CHAPTER - IV

TERRAIN RESOURCES - I :

LAND, SOILS, AND MINERALS

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TERRAIN RESOURCES : I

LAND, SOILS AND MINERALS

INTRODUCTION

The geomorphic and hydrometeoric conditions of any area are the important factors that determine terrain capability for evaluating the potential of basic resources like, land, soils and minerals. Basic and applied aspects of the geomorphic and hydrologic regime of the area have already been discussed in the preceding chapters which provide suitable background for analysing the land resources. The nature of geo-climatic environments operated during the late Quaternary period have been discussed in good details in the earlier chapter is very useful in understanding the genetic aspects of land base, resources. In this chapter a brief account of the occurrence and utilisation and management of the various resources is given.

LAND CAPABILITY

Land is not only a basic resource but also a cherished asset. It has to be utilised with its suitability and ecological capability. Unbearable pressure of growing population and its related activities cause overuse and over-exploitation. The injury thus inflicted on the land may well result in irreversible situation. It calls for appropriate land use planning based on optimal use of land in accordance with its suitability and capability. Land utilisation should be managed as to satisfy the basic needs of human beings like food production, shelter, recreation, communication, transportation etc. Extreme care must be taken in planning the landuse particularly, in selecting sites for industries, reservoir dams and in expansion of towns and cities. Another essential consideration of landuse planning is to recognise the need to keep the land fallow after a particular activity is completed, and restoring degraded land. Fertile agricultural land is permanently lost in the processes of urbanisation.

The carrying capacity of land in terms of its productivity and its ability to support various human activities are the primary basis of identifying land capability. Such studies help securing maximum amenities from the terrain at the cost of minimum ecological distress and reasonable economic expenditure. Land capability rating and mapping are being attempted by several workers viz. Turner and Coffman (1973), Keller (1982), Shafi (1982), Pofali et al (1982), Anderson et al (1976).

Shafi (1982) recognised three major categories of agricultural land on the basis of quality as shown in Table IV.1.

Table IV.1 Agricultural Land Catogories

Land Category	Land Quality	Productivity	Characteristics	Uses
I	Good	2	Thick mantle of nutrient rich soils.	Intensive cultivation
II	Medium	1	Wearing thinner soil carpet.	Farm land
III	Poor	0.5	Poor quality soil cover; poor lands & degraded lands.	Light Agri-culture and grass

On the basis of productivity rating index, it is observed that use of 1000 ha of good land for non-agricultural purposes implies a loss of 2000 ha, while if poor category land is taken, the actual utilisation would be 500 ha. It means conversion of good agricultural land for other purpose, the actual utilisation is 4 times of its area. In the study area, due to rapid rate of urbanisation, large hectarege of good quality land is converted to nonagricultural uses which implies that a great proportion of misutilisation of the precious resource. The land falling in the Baroda - Broach industrial zone suffers from this kind of practices.

Oslon (1981) proposed agricultural land classification into eight different classes based on degree of limitations and the risk of soil damage. Accordingly, the land of the study are be grouped into three major categories as in Table IV.2.

Table IV.2 : Agricultural land categorisation of the study area

Category	Locations \ Oslon Class		Characteristics
A	Land in the central and eastern parts.	I	Best quality of soil suffering least from limitations and exposed to minimum risk of damage.
		II	Soil suffering from some deficiencies and damage that can be corrected by moderate conservation measures.
		III	Soil suffering from severe maladies which limit the choice of plant types and require special treatment to restore it to its original health.
B	Land near coast and ravine areas.	IV	Very sick soil so that only very few types of plants can grow. The treatment has to be intensive and careful.
		V	Excepting erosion, the soil suffers from other maladies so that land cannot be used for agriculture.
		VI	Land wholly unsuitable for agriculture, but quite suited for pastures, forests and wild life sancturies.
C	Land along the coast line and estuary banks	VII	Soil suffering from many limitations so that the land can be used only for grazing, commercial plantations and wildlife sancturies.
		VIII	Severely sick soil unsuited for growth of vegetation of any kind so that the land can be used only for developing recreation parks, water-resources development, etc.

A map showing agricultural land categories of the study area is shown in Fig. IV.1.

