Chapter 4

Soil

CHAPTER - 4

SOILS

Soil is the most valuable natural resource we have in the country and is the basis of all agriculture production". (Rajan and Rao 1978) Though modern technology is developing the scientific measures to grow crops without soil, it seems an illusion in the 3wider spectrum of the significance of soils, for large scale crop raising.

The soils of the study area are part of the broadly classified soils of the "Kanam" region – the region characterized for its black soils and cotton crop. However, the sub-regional classification of soils (at district level) shows that there are, five types of soils within this broad region. Out of these, four types (1) Black cotton soil; (2) Gorat soil; (3) Bhatha soils; (4) Kyari soils, are found in the plain areas and fifth (5) stony soils are found in the hilly and forested areas of the district.

4.1 Soil Taxonomy

Soil taxonomy is a classification of soils. It is a grouping of soils into categories based on each soil's morphology (appearance and form). The first complete U.S taxonomic classification was published in 1938 and modified in 1949. In the 1950s and early 1960s a new system was developed through a series of enlarged publication called approximations. In 1961 a comprehensive seventh approximation was printed and distributed worldwide to soil taxonomists for suggestions. In 1965 the U.S Soil Conservation Service

officially began the use of this system and published it in December 1975. Although this U.S system has application worldwide.

The present U.S soil classification system (soil taxonomy) organizes all soils into 11 Orders, 54 suborders, 238 great groups, 1922 subgroups, and then families and series. Each series is subdivided into mapping unit, which are called phases of series; these mapping units are not a subdivision in the classification system.

Order is the most general category in the system. All soils belong to one of the 11 soil orders. Five of the soil orders exist in a wide variety of climates: Histosols (Organic Soils), the underdeveloped Entisols, the slightly developed Inceptisols and (volcanic material) Andisols, and the swelling clay Vertisols. The other six orders are mostly products of time and of the microclimatic conditions in which each developed. Mollisols are usually naturally fertile soils, slightly leached, that occur in semiarid to sub humid climates, originally under grasses or broadleaf forest. Alfisols are fertile soils in good moisture regimes; they are usually productive on irrigated lands. Ultisols are leached, acidic and of low to moderate fertility although they are probably the most productive soils because they are formed in areas with long frost-free periods and warm climates.

Table 4.1: Brief Characterisations Of The 11 Soil Orders

Soil Order	General Features
Entisols	Entisols have no profile development except perhaps a shallow marginal **A**. Many recent river floodplains, volcanic ash deposits, unconsolidated deposits with horizons eroded away, and sands are Entisols.
Inceptisols	These soils, especially in humid regions, have weak to moderate horizon development. Horizon development has been retarded because cold climates, waterlogged soils, or lack of time for stronger development.
Andisols	A tentative soil order. Andisols are soils with over 60 percentage volcanic eject (ash, cinders, pumice, basalt) with bulk densities below 900 Kg/m^3. They have enough weathering to produce dark **A** horizons and early stage secondary minerals (allophane, imogolite, ferrihydrite clay). Andisols have high adsorption and immobilization of phosphorus and very high cation exchange capacities.
Histosols	Histosols are organic sols (peat's and mucks) consisting of variables depths of accumulations plant remains in bogs marshes, and swamps.
Aridisols	Aridisols exists in dry climates and some have developed horizons of lime o gypsum accumulations, salty layers, and/or **A** and **B**-horizons.
Mollisols	Mostly these are grassland, but with some broadleaf forest-covered soils with relatively deep, dark **A** horizons; they may have **B**-horizons and lime accumulation.
Vertisols	Vertisols have a high content of clay that swell when wetted. Vertisols requires distinct wet and dry seasons to develop because deep wide cracks when the soil is dry are a necessary feature. Usually Vertisols have only deep self-mixed **A** horizons (top soil falls into cracks seasonally, gradually mixing the soil to the depth of the cracking). This soil exits most in temperate to tropical climates with distinct wet and dry seasons.
Alfisols	Alfisols develop in humid and sub humid climates, have precipitation of 500-1300 mm (about 20-50 in), and are frequently under forest vegetation. Clay accumulation in a **Bt** horizon and available water much of the growing season are characteristic features. A thick **E** horizon is also common. They are slightly to moderately acidic.
Spodosols	Spodosols are typically the sandy, leached soils of cool coniferous forest. Usually, **O** horizons, strongly acidic profiles, and well-leached **E's** are expected. The most characteristic feature is a **Bh** or **Bs** of accumulated organic material plus iron and aluminum oxides
Ultisols	Ultisols are strongly acid, extensively weathered soils of tropical and sub-tropical climates. A thick **E** and clay accumulation in a **Bt** are the most characteristic features.
Oxisols	Oxisols are excessively weathered; few original minerals are left un weathered. Often Oxisols are over 3m (10 ft) deep, have low fertility, have dominantly iron and aluminum oxide clays, and are acid. Oxisols develop only in tropical and subtropical climates.

When irrigated, Aridisols, the arid region soils, are often very productive. In contrast, the infertile Oxisols, formed in hot, wet tropics, often exist in climates excellent for year round plant growth. The acidic, sandy Spodosols, found in cool climates, are some of the poorest soils for cultivation. The brief characteristics of the soil Order are described in table. 4.1.

4.2 Method of Soil Survey

The soil survey conducted by the Soil Survey Organisation of SSNNL (Sardar Sarovar Narmada Nigam Limited) and the present researcher had participated in this survey and named it "The Reconnaissance Soil Survey".

Soil survey has been carried out in part of Phase – I area during the period 2002 to 2004. The base map of 1:50,000 or 1: 63,360 has been used. The physiographic units were delineated and verified during the field traverse. The open profile has been located in representative sites covering an area of 1000 ha. The open profile has been excavated up to depth of 180 cm or up to patent material or water table, whichever is met earlier. The open profile was described horizon-wise for its morphological characteristics like Colour, texture, consistency, concretions, routing depth, lime content, coarse fragment, etc. the auger bore has been taken up to the depth of 240 cm and soil samples were examined for colour, texture, lime content. In the field information on land parameters such as slope, erosion, surface drainage conditions, depth to water table, land use and cropping pattern were collected simultaneously.

The soil samples were collected from open profile horizon wise and brought to laboratory for testing for their physico-chemical properties such as

particle size, distribution, permeability, moisture holding capacity, pH, electrical conductivity, calcium carbonate, organic matter and exchangeable cations.

The soil distribution, associated soil series maps are based on the results of this survey.

4.3 Soil Series / Soil Zones

On the basis of morphological characteristics of the soil of the open profile, observed during the field investigation, and the data of laboratory testing of soil samples, the soil of the surveyed area in Phase – I have been compiled, co-related and grouped into different soil series / soil zones. The soils were classified as per the soil taxonomy USDA (1974).

In Phase – I area eighteen tentative soil series / soil zones have been identified and have been described in Table. 4.2.

Table 4.2: Taxonomic Classification of Soil Series / Soil Zone in Phase – I

Sr. NO	NAME OF SOIL SERIES	DESCRIPTION	FAMILY	SUB GROUP	GREAT GROUP	SUB ORDER	ORDER	LOCAL NAME	NAME OF SOIL
1	**Wakneda (WK)**	Moderately fine loamy mixed deep, becoming slightly coarse between 50 to 100 cm from the surface with cambic–B horizon, well-drained, hyperthermic Fluventic Ustochrepts.	Fine loamy mixed hyperthermic deep.	Fluventic - Ustochrept	Ustochrept.	Ochrept	Inceptisol	Kali mati	**Medium Black soil**
2	**Dodka (Do)**	Coarse loamy, mixed deep, with stratified AC profile, well drained, hyperthermic, Typic Ustifluvents.	Coarse loamy mixed hyperthermic deep.	Typic - Usticluvent	Ustifluvent	Fluvent	Entisol		**Alluvial soil**
3	**Mohmadpura (Mo)**	Coarse loamy, mixed, moderately calcareous increasing with depth, moderately deep with stratified AC profile, well drained, hyperthermic Typic Ustifluvents.	Coarse loamy mixed calcareous hyperthermic medium deep	Typic Ustifluvent	Ustifluvent	Fluvent	Entisol		**Alluvial soil**
4	**Chhidra (Chh)**	Fine, loamy, mixed, deep, with cambic – B horizon, well drained hyperthermic Fluventic Ustochrepts.	Fine loamy mixed hyperthermic deep.	Fluventic Ustochrept.	Ustochrept	Ochrept	Inceptisol		**Medium Black soil**
5	**Jantran (Ja)**	Vary fine, montmorrillonite, moderately calcareous deep , with vertic characteristics and fine clayey substratum below 100 cm from the surface. With imperfectly drained, hyperthermic Udic Chromusterts.	Fine montmorillonitic calcareous hyperthermic deep.	Uctic Chromusters.	Chromustert	Ustert	Vertisol		**Deep Black soil**
6	**Rajnagar (Ra)**	Fine loamy, mixed, deep, with cambic –B horizon, well drained, hyperthermic Udic Ustochrepts	Fine loamy mixed hyperthermic deep.	Udic Ustochrept	Ustochrept	Ochrept	Inceptisol		**Medium Black soil.**
7	**Khervadi (Kh)**	Fine, montmorillonitic slightly calcareous increasing with depth, very deep, with vertic characteristics imperfectly drained, hyperthermic typic chromusterts.	Fine, montmorillonitic. Calcareous hyperthermic deep.	Typic Chromustert	Chromustert	Ustert	Vertisol		**Deep Black soil**
8	**Atali (At)**	Fine, montmorillonitic, moderately calcareous, increasing with depth moderately deep with Cambic- B horizon and medium textured substratum below 100 cm from the surface moderately well drained, hyperthermic vertic Ustochrepts.	Fine montmorillonitic calcareous hyperthermic medium deep	Vertic Ustochrept	Ustochrept	Ochrept	Inceptisol		**Medium Black soil**
9	**Juni Jithardi (Ju)**	Fine, montmorillonitic, slightly calcareous increasing with depth, moderately deep with vertic characteristics and medium textured substratum between 90 to 120 cm from the surface. Imperfectly drained, hyperthermic Typic chromusterts.	Fine montmorillonitic calcareous hyperthermic deep.	Typic Chromustert	Chromustert	Ustert	Vertisol		**Deep Black Soil**

10	**Orwada (Or)**	Coarse loamy, mixed, deep becoming slight coarser between 50 to 100 cm from the surface with AC profile, excessively drained, hyper-thermic Typic Ustorthent.	Coarse, loamy mixed hyper-thermic deep	Typic Ustorthent	Ustorthent	Orthernt	Entisol		**Shallow Black soil**
11	**Wantarsa (Wa)**	Very fine, montmorillonitic, slightly calcareous, increasing with depth, deep, with vertic characteristics and medium textured substratum below 100 cm from the surface poorly drained, hyperthermic Typic Chromusterts.	Very fine montmorillonitic calcareous hyperthermic deep.	Typic Chromustert	Chromustert	Ustert	Vertisol		**Deep Black soil**
12	**Dahej (Da)**	Fine, montmorillonitic, deep, with medium textured substratum between 50 to 100 cm from the surface and cambic – B horizon associated by Salic horizon, poorly drained hyperthermic vertic Halquept	Fine montmorillonitic hyperthermic deep.	Vertichalaquept	Halquept	Aquept	Inceptisol		**Costal Alluvial Soil**
13	**Derol (De)**	Fine, montmorillonitic, slightly calcareous, increasing with depth, deep, with vertic characteristics imperfectly drained, hyperthermic Typic chromusterts.	Fine montmorillonitic calcareous hyperthermic deep.	Typic Chromusters.	Chromoustert	Ustert	Vertisol		**Deep Black Soil**
14	**Manjrol (Ma)**	Moderately fine loamy, mixed strongly calcareous, decreasing towards depth, moderately shallow becoming slightly coarser between 50 to 100 cm from the surface with cambic B horizon within 70 cm from the surface well drained hyperthermic Typic	Fine loamy mixed calcareous hyperthermic medium deep.	Typic Ustochrept	Ustochrept	Ochrept	Inceptisol		**Medium Black Soil**
15	**Motafofalia (Mo)**	Fine loamy. Mixed moderately deep, becoming slightly finer within 50 cm from the surface with cambic –B horizon, well vertic Ustochrepts.	Fine loamy mixed hyper thermic medium deep.	Vertic Ustochrept	Ustochrept	Ochrept	Inceptisol		**Medium Black Soil.**
16	**Kaledic (Kl)**	Moderately fine, montmorillonitic, moderately deep, becoming slightly coarser between 50 to 100 cm from the surface with cambic- B horizon within 75 cm from the surface moderately well drained, hyperthermic, Vertic Ustochrepts.	Fine montmorillonitic hyperthermic medium deep	Vertic Ustochrepts	Ustochrepts	Ochrept	Inceptisol		**Medium Black Soil.**
17	**Akteshwar (Ak)**	Moderately fine, montmorillonitic, shallow with hard pan within 50 cm from the surface and cambic –B horizon, moderately well drained, hyperthermic Lithic Ustochrepts.	Fine montmorillonitic hyperthermic shallow	Lithic Ustochrept	Ustochrept	Ochrept	Inceptisol		**Medium Black Soil.**
18	**Zariya (Za)**	Fine, montmorillonitic, shallow, with medium textured and strong gravely substratum within 50 cm from the surface with AC profile, well-drained, hyperthermic Vertic Ustorthent.	Fine montmorillonitic hyperthermic shallow	Vertic Ustorthent	Ustorthent	Orthent	Entisol		**Shallow Black Soil**

Source: Identified by researcher during field survey

4.4 Wakneda Soil Series/Zone (Wk) Tentative

The Wakneda Zone includes moderately fine loamy textured deep soil, becoming coarser (by one textured class) between 50 cm to 100 cm of the surface having cambic horizon under well-drained soil, typifying the central concept of sub group developed on alluvium. These are found to occur on nearly level to gently undulating lands. The soil pedon exhibits ABC profile with light yellowish brown to dark yellowish brown loamy sand to sandy loan and at places silty loam 'A' horizon grading to dark reddish brown loam to clay loam 'C' horizon. These soils earlier have been classified as alluvial soils in India.

Wakneda Zone comprises fine loamy mixed hyper-thermic deep family of Fluventic Ustochrepts.

Typifying Pedon: Wakneda sandy loam cultivated (colour are for dry Soil unless other wise noted)

Horizon	Depth in cm.	Description
AP	0 - 10	Brownish yellow (10YR 6/6 D) and light yellowish brown (10YR 6/4 M) Sandy Loam, weak fine sub angular blocky; dry loose, moist friable, wet non sticky, non plastic; no effervescence with dilute HCL; common fine to medium tubular pores moderately rapid permeability; clear smooth boundary neutral (pH 7.3).
B1	10 - 34	Reddish brown (5 YR 4/4 D), and dark reddish (5 YR ¾ M) loam moderate medium angular blocky breaking in to sub-angular blocky; dry slightly hard, moist friable wet slightly sticky and slightly plastic. No effervescence with dilute HCL; few fine to medium roots; common fine to medium tubular pores; moderate to moderately rapid permeability; gradual smooth boundary, mildly alkaline (pH 7.6)

B2	34 - 80	Reddish brown (5 YR 4/4 D) and dark reddish brown (5 YR ¾ M) sandy clay loam moderate medium angular blocky breaking in to sub-angular blocky; dry slightly hard moist friable wet sticky and plastic. No effervescence with dilute HCL; few fine medium roots. Common fine to medium simple tabular pores; moderate to moderately slow permeability; gradual smooth boundary neutral (pH 7.3)
B3	80 - 142	Reddish brown (5 YR 4/4 D) and dark reddish brown (5 YR ¾); sandy loam, moderate medium angular blocky breaking in too sub-angular blocky; dry slightly hard moist friable, wet sticky and plastic. No effervescence with dilute HCL; very few fine roots common fine to medium tabular pores; moderate permeability; gradual smooth boundary; mildly alkaline: (pH 7.6)
C	142 - 180	Brownish yellow (10 YR 6/6 D) and dark yellowish brown (10 YR 4/4 M) sandy loam, weak fine to medium sub-angular blocky; dry slightly hard, moist friable; wet slightly sticky and slightly plastics; vilent effervescence with dilute HCL; common micro pores permeability. Moderately alkaline (pH 7.9)

4.4.1 Range in Characteristics

The average thickness of the solum is generally more than 1 metre of the surface. The colour of the surface soil in 'A' horizon is in hue of 10 YR with value ranging from 6 to 4 while chroma is 4 to 3. The texture of the fine varies from loamy sand to sandy loam but at places silty loam soils are also met with. The colour of the 'B' horizon is dominantly in hue of 5 YR with value 3 and chroma 4. The texture of the B-horizon generally ranges from loam to clay loam but at places sandy clay loam and silty clay loam is also met with. The clay percent in B-horizon is generally moderate medium angular blocky breaking in to sub-

angular rocky. The salt content expressed as EC generally ranges from 0.05 to 0.23 mmhos/cm indicating non-saline nature of soil. The soil reaction is generally natural to moderately alkaline through the depth having pH values ranging from 7.3 to 7.9. The content of the organic matter varies from 0.31 to 0.56 percentage and shows irregular distribution. The calcium carbonate content varies from 0.25 to 5.75 percentage.

4.4.2 Availability in the study area

The open profile of the Wakneda soil series is located 1 km south west of village Wakneda, (Taluka Savli, District Vadodara) in the agro-climatic Region I. Here the soil occurs on nearly level to gently undulating lands with slope gradient ranging from 0 – 3 percentage. These are well-drained soils with moderate to moderately rapid permeability. The depth of the ground water is generally below 5 meters. A variety of crops are cultivated on these soils. These include Jowar *(Sorghum vulgare)*, Bajra *(Pennisetum typhoides)*, Tur (*Cajanus cajan)*, Tobacco *(Nicotina spp)*, Wheat *(Triticum aestivum)*, Oil seeds like Groundnut *(Arachis hypogaea)*, Mustard *(Brassica spp.)*, Sesamum *(Sesamum orientale)*, Banana (Musa supp.) and Sugarcane *(Saccharum officinarum)*. The natural vegetation comprises Mango *(Mangifera indica)*, Neem *(Azadirachtra indica)*, Bor *(Zyzyphus jujuba)*, Rayan *(Minuspes nexdra roxp.)*, Babul *(Acsia arabica)*, Pipal *(Ficus religious)* and Baniyan *(Ficus bengalensis)* etc.

4.5 Dodka Soil Series/Zone (Do) Tentative

Dodka series includes coarse loamy textured, deep soil, becoming more coarse Within 50 cm of the surface having stratified A & C. Profile under well-drained soil. Typifying the central concept of sub-group, yellowish brown very deep soils developed on alluvium. These are found to occur on gently sloping to gently undulating land. Soil Pedon exhibits irregular layeration. In India, these soils have been classified as 'Alluvial Soils'

Dodka Zone comprises members of coarse loamy, mixed, hyperthemic deep family of Type Ustiflyvents.

Identifying Pedon: Dodka sandy loam cultivated (colour are for dry soils unless otherwise noted).

