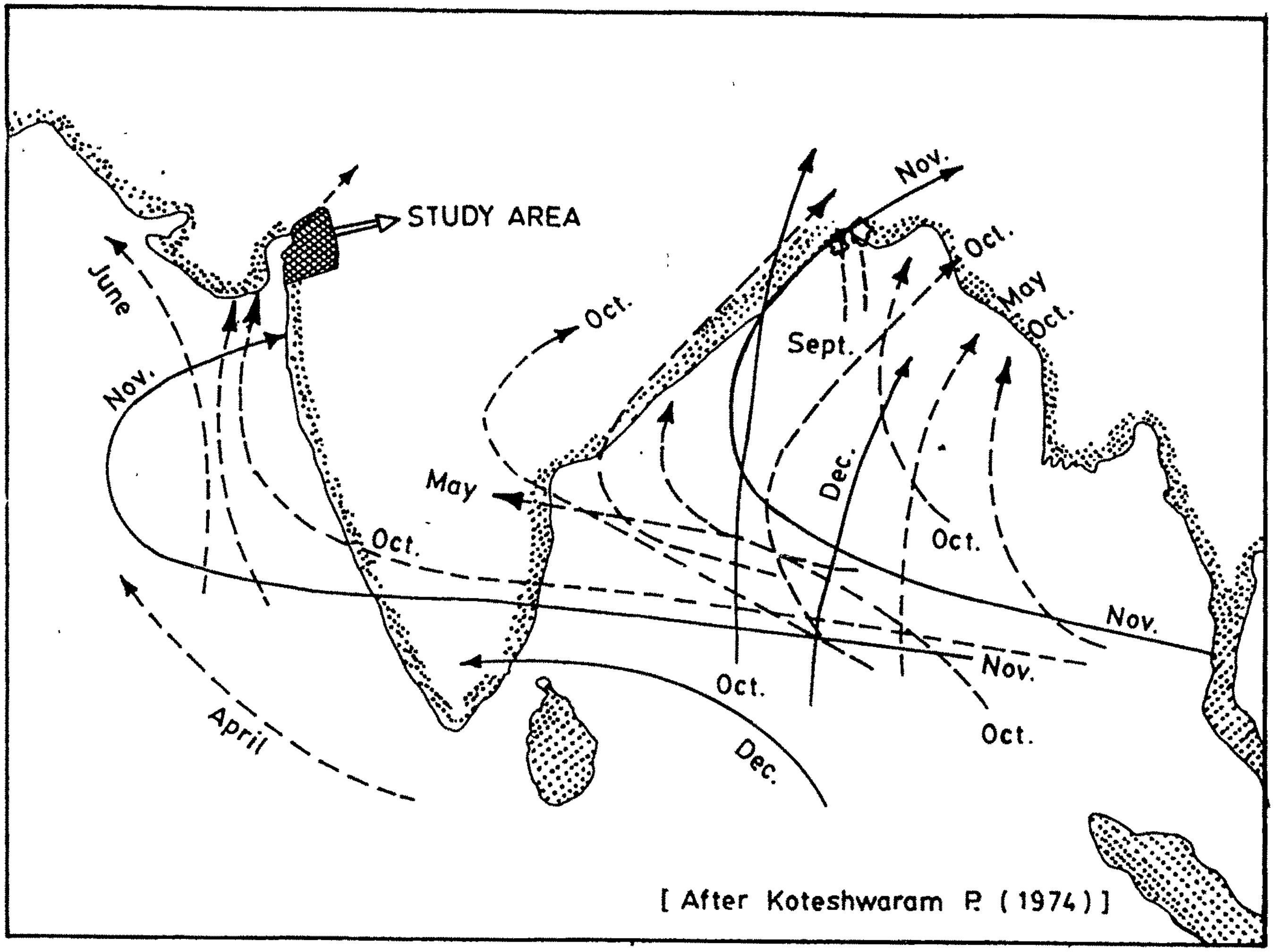


Fig.: VI-2



TRACKS OF TROPICAL CYCLONES

Gujarat recieves rainfall from the southwest winds during June to September. Many a times the storms arising in the Bay of Bengal influence this and combined effect brings rain storms in Gujarat. Mistry(1989) compiled data for the maximum storm rainfall for the past several years as given in Table VI-4.