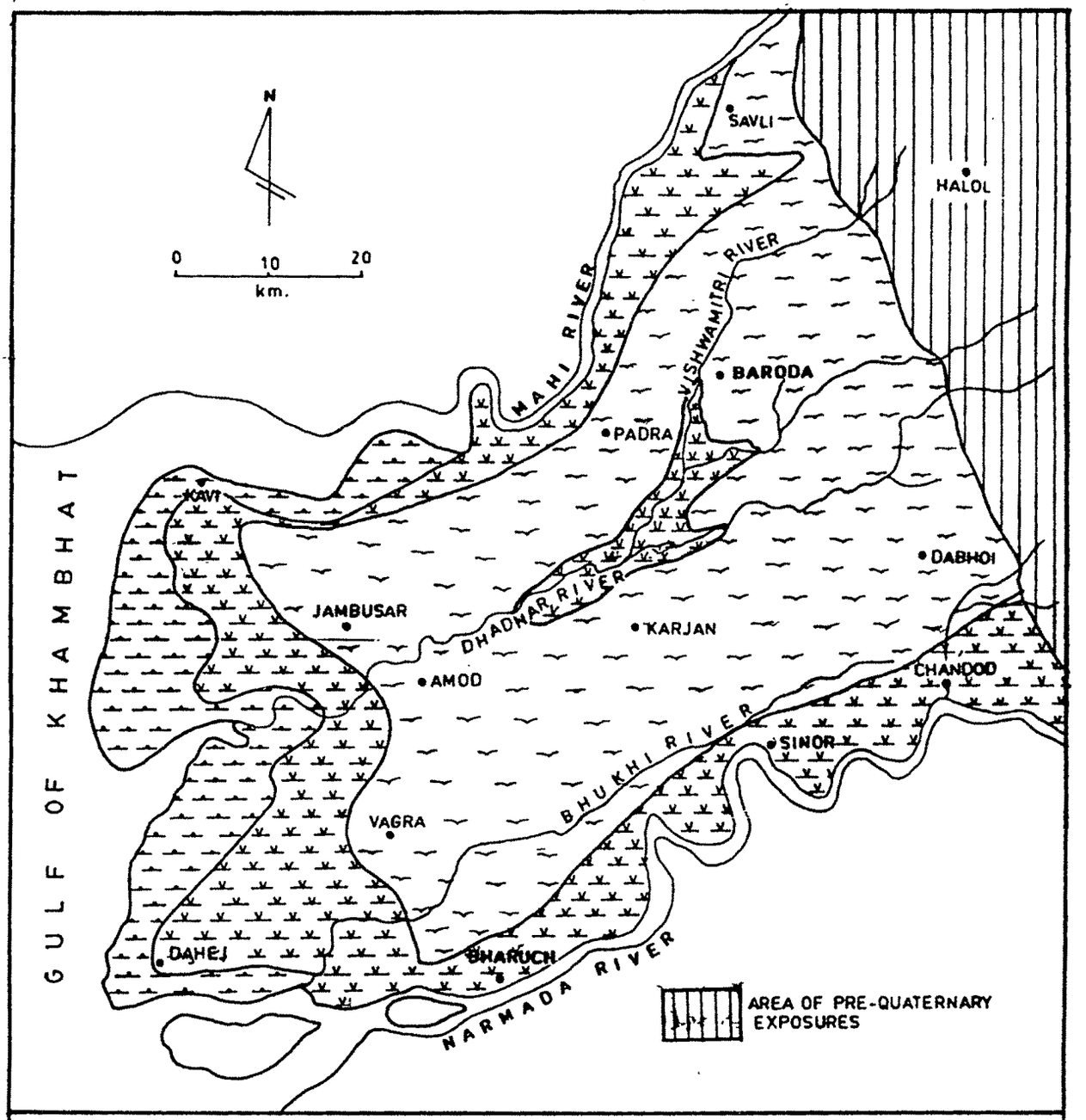
As per above classification the land of the study area that fall under 'B' and 'C' category have good scope for development. Central Soil and Water Conservation Research Centre (CSWCRC) located at Vasad, carrying out various pilot studies for ravine land improvement. However, no serious attempts for the coastal land improvement are yet been made. The 'A' category good quality land is under constant threat from degrading effects of neighbouring areas of inferior category. All this land is to be covered under canal irrigation from the on going Narmada project and intensive use of water, chemical fertilisers and pesticides etc. are quite likely to adversely affect the fertility if these applications are not carried out with due care.

In view of the high rate of urbanisation in several parts of the study area, the land management strategy should consider specific geological aspects as per the intended uses. Scheme for Urban landuse planning as proposed by Keller E.A. (1982) is very relevent for the study area. It is shown in Fig. IV.2. In the process of growing urbanisation where no space is available for asthetic and recreational activities development of slums takes place.

The classical approach of standard land classification from administrative facility point view which is being generally