Horizon	Depth in cm.	Description
AP1	0 - 12	Yellowish brown (10 YR 5.5/4 D) and brown (7.5 YR to 5/4 M); sandy loam; weak fine sub-angular blocky dry loose moist very friable, wet non sticky, non-plastic; common fine medium roots, many fine tomediy M simple tubular vertical in ped exped pores; moderately rapid permeability abrupt smooth boundary, moderately alkaline (pH 8.1).
A12	12 - 45	Dark reddish brown to reddish brown (5 YR 3.5/4 M); sandy loam; weak fine sub-angular blocky; dry loose, moist friable wet non sticky, non plastic many fine to medium roots; many fine to medium simple tubular vertical inped exped pores; moderately rapid permeability; clear smooth boundary moderately alkaline (8.1)
IIC1	45 - 79	Dark reddish brown (5 YR 3/3 M) loamy sand; weak fine sub-angular blocky; dry loose, moist very friable, wet non-sticky non-plastic; many fine to medium roots; many fine to medium simple tubular vertical inped and exped pores. Moderately rapid permeability; clear smooth boundary; moderately alkaline (pH 8.0)

II c2	79 - 100	Dark reddish brown (5 YR 5/3 M) loamy sand; weak fine sub-angular blocky dry loose, moist very friable, wet non sticky non plastic; very few fine roots, many fine to very fine tubular vertical inped exped pores; Moderately rapid permeability; Clear smooth boundary; moderately alkaline (pH 8.1)
II C3	104 – 166+	Dark reddish brown (5 YR 5/3 M); loam weak fine to medium sub-angular blocky dry slightly hard moist friable wet slightly sticky and slightly plastic very few fine roots; very fine to fine tubular vertical inped exped pores; moderately rapid permeability moderately alkaline (pH 8.1)

4.5.1 Range in Characteristics

The depth of the solum is generally more than 1 metre. The soil colour of the A horizon is in hue of 10 YR with value ranging from 4 to 5 and chroma 4 to 6. The lower layers have colour in hue of 5 YR and 7.5 with value ranging from 3 to 4 and chroma 4 to 3. The soil type ranges from sandy loam to loamy sand. The salt contents expressed in EC generally ranges from 0.05 to 0.78 mmhos/cm through the depth. The soil reaction is natural moderately alkaline through the depth. The profile indicates irregular distribution of the organic matter. C.F.C. in soils generally ranges from 9.6-to 23-mg/100 gram soil. The calcium carbon content in the profile generally; ranges between 0.13 to 5.13 percent.

4.5.2 Availability in the study area

The open profile of the Dodka soil series is located 1 km south of village, Dodka (Taluka Vadodara, District. Vadodara) in the agro-climatic Region II. Here the soil occurs on nearly level to gently undulating lands with slope gradient ranging from 0 – 3%. These are well drained to excessively drained soil with

moderately rapid to rapid permeability. The depth of the ground water is generally below 5 meters. A variety of crops are cultivated on these soils. These include Tobacco *(Nicotina spp)*, Tur *(Cajanus cajan)*, Bajra *(Pennisetum typhoides)*, Jowar *(Sorghum vulgare)*, Oil Seeds like Groundnut *(Arachis hypogaea)*, Castor *(Ricinus communis)* Mustard *(Brassica spp.)*, Sesamum *(Sesamum orientale)*. The natural vegetation comprises Neem *(Azadirachtra indica)*, Mango *Mangifera indica)*, Rayan *(Minuspes nexdra roxp.)*, Babul *(Acsia arabica)*, Samda *(Prosopis)* etc

4.6 Mohmadpura Soil Series/Zone (Mo) Tentative

Mohmadpura series includes coarse loamy textured moderately deep soil having stratified A. & C. Profile under well drained soil of fluvial origin typifying the central concept of sub group, moderately calcareous, amount increasing with depth. These soils occur on very gently sloping to nearly level fluvial terraces adjacent to river courses. The soils exhibit stratified Dark yellowish brown to yellowish brown layers of silty loam to sandy loam and sandy clay loam to clay loam texture. The soil effervesces violently with dilute HCL. The rooting depth extends up to 75 to 80 cm of the surface. These soils are classified in India as alluvial soils.

Mohmadpura soil comprises coarse loamy, mixed, calcareous, hyperthermic medium deep family of Typic Ustifluvents.

Typifying Pedon: Mohmadpura silty loam (Cultivated)

AP	0 – 10	Dark yellowish brown (10YR 4/6 and 10 YR 3/5 m) silty loam week fine, sub-angular blocky, dry slightly hard, moist friable, wet non sticky and non plastic, violent effervescence with dilute HCL; common for f to m roots many fine pores, moderate permeability clear smooth boundary (pH 8.1)
A12	10 - 32	Dark yellowish brown (10YR 3/6 m) silty loam, weak fine sub-angular blocky; dry hard, moist friable, wet non sticky and non plastic, violent effervescence with dilute HCL few find roots, may fine pores, moderately slow permeability gradual smooth boundary (pH 8.2)
C1	32 - 55	Dark yellowish brown (10 YR ¾ m) silty loam, weak, fine to medium sub-angular block; dry hard, moist firm, wet non sticky and non plastic violent effervescence with dilute HCL; few, fine, roots, many fine pores; moderately slow to slow permeability; clear smooth boundary (pH 8.5)
C2	55 - 80	Dark yellowish brown (10 YR 3/6 m); silty loam, weak, fine sub-angular blocky, dry slightly hard, moist vary friable wet non sticky and non plastic; violent effervescence with dilute HCL; very few fine roots, many fine few pores; moderate permeability clear smooth boundary (pH 8.8)
C3	80 – 150+	Dark yellowish brown (10 YR ¾) silty loam; weak, fine to medium sub-angular blocky; dry hard moist very friable wet non sticky and non plastic; violent effervescence with dilute HCL; moderately slow permeability (pH 9.2)
C4	150 – 180+	Yellowish brown (10 YR 3/5 m), loamy sand, weak fine sub-angular blocky; dry slightly hard, moist very friable, wet non sticky and non plastic, violent effervescence with dilute HCL; moderately permeability (pH 9.6)

4.6.1 Range in Characteristics

The thickness of the soil is more than 1.5 meters. The content of gravel/coarse fragments is in the range of 2 to 5%. The texture of fine 0 arth of the soil, material is generally loamy sand or loamy fine sand or fine sand. At

places sandy loamy texture is also met with. The Colour of the soil throughout the Pedon is dominantly in the hue of 10 YR with dry and moist values in the range of 5 and 4 and chroma 5 to 3. Rooting depth extends up to 80-85 cm. The soil reaction throughout the Pedon in strongly alkaline with soil pH ranging from 8.3 to 8.6 and even more. The soil reaction is highly alkaline in lower layer with soil pH more than 8.8. The salt content expressed in terms of the E.C. in mmhos/cm is generally less than 1 mmhos/cm. The soil matrix effervescence violently with dilute HCL and has CaCo3 equivalent percent generally ranging from 5.5 to 11.5. More than half the soils Pedon remain dry for more than 180 days during dry period for most years.

4.6.2 Availability in the study area

The open profile of the Mohmadpura soil series is located 2 km west of village Mohmadpura, (Taluka Padra, District Vadodara) in the agro-climatic Region II. Here the soil occurs on nearly level to very gently fluvial terraces with the gradient ranging from A to B. These are well-drained soils with rapid to moderately rapid permeability and rapid runoff. The depth of the ground water is in the range of 5 to 8 meters of the surface. A variety of crops are cultivated on these soils, Mostly rainfed crops like Cotton *(Gessypium spp.)*, Tur / Pigeon Pea *(Cajanus cajan)* and Wheat *(Triticum aestivum)* are grown. The natural vegetation comprises Mango *(Mangifera indica)*, Neem *(Azadirachtra indica)*, Bor *(Zyzyphus jujuba)*, Rayan *(Minuspes nexdra roxp.)*, Babul *(Acsia arabica)*, Pipal *(Ficus religious)* and Baniyan *(Ficus bengalensis)* etc

4.7 Chhidra Soil Series/Zone (Chh) Tentative

Chhidra Soil Zone includes fine loamy, deep soil having chambic-B horizon with stratified ABC horizons under well-drained soil developed on recent alluvium. These soils are found to occur on nearly level to very gently sloping lands. The soils have dark yellowish brown-to-brown sandy loam. "A" horizon grading into dark brown. 'B' horizon where as lower layers have yellowish brown colour. These Soils have been classified in India as alluvial soils.

Chhidra zone comprises member of fine loamy, mixed hyperthermic, deep family of Fluventic Ustochrept.

Typifying Pedon: Chhidra Sandy loam cultivated, (colours are for moist soils unless otherwise noted)

Horizon	Depth in Cm	Description
Ap	0 - 12	Dark yellowish brown (10 YR 4/4 D) and brown (10 YR 4/3 M); sandy loam; weak fine to medium sub-angular blocky, dry slightly hard, moist friable wet slightly sticky slightly plastic; few very fine irregular shape less than 1 percent lime concretion giving slight effervescence with dilute HCL; few fine roots, moderately rapid permeability clear smooth boundary (pH 8.1)
B1	12 - 34	Dark yellowish brown (10 YR 4/4 D) and brown (10 YR 4/3 M); clay loam; moderate medium sub-angular blocky; dry slightly hard moist friable wet slightly sticky and slightly plastic; few very fine irregular shape less than 1 percent lime concretions giving slight effervescence with dilute HCL; few very fine 1 to 2 mm rounded iron and manganese concretions loss than 1 percent few fine roots, moderately slow permeability clear smooth boundary (pH 8.7)

B21	34 - 65	Dark brown (10 YR 3/3) clay loam; moderate medium sub-angular blocky, dry hard, moist friable, wet slightly sticky and slightly plastic, lime nil, common fine roots, moderately slow permeability clear smooth boundary (pH 8.8)
B22	65 - 130	Dark brown (10 YR 3/3) clay loam, moderate medium angular blocky, breaking into sub-angular blocky; dry hard moist friable wet sticky and plastic, lime nil, few very fine 1-2 mm rounded iron and manganese concretions less than 1 percent few fine roots, moderately slow permeability; clear smooth boundary; (pH 8.3)
B3	130 - 150	Dark yellowish brown (10 YR 3/6) clay loam; moderate medium sub-angular blocky; dry slightly hard; moist friable wet slightly sticky and slightly plastic, lime nil, few fine 1-2 mm rounded iron and manganese concretions less than 1 percent very few fine roots, moderately slow permeability; clear smooth boundary (pH 7.7)
IIc	150+	Yellowish brown (10 YR 5/6) and dark yellowish brown (10 YR 3/6) loam, weak to moderate medium sub-angular blocky; dry slightly hard, moist friable, wet slightly sticky and slightly plastic; line nil, very few fine 1-2 mm rounded iron and manganese concretions less than 1 percent moderate permeability (pH 7.5)

4.7.1 Range in Characteristics

Average thickness of the solum ranges from 115 cm to 180 cm. The colour of the A horizon generally varies from yellowish brown to dark yellowish brown whereas B horizon is generally dark brown but at places dark yellowish brown colour is also observed. The lower layers have generally yellowish brown colour. The texture of 'A' horizon varies from sandy loam to sandy clay loam but at places clay loam. The texture of the fine earth in B-horizon is generally clay loam whereas in lower layers sandy loam-to-loam texture is generally observed. The salt content expressed as EC normally varies from 0.05 to 1.12 mmhos/cm

through the depth of the solum. The pH ranges from 7.2 to 9.8 through the depth. Very few fine, 1 to 2 m rounded iron and manganese concretions (less than 1 percent in volume) are observed in sub soils and lower layers. Few, irregular shaped lime concretions are also observed.

Availability in the study area

The open profile of the Chhidra soil series is located 200 metre east of village_Chhidra, (Taluka Jambusar, District Bharuch) in the agro-climatic Region IV. Here the soil occurs on nearly level to gently sloping lands with slopes less than 1%. These are well-drained soils with moderately well drained soils with moderately slow permeability. The depth of the ground water is generally below 5 meters during pre monsoon season. A variety of crops are cultivated on these soils. These include Cotton *(Gessypium spp.)*, Tur / Pigeon Pea (*Cajanus cajan)*, Castor *(Ricinus communis)*, Jowar *(Sorghum vulgare)*, Wheat *(Triticum aestivum)* and Gram (Cicer arietinum). The natural vegetation comprises Babul *(Acsia arabica)*, Thorny Bushes, Samda *(Prosopis)*, Neem *(Azadirachtra indica),* Vilayati Baval (Prospis juliflora).

4.8 Jantran Series/Zone (Ja) Tentative

These are Very fine textured deep soil with clayey textured sub stratum below 100 cm from the surface having vertic characteristics under imperfectly drained soil typifying the central concept of sub-group, moderately calcareous developed on recent alluvium. These soils are found to occur on nearly level lands. The soils have dark grayish brown to dark brown clay 'A' horizon grading

to very dark grayish brown to dark brown clay in sub soils whereas the lower layers have dark yellowish brown to silty loam. The soils have high shrink swell potential with high self-swelling property. The soils developed open cracks 2-5 cm wide on the surface during dry period in most of the years and extend vertically up to 60 cm and more. The sub soil layers are compact and exhibit intersecting slickensides forming parallel epipeds in the deeper layers. These soils have been classified as "Deep Black Soils" in India.

Jantran soil zone comprises members of very fine montmorillonitic calcareous hyperthermic deep family of Uctic Chromysters.

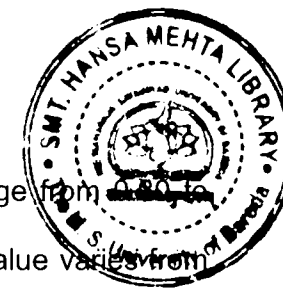
Typifying Pedon: Jantran clay cultivated. (Colours are for moist soils unless otherwise noted)

Horizon	Depth in cm.	Description
A1	0 - 18	Dark grayish brown (10 YR 4/2) clay, moderate medium to coarse sub-angular blocky, dry very hard moist firm, wet very sticky and very plastic. Very few fine 1-2 cm rounded basal-gravel less then 1 percent few fine irregular shape 1-2 cm 2.5 percent lime concretions giving strong effervescence with dilute HCL, few fine roots, moderately slow permeability, clear smooth boundary, (pH 9.0)
A2	18 - 50	Dark grayish brown (10 YR 4/2) clay, strong, coarse sub-angular blocky, dry very hard moist firm, wet very sticky and very plastic, very few fine 1-2 mm rounded basalt gravel less than 1 percent few fine irregular shape 1-2 mm 2.5 percent lime concretions giving strong effervescence with dilute HCL, few, fine roots, slow permeability; clear smooth boundary; (pH 9.0)

A3	50 - 95	Very dark grayish brown (10 YR 3/2) clay, moderate medium coarse angular blocky wedge shape peds with pressure faces, dry hard, moist firm wet very sticky and very plastic, very few fine 1-2 mm rounded basalt gravels less than 1 percent few fine irregular shape 1-2 mm 2.5 percent lime concretions giving slight to strong effervescence with dilute HCL, few fine roots slow permeability, gradual smooth boundary, (pH 8.5)
A4	95 - 146	Very dark grayish brown (10 YR 3/2) over prominent slickensides intersecting founding parallel epipeds tilted and breaking in to moderate medium to coarse angular blicky with shining pressure fales, dry hard, moist firm, wet very sticky very plastic few fine 1.3 mm less than 1% lime concretion giving slight effervescence with dilute HCL; few fine roots, flow permeability, flear smooth boundary, (PH 8.6)
	145 - 180	Very yellowish brown (10 YR 4/4) clay soil the medium sub-angular blocky, dry hard, moist friable, wet sticky and plastic, very few fine 1-2 mm less than 1 percent line concretions giving slight effervescence with dilute HCL; no roots slow permeability, (pH 8.5)

4.8.1 Range in Characteristics

Average thickness of the solum ranges from 130 to 180 cm. The colour of the surface horizon generally varies from dark reddish brown to dark brown whereas the sub soils have very dark grayish brown to dark brown colour. The lower layers have generally dark yellowish brown to yellowish brown colour. The surface texture is generally clay but at places clay loam texture is also met with the soils have clay texture. The lower layers have clay loam to clay texture and at places sandy loam to clay loam. The modality of A_p is moderate medium coarse sub-angular blocky while that in A_{12} strong coarse sub-angular blocky and in A_{13} it is moderate medium to coarse angular blocky and in A_{14} slickensides intersecting and breaking into moderate medium to coarse angular blocky with



shining pressure faces. The salt content expressed as EC range from 0.60 to 5.70 and at places increasing up to 12.0 m mhos/cm. The pH value varies from 7.10 to 8.70 but at places pH more than 9.5 is also observed. Very few basalt gravels 1 to 2 mm in size, are found through the depth of the profile. Very few common irregular shape 1.5 mm lime modules are also observed in the profile. Salts accumulations are generally found in lower parts of the solum and white incrustation observed on drying. About 1/3 of the moisture control section remains dry between 90 and 150 cumulative days in most of the years.

4.8.2 Availability in the study area

The open profile of the Jantran soil series is located 1 km south west of village Jantran (Taluka Jambusar, District Bharuch) in the agro-climatic Region IV. Here the soil occurs on nearly level lands with slope less than 1%. These are well-drained soils with moderate to moderately rapid permeability. The depth of the ground water is generally found below 5 meters from the surface in pre monsoon season. However in Vilayati Baval (Prospis juliflora) water table between 3 to 5 meters is also observed. . A variety of crops are cultivated on these soils. These include Cotton *(Gessypium spp.)*, Wheat *(Triticum aestivum)* and Jowar *(Sorghum vulgare)*. The natural vegetation comprises Mango *(Mangifera indica)*, Neem *(Azadirachtra indica)*, Bordi (Zyzyphus mauritiamn Lamk), Rayan *(Minuspes nexdra roxp.)*, Babul *(Acsia arabica)*, Pipal *(Acsia arabica)* and Baniyan *(Ficus bengalensis)*

4.9 Rajnagar Soil Series/Zone (Ra) Tentative

Rajnagar soil zone includes fine loamy deep soil with cambic-B horizon under well-drained, non-calcareous soil developed on alluvium. These soils are found to occur on nearly level to gently sloping land. The soil pedon are with A B C profile having yellowish brown to dark yellowish brown sandy loam 'A' horizon grading to very dark grayish brown to yellowish brown clay loam 'B' horizon and brown to yellowish brown clay loam horizon. These soils have earlier been classified as "Alluvial Soils" in India.

Rajnagar zone comprises member of fine loamy, mixed, hyperthermic, and deep family of Udic Ustochrepts.

Rajnagar Sandy loam cultivated (colours are for dry soils unless otherwise noted).

