3 Details of Study Area – The Coastal Saurashtra

3.1 General Details of the Saurashtra Region

3.1.1 Physiography

Saurashtra is a peninsular region of Gujarat forms a rocky tableland fringed by coastal plains, a major portion of which is occupied by the Deccan lava flows. The extensive sheet of lava covers more than half of the area of the region. Geographically Saurashtra has an extent of about 60,000 km^2 lying on the Arabian Sea coast, having a coastal border of about 765 km. The central portion of Saurashtra is like turtle's back and is made up of an undulating plain broken by hills and considerably dissected by various rivers flow out in all directions. There are total 71 rivers flowing in all the directions from the central portion of the plate and meeting the sea. (Refer Map 3.2). All these river basins are more or less homogeneous in their hydrometeorological characteristics. All these rivers are short in length and getting flood instantaneously and recedes quickly having rising limb flood hydrograph not more than 3 to 4 hours. Thus during rains, they gets flooded instantaneously and flood recedes quickly. Except Shetrunji and Bhadar rivers, all the rivers run dry after monsoon. The eastern fringe of Saurashtra is a low-lying ground marking the site of the former sea connection between the Gulfs of Kachchh and Khambhat. Today it is seen as a saline wasteland interspersed with marshes and lakes.

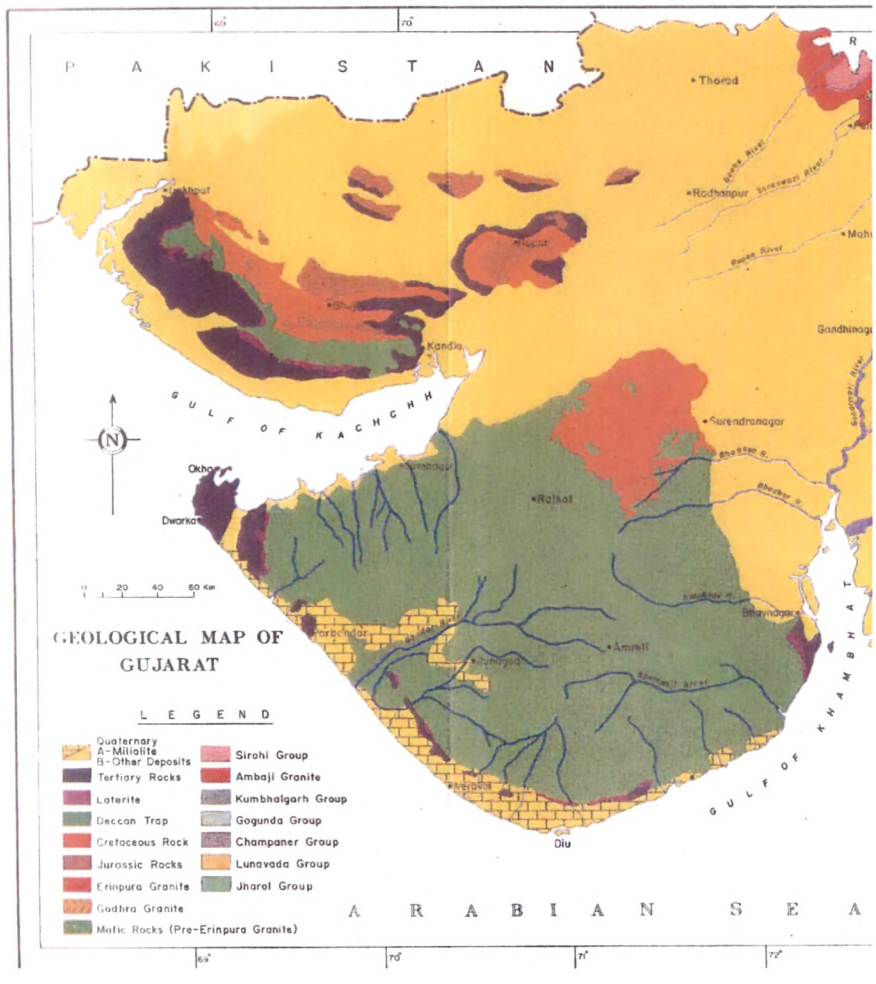
Altitudinal, the tableland varies from 300 to 1000 m. An elevated strip of ground connecting the highlands of Rajkot and Girnar forms the major water divide of Saurashtra.

3.1.2 Geology of the Saurashtra region

Hard rocks cover major portion of the region and some portion of the region is covered by recent alluvium. (Refer Map 3.1) Depending on their antiquity and mutual relationship, the major rock units of the region have been classified as under:

Geological Period	Super groups / Group / Formation	Major Rock Types
Recent and Quaternary (up to 3 million years)		Alluvial and loose sediment, Miliolite limestone.
Tertiary (3 to 70 million years)	▪ Nari Formation ▪ Gaj Formation ▪ Dwarka Formation	Marine to freshwater sedimentary rocks with fossils.
Cretaceous	▪ Bagh and Lameta Beds ▪ Deccan Traps	Marine and fresh water sediments. Volcanic lava flow and igneous rock intrusions into it.
Jurassic (135 to 180 million years)	▪ Cretaceous ▪ Bagh Bed	Marine sedimentary rocks with fossils.

Table 3.1: Geological Succession in Order of Their Superposition in Saurashtra Region



(Merh S.S. 1995)

Map 3.1: Geological Map of Saurashtra

3.1.3 Hydrogeology of Saurashtra Region

Geologically, the Saurashtra peninsula forms a structural block separated by major faults from the Gujarat mainland and the Kutch peninsula. The faults mark the hydrogeological boundaries and hence there is no groundwater transfer to the adjoining regions. It therefore forms a closed system for recharge, movement and storage.

The Saurashtra region consists of three important geological formations. Mesozoic sediments, the oldest formation, cover about 8% areas. The next younger formation of Deccan Trap basalts cover 60% area and the youngest Tertiary and Quaternary sedimentary including alluvium cover the rest 32% area. Hydrogeologically, the region mostly forms unconfined aquifer system of limited yield and varying quality.