FIG IV-1

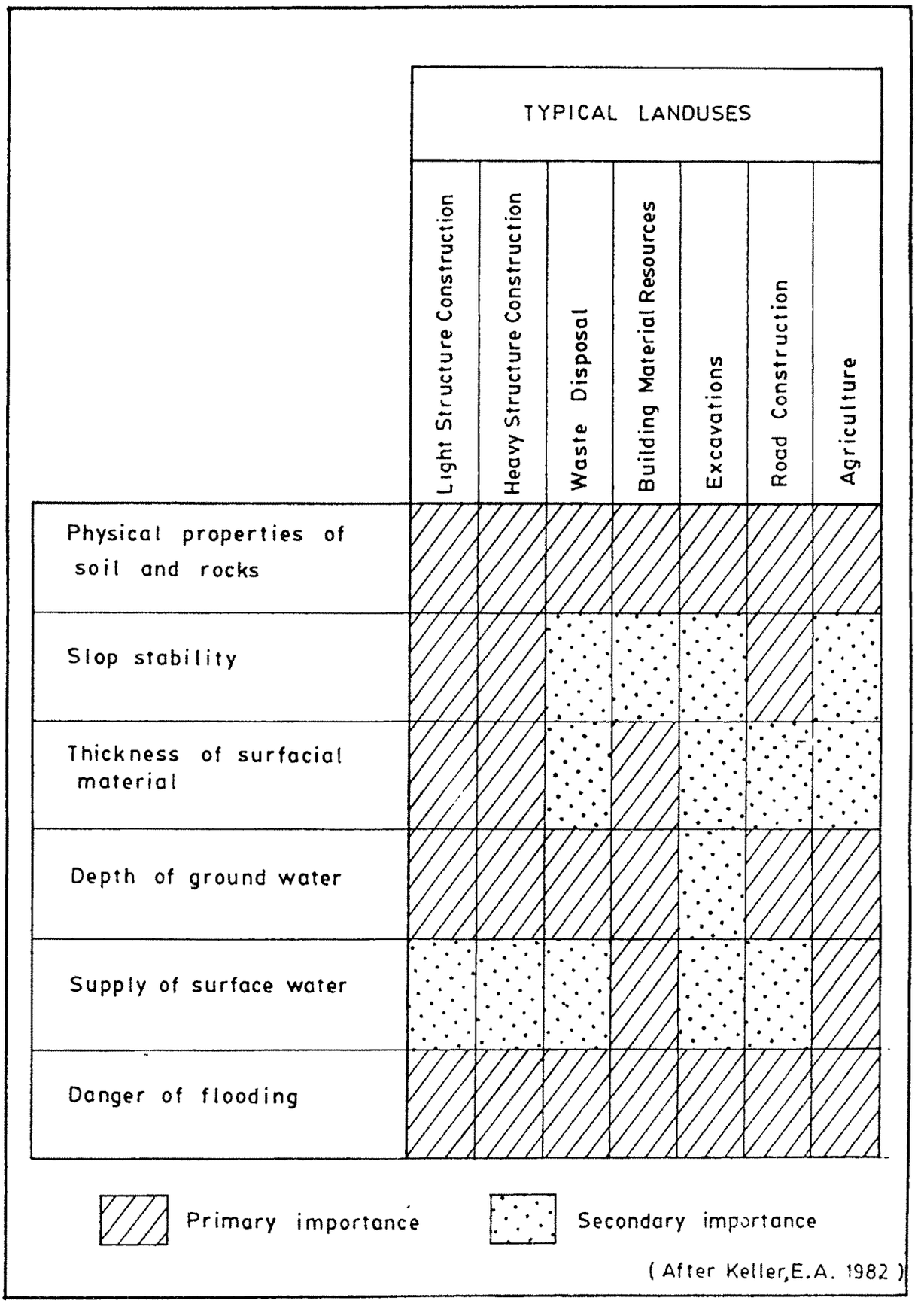
MAP OF AGRICULTURAL LAND CATAGORIES OF STUDY AREA



SYMBOL	CATAGORY	SOIL QUALITY	LAND STABILITY	LAND CLASS (OSLO-19)	APPROX AREA km^2 (%)
	A	GOOD TO BEST	MINIMUM	I and II	3700 (63)
	B	MEDIUM TO GOOD	MAXIMUM	III to V	1600 (26)
	C	VERY POOR	MODERATE	V to VIII	700 (11)

FIG- IV-2

GEOLOGICAL PARAMETERS RELATED TO URBAN LANDUSE PLANNING



(After Keller,E.A. 1982)

followed. Anderson et al (1976) have proposed a landuse and land cover classifications system using remote sensing data, keeping in view the natural resources of the terrain. To this approach, they call 'Resource Oriented' as against 'People Oriented' of the standard landuse system. The patterns of resource use and resource demand are constantly changing and remote sensing techniques facilitate the land use mapping with considerable ease and accuracy. They have proposed a classification upto IV levels depending upon the scale and resoultion details of the imagery, air photo etc. In the present context of the fast changing pattern of the landuse the proposed classification is more useful. Pofali et.al (1982) emphasised environmental approach in landuse planning and attempted a broad landuse classification for Gujarat. Employing remote sensing data they have divided the state into 11 different geomorphogenetic regions. Region wise details about present landuse and proposed landuse is given in Table IV.3. Our study area falls in the two regions of sub-humid plain and coastal plain. (Fig. IV.3).

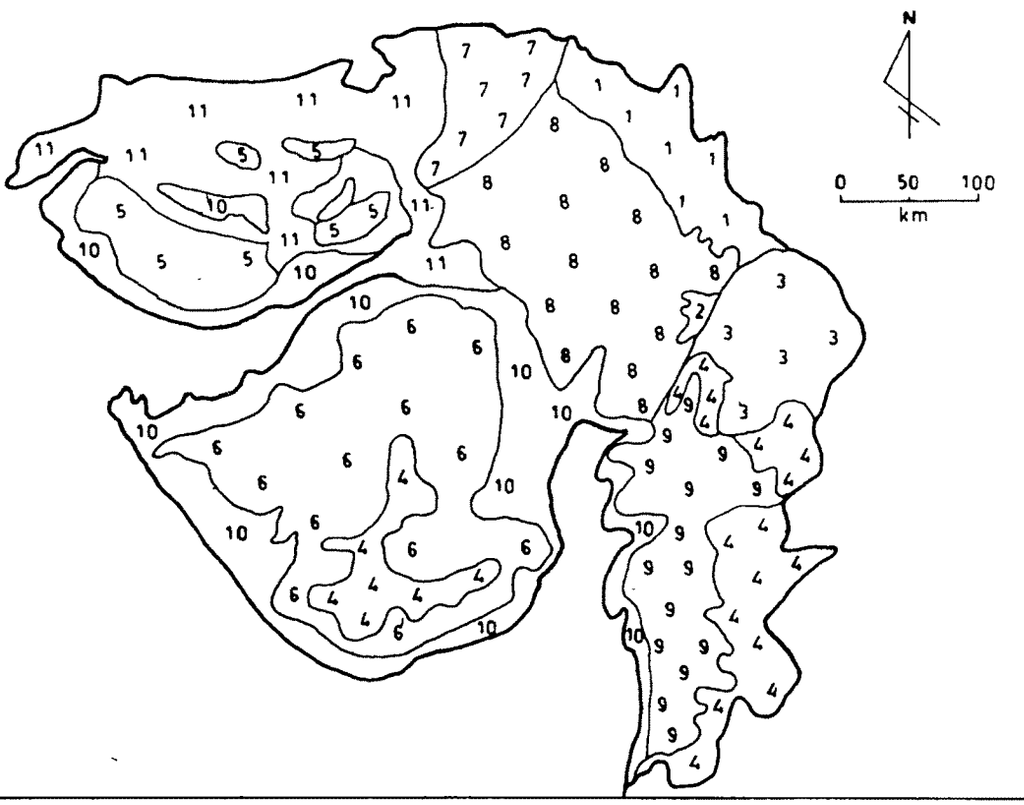
In the present day context of high rate resource exploitation activities in the area, the modern approach of landuse mapping involving geomorphogenic and geo-environmental parameters are very relevent.

Table IV.3 : Geomorphogenic Regions, Present and Potential Landuse for Gujarat State

Unit No.	Gemorphogenic Regions	Present Landuse	Potential Landuse
1.	Semi-arid metamorphic hilly terrain	Tropical dry deciduous forest, scrub and grass and cultivated to Sorgham rice, pulses, groundnut, cotton, etc.	Improvement of range land by soil and moisture conservation, afforestation, controlled grazing, development of semi pastoral farming, provision of wind breaks withholding sand movement development and management of irrigation resources including run off and gully pluggin.
2.	Semi-arid basaltic hilly terrain	Tropical dry deciduous forest, scrub and grass-land, cultivated to groundnut, sugarcane, pulses.	Conservation of soil and water by reducing run off and gully plugging, afforestation, controlled grazing and development of semi ecological pastural terraces, for maintainence of ecological balance, development of irrigation resources.
3.	Sub-humid metamorphic hilly terrain	Tropical dry deciduous forest, scrub, and grass land, cultivated to cotton, pulses, rice and ground nut.	-do-
4.	Sub-humid basaltic hilly terrain	Tropical semi-evergreen tropical moist and dry deciduous forest cultivated to cotton, rice, sorghum, pulses and groundnut.	-do-
5.	Arid sedimentary ridges, hommocks and peidmonts.	Scrub and grass land cultivated to pulses cotton corghum, perl millet, groundnut and wheat.	In addition to recommendation mentioned in unit II, development of live stock forming and sheep husbandary.
6.	Semi-arid basaltic plateau	Tropical dry deciduous forest, cultivated to groundnut, sorghum, pearl millet, pulses & cotton.	Development & management of irrigation resources soil and moisture conservation, bunding, contour cultivations and mulching restructuring of cropping pattern adopted to dryland and irrigation agriculture.