Horizon	Depth in cm	Description
Ap	0 – 10	Yellowish brown (10YR 5/4 D) and dark yellowish brown (10 YR 4/4 M) sandy loam, weak medium sub-angular blocky; dry slightly hard, moist friable, wet slightly sticky and slightly plastic; common medium to coarse roots; many tubular inped and eped pores; moderately rapid permeability; clear smooth boundary; slightly alkaline (pH 7.4)
B	10 - 58	Very dark grayish brown (10 YR 3/2 M) clay loam, moderate medium sub-angular blocky; dry hard, moist friable, wet sticky and plastic, very few fine 1-2 m rounded iron manganese concretion; common radium to coarse roots; common few fine tubular inped pores; moderate permeability clear smooth boundary; slightly alkaline (pH 7.4)
B2	58 - 80	Dark brown (10 YR 3/3 M); clay loam; weak fine to medium angular blocky breaking into sun-angular blocky dry hard, moist firm, wet sticky and plastic; very few fine 1-2 mm rounded iron manganese concretion; common fine to medium roots; many fine tubular inped pores, moderately slow permeability; gradual smooth boundary; slightly alkaline (pH 7.4)

B3	80 - 147	Yellowish brown (10 YR 5/4 M); clay loam moderate medium sub-angular blocky; dry hard, moist friable, wet sticky and plastic; few fine 1-2 mm rounded iron manganese concretion; few fine roots; few fine tubular inped pores, moderate permeability; clear smooth boundary mildly alkaline (pH 7.7)
C	147 - 175	Yellowish brown (10 YR 5/6 M) and brown (10 YR 5/3 M) clay loam; moderate medium sub-angular blocky; dry hard, moist friable, wet sticky and plastic 2-5 mm irregular size lime modules giving violent effervescence with dilute Hcl; moderate permeability; moderately alkaline (pH 8.4)

4.9.1 Range in characteristics

Average thickness of the sloum depth is more than 1.0 metre of the surface. The soil colour of 'A' horizon is in hue of 10 YR with value ranging from 4 to 3 and chroma 1 to 2, whereas the colour of the 'B' horizon is in hue of 10 YR with value ranging from 5 to 3 and chroma 4 to 2. The colour of 'C' horizon is in hue of 10 YR with ranging from 6 to 5 and chroma 4 to 6. The texture of fine earth fraction of the soil materials in 'A' horizon is generally sandy loam to clay loam but at places silty loam to silty clay loam are also met with. The texture of 'B' horizon generally varies from sandy clay loam to clay loam but at places silty clay loam to clay are also met with. The structure of the 'B' horizon is moderate to strong medium to coarse angular blocky breaking into sub-angular blocky. The clay content in 'B' horizon generally ranges from 19.6% to 36.4%. The salt content expressed as EC ranges from 0.06 to 1.0 mmhos/cm through the depth but at places in saline phase it varies from 0.14 to 1.85 mmhos/cm. The soil reaction is natural to moderately alkaline through the depth having pH values ranging from 7.1 to 8.1 while at places pH values vary between 7.8 to 9.3. The

content of the organic matter is generally ranging between 0.07 to 0.77% and is found to be decreasing towards depth. The calcium carbonate content in the upper part of profile is negligible but found to be abruptly increasing in lower depth.

4.9.2 Availability in the study area

The open profile of the Rajnagar soil series is located ¼ km north of village_Rajnagar, (Taluka Waghodia, District Vadodara) in the agro-climatic Region I. Here the soil occurs on nearly level to gently sloping land with slope gradient 0.00 to 2%. These are generally moderately well drained to well drained soil with moderate to moderately slow permeability. The depth of the ground water table ranges from 3 to 5 meters and more then 5 meters. A variety of crops are cultivated on these soils. These include Cotton *(Gessypium spp.)*, Paddy (Oryza sativa), Tur *(Cajanus cajan)*, Jowar *(Sorghum vulgare)*, Pulses, Wheat *(Triticum aestivum)* etc. The natural vegetation comprises Neem *(Azadirachtra indica)*, Mango *(Mangifera indica) indica)*, Babul *(Acsia arabica)*, *Samda (Prosopis)*, Pipal *(Ficus religious)* etc.

4.10 Kherwadi soil series/Zone (Kh) Tentative

Kherwadi series includes fine textured, very deep soil with vertic characteristics under imperfectly drained soil, slightly calcareous and developed on basaltic alluvium. These soils are found to occur on nearly level to very gently sloping land. The soil pedons are with AC profile having dark brown to very dark grayish brown clay A- horizon grading to dark brown to yellowish brown C-

horizon. These soils have high shrink swell potential and develop open cracks 2-4 cm, wide on the surface and extends vertically up to 80 cm. and more during dry period in most of the year. Sub soil layers are compact and exhibit intersecting slicken sides forming parallel epipeds in the deeper layer. These soils have earlier been classified as "Deep Black Soils" in India.

Khervadi zone comprises members of fine montmorillonitic hyperthermic family of Typic Chromusterts.

Typifying pedon: Kherwadi clay cultivated (colours are for dry soils unless otherwise noted)

Horizon	Depth in cm	Description
Ap	0 - 20	Dark grayish brown 10 YR 4/2 (D&M) clay; strong coarse columnar breaking into sun-angular blocky peds; dry hard, moist friable, wet sticky and plastic; 1-2 mm size few irregular shape lime concretion giving slight effervescence with dilute Hcl; very few fine basalt gravels; common fine to medium roots; moderately slow permeability common fine tubular pores; clear smooth boundary; moderately alkaline (pH 8.0)
A12	20 - 56	Very dark grayish brown 10 yr 3/2 (M); clay; moderate medium sub-angular blocky; dry hard, moist friable, wet sticky and plastic 1-2 mm size few irregular shape lime concretion giving slight effervescence with dilute Hcl; very few fine basalt gravels; common medium to coarse roots; moderately slow permeability; fine micro pores, gradual smooth boundary; mildly alkaline (pH 7.7)
A13	56 - 86	Very dark gray to very dark grayish brow 10 YR 3/2 (M) clay; strong medium to coarse angular blocky peds with prominent shiny pressure faces; dry hard, moist firm, wet sticky and plastic; very few fine 1-2 mm size irregular shape lime concretion giving slight effervescence with dilute Hcl; very few basalt gravels; common fine to medium roots; moderately slow to slow permeability, few fine to very fine pores; gradually smooth boundary; moderately alkaline (pH 8.4)

A14	86 - 130	Very dark gray to very dark grayish brown 10 yr 3/1.5 (M); clay; intersecting slicken sides forming parallel epipeds with long axes tilted that breaks into moderate medium to coarse angular blocky peds with shiny pressure faces; dry very hard, moist very fine, wet very sticky and very plastic, very few 1-2 mm size irregular shape lime concretions giving slight effervescence with dilute Hcl; very few fine Fe, Mn, concretions; very few basalt gravels; few fine to medium roots; slow permeability; few very fine pores; gradual smooth boundary; strongly alkaline (pH 8.5)
A14	130 - 170	Very dark gray to very dark grayish brown 10 YR 3/1.5 (M); clay intersecting slicken sides forming parallel pipeds with long axies tilted that breaks into moderate medium angular blocky peds with shiny pressure faces; dry hard, moist firm, wet sticky and plastic very few 1-2 mm size irregular shape lime concretion giving slight effervescence with dilute Hcl; very few basalt gravels; very few fine to medium roots; slow permeability few fine micro pores; clear smooth boundary; strongly alkaline (pH 8.6)
Ac	170 - 200	Dark brown 10 YR 3/3 (M); clay; moderate medium angular blocky breaking into sub-angular blocky dry hard moist friable, wet sticky and plastic, few 1-2 mm. size irregular shape lime concretion giving slight to strong effervescence with dilute Hcl; few basalt gravels; slow permeability; moderately alkaline (pH 8.2)

4.10.1 Range in Characteristics

Average thickness of the solum ranges from1.30 to 1.70 metre of the surface. The soil colour of the A horizon is in hue of 10 YR with value ranging from 4 to 3 and chroma 3 to 1.5 while in Ac horizon the colour is in hue of 10 YR value range from 3 to 5 and chroma varies from 3 to 6. The texture of the fine earth fraction of the soil materials is generally clay with clay percent generally ranging from 38 to 56%. The sub soil layers are compact and have intersecting slicken sides forming parallel epipeds with tilted long axies that breaks into

angular blocks with shiny pressure faces. The salt content expressed as EC generally ranges from 0.14 to 1.00 mmhos/cm through the depth but at places in saline phase it varies from 0.11 to 1.90 mmhos/cm and increases in some cases to more than 3 mmhos/cm in lower layers (below 90 cm). The soil reaction is mildly alkaline to strongly alkaline through the depth having PH values generally ranging from 7.7 to 8.9 while at places PH value exceed 9.0. The effective rooting depth is generally more than 1 metre of the surface. The content of organic matter varies from 0.17 to 1.5% in the profile. The calcium carbonate content in the profile generally ranges from 0.5% to as high as 20.5% with general tendency to increase towards the depth. The soil develops open cracks 2-5 cm wide on the surface and extends vertically up to 80 cm and more during dry periods. About 1/3 of the moisture control section remains dry for 150 or more cumulative days during dry period in most of the years.

4.10.2 Availability in the study area

The open profile of the Kherwadi soil series is located 1 km south west of village Kherwadi on Kherwadi Dandiapura (Taluka Waghodia, District Vadodara) in the agro-climatic Region I. Here the soil occurs on nearly level to gently sloping lower piedmont plain with slope gradient less than 1%. These are moderately well drained to somewhat imperfectly drained with moderately slow to very slow permeability. The depth of ground water table varies from 3 to 5 meters and more than 5 meters. A variety of crops are cultivated on these soils these include Cotton *(Gessypium spp.)*, Paddy (Oryza sativa), Tur *(Cajanus cajan)*,

Jowar *(Sorghum vulgare)*, Bajra *(Pennisetum typhoides)*, Wheat *(Triticum aestivum)* etc under rainfed crops. The natural vegetation comprises Neem *(Azadirachtra indica)*, Mango *(Mangifera indica) indica)*, Babul *(Acsia arabica) and Samda (Prosopis)* etc.

4.11 Atali Soil Series / Zone (At) Tentative

Atali series includes fine textured, deep soil with medium textured sub stratum below 100 cm from the surface, having cambic-B horizon with vertic characteristics under moderately well drained soil, moderately calcareous increasing with depth. Developed on basaltic alluvial material. The soils are found to occur on nearly level to very gently sloping lower pedmant plain and flood plain. The soil pedons are with ABC profile having dark brown clay loam to clay A horizon, grading to very dark grayish brown clay B horizon which is underlain by yellowish brown to dark yellowish brown unconsolidated alluvial parent material of soil, with indurate lime nodules. The soils are of montmorilonitic mineralogy and develop open cracks 2-3 cm wide extending vertically up to 30 to 45 cm in dry period. The peds in the sub soil exhibit angular blocky wedge shape peds with shining pressure faces. Indurated lime nodules are present throughout the depth and give strong to violent effervescence with dilute Hcl. These soils have been classified as "Deep black soils" in India.

Atali Zone comprises member of fine montmorilonitic, calcareous hyperthermic deep family of Vertic Ustochrepts.

Typifying pedon: Atali clay loam – cultivated. (Colours are for moist soils unless otherwise noted.)

Horizon	Depth in cm	Description
Ap	0 – 13	Dark brown (10 YR 3/3) clay loam; dark brown (10 YR 5/3 d) when dry weak; fine to medium sub-angular blocky; dry slightly hard, moist friable, wet slightly sticky and slightly plastic, fine indurate lime nodules violent effervescence with dilute Hcl; many fine to medium and course roots, moderately slow permeability; clear smooth boundary; (pH 8.8)
A12	13 – 30	Dark brown (10 YR 3/3) clay, medium moderate sub-angular blocky, dry slightly hard, moist friable, wet sticky and plastic, fine indurated lime nodules, violent effervescence with dilute Hcl; common fine to medium and coarse, roots, slow permeability, clear smooth boundary (pH 9.0)
B1	30 – 68	Very dark grayish brown (10 YR 3/2) clay, moderate medium angular blocky breaking into sub-angular blocky peds with shining pressure faces, dry slightly hard, moist friable, wet sticky and plastic, fine indurated lime nodules, violent effervescence with dilute Hcl, common fine to medium roots slow permeability gradual smooth boundary, (pH 9.1)
B2	68 – 102	Very dark grayish brown (10 YR 3/2) clay, moderate medium angular blocky peds with shining pressure faces, dry slightly hard, moist friable, wet sticky and plastic fine indurated lime nodules, violent effervescence with dilute Hcl, common fine to very fine roots, slow permeability clear smooth boundary, (pH 8.9)
B3	102 – 125	Very dark grayish brown (10 YR 3/2) mixed with yellowish brown (10 YR 5/4) clay, moderate medium sub-angular blocky, dry slightly hard, moist friable, wet slightly sticky and slight plastic, indurated lime nodules violent effervescence very few very fine roots, slow permeability clear smooth boundary, (pH 8.9)
C	125 – 150+	Yellowish brown (10 YR 5/4) sandy clay loam, moderate fine sub-angular blocky, dry slightly hard, moist very friable wet sticky and slightly plastic, common to many indurated lime nodules giving violent effervescence with dilute Hcl, moderate permeability, (pH 8.9)

4.11.1 Range in Characteristics:

The solum thickness ranges from 127 cm to 197 cm. The colour of the surface soil varies from very dark grayish brown to dark yellowish brown and that in the sub soil horizons varies, from very dark grayish brown to yellowish brown. The texture of the fine earth in A horizon varies from clay to silty clay loam while that in B-horizon varies from clay to silty clay. The pedality of B-horizon is generally strongly developed coarse angular blocky wedge shape with shining pressure faces breaking into moderate medium sub-angular blocky peds. The peds are hard when dry but friable when moist. The salt content in terms of Electrical Conductivity varies from 0.08 to 6.24 mmhos/cm through the depth of profiles. The soils have montmorillonitic mineralogy. The soil pedon up to the depth of 50 cm remains dry for more than 150 days during dry period.

4.11.2 Availability in the study area

The open profile of the Atali soil series is located 1 km south of village Atali, (Taluka Wagra, District Bharuch) in the agro-climatic Region IV. Here the soil occurs on nearly level to very gently sloping lower piedment plain slope generally less than 1%. These are moderately well drained to somewhat imperfectly drained soils with moderately slow to slow permeability. The depth of the ground water is generally more than 5 meters during pre monsoon season. A variety of crops are cultivated on these soils. These include Jowar *(Sorghum vulgare),* Cotton *(Gessypium spp.)*, Tur *(Cajanus cajan) and* Gram (Cicer arietinum). The natural vegetation comprises Babul *(Acsia arabica)*, Samda *(Prosopis)*, Neem *(Azadirachtra indica)*, *Mango (Mangifera indica)* etc.

4.12.1 Juni Jithardi Soil Series/Zone (Ju) Tentative

Juni Jithardi Series include, fine, textured, moderately deep soil with medium textured substratum between 100 to 120 cm from the surface with vertic characteristics under imperfectly drained soil slightly calcareous, increasing with depth derived from basaltic alluvium. The soils occur on nearly level to very gently sloping alluvial plains. The soils exhibit dark brown to dark grayish brown clay loam to clay A horizon grading to very dark grayish brown clayey A_{12} to $_{A14}$ horizons extending upto 100 to 120 cm underlain by dark yellowish brown to yellowish brown sandy loam to sandy clay loam or silty loam matrix impregnated with lime kankars (gravels). The soils have high swell-shrink potential. The soils develop open cracks 3 to 5 cm wide extending up to 70 cm depth during dry season. These soils are classified in India as deep black cotton soils.

Juni Jithardi Zone comprises members of fine, montmorrillonitic, and hyperthermic medium deep family of Typic Chromusterts.

Horizons	Depth in cm	Description
Ap	0 – 15 cm	Dark brown (10 YR 4/3) to (10 YR 3/3 M); clay loam, coarse prismatic breaking in to mo. Medium sub-angular blocky; dry hard; moist friable, wet sticky and plastic; slight effervescence with dilute Hcl; coarse fragments about 5-7%: lime concretions about 2%; common fine pores; many roots, mod. Slow permeability;
A12	15 – 40 cm	Very dark grayish brown (10 YR 3/2 m) clay; strong; medium to coarse angular blocky: dry hard: moist friable, wet sticky and plastic; slight effervescence with dil. Hcl: lime concretions 2-3% coarse fragment upto 5 mm size about 10%: common to many roots; common fine pores; slow permeability gradual smooth boundary (pH 7.6)
A13	40 – 7- cm	Very dark grayish brown (10 YR 3/2 m) clay; coarse slickensides breaking into strong coarse angular blocky peds; dry hard, moist firm wet sticky and plastic; effervescence on concretions about 5%: coarse fragments upto 5 mm size about 7-10%: many roots; common pores; slow permeability: gradual smooth boundary (pH 7.7)
A14	70 – 100 cm	Very dark grayish brown (10 YR 3/2 m): clay: coarse slickensides forming parallel epipeds and breaking in to strong, coarse, angular, blocky peds; dry hard, moist firm, wet sticky and plastic; violent effervescence with dilute HCl; concretions and powdery lime present about 5-7%: coarse fragments about 7-10% many fine, fibrous roots: common fine pores, slow permeability: gradual wavy boundary (pH 7.7)
AC	100 – 150 cm	Yellowish brown (10 YR 5/6 m) mixed with very dark grayish brown (10 YR 3/2 m) in 70-30 ratio: sandy loam: weak: fine to medium sub-angular blocky: dry slightly hard, moist friable, wet only slightly sticky and plastic: violent effervescence with dilute HCL: lime kankars/concretions and powdery lime about 15 to 20% coarse fragments 7 to 10%: rare roots: many fine pores: mod. Slow permeability (pH 7.7)
IIC	150 – 180 cm	Yellowish brown (10 YR 5/6 m): sandy loam: weak, fine, sub-angular blocky: dry slightly hard, moist friable, wet only slightly sticky and plastic; violent effervescence with dilute HCL lime kankars/concretions and powdery lime about 15-20%; many fine pores mod. Slow, permeability (pH 7.9)

4.12.1 Range in Characteristics

The average thickness of the solum ranges from 90 to 135 cm. The content of coarse fragments is around 2-5 percentage generally dispersed uniformly in the solum depth. The control section generally effervescence only slightly with dilute HCL; accumulation of lime as kankars is observed in the soil depth of 100 to 130 cm with lime content in the range of 7 to 20 percentage and even more. The soil content expressed in terms of Electrical Conductivity in m mhos/cm in 1:2 soil water ratio is generally less than 1.0. The soil reaction is moderately to strongly alkaline with soil pH in 1:2 ratio in the range of 7.9 to 8.5 and at places upto 8.8. The texture of the fine earth in the control section is generally clay with montmorrillonitic mineralogy while the texture of the under lying layers starting from 100 to 135 cm, depth is sandy loam to sandy clay loam impregnated with lime kankars. The colour of soil is in the hue of 10 YR with values and chroma ranging from 4 to 3 and 3 respectively for the surface layers.

The surface layers generally exhibit value and chroma 3 & 2 respectively. The padality in sub surface horizons is strong. Medium to coarse angular blocky with the A_{13} & A_{14} horizons exhibiting coarse intersecting slickensides forming parallel epipeds tilted at the axis at about 30' to 40' from the horizontal. The effective rooting depth extends upto 0.7 to 0.9 meter from the surface the soils remaining dry for more than 180 cumulative days during a year.

4.12.2 Availability in the study area

The open profile of the Juni Jithardi soil series is located 1.5 km North of village Juni Jithardi, (Taluka Karjan, District Vadodara) in the agro-climatic

Region II. Here the Soils occur on nearly level to very gently sloping alluvial plains with slop gradient less than 1%. These soils are generally moderately well drained with slow permeability. The depth to ground water is well below 15 to 20 meters from the surface. A variety of crops are cultivated on these soils. These include Cotton *(Gessypium spp.)*, Tur *(Cajanus cajan)*, wheat *(Triticum aestivum)*, Jowar *(Sorghum vulgare)*, Castor *(Ricinus communis)*, well irrigation is generally practiced and vegetables, Paddy (Oryza sativa) etc, are also cultivated. The natural vegetation comprises Mango *(Mangifera indica),* Bordi (Zyzyphus mauritiamn Lamk), Rayan *(Minuspes nexdra roxp.)*, Babul *(Acsia arabica)*, Pipal *(Ficus religious),* and Wad *(Ficus bengalensis).*

4.13 Orwada Soil Series/Zone (Or) Tentative

This series consists of coarse loamy textured deep soil, becoming more coarser between 50 cm to 100 cm of the surface having stratified A & C profile under excessively drained soil typifying the central concept of sub group, having materials like phillites, schists, granite and sandstone on gently sloping foot hills and out up lands. The soils have dark yellowish brown to yellowish brown loamy sand horizon followed by dark yellowish brown to dark brown loamy sand to sandy loam layer underlain by yellowish brown loamy sand horizon.