Table VI-4 Rainfall Storms in Gujarat.

Year	Point Rainfall in mm		
	One day	Two days	Three days
1982	736	1067	1158
1981	440	582	613
1980	470	630	680
1979	481	643	643
1976	502	560	576
1950	396	511	538
1894	450	533	543

HUMAN ACTIVITY

Ever since the human race took to agriculture, the symptoms of deterioration of the environment has been apparent and it aggravated with growth in industry and similar activities. Result of the human activities based on resource exploitation also add to the list of earlier discussed environmental parameters. The important human activities could be taken as agricultural practices, industry and urbanisation (Plate VI.3).

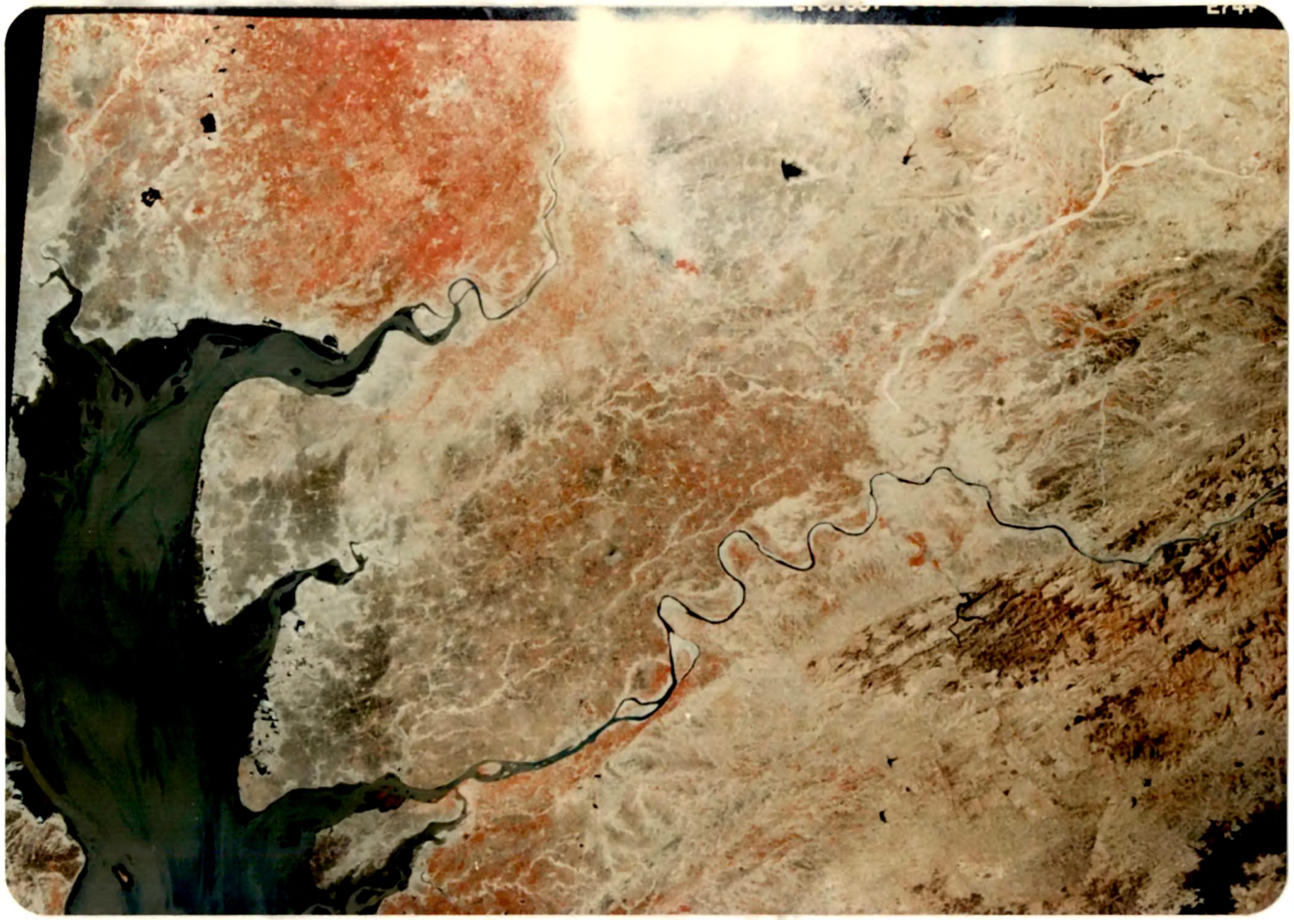


PLATE VI.3 A view of the LANDSAT-5, dt. 9th Nov. 1986 (TM Band 23 and 4) showing landuse characters, vegetation cover (red colour shade), drainage system, etc.

Agricultural Practices :

About 83% land of the study area is under agricultural use. Forest land is only 0.5%. The rest 16.5% land is under other uses. Agriculture is well developed in the area. Main source of irrigation is ground water (Plate VI.4). As per 1983-84 survey by the State Ground Water Development Corporation there were 1987 dug wells, 9387 dug-cum-bore wells, and 601 tube wells. All these sources account for 390 Mm^3 annual draft of water for irrigation 9105 ha. Surface irrigation at present is very limited. It is mainly thruogh small size storage tanks located along the eastern border of the study area. About 33% area in the west being affected by salinity hazard is not suitable for ground water irrigation. The entire area is to be covered under the Narmada Project Irrigation Command. Surface water irrigation map of the study area is shown in Fig.V-2. The study area is thus planned for full irrigation development in the very near future and a proper balance will have to be maintained between the irrigation water applications and soil and land capability since, the area is prone to environmental hazards related to salinity, water-logging, drainage, land erosion e c.