7.	Arid Plain	Scrub and grassland cultivated to pearl millet, sorghum and pulses.	Checking of soil erosion & moisture conservation, planning adaptable species, harnessing of rain water by constructing of farm pools. Construction of wind barriers for the stabilisation of sand dunes, cultivation of short duration crops, development of live stock farming and sheep husbandary, reclamation of saline patches.
8.	Humid plain	Scrubs and grass, waste land cultivated to cotton, sorghum, wheat rice and pulses.	Development and management of irrigation resources, adoptable of soil and water conservation measures by bunding, foresting, struturing and development of farm ponds, restructuring of cropping pattern suited to rain and soil conditions, minimize the ever exploition of ground water, reclamation of gulled land and sand patches.
9.	Sub-humid plain	Tropical dry deciduous forest scrub and grass land, waste land, cultivated to rice, cotton, mangoes and chickoos.	Development management of irrigation resources adaptable of soil conservation measures, reclamation of ravine lands, introduction of agriculture, restricted irrigation.
10.	Coastal plain	Scrub and grass land wasteland, marshy land cultivated to groundnut, pearl millet cotton, wheat, pulses and coconut.	Conservation of fresh water, constuction of embarkment across the esturicies and tidal inlets, construction of shelter belts to the migration of coastal dunes, plantation of salt resisting species, raising field levels and provision of channels to drain saline water, applications of sweet water, and amendments to reduce salinity.
11.	Rann	Sandy waste	Construction of barriers to check ingress of saline sea water and migration of coastal dunes, development of pastural farming and

FIG IV-3 **GEOMORPHOGENIC REGIONS OF GUJARAT**



REFERENCE

1	SEMI-ARID METAMORPHIC HILLY TERRAIN
2	SEMI ARID BASALTIC HILLY TERRAIN
3	SUB HUMID METAMORPHIC HILLY TERRAIN
4	SUB HUMID BASALTIC HILLY TERRAIN
5	ARID SEDIMENTARY RIDGES SHOMMOCKS AND PEDIMENTS
6	SEMI ARID BASALTIC PLATEAU
7	ARID PLAIN
8	HUMID PLAIN
9	SUB HUMID PLAIN
10	COASTAL PLAIN
11	RANN

(After POFALI et. al ; 1982)

PRESENT LANDUSE PRACTICE

The term landuse generally refere to its utilisation from economic point of view. As per 1981 census, the distribution of land in the ten talukas of study area is as under :

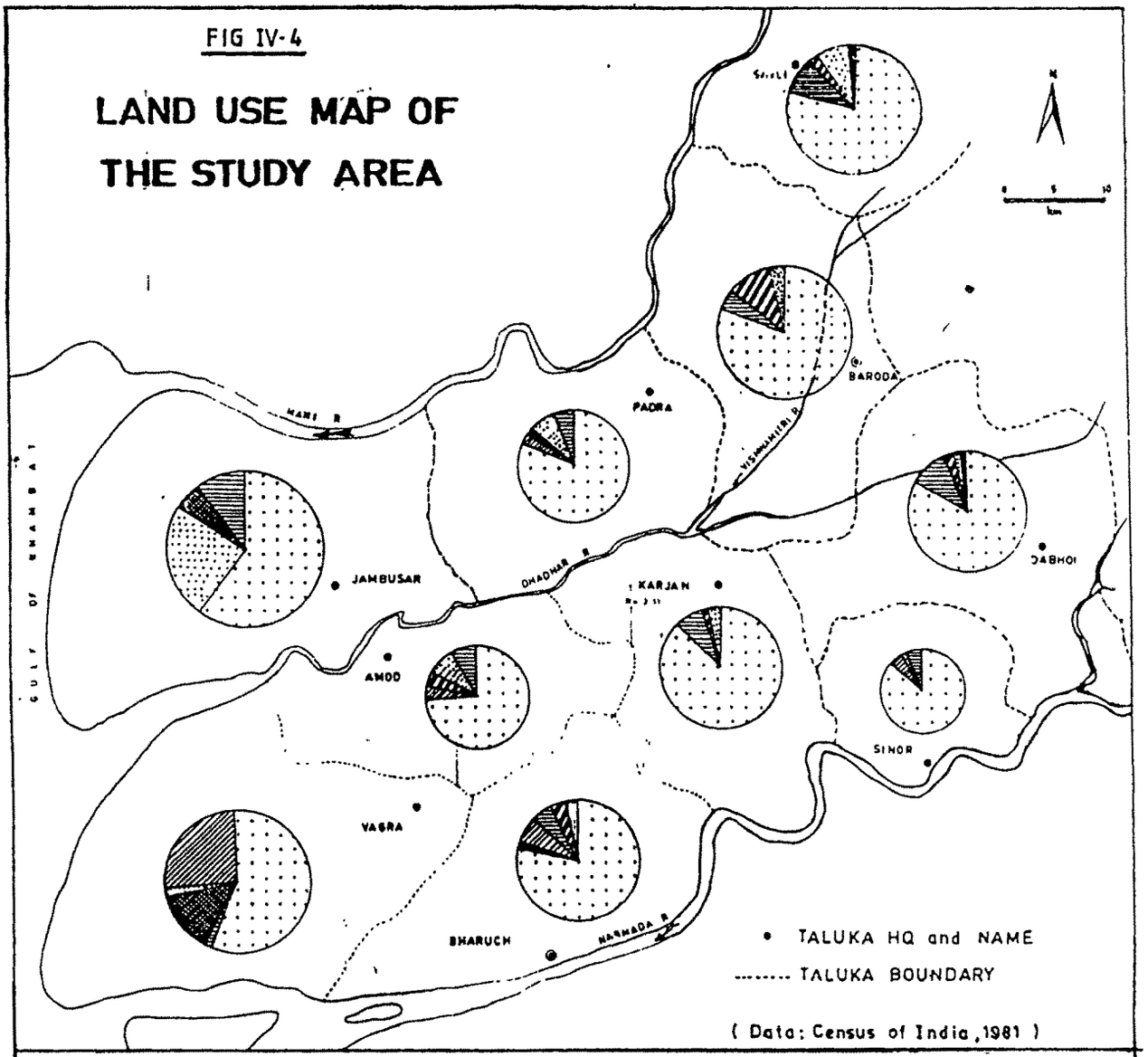
Land Use	Area in %
A. Land available for cultivation	
(i) Net cropped area	76.02
(ii) Cultivable waste land	3.38
B. Land not available for cultivation	
(i) Unclutivable waste land	7.51
(ii) Non agricultural uses	2.44
(iii) Grazing and pastuar land	4.47
(iv) Miscellaneous use	5.66
(v) Forest land	0.52
Total =	100.00