Orwada zone comprises members of course loamy, mixed hyperthermic deep family of Typic Ustorthent.

Typifying pedon: Orwada loamy sand – cultivated. (The colours are for dry soils unless otherwise noted).

Horizon	Depth in cm	Description
Ap	0 - 15	Yellowish brown (10 YR 5/6) and (10 YR 4/6 m); loamy sand; partly single grained and partly weak; fine, sub-angular blocky; dry only slightly hard, moist very friable, wet non sticky and non plastic; No reaction with dilute HCl; common fine to medium roots; many fine pores, mod. Rapid permeability; clear smooth boundary; (pH 7.0)
C1	15 - 45	Dark yellowish brown (10 YR 3/5 m), sandy loam; weak, fine sub-angular blocky; dry only slightly hard; moist v. friable, wet non sticky and non plastic, no reaction with dilute HCL; many fine to medium roots; Occasional coarse roots; many fine to medium pores; mod. Permeability; clear smooth boundary; (pH 7.1)
C2	45 - 77	Dark yellowish brown (10 YR 4/4 m); loamy sand, weak, fine, sub-angular blocky; dry only slightly hard, moist v. friable, wet non sticky and non plastic; no reaction with dilute HCL; Few, fine roots; many fine pores moderately rapid permeability; clear smooth boundary (pH 7.2)
C3	77 - 122	Dark yellowish brown; (10 YR 4/6 m); loamy sandy; weak fine, sub-angular blocky; dry only slightly hard; moist V. friable, wet non-sticky and non-plastic; V. few fine roots; many fine poresi moderately. Rapid permeability; clear smooth boundary (pH 7.2)
C4	122 – 162+	(10 YR 4/6 m); loamy sand; partly single grained and partly weak, fine sub-angular blocky; dry only slightly hard, moist v. friable, wet non-sticky and non-plastic No. Effervescence with dilute HCL; many fine and macro poresi moderately Rapid permeability clear smooth boundary; (pH 7.1)

4.13.1 Range in Characteristics

The principal soil type is loamy sand to sandy loam and gravelly sandy loam. The sub soils are also sandy loam to loamy sand and gravelly sandy clay loam. The soil matric is non-calcareous. However, some lime concretions are present through out the depth to give effervescences with dilute HCL, colour of

the 'A' horizon is in the hue of 10 YR & 7.5 YR with values ranging from 4 to 6 and chroma 3 to 5. The sub soils are also of the same hue, value and chroma. The lower layers have values ranging from 3 to 7 some quartz; gravels and other coarse fragments are present through the soil depth. The soil reaction is mildly to moderately alkaline. The soils are generally non-saline. These soils are susceptible to erosion hazard.

4.13.2 Availability in the study area

The open profile of the Orwada soil series is located 1 km south west of village Orwada (Taluka Savli, District Vadodara) in the agro-climatic Region I. Here the soil occurs gently sloping to moderately sloping foothills and ravine lands. These soils are excessively drained with rapid to moderately rapid permeability. The depth of the ground water is generally more than 5 meters of the surface. Some of the area is under forest vegetations while some cultivation is also done at suitable places.

4.14 Wantarsa Series/Zone (Wa) Tentative

Wantarsa series includes very fine textured deep soil with medium textured substratum below 100 cm from the surface having vertic characteristics under poorly drained soil typifying the central concept of subgroup, slightly calcareous, amount increasing with depth developed on basaltic alluvium caloareous materials. These are found on nearly level to gently slopping ground. The soil pedons are with AC profile having dark brown to very dark grayish brown clay to silty clay 'A' horizon grading to yellowish brown to dark yellowish brown

and brownish yellow unconsolidated calcareous 'C' horizon. The soil exhibits high swell and shrink properties. These soils develop gilgaimicro relief and open cracks about 2 to 5 cm wide extending upto 60 to 95 cm deep. The cracks 2 to 5 cm wide divide the soils into polypedons in different dimensions.

The sub soil layers exhibit prominent distinct slicken sides with wedge shaped parallel epipeds. These soils have been classified "deep black soils" in India Wantarsa series comprises member of very fine clayey montmorillonitic hyperthermic family of "Typic Chromuterts".

Typifying Pedon: Wantarsa clay (cultivated) colours are for moist unless otherwise noted.

Horizon	Depth in cm	Description
Ap	0 - 11	Dark brown (10 YR 4/3) dry and dark brown (10 YR 3/3 moist) silty clay, moderate fine sub-angular plocky, dry slightly hard, moist friable, wet sticky and plastic. About 1 X 1 to 2 mm size lime nodules giving slight effervescence with dilutes HCL on lime nodules only. Few fine roots, few micro pores; slow permeability, clear smooth boundary (pH 8.0)
A12	11 - 38	Dark brown (10 YR 4/3) dry and dark grayish brown (10 YR 4/2) clay, moderate medium angular blocky dry very hard, moist firm, wet very sticky and very plastic. About 1% to 1 to 2 mm size lime nodules giving slight effervescences with dilute. HCL on lime nodules only. Few fine roots, fine micro pores, slow permeability, gradual boundary (pH 8.0)
A13	38 - 75	Dark brown (10 YR 3/3) dry and very dark grayish brown (10 YR 3/2 moist) clay, strong coarse angular blocky, dry very hard, moist very firm. Wet very sticky and very plastic. The soil exhibit prominent slicken sides forming wedle shaped parallel epipeds. About 1% 1-2 mm size lime nodules giving slight effervescences with dilute. HCL on lime nodules only, few fine root, few very fine micro pores, very slow permeability gradual smooth boundary (pH 8.1)

A14	75 - 134	Dark brown (10 YR 3/3) dry and very dark, grayish brown (10 YR 3/2) moist clay; strong coarse angular blocky, dry very hard, moist very firm, wet very sticky and very plastic. The soil exhibit prominent distance stickon sides, forming wedge shaped parallel epipeds. About 1% 1 to 2 mm size lime nodules giving few fine roots, few very fine micro pores very slow permeability, gradual smooth boundary (pH 7.8)
AC	134 - 156	Yellowish brown (10 YR 5/6) dry to dark yellowish brown (10 YR 4/6 moist) silty clay loam, moderate medium angular blocky,, dry hard, moist firm, wet slightly sticky and plastic, more than 5 percent about 3 to 5 mm size lime nodules giving strong effervescence with dilute. HCL very few very fine roots; few very fine micro pores, moderate permeability, gradual weavy boundary (pH 8.2)
C	156 - 180	Brownish yellow (10 YR 6/6) dry yellowish brown (10 YR 5/6 moist) silty loam; weak fine sub-angular blocky, dry loose, moist friable, wet slightly sticky and non plastic; 5 to 7 mm size about 20 to 30% lime nodules giving violent effervescence with dilute HCL moderate permeability (pH 8.2)

4.14.1 Range in Characteristics

The average thickness of the solum varies from 97 to 168 cm. The colour of the surface and sub-surface horizon generally varies from dark brown to very dark grayish brown. In lower layers the colour of the soil is found brownish yellow to yellowish brown. The texture of the surface and sub surface varies from clay loam to clay and at places silty clay; while, in lower layers if varies from silty clay loam to silty loam strong coarse angular blocky and lower layers it is found medium moderate sub angular blocky and even weak fine sub-angular blocky. The sub-surface layers exhibit coarse intersecting slicken sides forming wedge shaped parallel epipeds. The salt count expressed as electrical conductivity is

generally less than 1 mmhos/cm and some of the areas have 1.1 to 2.5 m mhos/cm and at places it is raised upto 3.72 m mhos/cm. The area is non-saline to slightly saline in nature. The pH value varies from 6.9 to 8.5 and at places 8.8. The lime kankars in surface and sun-surface varies from 1 to 2% while that in lower layers (C horizon) it is found to very from 20 to 30 percent. About 1/3 of the moisture controlled sections remains dry for 150 to more cumulative days in most of the layers.

4.14.2 Availability in the study area

The open profile of the Wantarsa soil series is located about 2 km away from village Wantarsa in southwest direction. (Taluka Savli, District Vadodara) in the agro-climatic Region I. Here the soil occurs on nearly leveled to very gently slopping lands. These are somewhat imperfectly drained to poorly drained with slow to very slow permeability. The depth of the ground water is generally below 5 meters from the surface in pre-monsoon season. A variety of crops are cultivated on these soils. These include Cotton *(Gessypium spp.)*, Tur *(Cajanus cajan)*, Jowar *(Sorghum vulgare)*, Wheat *(Triticum aestivum)*, and Bajra *(Pennisetum typhoides)*. The natural vegetation comprises Mango *(Mangifera indica)*, Neem *(Azadirachtra indica)*, Bordi (Zyzyphus mauritiamn Lamk) and Rayan *(Minuspes nexdra roxp.)*.

4.15 Dahej Soil Series / Zone Dahej (Da) Tentative

Dahej Zone includes fine textured deep soil becoming medium textured between 50 cm to 100 cm of the surface having cambic horizon under poorly drained soil associated by salic (Secondary) horizon developed from tidal deposits. These are found to occur on level and flat lands along the seacoast. The soil pedon exhibits dark grayish brown to dark brown silty clay 'A' horizon grading to very dark grayish brown to dark brown clayey 'B' horizon underlain by yellowish brown to dark yellowish brow, massive tidal deposits impregnated with indurated lime. The soil pedon remained saturated for most part of the year and the matrix exhibits abundant mottles.

The salt incrustation and effervescence are observed on the surface during the dry period. These soils have been classified, as "saline soils". Dahej Zone comprises fine montmorrillonitic hyperthermic deep family of Vertic Halaquepts.

Horizon	Typifying Pedon	Dahej silty clay (Barren land)
A1	0 - 13	Dark grayish brown (10 YR 4/2) Dark brown (10 YR 3/3 m) silty loam, moderate medium sub-angular blocky; dry hard, moist firm, wet sticky and plastic, violent effervescence with dilute HCL, Roots absent; slow permeability; abrupt smooth boundary, (pH 7.4)
B1	13 - 38	Very dark grayish brown (10 YR 3/2); silty clay, weak thin platy, moist firms; wet very sticky and plastic; violent effervescence with dilute Hcl; few faint mottles of 2.5 yr 3/2 (Dusty red) very slow permeability clear smooth boundary (pH 7.3)
B21	38 - 60	Dark brown (10 YR 3/3); silty clay, moderate thick platy; moist firm, wet very sticky and plastic, strong to violent effervescence with dilute HCL. Common to many distinct mottles of 2.5 YR 3/2 (Dusty red) very slow permeability clear smooth boundary (pH 7.4)
B22	60 - 86	Very dark grayish brown (10 YR 3/2 m) silty clay weak columnar breaking in to thin laminar peds strong effervescence with dilute HCL. Abundant prominent mottles of 2.5 YR 3/2 (Dusty red); very slow permeability diffused smooth boundary (pH 7.6)
B3	86 - 125	Very dark grayish brown (10 YR 3/2 m) silty clay moderate medium columnar strong effervescence with dilute HCL abundant prominent mottles of 2.5 YR 3/2 (Dusty red); very slow permeability clear smooth boundary (pH 7.5)
C1	125 - 180	Yellowish brown (10 YR 5/4); silty clay moderate medium columnar, strong to violent effervescence with dilute HCL; abundant mottles of 2.5 YR 3/2 (Dusty red) indurated lime nodules and powdery moderate slow permeability (pH 7.6)

4.15.1 Range in Characteristics

The thickness of sloum is 180 cm. The colour of the surface soils varies from dark grayish brown to dark brown while that in the subsurface horizons varies generally from very dark grayish brown to dark brown. The colour in the lower layers is generally yellowish brown. The soil pedon remains saturated for most part of the year and the matrix exhibit abundant mottles in the lower horizon. The salt content expressed as EC is generally more than 56.0 mmhos/cm. The pH values very from 7.3 to 8.5.

4.15.1 Availability in the study area

The open profile of the Dahej soil series is located ½ km north west of village Dahej, on the right side of Dahej-Paniadra road (Taluka Amod, District Bharuch) in the agro-climatic Region IV. Here the soil occurs on level to merely mudflat lands along the seacoast with slope less than 1%. These soils are Imperfectly drained to poorly drained soils with slow to very slow permeability. The depth of the ground water is between 1.5 to 3 meters from the surface in dry period fluctuating near the surface during rainy periods and period of tidal ingress. Generally the soil is uncultivated and left as barren.

4.16 Derol soil Series/Zone (De) Tentative

Derol soil series include fine textural, deep soil with vertic characteristics, under imperfectly drained soil, slightly calcareous increasing with depth derived from the basaltic alluvium of the deccan trap and occur on nearly level to very gently sloping alluvial plains. The soil pedon exhibits AC profile with dark grayish brown clayey A horizon grading to very dark grayish brown clayey A_{12} to A_{15} horizons under lain by dark yellowish brown to yellowish brown sandy loam to silty loam C horizon. The subsoil horizons exhibit coarse intersecting slicken sides. The soils have high swell-shrink potential and develop cracks 3 to 5 cm wide during dry season. These soils are classified in India as "Deep black soils".

Derol series comprises member of fine monthorrillenitic, hyperthermic deep family of Typic Chromosterts

. Typifying Pedon: Derol clay (Cultivated) - (The colours are for dry soils unless otherwise denoted).

Horizon	Depth in cm	Description
Ap	0 – 13 cm	Dark grayish brown (10 YR 3/3 d & m) clay; moderate, medium, sub-angular blocky; dry hard, moist friable, wet sticky and plastic; slight effervescence with dilute HCL; few, lime concretions; few roots; common, fine pores; slow permeability; clear smooth boundary: (pH 8.2)
A12	13 – 42 cm	Very dark grayish brown (10 YR 3/2 m) clay; prismatic aggregates breaking into strong, medium to coarse, angular blocky peds; dry hard, moist friable wet sticky and plastic; slight effervescence with dilute HCL; few, lime concretions; common few to medium roots; common pores, slow permeability; gradual smooth boundary; (pH 7.9)
A13	42 – 90 cm	Very dark grayish brown (10 YR 3/2 m) clay; coarse slickensides with tilted syis breaking into angular blocky, dry hard, moist firm, wet sticky and plastic; slight effervescence with dilute HCL, few lime concretions; common roots; many, fine, pores, slow permeability; gradual smooth boundary (pH 7.8)
A14	90 – 138 cm	Very dark grayish brown (10 YR 3/2 m) clay; coarse, intersecting slickensides with tilted axis at 30' from the horizontal & breaking into angular blocky peds; dry hard, moist firm, wet sticky and plastic; slight effervescence with dilute HCL; very few roots, many fine pores, slow to very slow permeability, gradual smooth boundary (pH 8.0)
AC	138 – 157 cm	Dark brown (10 YR 3.5/3 m) silty clay loam, mod. Medium to coarse, sub-angular blocky; dry hard, moist firm wet sticky & plastic; violent effervescence with dilute HCL; lime concretions upto 1 cm. size about 5-7% by volume; common, fine, pores; slow permeability; gradual wavy boundary; (pH 8.0)
C	157 – 190 cm	Dark Yellowish brown (10 YR 4/4 m) loam; weak, fine to medium sub-angular blocky; dry slightly hard, moist friable, wet non-sticky and slightly plastic; violent effervescence with dilute HCL; lime concretions upto 1 cm. size about 5-7% by vol. many pores; moderately. Slow permeability (pH 8.1)

4.16.1 Range in Characteristics

The average thickness of the solum is in the range of 125 to 155 cm from the surface. The content of the coarse fragment is in the range of 2 to 4%. The soil effervescence only slightly in the control section with diluted HCL; but effervescence violent in the lower layers, with lime content in the lower layers, with lime content in the range of 5 to 7 percentage The soil reaction is moderately to strongly alkaline with pH in the range of 8.1 to 8.4 and at places upto 8.8. The soil salinity expressed in terms of E.C. in mmhos/cm in 1:2 soil water ratio is less than 1 mmhos/cm. The colour of the soil is in the hue of 10 YR, with values and chroma ranging from 4 to 3 in the surface, 3 to 2 in the sub surface and 6 to 3 in the lower layers. The texture of the fine earth in surface and sub-surface is clay with clay ranging from 35 to 67 percentage while that in the lower horizons from 125 to 155 downwards is sandy loam to silty loam, with clay percentage ranging from 12 to 23 percentage. The pedality of the surface horizon is moderately medium sub-angular blocky while that in the subsurface is a prismatic aggregate breaking into angular/sub-angular blocky peds. The sub surfaces below 60-70 cm. exhibit intersecting slicken. Slides with tilted axis forming parallel epipeds. The underlain horizon has fine to medium sub-angular blocky peds. The soils remain dry for more than 180 days cumulative in a year and develop cracks 3 to 5 cm. wide extending upto 90 cm. The rooting depth extends upto 100 cm.

4.16.2 Availability in the study area

The open profile of the Derol soil series is located 1.5 km north west of village Derol, **(Taluka Bharuch, District Bharuch)** in the agro-climatic Region III. Here the soil occurs on nearly level to very gently sloping alluvial plains with slope gradient less than 1 percentage The soils are moderately well drained to somewhat imperfectly drained with slow to very slow permeability. The depth of ground water in wells is in the range of about 15 meters from the surface. These are mostly cultivated for rainfed crops like Tur ***(Cajanus cajan)***, Cotton **(Cicer arietinum)**, Jowar ***(Sorghum vulgare),*** Wheat ***(Triticum aestivum) and*** Pulses. Well irrigation is also practiced and crops like Sugarcane ***(Saccharum officinarum)***, Fruits, vegetables are also taken in some small areas.

4.17 Manjrol soil series/Zone (Mn) Tentative

Manjrol Zone includes moderately fine loamy textured, moderately shallow soil becoming coarser (by one textured class) between 50 cm and 100 cm of the surface having cambic horizon within 70 cm from the surface, under well drained strongly calcareous soil, amount decreasing towards depth, typifying the central concept of sub group, developed on alluvium. These soils are sound to occur on nearly level to gently sloping land. The soil pedons are with ABC profile having yellowish brown (10 YR 5/6 m) sandy loam. 'A' horizon, grading to yellowish brown to dark yellowish brown B horizon and yellowish brown sandy loam C horizon. These soils have earlier been classified as "Alluvial Soils" in India.

Manjrol Zone comprises fine loamy, mixed, calcareous hyperthermic medium deep family of "Typic Ustochrepts".