Industry and Urbanisation :

The central part of the study area is heavily loaded with a large number industrial growth centres. Close crowding has taken place along the main communication link of national highway and broad guage railway passing through the central part of the area.

PLATE VI.4 A view of the irrigated land by tube well, Loc. near Karjan

PLATE VI.5 Dhadhar river section through alluvium and bed with stagnant pool of polluted water Loc. Near Por. N.H.8

The area around the cities of Vadodara and Bharuch has maximum concentration of idustries. Rapid urbanisation around the industrial centres has cropped up during last two decades. The decennial population growth rate of urban area is against the rural areas of 20.6%. These urban areas lack basic amenity of sewerage disposal. The industrial waste is normally discharged into the lowlying areas around factories from where it passes into the streams and rivers. (Plate VI -5). The major industrial units near Baroda have made arrangements for large scale treatment of the waste near Sarod carrying for about 40 km long canal (Plate VI.6). But the polluted waste is utilised for irrigation by the people on the way (Plate VI.6). Thus the pollutents enter the soil and ground water aquifers. The studies by Gujarat Pollution Control Board (1988) showed that the pH, DO, BOD, NH and N values in Mini, Vishwamitri and Dhadhar of the study area alongwith several other rivers in the state have crossed the critical limits and waters are harmful for both fauna and flora. The decrease in Dissolved Oxygen levels is also noticed in majority of streams in these areas. A map showing the pollution in river waters in Gujarat based on works of Gujarat Pollution Control Board(1988) and Phadtare (1988) is shown in Fig. VI.3.