Talukawise percentage distribution of land under different uses is shown in Fig. IV.4 and Table IV.4.

It is seen that 79.4% of total study area is available for cultivation, while uncultivable waste land is only 7.51%. Thus, the land is under two main uses as agricultural and non-agricultural.

FIG IV-4

LAND USE MAP OF THE STUDY AREA



REFERENCE

A LAND AVAILABLE FOR CULTIVATION (76·5 %)

- NET CROPPED AREA
- CULTIVABLE WASTE AND OTHER FALLOW

B LAND NOT AVAILABLE FOR CULTIVATION (23·5 %)

- UNCULTIVABLE WASTE LAND
- GRAZING LAND
- NON-AGRICULTURAL LAND
- MESCALLANEOUS LAND
- FOREST LAND

NOTE :- Divided circles are in proportions to Taluka area

TABLE : IV.4. Talukaswise Distribution of Land under different uses

Sr. No.	Taluka	Total area in ha	Land available for cultivation		Land not available for cultivation					% of total study area
			Net cropped area %	Cultivable waste and other follow %	Uncultivable waste land %	Non-agricultural land %	Grazing land %	Misc land %	Forest land %	
(A)	Baroda Dist.									
1.	Vadodara	67494	75.30	0.99	3.24	12.47	5.18	0.16	0.04	10.25
2.	Savli	80197	78.19	0.59	0.54	2.61	9.03	-	0.042	12.18
3.	Dabhoi	63730	63.10	0.89	2.09	2.95	10.97	-	-	9.68
4.	Padra	53970	80.52	-	7.76	-	3.20	6.16	2.36	8.19
5.	Sinor	31658	32.29	-	0.56	-	4.7	7.41	-	4.80
6.	Karjan	62389	86.21	0.54	2.75	0.76	09.99	-	-	9.47
(B)	Bharuch Dist.									
1.	Bharuch	67004	78.1	0.6	2.9	5	8.8	4.6	-	10.17
2.	Jambusar	109939	61.0	5.00	2.4	8	-	2	-	16.70
3.	Amod	47347	82.38	0.27	6.38	-	2.63	8.34	-	7.19
4.	Vagra	74577	71.85	11.05	2.11	-	1.04	7.8	0.14	11.36
Total Study area (ha)		658305	500483	22275	49453	16083	31430	37317	1264	100
(%)			(76.02)	(3.38)	(7.51)	(2.44)	(4.47)	(5.66)	(0.52)	

Data Source : Census of India, 1981.

AGRICULTURAL USES

Agriculture is the mainstay of the economy of the area and 69.78% of the total reported land area is used for agricultural cropping. The variation in cropping is influenced by the factors of terrain morphology, soil fertility and availability of water for irrigation. The main crops of the land are cotton, jowar, peddi, wheat, banana, bajri (millet) tur, etc. In addition to this; fruit, vegetables and fodder crops are also grown. About 14% of the total land of the study area is under irrigation. Out of which 92% is irrigated by wells (ground water) and 8% is by surface irrigation sources. The lower percentage of land under plough in the western parts and along the river banks i.e. parts of Jambusar, Vagra, Padra, Bharuch talukas) is on account of adverse effects of the various factors like salinity in soils and water, gully erosion etc. The central and eastern parts of the area (i.e. parts of Vadodara, Karjan, Dabhoi, Savli talukas) more than 83% of land is used for cropped cultivation due to suitable land irrigability factors and it accounts for higher agricultural produce.

There is over development of industries along the national highway joining Baroda and Broach in the central part of the area and steadily growing industries along the state highway joining Savli and Tilakwada in the eastern part of the area are attributed to conversion of good amount of rich agricultural land into non-agricultural uses.

Towards the western parts of area i.e. in Jambusar and Vagra talukas higher proportion of land (5 to 17%) is cultivable waste and other fallow land. It is due to salinity influence to soil as well as ground water. In the near future almost all the cultivable land will be covered under canal irrigation of the Narmada project.

Non-Agricultural Uses

The saline waste land and ravine land are not suitable for agricultural purpose and there is considerable portion along the river banks and along the sea coast fall under this category. The problem of salinity, alkalinity and erosion have tendency to enchroch the neighbouring good agricultural land. Such bad-land comprise about 8% of total study area. The land under other miscellaneous use is 5.66% and there is more and more land is progressively added to this every year on account of high rate of urbanisation and industrial growth. The grazing and pastural land is only 4.47%. However, major nurishment to cattle is from fodder crops and other processed cattle feeds. 2.44% of the land used for habitation and other related purposes like roads and buildings, is proportional to population and other developmental activities. It is evidently seen that in Baroda, Broach and Jambusar talukas have relatively higher proportion of land under such uses.

The geomorphological set-up of the area has broadly controlled the present landuse practices. It is observed that variations in use pattern within the study area are along E-W direction is quite remarkable than that along the N-S direction. This is in accordance to the natural variation pattern of terrain capability and availability of natural potential.