3.2 General Details of Coastal Belt of Saurashtra

Gujarat has approximately one-third part of the total coastal length of India. In Gujarat, which has 1600 km long coastal reach, Saurashtra has 925 km long coastal reach, starting from Bhavnagar to Okha and from Okha to Malia. The study area covers parts of the districts of Bhavnagar, Amreli, Junagadh, Porbandar, Jamnagar and Rajkot. These coastal talukas are shown in the table 3.2 and Map 3.3

District	Taluka	Area (in km^2)	District	Taluka	Area (in km^2)
Bhavnagar	Bhavnagar	1462.40	Porbandar	Porbandar	1133.2
	Ghogha	437.1	Jamnagar	Kalyanpur	1412.2
	Talaja	869.7		Okhamandal	716.8
	Mahuva	1220.7		Khambhalia	1214.2
Amreli	Rajula	825.8		Lalpur	1075.6
	Jafrabad	355.6		Jamnagar	1227.2
Junagadh	Una	1578.4		Dhrol	569.6
	Kodinar	536.8		Jodiya	868.7
	Veraval	687.7	Rajkot	Malia	770.0
	Malia	539.7			
	Mangrol	572.6			

Table 3.2: Coastal Talukas of Saurashtra & its Area In km^2

Agriculture, fisheries, Limestone mines and Salt mining are main occupations of the people of coastal belt of Saurashtra. Various gigantic industries like Ambuja cement, Saurashtra Chemicals, Reliance Petroleum, Essar Oil, other mini cement plants and different industries at Pipavav port are situated in this coastal belt. This narrow coastal plain along the South coast of Saurashtra has long been

known as a very fertile and productive tract for its growth of vegetables, fruits, sugarcane and other high value cash crops. This plain was popular as "Lili Nagher". The fertile patches of Miliolite limestone are yet be seen clearly in Madhavpur, Mangrol, Chorwad, Veraval, Kodinar, Una, Mahuva and Ghogha talukas of coastal area. Due to the low reliability of monsoon rainfall, lack of availability of sufficient surface water and groundwater being the only handy resource, the peoples of this area heavily depends on this resource. Moreover, with the progress of civilization and development of agricultural techniques has increased the agricultural production with the improvement in techniques of supplying groundwater. With the development of gigantic industries in the coastal belt and development of various ports, the demand of groundwater has been increased to highest.

The availability of groundwater depends on the precipitation, which is very scanty and erratic, on the geology of the region because 80% of the area is covered by Basaltic rocks formation, which has very low transmissibility.

On account of very low amount of precipitation and its erratic nature, irregular distribution, short duration of rainfall on one side and highly porous, deep geological formation in recharge zone, salt laden winds of high velocity, reverse saucer type shape of the area, less recharge and heavy withdrawal in the area compel seawater to ingress inland through shallow aquifers rendering good cultivable land useless and putting the wells unsuitable for irrigation and drinking purposes. The areas proximity to sea has aggravated the situation due to the tides rendering saline water to come inland through estuary and increasing by way of lateral inflow of saline water through the banks of the river.

3.2.1 Coastline of Saurashtra

The northern coast (Jamnagar-Okha) of Saurashtra trending E-W overlooks the Gulf of Kachchh and shows a crenulated rocky shoreline with the sub-tidal zone consisting of channels, shoals, submerged islands, sand-bars, coral reefs and mangroves. The southwest coast of Saurashtra (Jamnagar – Diu) faces the Arabian Sea. From Dwarka to Veraval the coast has a characteristically straight NW-SE trend marked by well developed sandy beaches. The shoreline features between Veraval and Diu (E-W) are identical to those occurring along the Dwarka and Veraval coast. The coastal segment to the east of Diu to Bhavnagar shows a transition from open sea to gulf environment. The abundance of tidal mud to the east of Diu points to the influence of the Gulf of Khambhat. The Shetrunji River which meets the gulf near Gopnath forms a prominent estuarine delta at Saltanpur. From Gopnath to Ghogha the coastline is rocky with small narrow non-calcareous sandy beaches. To the north of Ghogha, right upto the mouth of Sabarmati the coast is highly muddy and shows extensive development of mud-flats and mud-banks. (Refer Map 3.3 to 3.9 for various details pertaining to

Geomorphology, Type of Soil Material, Soil Drainage, Soil pH, AAR, Elevation and Soil Type of coastal talukas of Saurashtra).

3.2.2 Geology of the Coastal Region

The stratigraphic sequence in the coastal area of Saurashtra is detailed as under:

Formation	Lithology	Thickness	Age
Alluvium	Soil, coastal sand, saline marshy land and oyster beds	5 to 20 Meter	Recent
Miliolite Limestone	White to pale brown oolitic sandy limestone occasionally grits and conglomerates	200-300 Meter	Pliostocene to recent.
Dwarka Beds	Yellow calcareous clays, Marls yellow fossiliferous limestone	200-300 Meter	Upper Miocene to Pliocene
Gaj Beds	Grey clay and fossiliferous limestone	-	
Laterites	Hard red laterites, also sometimes bauxitic tuffaceous material, volcanic ash	-	Post trappean Sediments
Deccan Trap	Plutonic masses with dykes intrusive in trap flows	-	Palaocene to upper cretaceous

Table 3.3: Stratigraphic Sequence in Coastal Saurashtra Region

3.2.2.1 Miliolite Limestone

Miliolite Limestone is composed of the remains of Foraminifers and other fossils embedded in calcareous matrix. The rock consists of bands of shale and hard compact limestone of varying thickness. Miliolite Limestone at depth contains numerous cavities of varying dimensions. The bands of shale in compact limestone are responsible for higher permeability of this formation.

3.2.2.2 Deccan Trap

In Saurashtra, the basaltic rocks of the Deccan Traps are large area of about 10 to 15 km inland and are very prominently exposed. The Tertiary and Quaternary rocks along the coastal plains of southwest fringe Deccan trap.

3.2.2.3 Laterite

Laterite rocks form almost a continuous zone between the Deccan trap and the tertiary Gaj formation, and occur as discontinuous patches right from Jamnagar in the north up to Bhavnagar in the south. Laterite Exposures along the coastal plain in Junagadh and Amreli districts are fragmentary and highly ferruginous.

3.2.2.4 Gaj Formation

Gaj formation occurs as a series of discrete out crops of marine Miocene rocks all along the coastal tracks of Saurashtra. The Gaj Formation represents the upper most part of the lower Miocene. At many places, the formation is overlain by Miliolite Limestone.

For convenience in detail study, Saurashtra coast is divided into three parts as below. (Refer Map 4.1)

i) Bhavnagar to Una reach.
ii) Una to Madhavpur reach.
iii) Madhavpur to Malia reach.

3.3 Bhavnagar to Una Reach

3.3.1 Location

The length of coast between Bhavnagar to Una is about 180 km. The area falls between latitudes 21^0 45′ to 23^0 35′ and longitudes 70^0 40′ to 70^0 20′, area covered in the survey of India topo-sheet Nos. 46 C/1, 46 C/2, 46 C/6, 41 C/3, 41 C/7, 41 P/5, 41 P/9, 41 P/12, and 41 C/1.