Typifying Pedon: Manjrol sandy loam cultivate (Colours are for dry soils unless otherwise noted)

Horizon	Depth in cm	Description
Ap	0 - 12	Yellowish brown (10 YR 5/6 m) sandy loam, weak medium sub-angular blocky structure, dry slightly hard, moist friable wet slightly, slightly plastic, lime concretion 10% of 1 cm, violent effervescence with dilute HCL; common fine to coarse roots, common fine to coarse pores, moderately permeability, gradual smooth boundary (pH 8.5)
B1	12 - 39	Yellowish brown (10 YR 5/6 m) loam, moderate medium sub-angular blocky structure dry loose, moist very friable wet slightly sticky slightly plastic. Lime concretion 10% of 0-1 cm size, violent effervescence with dilute HCL; common fine to coarse roots fine to coarse imped exped pores, clear smooth boundary (pH 8.5)
B2	39 - 72	Yellowish brown (10 YR 5/6 m) clay loam, moderate medium sub-angular blocky structure, dry hard moist friable wet slightly sticky, slightly plastic, lime concretions 8% of 0 – 1 cm size violent effervescence with dilute HCL, few fine vertical and horizontal roots, common fine pores clear smooth boundary (pH 8.45)
C1	75 - 120	Yellowish brown (10 YR 5/7 m) sandy loam, weak fine sub-angular blocky structure dry slightly hard moist vary friable, wet slightly sticky and slightly plastic, lime concretion 0-1 CM size 5% violently effervescence with dilute HCL, common fine pores, clear smooth boundary (pH 8.65)
C2	120 - 175	Yellowish brown (10 YR 5/8) sandy loam, weak fine sub-angular blocky structure, dry slight hard moist very friable, wet non sticky non plastic lime concretions 0-1 CM size 3% violent effervescence with dilute HCL, fine pores clear smooth boundary (pH 8.65)

4.17.1 Range in Characteristics

The average thickness of solum ranges from 0.7 to 1.80 meters. The soil is generally very deep. The soil colour through the depth is in the hue of 10 YR with values ranging from 5 to 4 and chroma 6 to 4 and at places 3. The texture of the surface soil varies from sandy loam to sandy clay loam and silty loam. The texture of 'B' horizon is generally sandy loam to clay loam. The lower horizon has soil texture of loamy sand to loam and even silt loam is met with. The calcium carbonate content varies from 4.75 to 20 percentage throughout the depth and the lower layers have high calcium carbonate content. The pedality of 'B' horizon is moderate medium sub-angular blocky. The salt content expressed as EC generally varies from 0.15 to 1.0 mmhos/cm but at places even 2.B is observed through the depth. The soil reaction is generally moderately alkaline with pH values ranging between 7.2 & 8.9. The soil pedon remains dry more than halls the parts i.e. for more than 180 days during the dry period in most years.

4.17.2 Availability in the study area

The open profile of the Manjrol soil series is located 1.5 km south east of village Manjrol, (Taluka Sinor, District Vadodara) in the agro-climatic Region I. Here the soil occurs on nearly level to very gently sloping land with slope gradient 0.0 to 2.0 percentage. These soils are generally moderately well drained to well drained soil with moderately slow permeability. The depth of ground water table is more than 5 meters from the surface. A variety of crops are cultivated on these soils. These include cotton (Cicer arietinum), Tur *(Cajanus*

cajan), Jowar *(Sorghum vulgare)*, Bajra *(Pennisetum typhoides)*, and Sundhia. The natural vegetation comprises Bor *(Zyzyphus jujuba)*, Samda *(Prosopis)*, Neem *(Azadirachtra indica)*, Mango *(Mangifera indica)*, and Babul *(Acsia arabica)*.

4.18 Mota Fofalia Series/Zone (Mo) Tentative

Mota Fofalia Zone includes fine loamy, moderately deep soil becoming fine within 50 cm from the surface having cambic – B-horizon with vertic characteristics under moderately well drained soil developed on basaltic alluvium. These are found to occur on nearly level to gently slopping land. The soil pedon exhibits ABC profile having dark brown clay loam to clay 'A' horizon dark brown grading to dark grayish brown B horizon, underlain by yellowish brown C horizon. The indurated line nodules are observed in the last horizon. Soil developed open cracks of 2 cm width upto 45 cm during dry period. These soils have been classified as medium "Black soils" in India.

Mota Fofalia zone comprises member of fine loamy, mixed, hyperthermic, medium deep family of Vertic Ushochrepts.

Typifying Pedon: Mota Fofalia clay loam cultivated (colours are of dry soils unless and otherwise noted)

Horizon	Depth in cm	Description
Ap	0 - 10	Dark brown (10 YR 3/3 m) clay loam, moderate medium sub-angular blocky structure dry hard, moist friable wet sticky and plastic, very few concretions No effervescence with dilute Hcl. 1 to 2 cm wide cracks, common fine to medium roots, common fine to medium pores, clear smooth boundary, moderately Slow permeability (pH 7.8)
B1	10 - 31	Dark brown (10YR 4/3 m) clay loam mod. Medium sub-angular blocky structure, dry hard, moist friable wet sticky and plastic, very fine manganese concretions, No effervescence with dilute Hcl, common fine to medium roots, common fine to medium pores, clear smooth boundary (pH 8.1)
B21	31 - 46	Dark brown (10 YR 4/3 m) clay strong coarse angular blocky breaking with sub-angular blocky structure; dry hard moist friable, wet sticky and plastic, few lime concretion, strong effervescence with dilute Hcl, few fine roots, common fine inped exped pores, Gradual smooth boundary (pH 7.9)
B22	46 - 95	Dark brown (10 YR 4/3 m) clay loam, moderate medium angular blocky structure, dry hard, moist friable, wet slightly sticky and plastic lime concretions upto 5% strong effervescence with dilute Hcl; very few very fine roots many fine pores, vertical smooth boundary (pH 9.1)
C1	95 - 147	Yellowish brown (10 YR 5/6 m) sandy loam, weak fine sub-angular blocky structure dry slightly hard moist very friable wet non sticky non plastic, lime concretions present violently effervescence with dilute Hcl; note very fine roots, many fine pores, clear smooth boundary (pH 8.2)
C2	147 - 185	Yellowish brown (10 YR 5/6 m) sandy loam weak fine sub-angular blocky structure dry slightly hard, moist friable, wet non sticky non plastic, lime concretions present violent effervescence with dilute Hcl; many fine inped exped pores clear smooth boundary (pH 8.5)

4.18.1 Range in Characteristics

The soil is deep to very deep solum thickness ranging from 90 to 125 cm. The colour of the surface soil varies from 10 YR with value 4 and chroma 2 to 3

and the subsurface has generally colour with value from sandy loam to clay loam and in subsurface layers clay loam to clay texture is met with. The structure of the sub surface soil is medium to moderate to strong angular blocky. The salt content expressed in electrical conductivity varies from 0.10 to 1.54 m mhos/cm. However in saline patches, the EC goes upto 2.2 m mhos/cm. The pH value varies from 7.7 to 8.6.

Availability in the study area

The open profile of the Mota Fofalia soil series is located 1.5 km west of village Mota Fofalia, (Taluka Sinor, District Vadodara) in the agro-climatic Region II. Here the soils occur on nearly level to gently slopping land with slope gradient less than 1%. These soils are moderately well drained to somewhat imperfectly drained with moderately slow to very slow permeability. A variety of crops are cultivated on these soils. These include Cotton *(Gessypium spp.)*, Tur *(Cajanus cajan)*, Bajra *(Pennisetum typhoides)*, Maize (Zea mays), Jowar *(Sorghum vulgare)*. The natural vegetation comprises Neem *(Azadirachtra indica)*, Babul *(Acsia arabica)*, Samda *(Prosopis)*, *Mango (Mangifera indica) etc*

4.19 Kaledia Soil Series/Zone (Ke) Tentative

Kaledia zone includes moderately deep soil, becoming coarser (by one textured class) between 50 cm to 100 cm from the surface, having cambic horizon within 75 cm from the surface under moderately well drained soil, typifying the central concept of subgroup, derived from weathered basaltic materials. These soils are found to occur on gently undulating to gently sloping

pediment slope of isolated hills having a gradient ranging from 1 to 3%. Gravels and stone are observed on the surface and also in the profile depth. The soil pedon are with ABC profile having dark brown to very dark grayish brown clay loam 'A' horizon under lain by light yellowish brown to dark brown clay B horizon under lain by light yellowish brown to pale brown to dark yellowish brown 'C' horizon with weathered basaltic materials. The soils are of montmorillonitic mineralogy and develop 1 to 2 cm wide cracks during dry period. The sub soils exhibit pressure faces and faint slickensides. These soils have been classified as medium "Black soils" in India.

Kaledia Zone comprises members of fine Montmorillonitic hyperthermic medium deep family of Vertic Ustochrepts.

Typifying pedon: Kaledia – clay loam cultivated (colours are for dry soils unless otherwise noted)

Horizon	Depth in cm	Description
Ap	0 - 9	Dark brown (7.5 YR 3/2 D & M) clay loam; moderate medium sub-angular blocky dry hard moist friable, wet sticky and plastic, 2-5 mm, few basalt gravels very ew fine 1-2 mm iron manganese concretion, common fine to medium roots, many micro inped exped tubular pores, moderate permeability; clear smooth boundary; (pH 7.0)
B1	9 - 27	Very dark grayish brown (10YR 3/2 m) clay; strong to moderate medium sub-angular blocky; dry hard, moist friable wet sticky and plastic; 2-5 mm. Few basalt gravels, many fine to medium roots; many fine inped exped vertical tubular pores; moderately slow permeability clear smooth boundary (pH 7.2)

B21	27 - 55	Very dark grayish brown (10 YR 3/2 M) clay, moderate medium to coarse angular blocky breaking in to sub angular blocky, shining pressure faces and slicken sides, dry very hard, moist firm, wet very sticky and very plastic, few basalt gravels, few fine roots, many micro pores, moderately slow permeability, clear smooth boundary (pH 7.4)
B22	55 - 75	Very dark grayish brown (10 YR 3/2 M) clay, moderate medium angular blocky breaking in to sub-angular blocky; shiny pressure faces and slicken sides, dry very hard, moist firm, wet very sticky and very plastic, few basalt gravels, few fine roots, many micro pores, moderately slow permeability, clear smooth boundary (pH 7.4)
B3	75 - 87	Dark grayish brown (10 YR 4/2 M) and dark yellowish brown (10 YR 4/4 M) clay loam; moderate medium angular blocky, breaking in to sub-angular blocky, dry hard, moist friable, wet sticky & plastic, very few fine roots, strong effervescence with dilute HCL: few fine micro pores, moderately slow permeability clear smooth boundary (pH 7.4)
IIC	87+	Light yellowish brown (10 YR 6/4 M) and dark yellowish brown (10 YR 4/4 M), weathered basaltic material mixed with lime.

4.19.1 Range in Characteristics

The thickness of the solum ranges from 25 cm to 90 cm. The colour of the surface soil in 'A' horizon is generally in the hue 10 YR (at places 7.5 YR) with value of 4 & 3 and chroma 3 and 2. The surface texture varies from clay loam to clay. The texture of the 'B' horizon is generally clay. The pedality of 'B' horizon is moderate to strong medium to coarse angular blocky breaking into sub-angular blocky. The shiny pressure faces and weakly developed slickensides are observed in sub surface. Basalt and quartz gravels are found to spread commonly on surface. These are also observed in the profile. The salt content expressed as EC is generally less than 0.5 m mhos/cm through the depth but at

places it reaches up to 1.14-m mhos/cm, pH value in the soil generally varies from 7.0 to 8.2 indicating neutral to moderately alkaline soil.

4.19.2 Availability in the study area

The open profile of the Kaledia soil series is located 1 km west of village Kaledia village and 60 meters north of Kaledia chametha village road (Taluka Naswadi, District Vadodara) in the agro-climatic Region I. Here the Soils occur on nearly level to gently slopping land with slope gradient less than 1 percentage. moderately well drained soils with moderate to moderately slow permeability. Depth of the ground water table is generally well below 5 meters. A variety of crops are cultivated on these soils. Major area is under rainfed crops like Jowar *(Sorghum vulgare)*, Bajra *(Pennisetum typhoides)*, Cotton *(Gessypium spp.)*, and Tur *(Cajanus cajan)*. The natural vegetation comprises Neem *(Azadirachtra indica)*, Khakhar, Babul *(Acsia arabica)*, Mango *(Mangifera indica)*, Mahuda *(Madhuca latifolia)*, Bordi (Zyzyphus mauritiamn Lamk), and Samda *(Prosopis)* are observed.

4.20 Akteshwar Soil Series/Zone (Ak) Tentative

Akteshwar Zone includes moderately fine textured shallow soil with a hard pan with 50 cm of the surface having cambic horizon under moderately well drained soil typifying the central concept of subgroup, dark brown to dark reddish brown soils developed on inter trappean basalt rock. These soils are found to occur on foothill and/or pediment slope of isolated residential hummocks having gently to moderately undulating upland with slope gradient 1 to 3 percentage and

more. The soils are generally free from lime. Basaltic rock fragments, gravels and ferromanganese concretions are found. These soils have earlier been classified as "shallow red soils" in India.

Akteshwar zone comprises members of fine montomorillonitic hyperthermic shallow family of Llithic Ustochrepts

Typifying Pedon: Akteshwar sandy loam cultivated (Colours are for dry soils unless otherwise noted.)

Horizon	Depth in cm	Description
Ap	0 - 12	Dark brown (7.5 YR 4/4 & 7.5 YR 3/2 D and M) sandy loam; weak medium sub-angular blocky peds dry slightly hard, moist friable, wet sticky and plastic, abundant fine roots. Many micro pores, vertical inped and exped tubular and simple, moderately rapid permeability; clear smooth boundary; neutral (pH 7.3)
B	12 - 50	Dark reddish brown (5 YR 3/2 M) clay; moderate medium to coarse prismatic breaking in to sub-angular blocky dry hard, moist friable, wet sticky and plastic; few irregular basaltic rock fragments; few fine fibrous roots, many micro vertical inped exped tubular simple pores, moderate permeability clear smooth boundary; neutral (pH 7.2)
C	50+	Weathered basalt rock mixed with soft murrum, gravels etc.

4.20.1 Range in Characteristics

Average thickness of the solum ranges from 20 to 70 cm. The soil colour is in hue of 7.5 YR and 5 YR with value ranging from 4 to 3 and chroma 3 to 2. The texture of the surface soil varies from sandy loam to sandy clay loam where as in sub surface it varies from clay to clay loam. The pedality of surface soil is weak medium sub-angular blocky while in B-horizon it becomes medium to coarse prismatic breaking in to sub-angular blocky. The salt content as

expressed as EC ranges from 0.05 to 0.11 m mhos/cm. indicating non-saline nature of the soil. The soil reaction in generally neutral too slightly alkaline throughout the depth. Abundant roots are present upto 10-30 cm depth. Spreading of gravels and few stones on the surface is observed.

4.20.2 Availability in the study area

The open profile of the Akteshwar soil series is located ¼ km north of Akteshwar village (Taluka Rajpipla, District Narmada) in the agro-climatic Region I. Here the Soils occur on gently to moderately undulating lands on foothill slope/piedmont slope with slope gradient 1 to 3 percentage and more. The soils are moderately well drained with moderate to moderately rapid permeability. Depth of ground water table is generally found well below 5 meters from the surface. A variety of crops are cultivated on these soils. Major area is under rainfed crops like Jowar *(Sorghum vulgare)*, Bajra *(Pennisetum typhoides)*, Cotton *(Gessypium spp.)*, and Tur *(Cajanus cajan)*. The natural vegetation comprises Neem *(Azadirachtra indica)*, Khakhar, Babul *(Acsia arabica)*, Mango *(Mangifera indica)*, Mahuda *(Madhuca latifolia)*, Bordi (Zyzyphus mauritiamn Lamk), and Samda.

4.21 Zaria Series/Zone (Zr) Tentative

Zaria Zone includes fine textured shallow soil becoming medium textured, strong gravely within 50 cm of the surface having stratified A-C profile under well-drained soil typifying the central concept of sub group.

This soil occurs on pediment slope of isolated residual hummocks and ridges having gently to moderately undulating land. The soils have dark brown clayey horizon followed by reddish brown clay loam horizon. The soils are generally free from lime Basaltic stone pieces are observed on the surface and stone and gravels of mixed mineralogy in the profile depth.

Zaria Zone comprises member of fine clayey monimonillonitic hyperthermic shallow family of Vertic Ustorthents.

Typifying Pedon: Zaria clay cultivated (The colour are for dry soils unless otherwise noted)

Horizon	Depth in cm	Description
Ap	0 - 18	Dark brown (7.5 YR 33/4 m) clay; moderate medium sub-angular blocky; dry very hard, moist firm wet very sticky and very plastic No reaction with dilute HCL. Vertical 2 to 3 cm. vide cracks observed. Many fine fibrovers roots; many fine pores; moderate permeability; clear smooth boundary (pH 6.8)
Ap	18 - 42	Dark brown (7.5 YR ¾) gravelly clay; moderate medium sub-angular blocky; dry very hard moist, firm wet sticky and plastic. No reaction with dilute HCL 30 to 40% 1.5 cm to 3 cm. in size weathered stones and gravel pieces of mixed mineralogy observed, few fine fibers roots, few fine pores moderately; clear smooth boundary (pH 6.9)
IIC1	42 - 62	Reddish brown (5 YR 4/4) gravelly clay loam; moderate, medium, sub-angular blocky dry hard moist friable wet sticky and plastic. No reaction with dilute Hcl 40% 1 to 3 cm size weathered stone pieces and gravels of mixed mineralogy observed very few very fine pores; clear smooth boundary (pH 7.0)
IIC2	62 – 90+	Reddish brown (5 YR 4/4) weathered basalt.

4.21.1 Range in Characteristics

Thickness of the solum ranges from 25 to 45 cm. The soil colour is in hue of 7.5 YR and 5 YR with value ranging from 3 to 4 and chroma 2 to 4. The texture at the surface and subsurface soil varies from clay to clay loam. The structure of soil is moderate medium sub-angular blocky, grading to sin grained structure in 'C' horizon. Basalt rock fragment, gravels are present throughout the profile depth. The salt content expressed in terms of EC ranges from 0.05 to 0.10 mmhos/cm. indicating non-saline nature of the soil. The soil reaction is generally neutral through the depth. Common fine roots are present upto 35 to 45 cm. The soils remain dry for more than 180 cumulative days in a year.