SOILS

Besides land, soil is equally precious resource. Soils comprising ultimate products of rock weathering intermixed with biogenic organisms and interspaces filled with moisture and air have their own microclimate and basic geological material. Soils, thus forming a carpet of variable thickness over the land has sustained a succession of life and civilisation providing food, fodder, fibre and fuel supporting shelters and dwellings including major civil structures. Soil is integrately connected with rocks around, vegetation above and percoalating water through it.

The soils of the area are of typical alluvial origin. On the basis of textural characters these transported soils have been divided into three broad groups as under :

i) Alluvial Sandy Loam

It is medium to deep of uniform nature with moderate to high permeability and derived from Precambrian crystallines

blended with aeolian sands. It covers about 30% of the area in the north eastern parts mostly along the Mahi river bank.

ii) Black Soil

It is medium to deep having clayey loam texture and neutral to alkaline reaction with medium permeability and mainly derived from Trappean Basalts. It covers about 55% of the study area in south central and eastern parts.

iii) Saline - Alkaline Coastal Alluvial Soil

It is deep to very deep, poorly drained, clayey loam, with high salt content giving strong alkaline reaction, mainly formed under marine inundation conditions. It covers about 15% of the study area along the coastline.

MODERN SOIL CLASSIFICATION

The entire study are has been covered within the irrigation command of the Narmada project and it is located just at the head reaches of the main canal. It was therefore, taken for detailed survey by the State Departments. Close interval profile pits and auger bores were taken and observation about texture, structure, colour, consistancy, depth of creeks, root zone depth, concretions etc. were carried out. The results, were analysed according to U.S. Comprehensive Classification System. This is six level classification, (Buol et.al. 1980). The soils of the study area accordingly, can be grouped into 3 Orders, 5 Sub-orders, 5 Greatgroups, 9 Subgroups, 9 Families and 17 Series.

The names of soil series are given from the village/town locality where the soil shows best development of the characteristics. Accordingly, the soil classification for the study area is given in table IV.5.

TABLE IV.5 : Modern Classification of Soils of study area

Sr. No.	Series	Sub-Group/ Families	Great Group	Sub-Order	Order
1. 2. 3. 4.	Mulad Haldar Karmali Rampura	Typic Chromterts	Chrom-terts.	Usterts	VERTISOL shrinking and swelling dark clay soils
5.	Dehgam	Udic Chromterts.			
6. 7. 8.	Jolepur Kabilpur Sisdora	Vertic Ustochrepts	Ustoch-repts.	Ochrepts	INCEPTISOL Embrionic soils with few diag-nostic features
9. 10.	Att Onjal	Fluventic Haplaquepts	Hapla-quepts.	Aquepts.	
11. 12.	Rahkui Ankhi	Fluvantic Ustochrepts			
13.	Garat	Typic Haplaquepts			
14. 15.	Dabka Balota	Typic Ustifluventic	Usti fluvents	Fluvents	ENTISOL Recently formed soil
16.	Hinglot	Aquic Ustifluventic	Ustorth ents	Urthents	
17.	Karali	Typic Ustrothents			

A map showing distribution of different Greatgroups and Families along with Series names for the study area is given in Fig. IV.4. It is seen that soils showing characters of Vertisol order are found covering extensive areas between the Narmada and Dhadhar rivers. While that occur mainly between Mahi and Dhadhar show characters of Inceptisol. The soils in the coastal area show Entisol characters. This sort of distribution is obviously controlled by factors of parent material of sediments, geomorphic configuration, subsurface condition of ground water, inherent salt content and microclimatic variations. Mahi-Dhadhar block derived its material mainly from Pre-cambrians while Narmada-Dhadhar block derived from trappean areas are clearly reflected in their texonomic characters.

The vertisols (Verto-turn) are black cotton soils (regur) have more than 30% clay in all horizone, pH 6.0-7.0 characterised by carbonates of Ca and Mg (6-8%), Al_2O_3 (less than 10%) iron oxides (9-10%), small amount of potash (0.5%) and soda and traces of phosphates. These ingradients have made the soil very fertile. It has high amount of swelling montmorillonite clays (40-48%). In dry season it shrinks so that the surface becomes riddled with a net work of 5-10 cm deep cracks. In rainy season it is converted into a plastic sticky mass. This swelling and shrinking characteristics of the vertisols make it a bad foundation material for buildings and civil structures.

FIG IV-

SOIL MAP OF THE STUDY AREA

REFERENCE :

NOTATION	SUB GROUP	ORDER
	Typic Chromsterts	VERTISOLS
	Udic Chromsterts	
	Vertic Ustochrepts	INCEPTISOLS
	Fluventic Haplaquepts	
	Fluventic Ustochrepts	
	Typic Haplaquepts	
	Typic Ustifluventic	ENTISOLS
	Aquic Ustifluventic	
	Typic Ustrothents	

N

0 10 20
km.

MAHI RIVER

DHADHAR RIVER

KHAMBHAT

SAVLI
BARODA
PADRA
KAVI
JAMBUSAR
AMOD
KARJAN
DABHOI

Rki
Hdr
Ank
Hdr-Jal
Rmp-Rki
Rmp
Hdr
Mid-Jal
Kbr
Hng
Dbk
Blt
Jal-Sda
Hdr-Sda
Ank-Kri
Dgm
Onj-Blt
Jal
Kbr-Sda
Gat

Inceptisol (inceptum = begining) are predominantly occurring in the northern parts of the area. The pedogenic horizon is made up of considerably altered material transported by rivers. They are monotonously light in colour, loamy in texture, drier in composition and extremely variable in thickness from place to place. They are generally acidic (pH 5.5), at times calcareous with variation of base content as 40 to 70%, towards coast it turn alkaline become unfit for cultivation. The Entisols (skeletal) show some patchy occurrence are characterised by absence of pedogenic horizons and great variability of texture, colour and composition.

The detailed classification has showed a very wide variations in the characters of the soil types. It is indicative of the complex combination of the formative material provided by the late Quaternary depositional processes and recent microclimatic variations. It is seen that predominantly fluvial material with local loessic intercepts have formed the base and major texonomic characteristics are dependent to them. The climatic variations seems to have been varied from subarid to subhumid. The present scenario of the soilscape in the area these calls for very careful management system for agricultural and other engineering practices. Serieswise description of soil properties, area of occurrence and main crops is briefly summarised and given in Table IV.6.