3.3.2 Physiography and Geomorphology

This coastal belt has southwestern sloping ground from inland towards the Bay of Cambay and Arabian Sea near Una. The coastline area is mostly covered with Miliolitic limestone cliffs near Babarcot and Jafrabad seacoast, high sand dunes at Simar, Navabandar and Mandvi sea coast of Una taluka. Locations like marshy lands, mud flats, low lying depressions where seawater intruded through creeks and estuaries of the rivers are developed near Jafrabad, Tarsara, Pipavav and Majadar ports and they are used for saltpans.

3.3.3 Drainage

Southwestern flowing rivers like Maleshri, Shetrunji, Dhatarvadi, Malan, Machchundri and Raval are draining this area. They form small deltaic fans among the coast and deposit fine sand and silt. The major drainage pattern is dendrite type.

3.3.4 Rainfall

The average annual rainfall occurs during June to October in the area is 795 mm as per IMD 50-year average of "normal rainfall data". The rainfall data from 1981 to 2000 is tabulated in table 3.4. A graphical representation of rainfall and departure from normal is shown in graph 5.1 to 5.5

Year	Rainfall In mm						
	Una	Jafrabad	Rajula	Mahuva	Talala	Ghogha	Bhavnagar
1981	853.0	634.0	621.0	640.0	485.0	500.0	762.0
1982	784.0	512.0	597.0	293.0	380.0	175.0	178.0
1983	1202.0	957.5	1210.0	1043.0	1401.0	780.0	665.0
1984	1021.0	381.0	358.0	432.0	699.0	480.0	530.0
1985	516.0	496.0	538.0	553.0	474.0	644.0	659.0
1986	517.1	424.0	413.0	322.0	232.0	335.0	364.0
1987	345.7	767.0	220.0	285.0	214.0	141.0	105.0
1988	1086.0	1248.0	1562.0	1256.0	535.0	623.0	761.0
1989	526.0	410.0	489.0	546.0	413.0	544.0	573.0
1990	741.0	431.0	373.0	455.0	460.0	851.0	712.0
1991	513.0	383.0	240.0	298.0	327.0	380.0	348.0
1992	582.0	452.0	381.0	525.0	747.0	590.0	612.0
1993	696.0	655.0	753.0	677.0	683.0	490.0	466.0
1994	1048.0	1097.0	915.0	887.0	524.0	675.0	788.0
1995	874.0	543.0	370.0	297.0	360.0	600.0	585.0
1996	883.0	707.0	496.0	451.0	463.0	581.0	659.0
1997	782.0	630.0	672.0	871.0	667.0	467.0	563.0
1998	671.0	833.0	637.0	774.0	536.0	624.0	770.0
1999	1332.0	244.0	232.0	310.0	383.0	515.0	433.0
2000	341.0	312.0	195.0	315.0	357.0	340.0	173.0
2001	716.0	448.0	496.0	532.0	439.0	541.0	622.0
2002	735.0	746.0	672.0	596.0	649.0	767.0	831.0
2003	991.0	805.0	884.0	585.0	559.0	797.0	537.0
2004	794.0	616.0	524.0	574.0	400.0	718.0	549.0
2005	1260.0	1148.0	1490.0	1157.0	898.0	927.0	947.0
2006	1111.0	766.0	567.0	635.0	764.0	579.0	893.0
AAR (In mm)	804.65	640.21	611.73	588.81	540.35	546.00	593.27
IMD AAR (In mm)	960.10	743.30	743.30	812.80	800.60	754.30	754.30

(Source – GWRDC, NWRWS DEPT., GOG)

Table 3.4: Rainfall Details for Bhavnagar to Una Reach for the Years 1981 – 2006

3.3.5 Geology

Deccan trap basalts are the oldest rocks in the area having very low permeability. Towards the coast, Gaj limestone of lower Miocene age is overlying the basaltic hard rock. Coastal fringes, coastal cliffs, ridges and small hillocks along the coast are formed of Miliolitic limestones. Coastal sedimentary deposits are mainly of alluvium, sand, conglomerates, clay and silt deposited along seacoast except Talaja. The geological formations in their natural order of superposition, mode of occurrence, lithology, estimated thickness and aquifer characteristics are shown in table 3.5.

Geological Age	Formation	Mode of Occurrence	Lithology	Estimated Thickness	Aquifer Charact eristics
Recent to Sub-Recent	Alluvium	Forming the topsoil along the coast and around river channels.	Soil, Coastal sand and Alluvium, Marshy lands, River sand, Gravel, Silt clay and Mud	Upto 10m	Pervious to Semi-Pervious
Pleistocene to Sub-Recent	Miliolite Limestone	Along the seacoast	Light Yellow to White sandy Limestone	Upto 35 m	Low to Highly Pervious
Mio-Pliocene	Ghogha Beds	On the East coast	Limestone and Conglomerates	30 m	Pervious.
Lower Miocene	Gaj Beds	Along the coast and resting below MSL	Yellow limestone with alternate beds of clay and limestone	100 m	Low to Very Low Pervious
Erosional Unconformity					
Post Trappen Sediments	Supra Trappeans	Overlying the Deccan Trap Basalts	Laterites, Ash and Clay beds	Upto 21m	Low Pervious
Cretaceous to Lower Eocene	Deccan Trap Basalt	Plateau Basalt, Flows, Sills and Dykes	Dark coloured basic lave flows of Basaltic mineral composition	1000 m and more	Low Pervious

(Source – GWRDC, NWRWS DEPT., GOG)

Table 3.5: Geological Formations in Their Natural Order of Superposition for Bhavnagar to Una Reach

3.4 Una to Madhavpur Reach

3.4.1 Location

The 160 km stretched coast between Bhavnagar to Una is situated on south coast of Saurashtra on Arabian Sea. The area falls between North latitudes 20^0 45′ to 20^0 55′ and 21^0 15′ to 21^0 25′ and East longitudes 71^0 15′ to 69^0 55′ and covered in the survey of India degree sheet Nos. 41 G, 41 K, 41 L and 41 P.

3.4.2 Physiography and Geomorphology

This coastal belt has southwestern sloping ground from inland towards the Arabian Sea. The inland area consists of "Deccan trap" where as the coastline is covered with and sand dunes. Wetlands, marshy land and mud flats are found in the estuarine area of the rivers.

3.4.3 Drainage

The area is being drained by south and southwestern flowing rivers like the Netravati, Noli, Meghal, Devka, Saraswati, Hiran, Somat, Shingoda, Sangavadi, Rupen and Machhundri. The drainage pattern is dendrite type.