GEO-ENVIRONMENTAL ZONNING

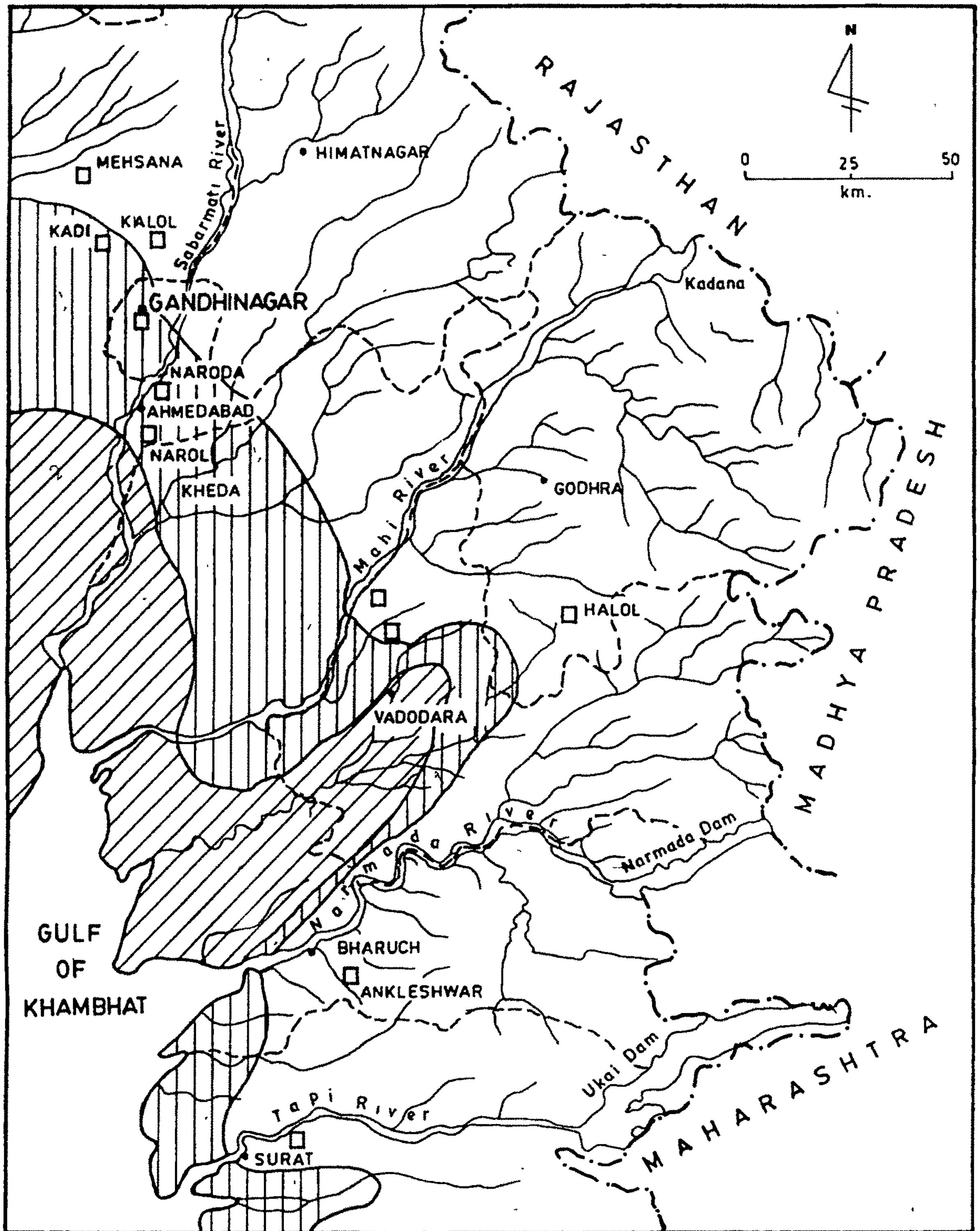
Taking into account the relative impact and intensity of different environmental factors discussed above, the study area has been divided into four major Geo-environmental Zones are given in the Table VI-5

PLATE VI.6 A view of showing the effluent channel project, Loc. near Sarod

PLATE VI.7 A view of the IPCL effluent cannal being pumped and used for irrigation, Loc. near Sarod

FIG- VI- 3

INDUSTRIAL POLLUTION IN SOUTH CENTRAL GUJARAT



(After G.P.B.-1988, Phadtre P.N.-1988, C.P.C.B.-1988)

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Table VI-5 : Geo-environmental zones of study area

Zone	Name of area	Notation	Area km^2 (%)	Category
I	Central Alluvium	CA	2400 (40)	Sensitive
II	Eastern Upland	EU	900 (15)	Stable
III	Revine Land	RL	700 (12)	Fragile
IV	Costal Saline Land	CS	2000 (33)	Fragile

A map showing distribution of the geo-environmental zones is given in Fig. VI.4. Based on impact assessment of each parameter an overall evaluation of each environmental zone has been attempted. Qualitative rating score and its parametric impact is considered as 1=Low, 2= Modera e and 3 = High. For evaluation total score index assigned as A for less than 10, B for 11 to 15 and C for more than 15. Accordingly, an overall evaluation for individual zone is given in Table VI-6.