4.21.2 Availability in the study area

The open profile of the Zaria soil series is located 1 ½ km North East of Zaria village and ¼ km North at Jharia Ashram & Kevadia Tanakhala Road (Taluka Rajpipla, District Narmada) in the agro-climatic Region II. Here the soil occurs on gently to moderately undulating land on pediment slope & ridges with slope gradient 1 to 3 percentage. The soils moderately well drained with moderate permeability. The depth of ground water table is generally found well below 5 meters from the surface. A variety of crops are cultivated on these soils. These include Cotton *(Gessypium spp.)*, Jowar *(Sorghum vulgare)*, Tur *(Cajanus cajan)*, Maize (Zea mays) etc. The natural vegetation comprises of Neem *(Azadirachtra indica)*, Mahuda *(Madhuca latifolia)*, Mango *(Mangifera indica)*, Tad, Samda *(Prosopis)* and Babul *(Acsia arabica)*. (Table. 4.3) (Figure 41 to 4.5)

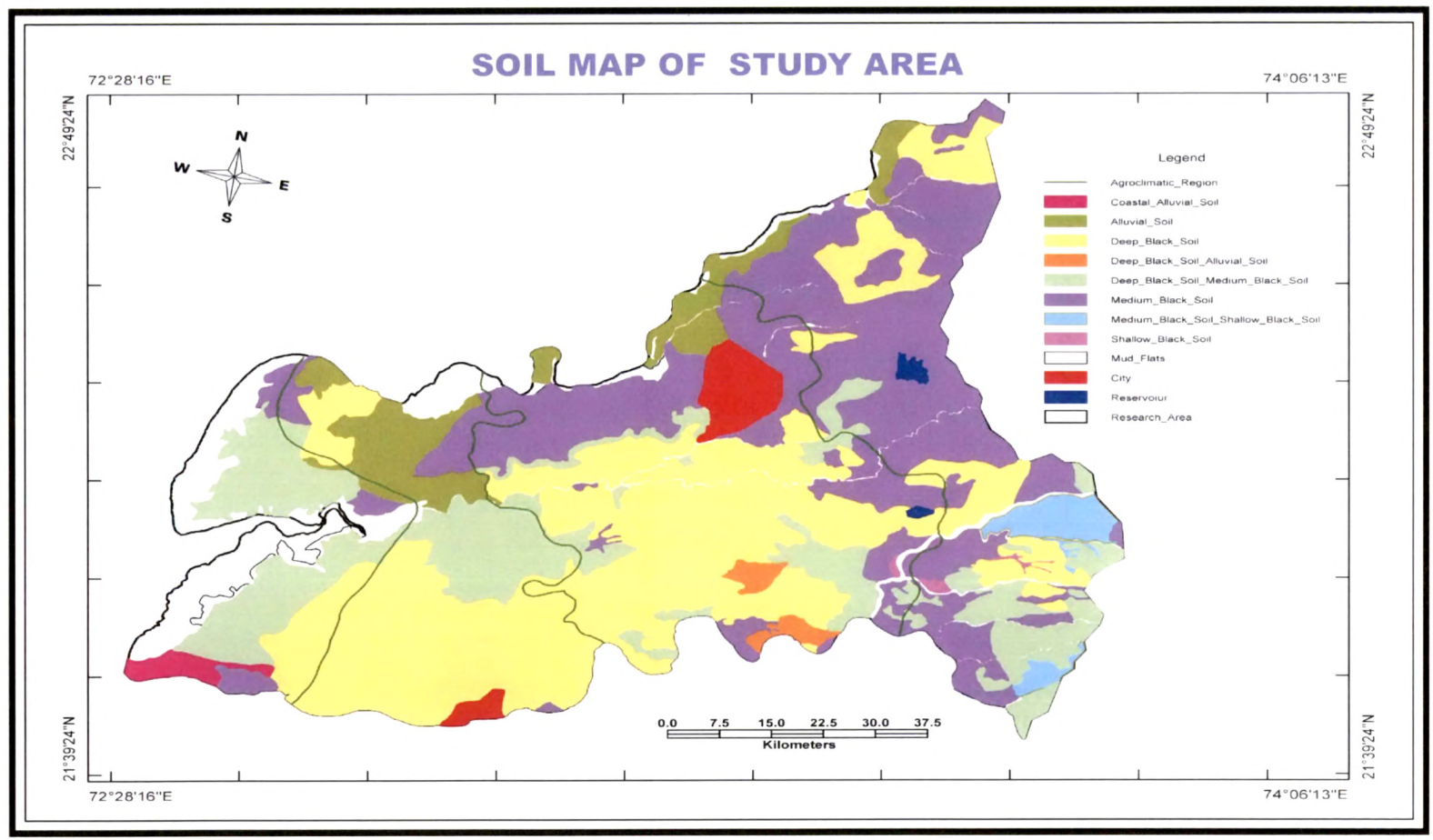

SOIL MAP OF STUDY AREA
72°28'16"E
74°06'13"E
22°49'24"N
21°39'24"N
N
W
E
S
Legend
Agroclimatic_Region
Coastal_Alluvial_Soil
Alluvial_Soil
Deep_Black_Soil
Deep_Black_Soil_Alluvial_Soil
Deep_Black_Soil_Medium_Black_Soil
Medium_Black_Soil
Medium_Black_Soil_Shallow_Black_Soil
Shallow_Black_Soil
Mud_Flats
City
Reservoir
Research_Area
0.0 7.5 15.0 22.5 30.0 37.5
Kilometers

Figure 4.1

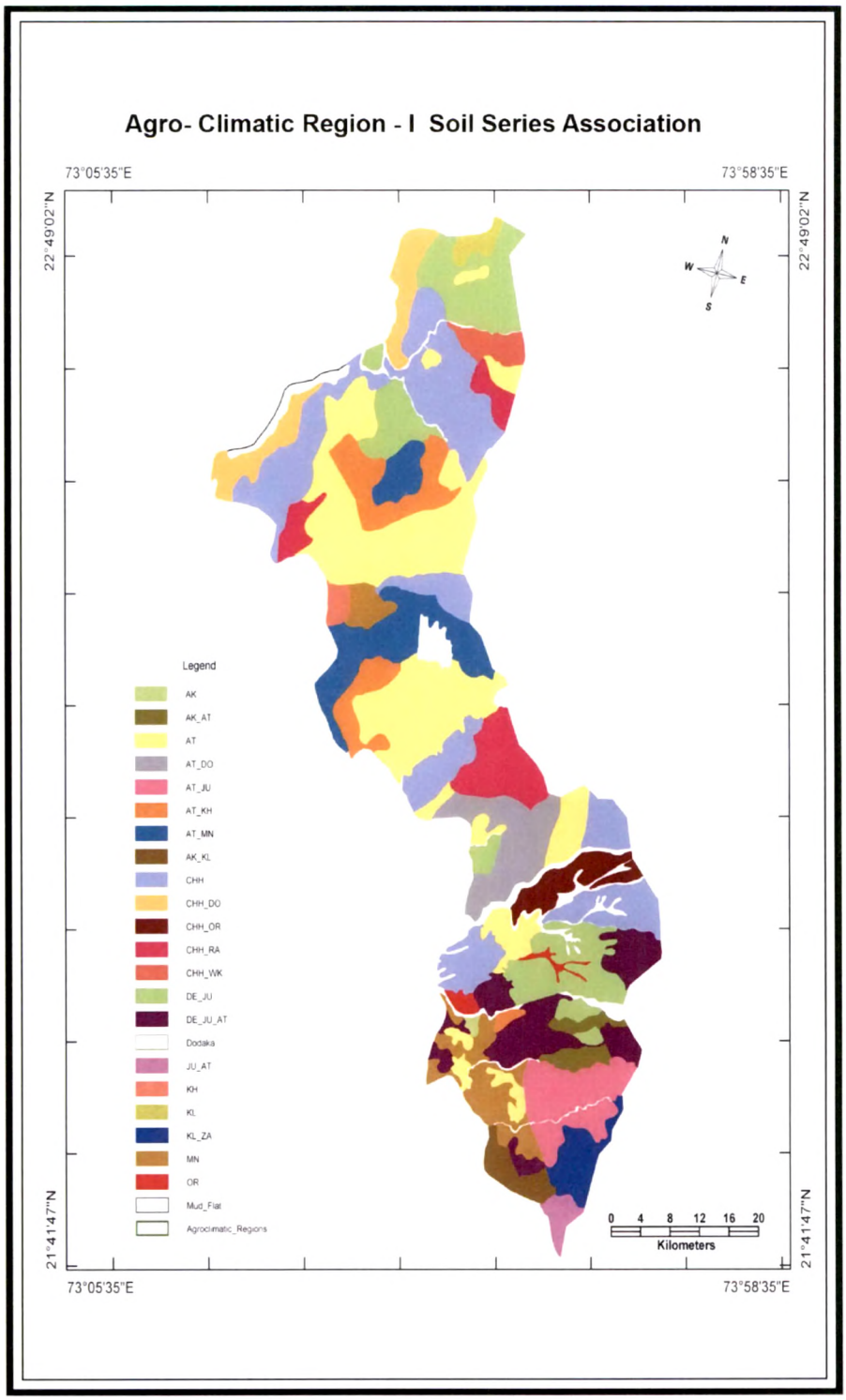

Agro- Climatic Region - I Soil Series Association
73°05'35"E
73°58'35"E
22°49'02"N
21°41'47"N
N
W
E
S
Legend
AK
AK_AT
AT
AT_DO
AT_JU
AT_KH
AT_MN
AK_KL
CHH
CHH_DO
CHH_OR
CHH_RA
CHH_WK
DE_JU
DE_JU_AT
Dodaka
JU_AT
KH
KL
KL_ZA
MN
OR
Mud_Flat
Agroclimatic_Regions
0 4 8 12 16 20
Kilometers

Figure 4.2

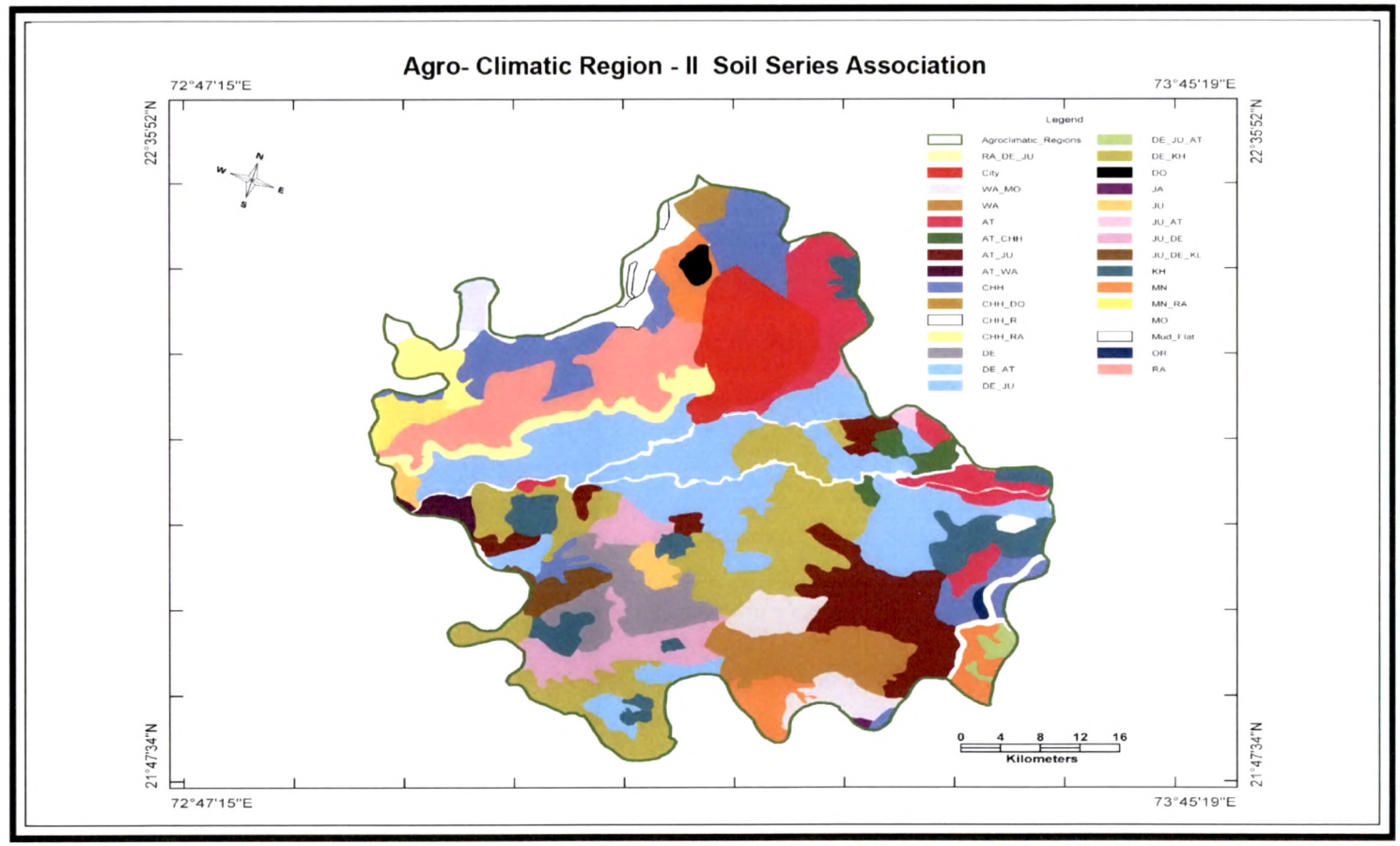

Agro- Climatic Region - II Soil Series Association
72°47'15"E
73°45'19"E
22°35'52"N
21°47'34"N
Legend
Agroclimatic_Regions
RA_DE_JU
City
WA_MO
WA
AT
AT_CHH
AT_JU
AT_WA
CHH
CHH_DO
CHH_R
CHH_RA
DE
DE_AT
DE_JU
DE_JU_AT
DE_KH
DO
JA
JU
JU_AT
JU_DE
JU_DE_KL
KH
MN
MN_RA
MO
Mud_Flat
OR
RA
0 4 8 12 16
Kilometers

Figure 4.3

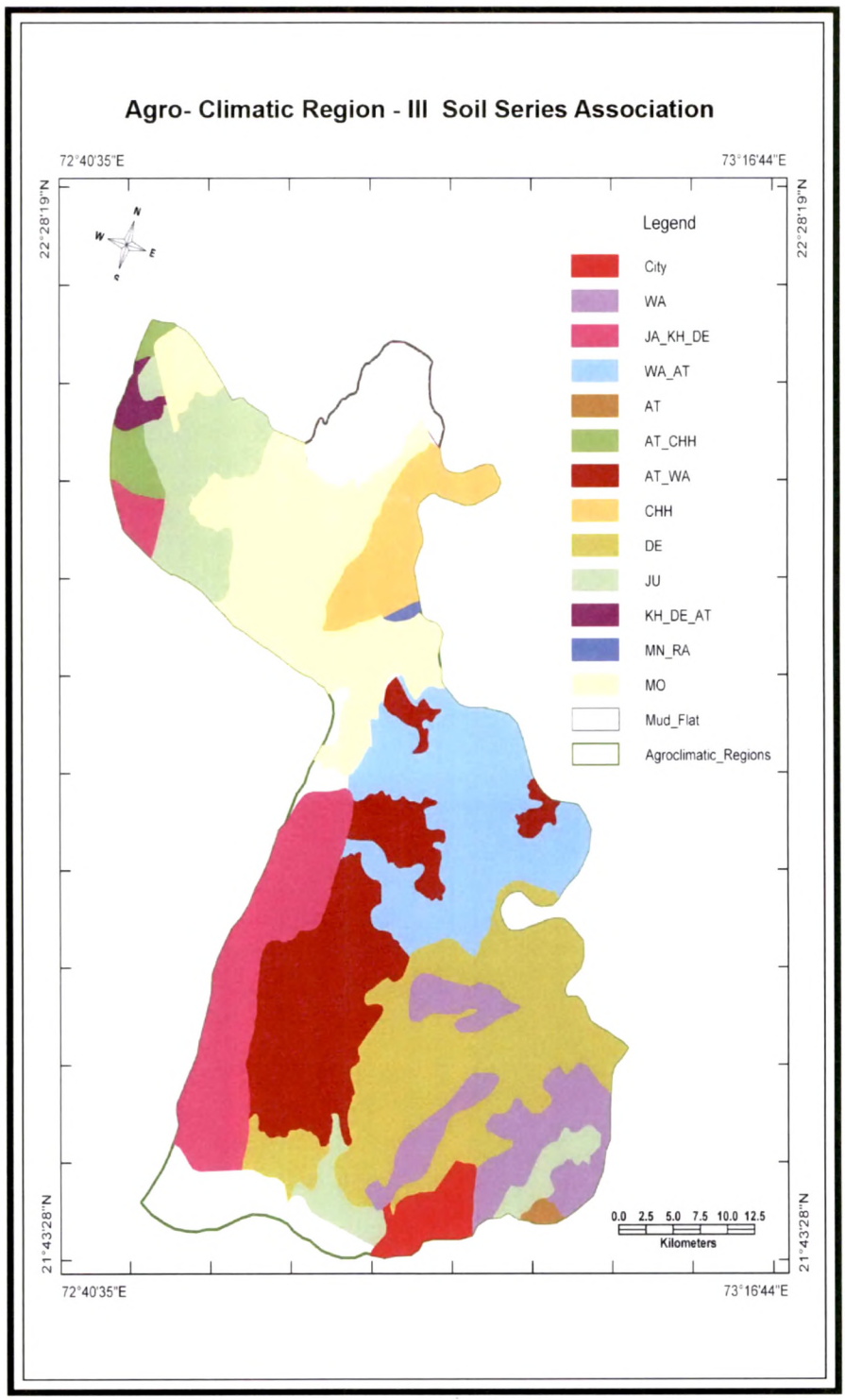

Agro- Climatic Region - III Soil Series Association
72°40'35"E
73°16'44"E
22°28'19"N
21°43'28"N
N
W
E
Legend
City
WA
JA_KH_DE
WA_AT
AT
AT_CHH
AT_WA
CHH
DE
JU
KH_DE_AT
MN_RA
MO
Mud_Flat
Agroclimatic_Regions
0.0 2.5 5.0 7.5 10.0 12.5
Kilometers

Figure 4.4

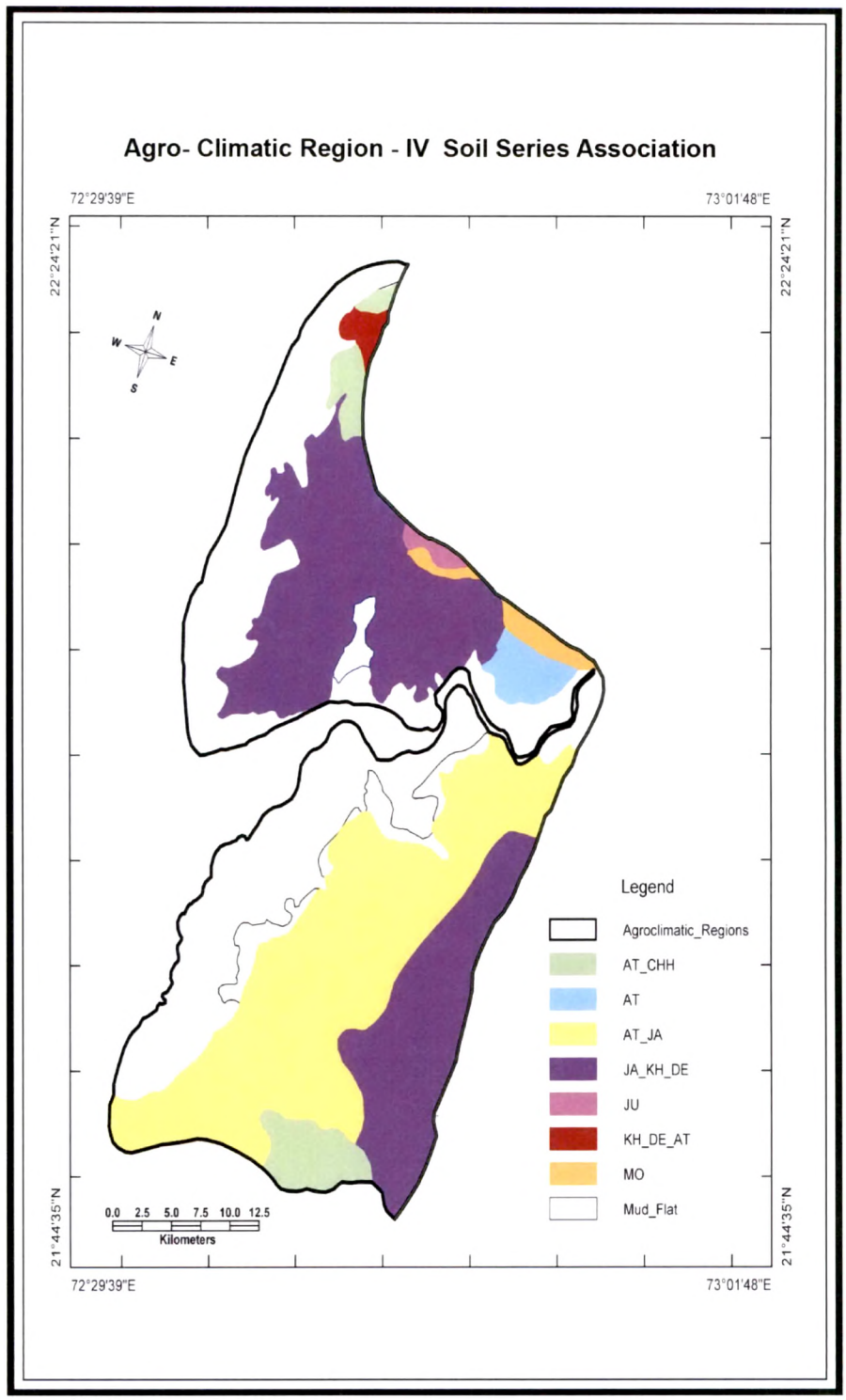

Agro- Climatic Region - IV Soil Series Association
72°29'39"E
73°01'48"E
22°24'21"N
21°44'35"N
N
W
E
S
0.0 2.5 5.0 7.5 10.0 12.5
Kilometers
Legend
Agroclimatic_Regions
AT_CHH
AT
AT_JA
JA_KH_DE
JU
KH_DE_AT
MO
Mud_Flat