3.4.4 Rainfall

The average annual rainfall occurs during June to October in the area is 800 mm as per IMD's 50-year average of "normal rainfall data". The rainfall is recorded at thirteen hydromet stations between Una to Madhavpur. The rainfall data for the whole reach from 1980 to 1999 is tabulated in table 3.6 Refer Graph 5.6

Year	Average Annual Rainfall In mm	Year	Average Annual Rainfall In mm
1980	1002.90	1990	878.80
1981	881.60	1991	627.00
1982	729.00	1992	880.12
1983	1497.00	1993	526.00
1984	781.00	1994	1022.60
1985	373.00	1995	666.20
1986	543.00	1996	1010.00
1987	157.00	1997	651.00
1988	1232.50	1998	1152.00
1989	705.46	1999	430.50
Average Annual Rainfall (In mm)			787.33
IMD Avg. Annual Rainfall (In mm)			800.00

(Source – SIPC, NWRWS DEPT., GOG)

Table 3.6: Details of Rainfall for Una to Madhavpur Reach for the Years 1980 – 1999.

3.4.5 Geology

Deccan trap basalts are the oldest rocks in the area having very low permeability. Towards the coast, Gaj limestone of lower Miocene age is overlying the basaltic hard rock. Coastal fringes, coastal cliffs, ridges and small hillocks along the coast are formed of Miliolitic limestones. Gaj limestone alternate with clay beds occurs. The geological formations in their natural order of superposition, mode of occurrence, lithology, estimated thickness and aquifer characteristics are shown in table 3.7

3.5 Madhavpur to Malia Reach

3.5.1 Location

The coastal area of Madhavpur to Malia exposed to the Arabian Sea and Gulf of Kachchha forms the western most part of the country and of Gujarat. The area falls between the North latitude 21^0 30' to 23^0 30' and East longitudes 69^0 00' to 71^0 00' and covered in the survey of India degree sheet Nos. 41 G, 41 K, 41 F, 41J and 41 I.

Geological Age	Formation	Mode of Occurrence	Lithology	Estimated Thickness	Aquifer Characteristics
Recent to Sub-Recent	Alluvium	Forming the topsoil and thick piles along river channels.	Soil, Coastal sand and Alluvium, Marshy lands, River sand, Gravel.	Upto 20m	Pervious to Semi-Pervious
Pleistocene to Sub-Recent	Miliolite Limestone	Along the seacoast as beds and petrified dunes inland.	Light Yellow to White sandy Limestone	Upto 40 m	Low to Highly Pervious (25 – 200 m/day)
Lower Pleistocene	Graval & Sand	Discontinuous lenses.	Gravels / Sands	80 m	Highly Pervious (60 – 120 m/day)
EROSIONAL UNCONFORMITY					
Lower Miocene	Gaj Beds	Exposed as Discontinuous lenses along the coast.	Yellow limestone with alternate beds of Gypsyferous clay, sands and grit.	115 – 300m	Low to Moderate (25 – 60 m/day)
UNCONFORMITY					
Upper Cretaceous to Lower Eocene	Deccan Trap Basalt	Plateau Basalt, Flows, Sills and Dykes	Dark coloured basic lave flows of Basaltic mineral composition	1000 m and more	Low Pervious (upto 25 m/day)

(Source – SIPC, NWRWS DEPT., GOG)

Table 3.7: Geological Formations in Their Natural Order of Superposition for Una to Madhavpur Reach

3.5.2 Geomorphology and Drainage

Geomorphologically, the area can be divided into three divisions:

i) Madhavpur to Miyani.
ii) Miyani to Okha.
iii) Okha to Malia.

3.5.2.1 Madhavpur to Miyani

This area is adjoining to Arabian Sea in Porbandar district and can be divided into four topographic divisions.

i) Hilly terrain of Barda hills. It occurs in north-east of Porbandar.
ii) Low lying coastal depression between Madhavpur and Medha creek.
iii) Coastal ridges and coastal dunes of stabilized sand.
iv) Area of Okha taluka comprising of tidal mud and saltpans.

The main rivers cutting across the coastal area are Bhadar, Sambo, Ozat, Madhuvanti, Vartu, Karman, Sorthi and Sani.

3.5.2.2 Miyani to Okha

This area is adjoining to Arabian Sea in Jamnagar district and can be divided into three topographic divisions.

i) Cultivable area.
ii) Stony waste area.
iii) Tidal mud area. This area is inundated by creek water.

The main rivers cutting across the coastal area is Gomti. There are two saltpans existing one at Mithapur and another at Arambhada.

3.5.2.3 Okha to Malia

Most of the area from Okha to Malia forms northern part of the Jamnagar district. Drainage slopes from south to north. The low lying coastal area forms approximately 6 km wide coastal belt. The main rivers draining in the area and flowing to Gulf of Kachchha are Ghee, Rani, Sinhan, Vedmati, Sasoi, Nagmati, Suveda, Ruparel, Kankavati, Fulzar, Und and Aji.

3.5.3 Rainfall

The area receives rainfall during June to October through the northwest monsoon. The taluka-wise average annual rainfall from 1985 to 2004 is given in table 3.9

3.5.4 Geology

The geology of the area between Madhavpur to Malia reach indicates occurrence of varied geological formations. These formations are broadly igneous lava flows, marine deposits and alluvial deposits. The geological formations in their natural order of superposition, mode of occurrence, lithology, estimated thickness and aquifer characteristics are shown in table 3.8.

Geologically the coastline comprises of a narrow strip of Tertiary and Quarternary formations overlying the basement of Deccan Trap Basalt. The strip of sedimentary formations is narrowest near Medha creek where Deccan trap is seen exposed close to the coast at village Gandhavi. The Miliolitic limestone varying in colour from pink to white and pale is exposed along the coast between Madhavpur and Porbandar and Kindri creek to Medha creek in form of ridges and mounds.