Fig.-, VI-4 GEO-ENVIRONMENTAL ZONING MAP OF STUDY AREA

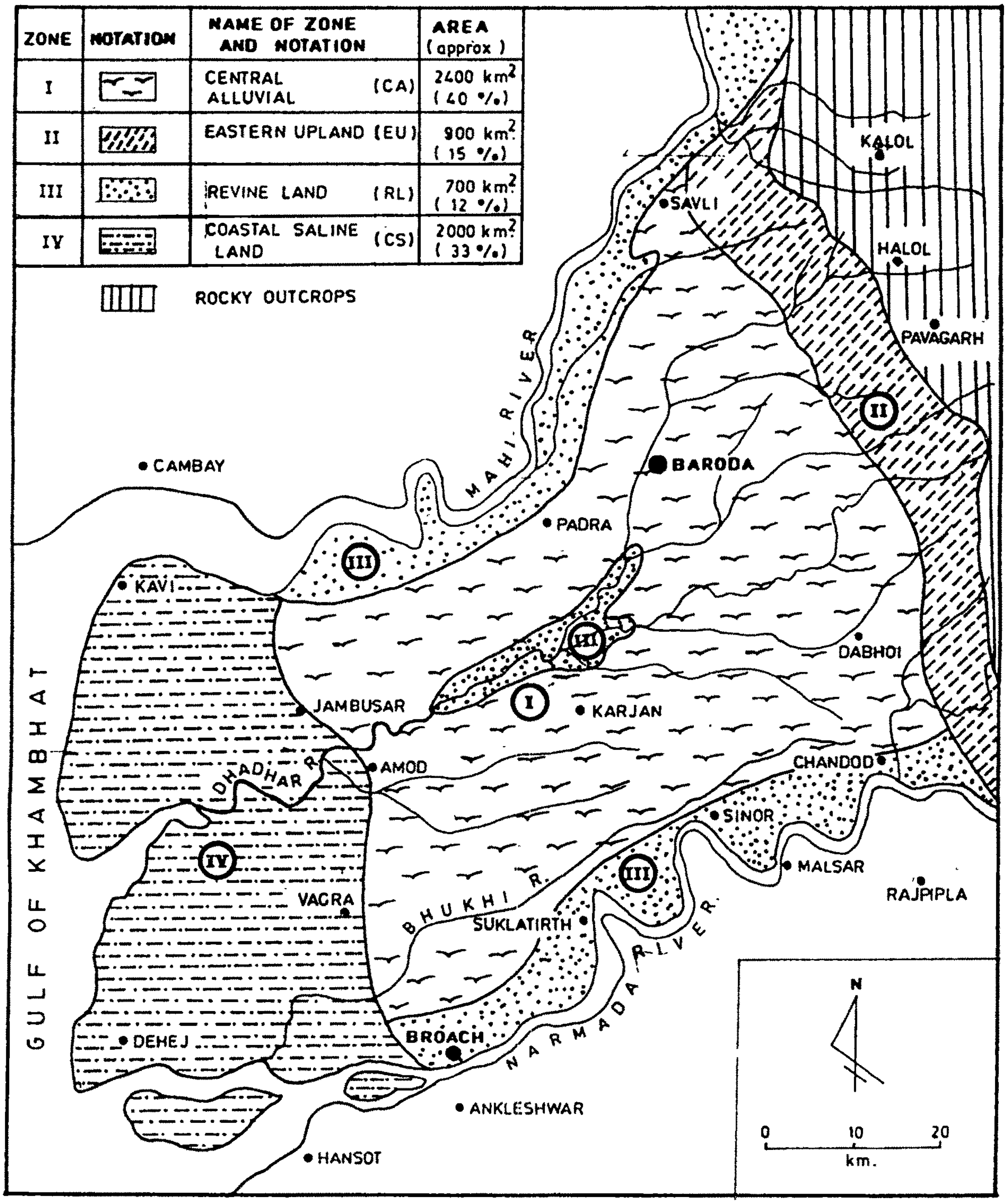

Table VI-6 - Qualitative evaluation of the geo-environmental zones.