Table : IV.6 Seriaswise Soil Description Of The Study Area

Sr. No.	Series name and area of occurrence	Properties	Main crops
1.	Mulad Series (Padra and Vagra)	Deep to very deep, clayey, slow permeability, poorly drained, calcerous, sodium and other salts present, deep and wide cracks when dry, reaction is moderate to strongly alkaline.	Paddy, Cotton, Jowar, Legumes, and wheat.
2.	Haldar Series (Karjan, Jambusar, Baroda, Sinor, Barouch, Amod, Dabhoi, Vagra, Savli).	Deep to very deep, non-calcarious, clayey, laid on permeable material, imperfectly drained soilscape nearly level to very gently sloping cracks moderately deep during dry season, reaction is neutral to midly alkaline	Cotton, tur, paddy, wheat, beans, kodra, bajari, fruits and vegetables
3.	Karunali Series (Bharouch)	Very deep, moderately drained and moderately permeable, clay.	Jawar, Cotton banana etc.
4.	Rampura Series (Savli)	Very deep, clayey, non-calcarious moderately to well drained with medium to slow permeability.	Jawar, Cotton and tur.
5.	Dehgam Series (Jambusar)	Deep to very deep, calcarious, very slow permeability and poor in external drainage, found with accumulation of harmful salts in sub-soil horizons, cracks during dry season, strongly alkaline reaction.	Jawar, Wheat and cotton.
6.	Jalalpur Series (Karjan, Baroda Sinor, Amod, Padra Dabhoi)	Deep to very deep, clayey, calcarious, moderately drained, medium permeability, reaction is neutral to midly alkaline.	Paddy, Cotton Jawar, Legumes wheat, tur, partly under grass and as waste land.
7.	Kabilpur Series (Karjan, Baroda, Sinor, Barouch, Amod, Dabhoi)	Deep to very dep, well drained, moderate permeability, occures in gently rolling natural levee with medium texture, strongly alkaline.	Jawar, tur, cotton, wheat vegetables and sugarcane.
8.	Sisodra Series (Baroda, Sinor, Dabhoi, Savli)	Deep to very deep, moderately drained, medium to slow non-calcarious, moderate to strongly alkaline.	Jawar, paddy, wheat, kodra, bajra, maize, & beans, ground-nut.
9.	Att Series (Barouch, Amod, Vagra)	Moderately deep and poorly drained, they occurs in convana type topography, and subjected to increase of tidal water from sea.	Jawar, Cotton paddy, vegeta-bles & tobacco

10.	Onjal Series (Jambusar,Vagra)	Deep to very deep, poorly drained, very slow permeability, saline alkaline coastal alluvial soils, having high concentration of salt and high clay contents, reaction is moderately alkaline.	Cotton, Jawar bajri, vegetables, wheat, and pulse.
11.	Rahkai Series (Savli)	Moderately well drained with medium permeability.	Main crops are Jawar, Cotton and tur.
12.	Ankhi Series (Jambusar, Amod, Padra, Dabhoi)	Deep to very deep non-calcarious, recent alluvial well drained slow permeability, having fine sands in upper and lower horizons, middle part has medium texture, reaction is almost neutral. Mixed with accumulation of harmful salts.	Groundnut, tobacco,vegetables, tur, bajari banana, and legumes, Occasionally posture.
13.	Garat Series (Barouch,Karjan Sinor)	Deep to very deep, moderate to well drained, medium permeability, occuring in enarly level to very gently sloping flood soils, free from lime concentration but moderately alkaline.	Cotton,Jawar bajari,vegetables, wheat, and pulse.
14.	Dabka Series (Padra)	Shallow to moderately deep, moderately drained medium permeability calcarious medium textural, recent alluvial soil.	Cotton,Wheat banti, Jawar, bajari,castor.
15.	Balota Series (Jambusar, Vagra)	Deep to very poorly drained, moderately permeable, fine sandy texture saline to alkaline, coastal recent alluvial having high concentration of salts, exchangeable of Na is high in the profiles.	Mostly unculti-vable, remain under submergance during high tide of sea or monsoon floods, partly cultivable after reclaimation crops are cotton and wheat.
16.	Hinglot Series (Baroda, Padra)	Deep, well drained to excessively drained, highly permeable, calcarious, situated in undulating to rolling high recent alluvial terraces under rejuvenoscence and dynamics of Mahi river.	Partly under cultivation & partly under grassland and wasteland, main crops are tobacco,ground nut, jawar, bajari, beans and tur.
17.	Karali Series (Savli, Dabhoi)	Deep to very deep, moderately drained, medium permeablity non-calcarious, occuring in plain to gently sloping land.	Cotton,paddy and vegetables.

MINERAL RESOURCES AND GENESIS

The terrain of the study area is richly endowed with the other economic raw materials required for chemical and building industries. These include salt, sand, gravel, brick earth, kankar, etc. There are widely distributed and extensively occur in the area.

Salt

The appropriate combination of lowlying coastal landscape, high range of tidal influence and suitable climate have provided excellent conditions for the salt deposition. Brine bearing shallow aquifers are also the rich resources for salt manufacture. The late Quaternary sea level fluctuations, climatic variations helped in producing the liquid salt bearing aquifers. These are large number of shallow wells drawing brine from the semi-confined sandy and gravelly aquifers within 15m to 30m depth. Several salt works located along the coast line of the study area produce about 2.75 lakh tonnes per year. (Personal communication, Gujarat Alkalies and Chemicals Limited, Baroda). The salt works in the vicinity of Dahej alone produce 1.75 lakh tonnes/year, while the salt works around Jambusar-Gandhar and Devla produce about one lakh tonne/year. While processing salt, calcium sulphate (Gypsum), magnesium sulphate, magnesium chloride and sodium sulphate are obtained as by products. This salt finds its use in different chemical industries like caustic soda, rayons, hydrochloric acid

manufacture, pharmaceuticals, etc. It is also used for leather, food-processing, ceramics and textile industries.