Geological Age	Formation	Mode of Occurrence	Lithology	Estimated Thickness	Aquifer Characteristics
Sub-Recent to Recent	Alluvium	Forming the topsoil and along coast.	Soil, Coastal sand, Marshy lands, River sand, Gravels, Silts, Clays and Muds	Upto 10m	Pervious to Semi-Pervious
	Coral Limestone	As coral islands in the Gulf of Kachchha	Colonies of Coral limestone	Upto 4 m	Highly pervious
Pleistocene to Recent	Miliolite Limestone	Along the seacoast as beds.	Pale White to Buff colour sandy Limestone and littoral concrete	Upto 20 m	Low to Highly Pervious
EROSIONAL UNCONFORMITY					
Mio-Pliocene	Dwarka Beds	In Okha the area	Fossiliferrous limestone with gypsum clays	Upto 2.5m	Low pervious
Lower Miocene	Gaj Beds	Along the coast below Miliolitic limestone	Yellow limestone, Gypsyferous clays, sands and grit.	115 – 300m	Low to Moderate
UNCONFORMITY					
Post Trappean	Supra Trappeans	Overlying the trap basalts	Clays, ash beds and laterites	10 to 12 m	Low pervious
Upper Cretaceous to Lower Eocene	Deccan Trap Basalt	Plateau Basalt, Flows, Sills and Dykes	Dark coloured basic lave flows of Basaltic mineral composition	1000 m and more	Low Pervious

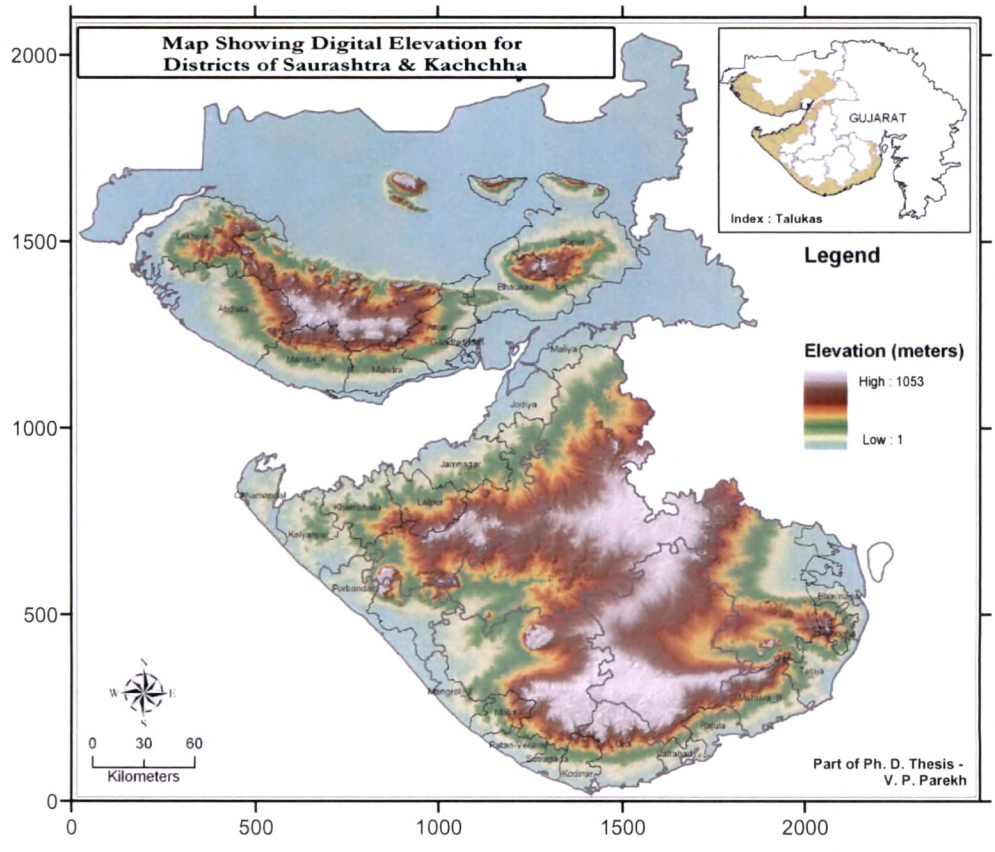
(Source – GWRDC, NWRWS DEPT., GOG)

Table 3.8: Geological Formations in Their Natural Order of Superposition for Madhavpur to Malia Reach

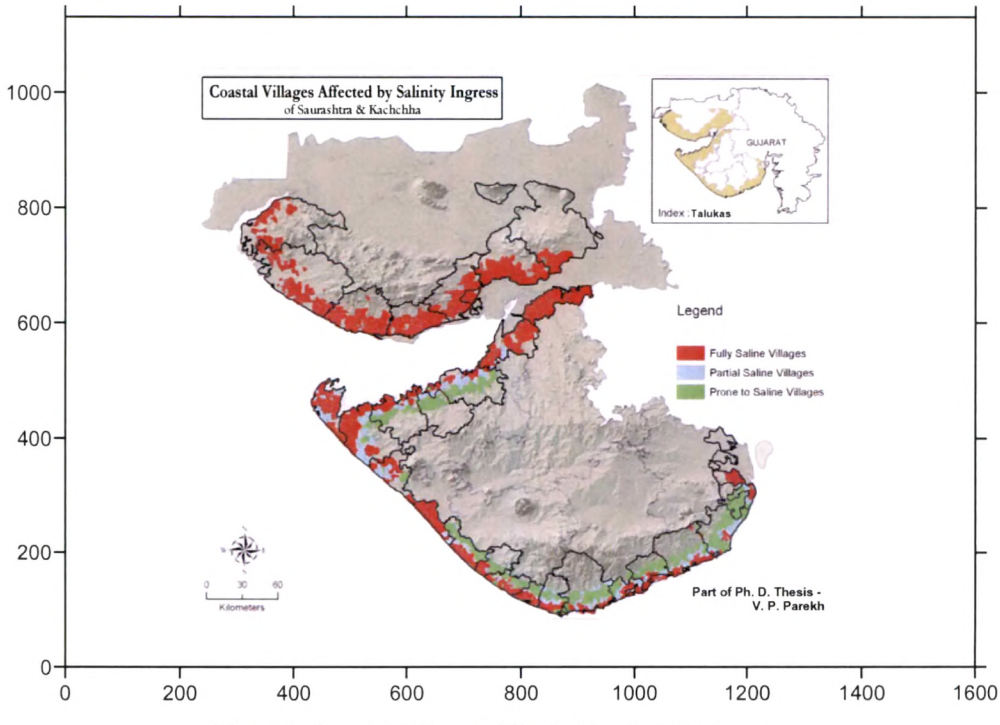
Year	Rainfall In mm										
Station	Mangrol	Porbandar	Ranavav	Okha	Kalyanpur	Khambhaliya	Lalpur	Jamnagar	Dhrol	Jodiya	Maliya
1985	389.00	249.00	229.00	201.00	207.00	281.00	223.00	208.00	278.00	352.00	324.00
1986	853.00	527.00	462.00	156.00	271.00	388.00	438.00	189.00	266.00	323.00	374.00
1887	126.00	21.00	16.00	36.00	15.00	53.00	62.00	36.00	139.00	28.00	53.00
1988	2032.00	774.00	862.00	457.00	449.00	795.00	962.00	492.00	1314.00	984.00	571.00
1989	1065.00	643.00	727.00	336.00	572.00	432.00	540.00	286.00	508.00	329.00	394.00
1990	857.00	218.00	238.00	150.00	260.00	663.00	520.00	239.00	205.00	304.00	283.00
1991	351.00	338.00	318.00	88.00	423.00	269.00	430.00	275.00	231.00	145.00	345.00
1992	954.00	549.00	470.00	558.00	498.00	507.00	617.00	446.00	493.00	528.00	460.00
1993	349.00	156.00	216.00	108.00	181.00	137.00	232.00	194.00	283.00	239.00	98.00
1994	874.00	1444.00	867.00	408.00	488.00	636.00	636.00	1050.00	1148.00	1373.00	692.00
1995	575.00	548.00	537.00	141.00	441.00	233.00	257.00	267.00	300.00	476.00	304.00
1996	836.00	449.00	487.00	199.00	341.00	394.00	543.00	394.00	588.00	440.00	270.00
1997	530.00	841.00	662.00	426.00	628.00	600.00	654.00	977.00	891.00	645.00	470.00
1998	1372.00	1111.00	908.00	731.00	1274.00	950.00	743.00	463.00	467.00	400.00	392.00
1999	807.00	201.00	314.00	203.00	624.00	161.00	252.00	239.00	242.00	305.00	279.00
2000	664.00	432.00	427.00	484.00	517.00	480.00	535.00	252.00	340.00	238.00	191.00
2001	771.00	623.00	787.00	346.00	1196.00	726.00	641.00	583.00	453.00	371.00	509.00
2002	221.00	271.00	270.00	136.00	371.00	210.00	390.00	433.00	354.00	275.00	180.00
2003	690.00	666.00	912.00	437.00	882.00	555.00	1095.00	1362.00	755.00	772.00	542.00
2004	1072.00	477.00	546.00	274.00	574.00	334.00	642.00	852.00	500.00	468.00	428.00
2005	913.00	903.00	735.00	413.00	353.00	642.00	--	--	--	--	--
AAR (In mm)											
	818.19	620.92	605.92	327.04	584.96	504.10	589.70	563.00	569.50	470.00	373.70
IMD AAR (In mm) Last 50 Years											
	863.60	594.30	594.30	499.40	603.80	520.70	520.70	652.15	706.12	630.78	609.60