Figure 4.5

Table 4.3: Statement showing distribution of area in terms of soil series

Sr. No.	NAME OF SERIES (Local Name)	Area in Hectare	%
1	KHERVADI	21905	2.77
2	DEROL	32369	4.09
3	JUNI JETHERDI	35693	4.51
4	WANTARSA	23827	3.01
5	KHERVADI + DEROL	28967	3.66
6	DEROL + JUNI JITHERDI	69948	8.85
7	KHERVADI + DEROL + JANTRAN	52536	6.64
8	MOTA FOFALIA	10003	1.26
9	ATALI	49988	6.32
10	KHERVADI	2621	0.33
11	DEHEJ	1372	0.17
12	WANTARSA + MOTAFOFALIA	8273	1.05
13	KHERVADI + ATALI	4245	0.54
14	DEROL + JUNI JITHERDI + RAJPURA	3804	0.48
15	DEROL + JUNI JITHERDI + ATALI	12390	1.57
16	DEROL + JITHERDI + KHERVADI	7858	0.99
17	DEROL + ATOLI	4221	0.53
17	JUNI JITHERDI	34219	4.33
18	WANTARSA + ATALI	49580	6.27
19	JAWTRAN + ATALI	34946	4.42
20	MANJROL	16791	2.12
21	RAJNAGAR	16811	2.13
22	CHHIDRA	77890	9.85
23	WANKNEDA	2307	0.29
24	MANJROL + RAJNAGAR	4749	0.60
25	MANJROL + ATALI	16470	2.08
26	MANJROL + CHHIDRA	6467	0.82
27	RAJNAGAR + ATALI	5855	0.74
28	RAJNAGAR + CHHIDRA	11868	1.50
29	ATALI + CHHIDRA	18050	2.28
30	KALEDIA + AKTESHWAR	3564	0.45
31	CHHIDRA + WANKHEDA	3343	0.42
32	CHHIDRA + DODKA	6040	0.76
33	KALEDIA + ZARIA	6600	0.84
34	MOHMADPURA	2366	0.30
35	ORWADA	8941	1.13
36	DODKA	1494	0.19
37	Other Area	27025	3.42
37	CITY, WATER BODIES ETC.	38856	4.91

4.22 Important Soil Characteristics and Land Features

The important soil physico-chemical characteristics and land features for Phase – I area

Physical Characteristics

4.22.1 Soil Depth

The distribution of soils of the area into different depth classes on the basis of the thickness of soil and its percentage are given in the table 4.4. It can be seen from the table that the dominantly large area has deep soil (Figure 4.6).

Table 4.4: Depth of soil

Soil Depth in Cm	Area in Ha.	%
Less then 22.5	590	0.07
22.5 to 45	1348	0.17
45 to 90	20814	2.63
More then 90	702367	88.80
Other Area (Hilly, Highly undulating & Cut up Area	27025	3.42
City, Water Bodies etc.	38856	4.91
Total Area.	**791000**	**100.00**

4.22.2 Soil Texture

The extent and distribution of the area and percentage based upon the field and laboratory data under different textural groups for surface textures are given in the following table 4.5 and the sub surface soil textures are given in the table. 4.5 & 4.6

Table 4.5: Soil Textural Groups upto 30 cm from surface

Textural Groups	Surface (0–30 Cm) Area in Ha.	%
Sand (S), Loamy sand (LS)	9,105	1.15
Sandy loam (SL)	80,480	10.18
Loam(L), Silt loam (SiL), Silt (Si)	46,829	5.92
Sandy clay loam (CL), Silty clay loam (SCL), clay loam (SiC)	1,45,244	18.36
Clay (C), silty clay (SC), Sandy clay (SiC)	4,43,461	56.06
Others	27,025	3.42
City, Water Bodies etc. Area	38,856	4.91
Total Area	**7,91,000**	**100.00**

Table 4.6: Soil Textural Groups 30-90 cm from surface

Textural Groups	Sub Surface Area	30-90 Cm %	Sub Surface Area	More then 90 Cm. %
Sand (S), Loamy sand (LS)	5,540	0.70	19,425	2.46
Sandy loam (SL)	51,076	6.46	1,40,311	17.74
Loam(L), Silt loam (SiL), Silt (Si)	47,681	6.03	1,01,502	12.83
Sandy clay loam (CL), Silty clay loam (SCL), clay loam (SiC)	52,561	19.29	1,83,231	23.10
Clay (C), silty clay (SC), Sandy clay (SiC)	4,67,671	59.12	2,57,898	32.60
Others	27,025	3.42	27,025	3.42
Soil Depth Less than 30/90 Cm.	590	0.07	22,752	2.88
City, Water Bodies etc. Area	38,856	4.91	38,856	4.91
Total Area	**7,91,000**	**100.00**	**7,91,000**	**100.00**

It can be seen from the above table, that the dominantly large areas have medium to fine textured soil. The sub surface soils have generally moderately fine-to-fine texture. In the lower layers the soils have medium to moderate fine textured. (Figure 4.7)

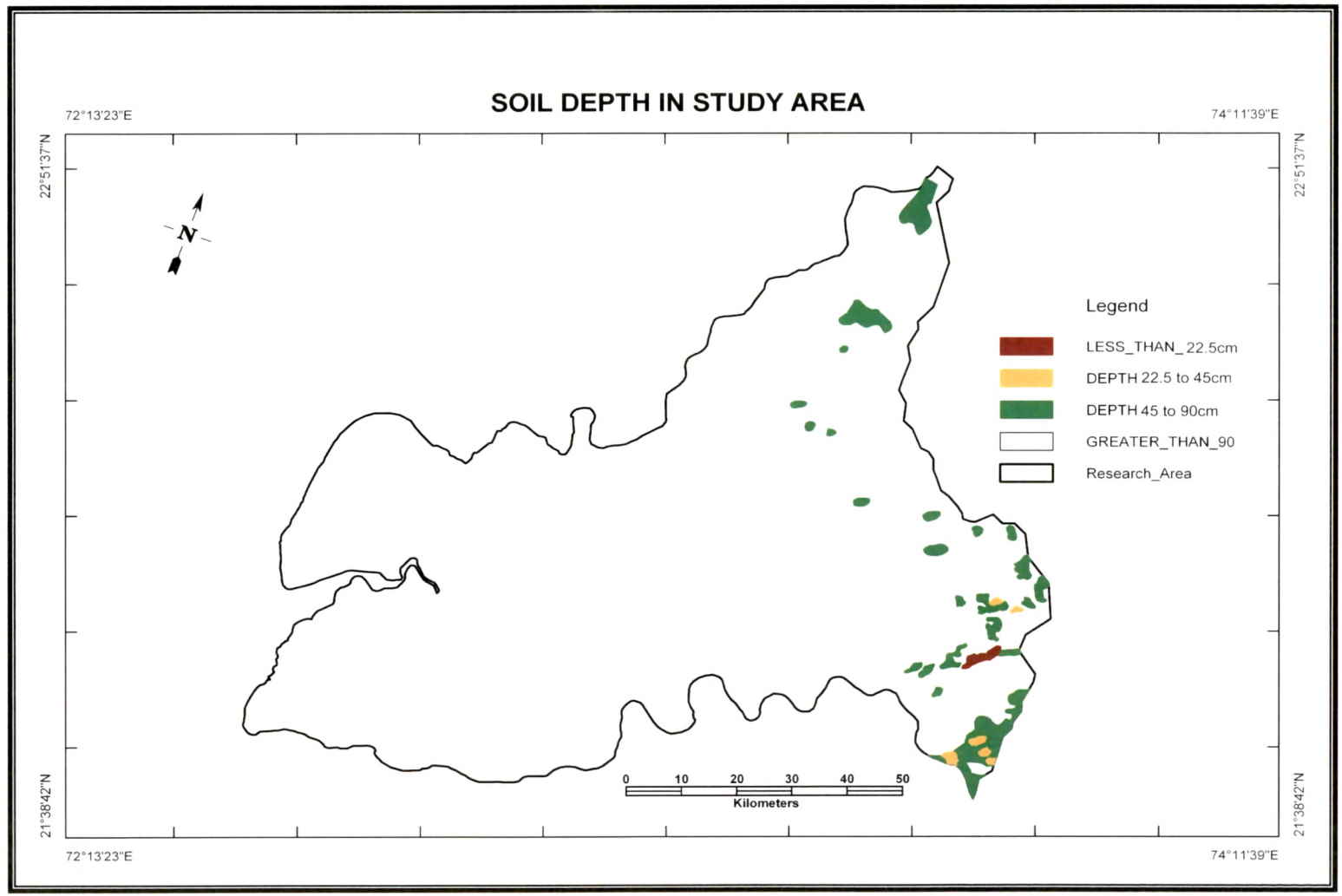

SOIL DEPTH IN STUDY AREA
72°13'23"E
74°11'39"E
22°51'37"N
21°38'42"N
N
Legend
LESS_THAN_ 22.5cm
DEPTH 22.5 to 45cm
DEPTH 45 to 90cm
GREATER_THAN_90
Research_Area
0 10 20 30 40 50
Kilometers

Figure 4.6

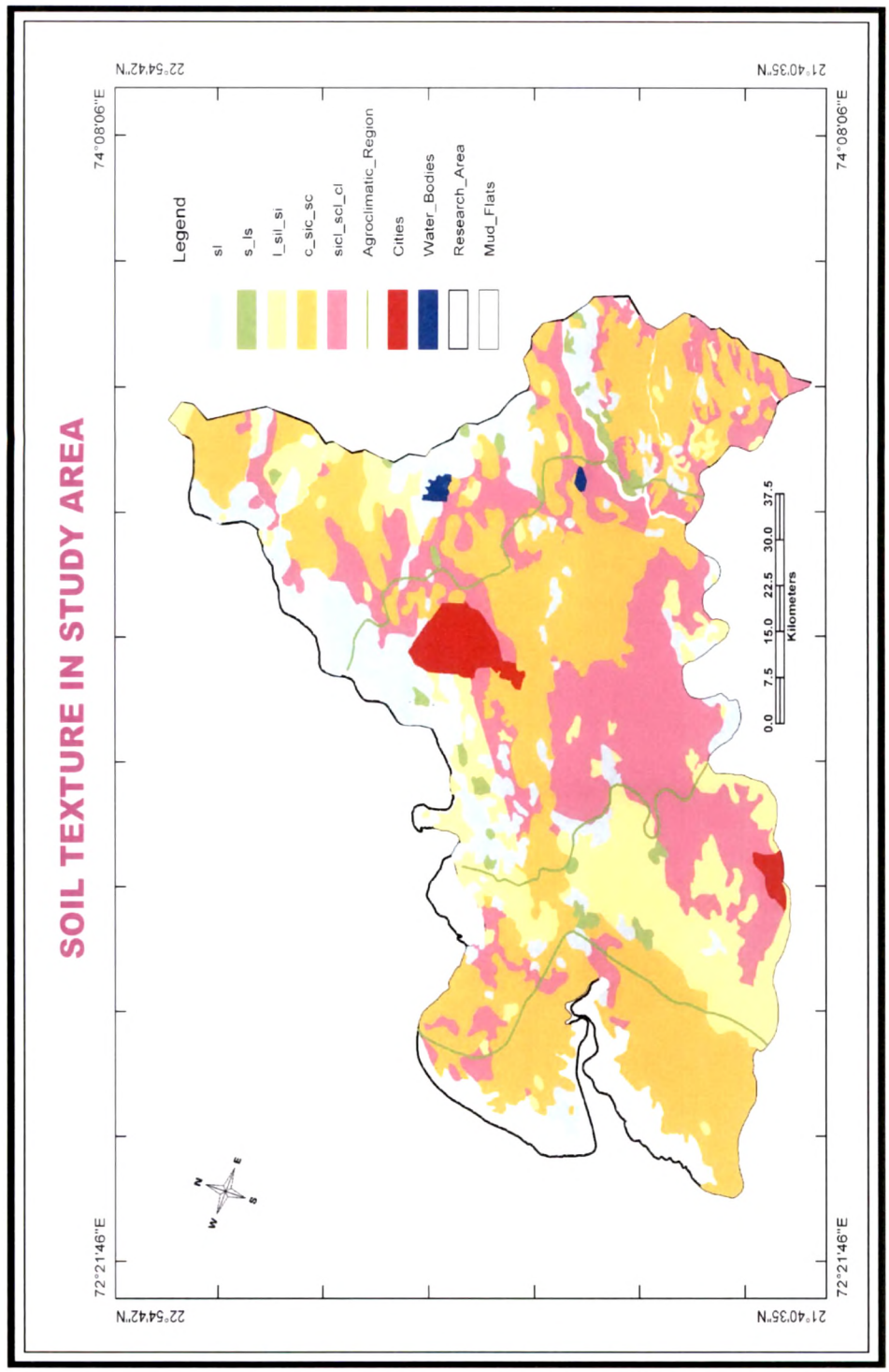

SOIL TEXTURE IN STUDY AREA
Legend
sl
s_ls
l_sil_si
c_sic_sc
sicl_scl_cl
Agroclimatic_Region
Cities
Water_Bodies
Research_Area
Mud_Flats
0.0 7.5 15.0 22.5 30.0 37.5
Kilometers
74°08'06"E
72°21'46"E
22°54'42"N
21°40'35"N

Figure 4.7

4.22.3 Available water Holding Capacity

The available Water holding capacity of soil have been computed from soil texture data for 90 cm depth using (i) Hand Book on irrigation water management Part –II – 10 published by Water Management Division of Ministry of Agriculture, New Delhi and (ii) Guide used for making Soil Survey interpretation USDA-SCS, Texas 1965. The table 4.6 indicates different ranges of available Water Holding Capacity (AWHC) in Phase – I area. (Table. 4.7)

Table 4.7: Water holding capacity of soils

A.W.H.C. Range Cm/90 Cm	Area in Ha	%
More than 12	64,698	8.17
9 – 12	62,912	7.95
6 – 9	14,546	1.83
2 – 6	1,523	0.19
Less than 2	-	-
Other Area	27,025	3.41
City, Water Bodies etc. Area	38,856	4.91
Total Area	**7,91,000**	

It can be seen from the above table that, a dominantly large area has soil with adequate A.W.H.C. (Figure 4.8)

4.22.4 Permeability

The permeability or rates of intake of water for different soil samples were determined in terms of Cm/hr.

The following table shows the distribution of soils under different ranges of permeability and least permeable horizon.

Table 4.8: Soil Permeability

Sr. No.	Permeability Class	Permeability Range in cm/hr.	Area in Ha	%
1.	Moderate to Moderately Slow	0.5 – 5.0	1,23,640	15.63
2.	Slow or Moderately Rapid	0.13 – 0.50 or 5.00 - 13.00	2,38,593	30.16
3.	Slow to Very Slow or Rapid	0.03 – 0.13 or 13.00 – 25.00	58,640	7.41
4.	Very Slow or Very Rapid	Less than 0.03 or more than 25.0	3,04,246	38.47
5.	Other		27,025	3.42
6.	City, Water Bodies etc. Area		38,856	4.91
Total			**7,91,000**	**100.00**

It can be seen from the above table that about 15.63% area has moderate to moderately rapid permeability 30.16% area has slow or moderately rapid permeability, 7.41% area has slow to very slow or rapid permeability and about 38.47% area is having slow or very rapid permeability.

4.23 Soil Chemical Characteristics

Soil chemical characteristics have been derived in terms of salinity, alkalinity and pH values.

4.23.1 Soil Salinity

The soil salinity has been measured in terms of electrical conductivity in 1: 2 soil water extract for all the soil samples of open profiles and auger bores in mm hos / cm at 25°C.

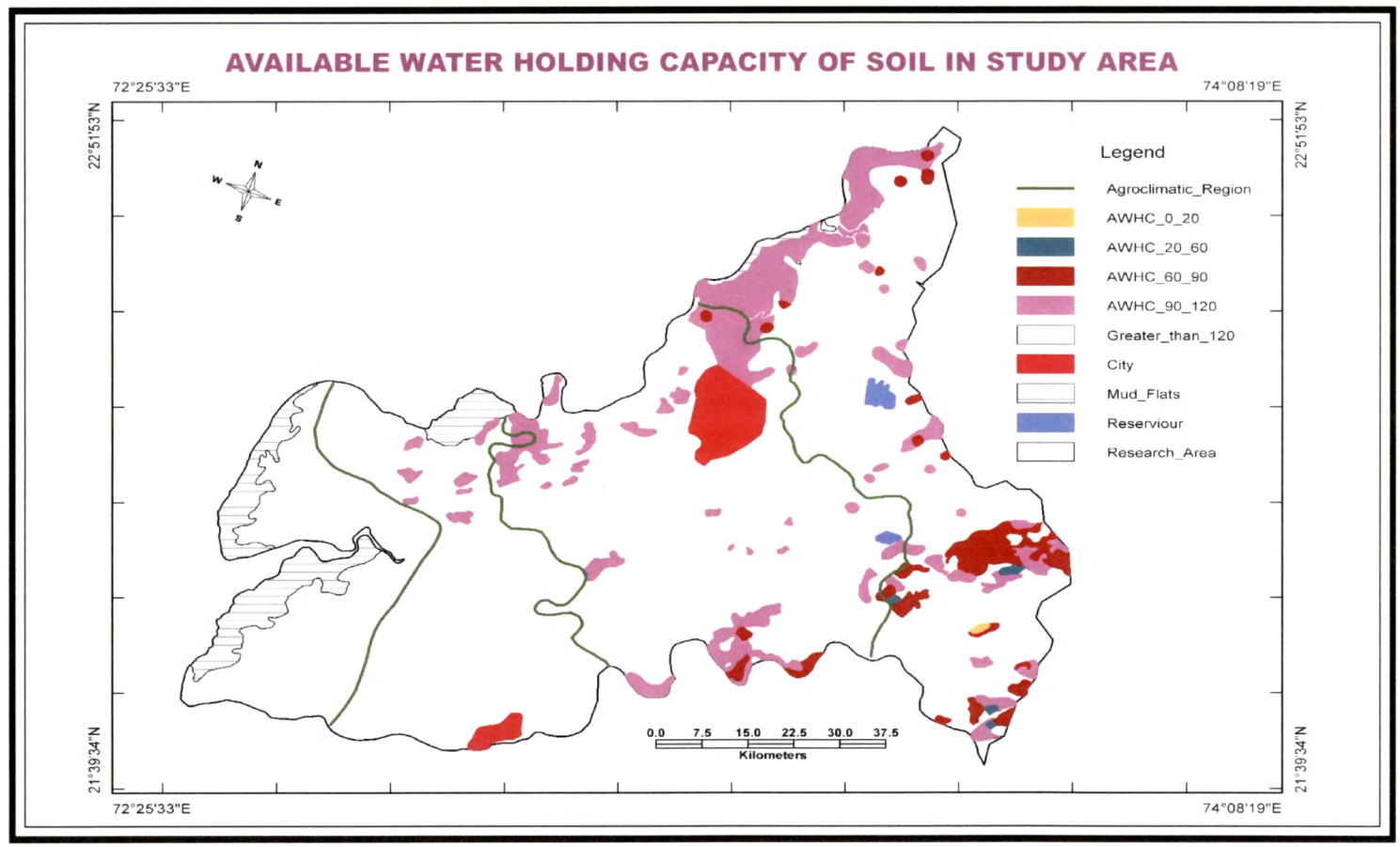

AVAILABLE WATER HOLDING CAPACITY OF SOIL IN STUDY AREA
72°25'33"E
74°08'19"E
22°51'53"N
21°39'34"N
Legend
Agroclimatic_Region
AWHC_0_20
AWHC_20_60
AWHC_60_90
AWHC_90_120
Greater_than_120
City
Mud_Flats
Reserviour
Research_Area
0.0 7.5 15.0 22.5 30.0 37.5
Kilometers

Figure 4.8

It can be seen from the above table that surface soil of about 74.64% area have non saline soil, 5.75% area have moderately saline soil; while 1.58% and 3.60% have highly saline to very highly saline soil respectively in the upper 90cm depth. Depth below 90 cm depth from surface, about 65.53% area have non-saline soils. 5.37% area have slightly saline soil, 7.16% area have moderately saline soil, while 2.83% and 7.90% areas have highly saline to very highly saline soil respectively. (Table. 4.9) (Figure 4.9)

Table 4.9: Electric Conductivity of soils (EC)

EC Ranges in mm hos/cm in 1:2 Soil Water Ratio	Soil depth 0-90 cm		Soil depth more than 90 cm	
	Area in Ha	%	Area in Ha	%
0 – 1.0	5,90,391	74.64	5,18,344	65.53
1.0 – 1.5	48,221	6.10	42,4884	5.37
1.5 – 2.5	45,534	5.75	56,634	7.16
2.5 – 3.0	12,516	1.58	22,428	2.83
More than 3.0	28,457	3.60	62,477	7.90
Other Area	27,025	3.42	27,025	3.42
Area Under Soil depth Less than 90 cm	-	-	22,752	2.88
City, Water Bodies etc. Area	38,856	4.91	38,856	4.91
Total	**7,91,000**	**100.00**	**7,91,000**	**100.00**

4.23.2 Soil Alkalinity

The soil alkalinity was measured in terms of pH in 1:2 soil water ratio. The following table 4.10 shows the soil alkalinity status of the area for soil depth 0-90 cm and more than 90 cm.