Geo-environmental Parameters	Zone I Central Alluvium (CA)	Zone II Eastern Upland (EU)	Zone III Ravine Land (RL)	Zone IV Costal Saline Land (CS)
1. Seismicity	2	1	2	3
2. Floods and inundation	2	1	3	3
3. Erosion and Deposition	1	2	3	2
4. Salinity of land and water	1	-	1	3
5. Cyclones and Storms	2	1	2	3
6. Agricultural Practices	3	2	2	2
7. Industry and Urbanisation	3	2	3	2
Total Score	14	9	16	18
Evaluation Index	B	A	C	C
Category	Sensitive	Stable	Fragile	Fragile
Area Overall	------------- Sensitive -------------			

The central alluvial zone has its 'sensitive' character mainly due to higher concentration of human activity, otherwise its natural environments are quite stable. While in the Eastern upland zone, show stable nature mainly due to amicable natural environments and human activity a well within the absorbing capability of the terrain resources. The other two 'fragile' category zones of coastal saline land and Ravine land are subjected to hazardous natural environments. The total 2700 km^2 of the study area being sensitive, it calls for appropriate management strategy of the environmental conservation.

MANAGEMENT STRATEGY

Detail knowledge of the geological processes plays a crucial role to understand, preserve ameliorate and restore the mechanism of various earth processes that not only give rise to mineral deposits, development of soils, permit movement of surface and underground waters and also shapes terrain morphology and landscapes. Knowledge of the characters and capabilities of the terrain, permits scientifically sound and ecologically appropriate development of the resources for optimum benefit and minimum damage. Keeping this in view, management aspects for each parameter are identified as under :

1. Seismicity and Cyclones

   i) Strengthening of the existing civil structures.

   ii) Providing appropriate risk factor in the design of the proposed and under construction civil engineering structures.

   iii) Preparing hazard preparedness plans training of concerned agencies and public awareness programmes.

2. Floods and Inundation

   Design of dam reservoir projects across Mahi and Narmada have included flood control measures. Effective warning system and evacuation arrangement of preidentified areas be provided.

ii) Adequate drainage and waterways provided by adopting proper channelisation programme to all identified areas that are prone to inundation and flooding.

iii) Enchroachment of habitation along natural drain courses be checked.

iv) Effective storm water drains be provided to all inundation prone areas.

3. Land Erosion

i) Gully plugging and peripheral bunding.

ii) Afforestation and grassland development.

iii) Soil conservation measures by contour bunding.

4. Salinity of Land and Water

i) Tidal regulators

ii) Earthen Embankments near the coast.

iii) Construction of check dams for fresh water storages.

iv) Developing grass and bushes of salt tolerent species.

5. Agricultural practices

i) Planning conjunctive use of surface water and ground water for irrigation in view of planned development of perennial canal irrigation from Narmada Project.

ii) To control the use of chemically contaminated ground water for irrigation to stop further degradation of soil quality.

iii) To provide sufficient surface and sub-surface drainage in the identified areas, prone to water logging and salinity hazard.

iv) Controlled use of chemical fertilisers, pesticides, etc. and to stop using the toxic industrial effluent for irrigation to safeguard against pollution of soil and water.

v) Adoption of suitable crop pattern to maintain soil fertility on sustained basis.

6. Industry and Urbanisation

i) To check the over development of certain industrial growth cen res e.g. those in the vicinity of Vadodara and Bharuch.

ii) To ensure efficient treatment and safe disposal of industrial waste.

iii) To regulate the imbalanced population growth of urban and rural areas.