(Source – GWRDC, NWRWS DEPT., GOG)

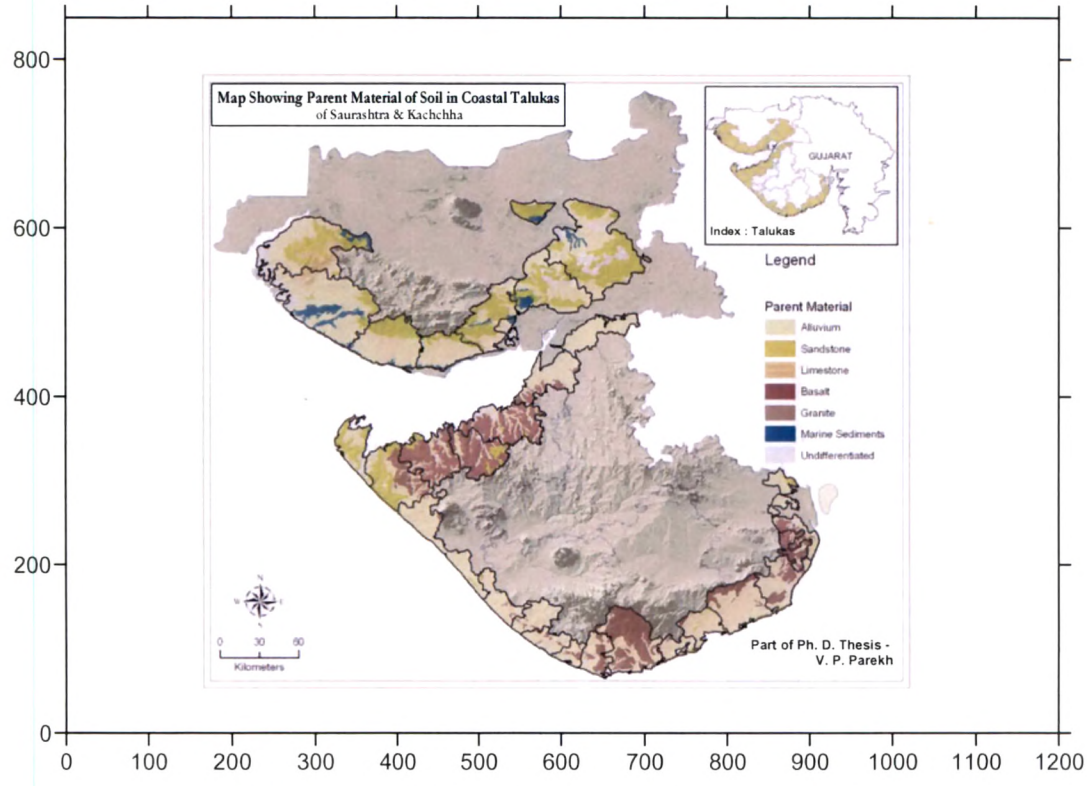
Table 3.9: Rainfall Details for Madhavpur to Malia Reach for the Years 1985 – 2005