Sand and Gravel

These natural aggregates are found in very large quantities from the river beds of Mahi, Dhadhar and Narmada. The Mahi and Dhadhar, drain the Pre-cambrian crystalline rocks yield good quality materials while the Narmada river catchment being predominantly formed of Trappean basalts, the aggregate so derived is relatively of inferior quality. Occurrence of large quantity of sand and gravel in the river beds indicate high energy fluvial regime of these rivers during, recent and sub-recent times. Large size pockets of sand and gravel are available from recently abundant rivers courses. A big sand quarry has been opened in one such burried channel of Dhadhar river near por village (Plate IV.1). The river beds have enourmous quantity of aggregates. Approximately 3 lakh tonnes of gravel and 12 lakh tonnes of sand are annually obtained form the river beds for building construction activities in the area (Personal communication, D.G.M., Baroda).

Brick Earth

The earth suitable for the manufacture of high strength bricks is amply available from the extensive alluvial plains of the central part. The alluvial sandy loam between Mahi and Dhadhar is more suitable for the brick manufacture. There are more than 75 kilns in area north of Dhadhar while only 15 kilns

PLATE IV.1 A view of sand quarry on Dhadhar river bank, Loc. Por village N.H-8

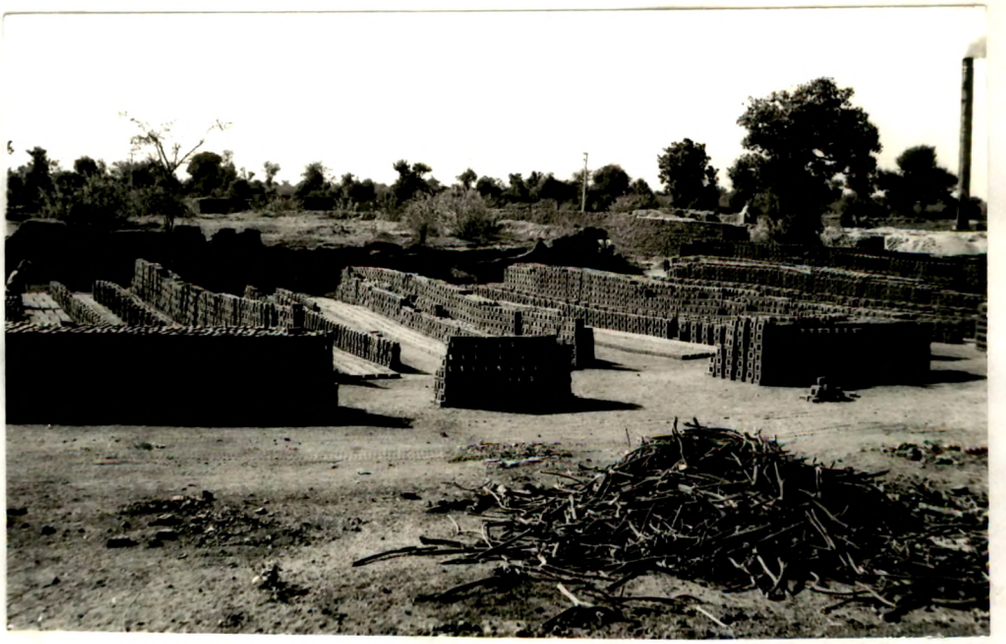


PLATE IV.2 A view of brick kiln, Loc. Near Padra

in the southern part. Strength tests on bricks carried out by GERI (1981). It is seen from the results that the bricks from the north of Dhadhar have higher strength than that from south of it. Comparative figures as shown below gives an idea of the strength.

Area	Compressive Strength	Flexural Strength	Water Absorption %
N of Dhadhar	66.2 kg/cm^2	9.7 kg/cm^2	16.2 %
S of Dhadhar	54.5 kg/cm^2	7.5 kg/cm^2	22.0 %

A brick manufacturing work near Padra is seen in Plate IV.2.

Kankar

A concretionary form of calcium carbonate is extensively found associated with clayey layers underlying the soil mantle. The kankar nodules are formed under specific climatic conditions. In the arid and semi-arid conditions where evapotranspiration is higher than precipitation the soil becomes progressively deficient in moisture, particularly during summer. In the absence of sufficient water, the base (Ca, Mg) and alkalies (K,Na) dispersed thinly through the soil are not leached out leading to their enrichment. There is also an enrichment in colloids which occur in flocculated state and hold the soil in aggregate form. To aggrevate the problem, capillary action brings up additional quantities of carbonates from deeper layers and deposits in the upper layers, in the form of concretionary nodules called 'calcrete' or 'kankar'. In earlier days kankar

was extensively burnt to prepare lime mortar for building construction. Two prominant kankar horizons are seen extensively developed in the alluvial sections cut by the river of Mahi and Narmada. These indicate the two cycles of semi-arid climatic phases during late Quaternary.

MINERAL GENESIS

Generic processes of the mineral resources described above are briefly summarised and given in Table : IV.7.

Table : IV.7 Mineral resources and genetic environments

Environments	Salt	Natural Aggregates	Brick Earth	Kankar
Depositional processes	Marine a. Wide open inter tidal zone and suitable climate b. Formation of brine bearing aquifers.	High energy fluvial activity and crystalline catchment in the vicinity	Semi-arid climate with favorable source material	Leaching of $CaCo_3$ in clayey beds under semi-arid climate
Geomorphic Set up	Extensively flat waste land along coast and creeks	Almost gradient less river course with meandering & point bars.	Shallow local depressions in alluvial plains.	Newer and older alluviums, and raised mud flats.
Area of Occurrence	Coastal lowlands	River courses	Central alluvial plains.	Lowlands in Western parts.

Patel and Unni (1982) have discussed the economic mineral occurrences of the Quaternary terrains of Gujarat in general. In the study area, the various processes related to Quaternary environments as discussed in the earlier chapters have all contributed collectively for the rich resources potential of the terrain. The fluvio-marine depositional environments and the climatic variations have played a very vital role in giving rise to these resources. Detailed understanding of these genetic processes help in further development and exploitation of these resources. As such, there is very high potential and it can be planned for systematic development. At present the resource exploitation activity provides good employment opportunity to the people of the area. Especially, the poor people in the coastal areas. The salt workings have much greater scope for further development of the resources.