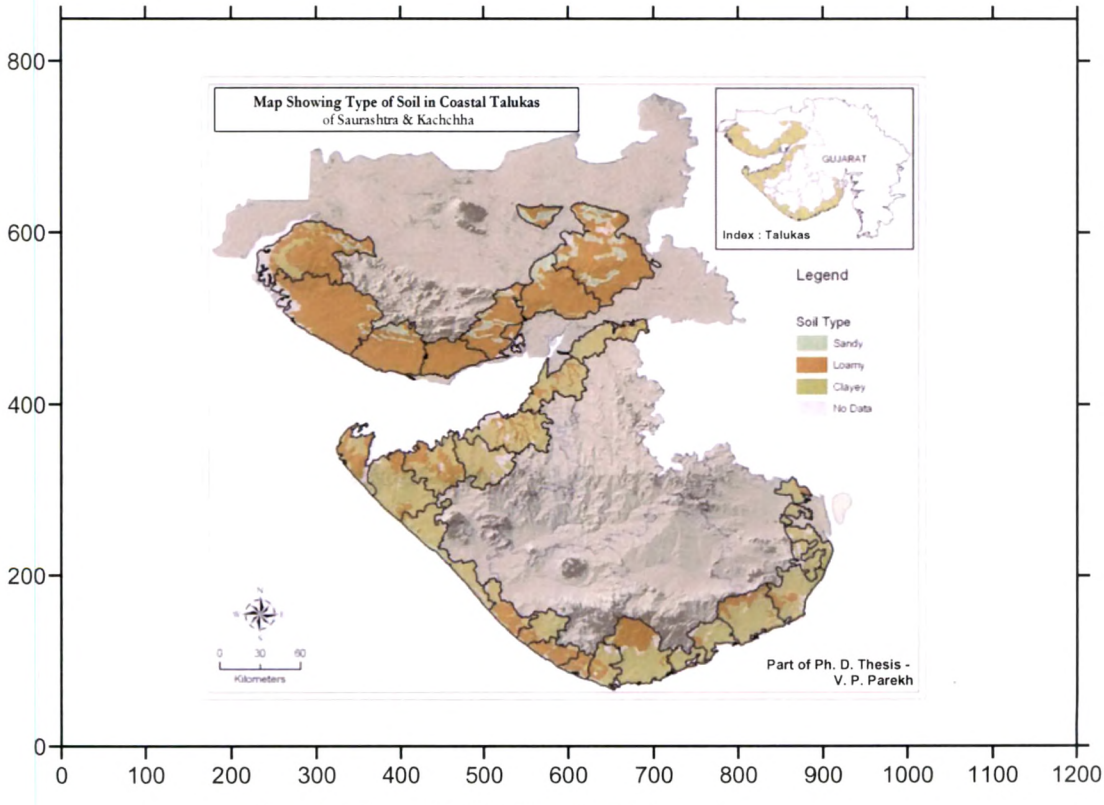
Map 3.2: Map Showing Digital Elevation of Saurashtra & Kachchha



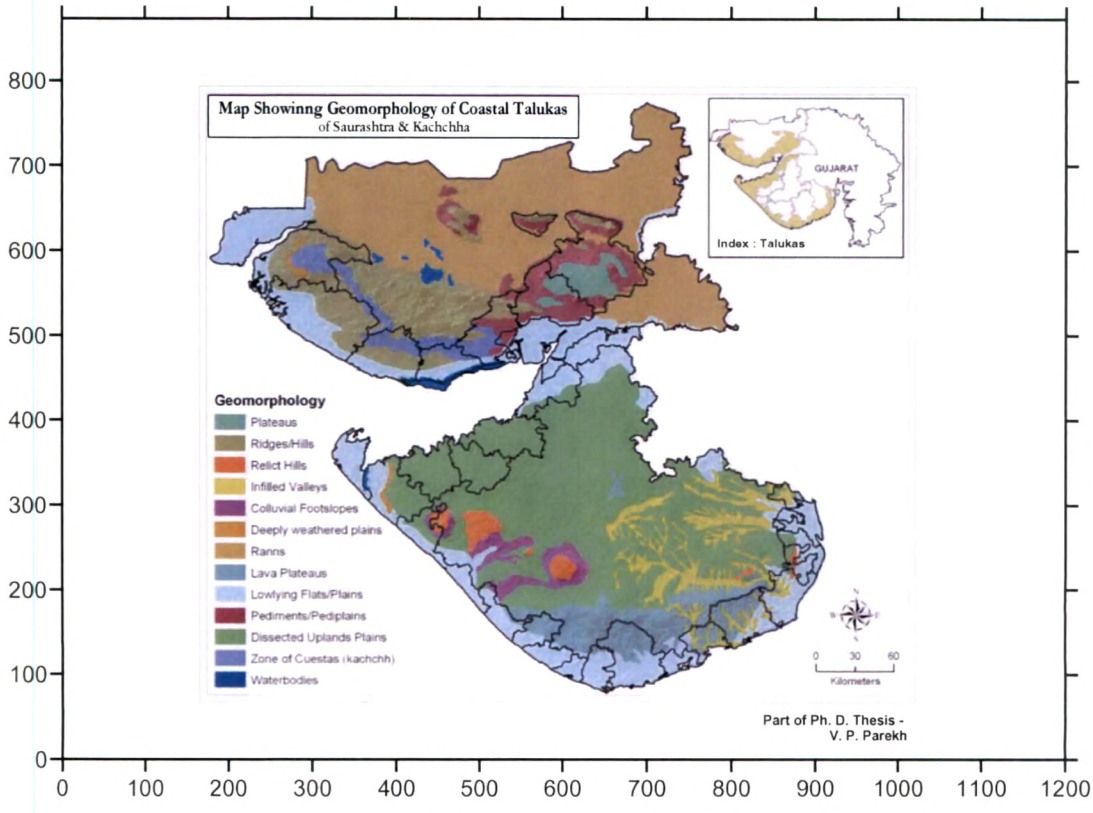
Map 3.3: Coastal Villages Affected by Salinity Ingress



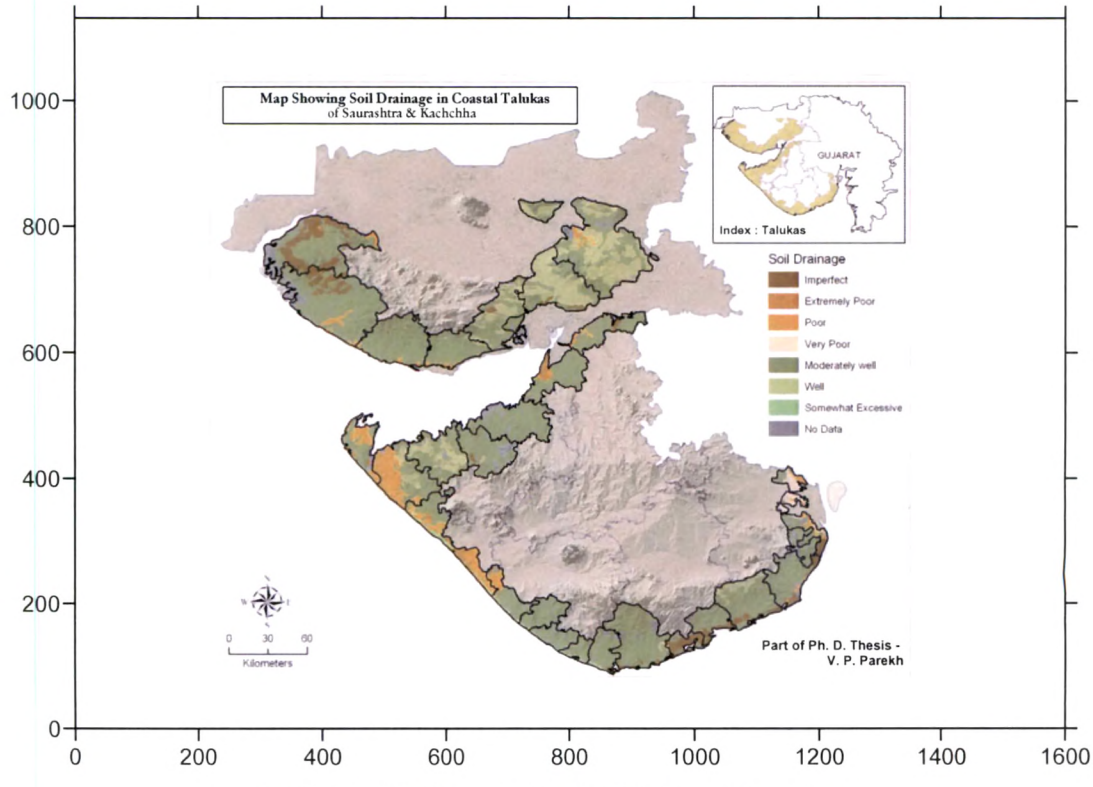
Map 3.4: Parent Material of Soil in Coastal Talukas of Saurashtra



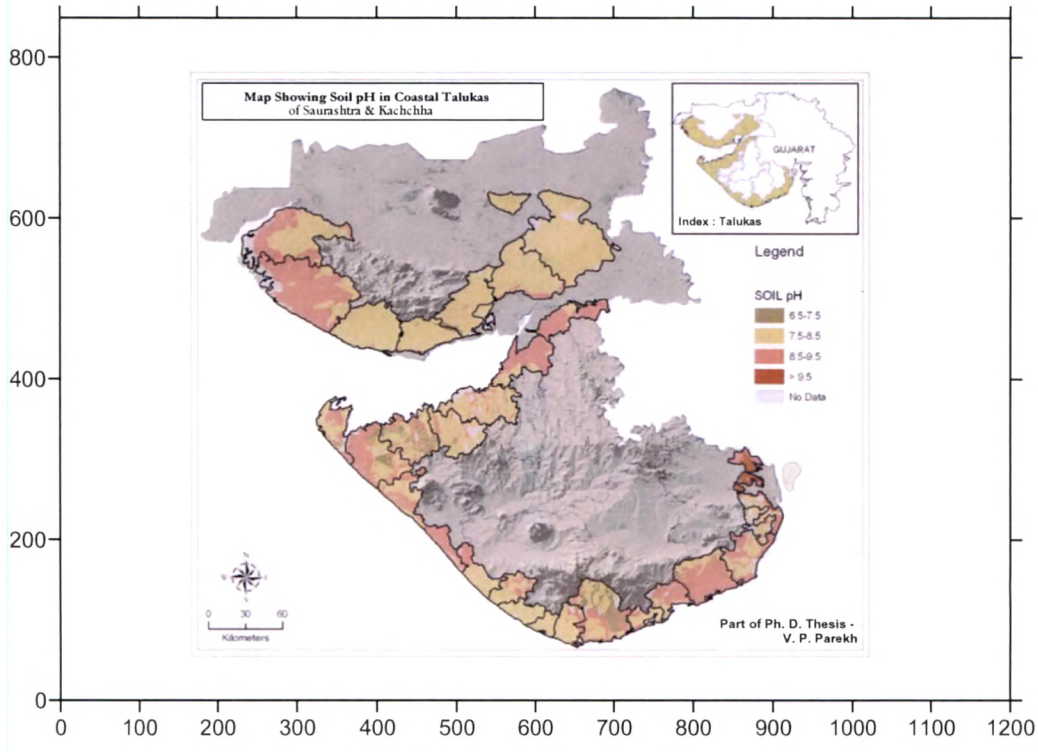
Map 3.5: Type of Soil in Coastal Talukas of Saurashtra



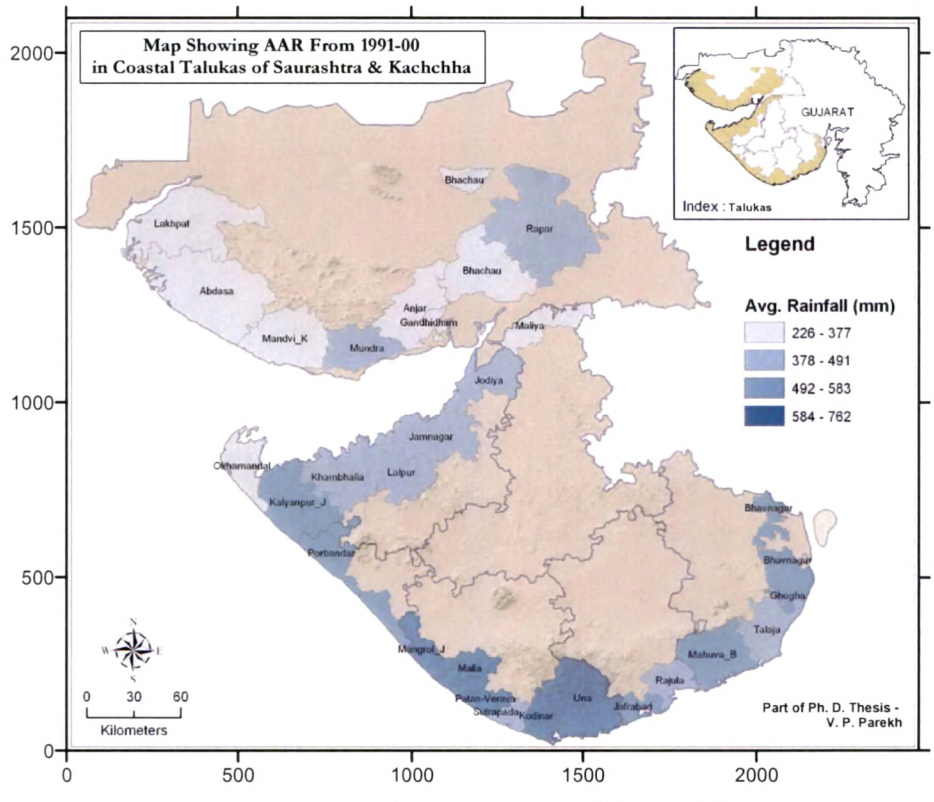
Map 3.6: Geomorphology of Coastal Talukas of Saurashtra



Map 3.7: Soil Drainage in Coastal Talukas of Saurashtra



Map 3.8: Soil pH in Coastal Talukas of Saurashtra



Map 3.9: Average Annual Rainfall in Coastal Talukas of Saurashtra