Table 4.10: Soil pH

Soil pH Range	Soil depth 0-90 cm		Soil depth more than 90 cm	
	Area in Ha	%	Area in Ha	%
6.7 – 7.3	28,998	3.29	27,208	3.44
7.3 – 7.8	97,347	12.31	96,530	12.20
7.8 – 8.4	3,76,821	47.64	3,38,535	42.80
8.4 – 8.8	1,80,942	22.87	1.85,103	23.40
More than 8.8	44,011	5.56	54,991	6.95
Other Area	27,025	3.42	27,025	3.42
Area Under Soil depth Less than 90 Cm	-	-	22,752	2.88
City, Water Bodies etc. Area	38,856	4.91	38,856	4.91
Total	**7,91,000**	**100.00**	**7,91,000**	**100.00**

It can been seen from the Table 4.10 that in the top 90 cm soil about 3.29% area have neutral reaction, 12.31% area have slightly alkaline soil, 47.64% area have moderately alkaline soil, 22.87% and 5.56% area have strong to very strong alkalinity respectively.

Soils below 90 cm depth from surface about 3.44% area have neutral reaction, 12.20% area have slightly alkaline, 42.80% area have moderately alkaline, 23.40% and 6.95% area have strong to very strongly alkaline respectively (Figure 4.10).

4.23.3 Cation Exchange Capacity and Exchangeable Sodium Percentage

The cation exchange capacity of soils of the typifying pedon have found to vary between 10.5 to 51.0 me/100 gm of soils, the exchangeable sodium percentage for dominant portion of the surveyed area does not exceed 15% except for a few patches in the coastal strip.

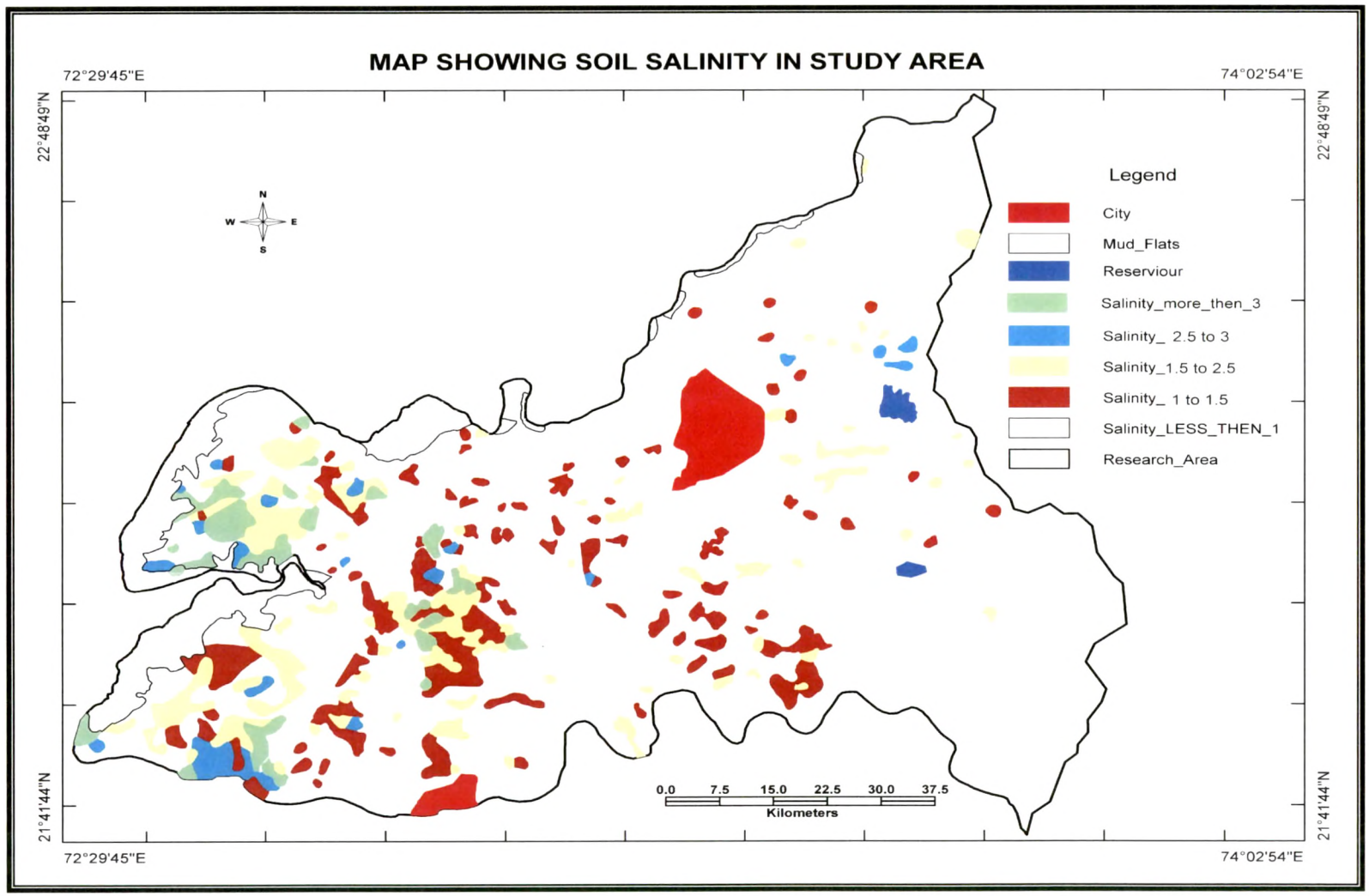

MAP SHOWING SOIL SALINITY IN STUDY AREA
72°29'45"E
74°02'54"E
22°48'49"N
21°41'44"N
N
W
E
S
Legend
City
Mud_Flats
Reserviour
Salinity_more_then_3
Salinity_ 2.5 to 3
Salinity_1.5 to 2.5
Salinity_ 1 to 1.5
Salinity_LESS_THEN_1
Research_Area
0.0 7.5 15.0 22.5 30.0 37.5
Kilometers

Figure 4.9

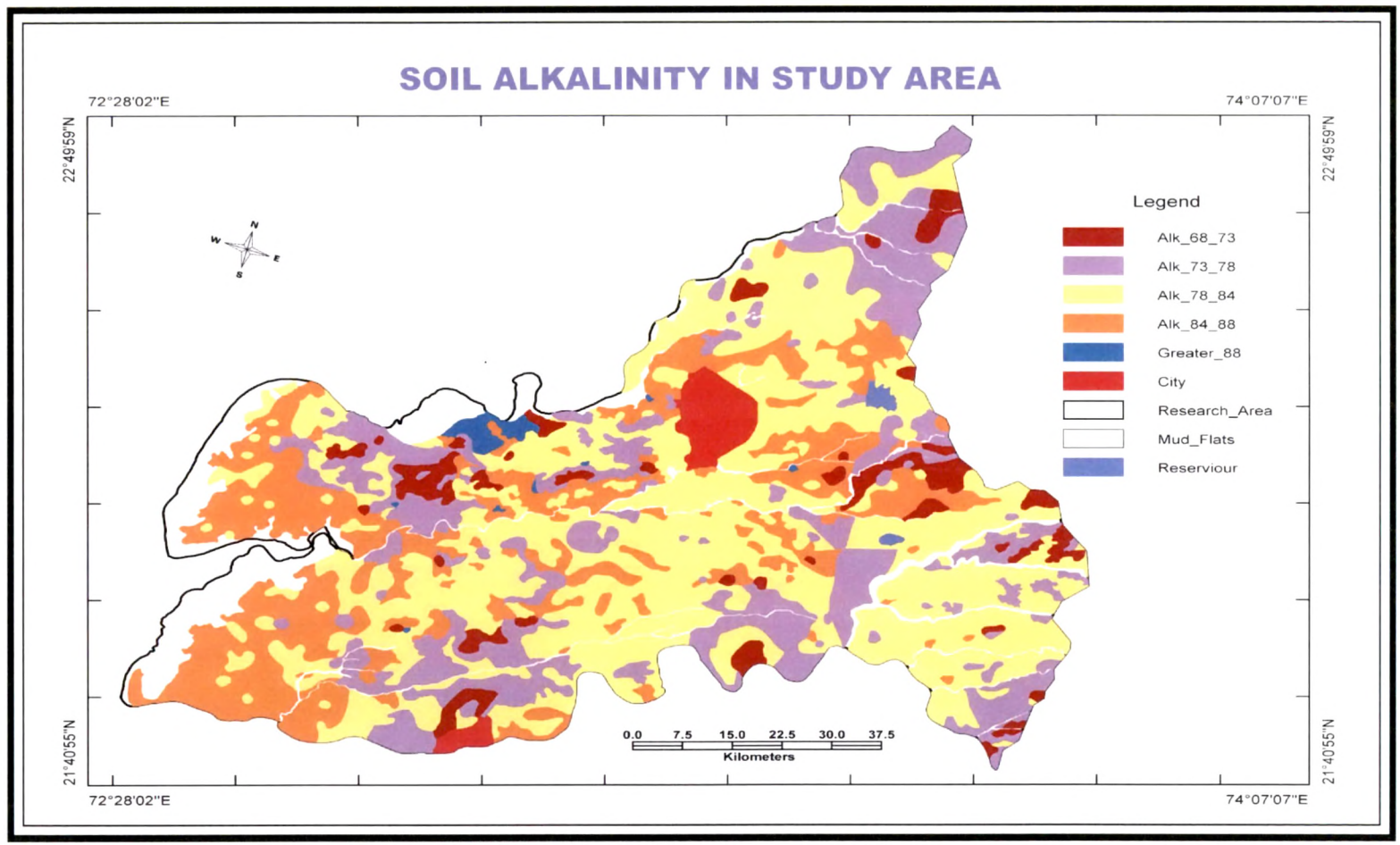

SOIL ALKALINITY IN STUDY AREA
72°28'02"E
74°07'07"E
22°49'59"N
21°40'55"N
Legend
Alk_68_73
Alk_73_78
Alk_78_84
Alk_84_88
Greater_88
City
Research_Area
Mud_Flats
Reserviour
0.0 7.5 15.0 22.5 30.0 37.5
Kilometers

Figure 4.10

4.23.4 Organic Matter

The organic matter content in the soil of the dominant portion of the surveyed area has generally been less then one percent, while it reaches up to as high as 1.66% in a few places

4.23.5 Calcium Carbonate Equivalent

The soil matrix generally is free from line up to saline depth. However, eroded phases exhibits strong to very strong reaction with dilute hydrochloric acid. The soil solum has few time concreations, which generally increase with depth. The lime concreations increases as high as 15 to 20 percent below solum depth (Table. 4.11).

4.24 LAND FACTORS

4.24.1 Slope

The slope gradient of a dominantly large portion of the area IS less then 1%, in the east and northeastern portion. Some parts have slope percent in the range of 1 to 3%.

4.24.2 Depth of Ground Water

The extent of areas under different ranges of the depth to ground water is given in the following table 3.12

Table 4.11: Statement Showing Analytical Results of Typifying Pedons for Different Soil Series under Command Area Phase – I

Sr. N0.	Name of Village Taluka and District.	Depth Cm.	EC	pH	O.M %	$CaCo_3$	C.E.C	Na^+	K^+	ESP	Clay	Silt	Sand	Tex	MHC	P
1.	**Wakneda** Savli Vadodara	0-10	0.05	7.3	0.50	0.25	13.0	0.24	0.11	1.85	16.5	6.2	77.3	Sl	-	-
		10-34	0.10	7.6	0.38	0.50	16.0	0.24	0.21	1.50	18.4	11.0	70.6	L	-	-
		34-80	0.07	7.3	0.28	0.50	18.0	0.24	0.14	1.33	21.0	8.5	70.5	ScL	-	-
		80-142	0.12	7.6	0.16	1.00	9.0	0.24	014	3.4	10.5	12.8	77.4	Sl	-	-
		142-180	0.14	7.9	0.14	5.75	13.0	0.24	0.07	1.85	16.2	2.2	81.6	Sl	-	-
2.	**Dodka** Savli Vadodara.	0-12	0.23	8.1	0.34	0.63	12.8	0.96	0.14	7.5	14.02	7.79	78.20	Sl	32.66	5.68
		12-45	0.20	8.1	0.35	0.30	10.0	0.68	0.21	6.8	12.5	10.37	76.72	Sl	45.78	5.68
		45-79	0.19	8.0	0.33	0.63	7.4	0.68	0.21	9.7	8.92	18.45	70.44	LS	45.95	1.51
		79-104	0.22	8.1	0.46	0.63	9.4	0.24	0.21	2.7	10.21	22.58	69.30	LS	41.49	3.78
		104-160	0.21	8.1	0.65	0.75	9.8	0.48	0.35	5.3	10.77	24.48	62.75	Sl	48.15	1.13
3.	**Mohmadpura** Padra Vadodara.	0-10	0.21	8.1	1.66	5.25	27.0	0.4	0.20	1.5	28.11	28.88	45.01	SiL	53.13	1.70
		10-32	0.12	8.2	1.04	3.75	19.0	0.3	0.24	1.6	21.65	29.41	48.74	SiL	48.45	1.13
		32-55	0.10	8.3	0.79	5.25	11.0	0.3	0.15	2.7	1375	31.36	54.89	SiL	44.62	4.07
		55-80	0.11	8.8	0.41	5.25	9.0	0.3	0.18	3.3	10.98	30.19	58.83	SiL	40.30	3.97
		80-150	0.27	9.2	0.40	5.50	8.5	0.4	0.19	5.0	9.98	27.97	62.35	SiL	60.20	5.39
		150-180	0.60	9.6	0.26	7.50	6.0	0.24	0.82	4.0	7.72	8.82	83.46	LS	44.88	3.88
4.	**Chhidra** Jambusar Bharuch	0-12	0.24	8.4	0.64	0.74	9.2	0.24	Nil	2.6	10.9	9.9	79.2	SL	39.9	1.14
		12-34	0.14	8.7	0.25	0.49	20.0	0.24		1.20	22.1	9.5	68.4	CL	47.9	0.30
		34-65	0.12	8.8	0.32	0.49	28.0	0.46		1.64	30.9	11.9	57.2	CL	50.7	0.28
		65-130	0.29	8.3	0.17	0.49	27.6	0.48		1.74	30.2	12.9	56.9	CL	52.5	0.19
		130-150	1.02	7.7	0.20	0.74	26.6	0.24		0.90	29.4	14.2	55.9	CL	51.6	0.19
		150+	1.12	7.5	0.22	0.37	21.8	0.48		2.2	23.7	21.3	55.0	CL	49.0	1.23
5.	**Jantran** Jambusar Bharuch	0-18	0.22	9.0	0.58	6.67	51.0	4.8	Nil	9.41	50.1	25.0	24.9	CL	35.5	0.19
		18-50	0.32	9.0	0.58	6.92	48.0	5.52		10.9	61.9	15.5	22.6	CL	59.5	0.19
		50-95	1.76	8.5	0.67	6.67	51.0	6.96		13.6	61.6	14.8	23.6	CL	64.4	Nil
		95-146	3.52	8.6	0.77	5.19	48.0	10.5		22.0	58.10	16.0	25.9	CL	-	-
		146-180	4.48	8.5	0.39	5.85	42.0	11.5		27.4	48.7	16.9	34.4	CL	-	-
6.	**Rajnagar.** Waghodia Vadodara	0-10	0.09	7.4	0.57	1.75	11.4	-	0.35	-	12.4	5.7	81.9	SL	35.0	2.08
		10-58	0.12	7.4	0.51	3.50	30.6	0.24	0.21	0.78	30.9	10.1	59.0	CL	51.3	1.70
		58-80	0.09	7.4	0.42	1.00	30.6	0.24	0.35	0.78	31.3	8.5	60.2	CL	53.2	1.52
		80-147	0.13	7.7	0.31	1.50	25.2	0.24	0.28	0.95	27.0	9.0	64.0	CL	50.5	1.33
		147-175	0.16	8.4	0.17	19.0	26.0	1.44	0.28	5.53	28.3	8.6	63.1	CL	37.0	2.27

7.	**Kherwadi** Sankheda Vadodara	0-20	0.20	8.0	1.00	2.75	51.0	-	-	-	44.0	14.2	41.8	CL	-	-
		20-56	0.16	7.7	0.77	2.75	54.0				44.5	10.2	45.3	CL		
		56-86	0.25	8.4	0.74	2.00	54.5				49.2	14.0	36.8	CL		
		86-100	0.29	8.5	0.69	3.00	54.0				46.7	12.0	41.3	CL		
		100-180	1.00	8.2	0.62	4.75	51.0				47.5	13.3	36.2	CL		
8.	**Atali** Vagra Bharuch	0-13	0.31	8.8	0.86	7.0	26.0	3.84	-	-	28.2	23.3	48.5	CL	62.87	0.87
		13-30	0.38	9.0	0.68	9.15	37.0	5.28			39.9	23.3	36.8	C	57.34	-
		30-68	0.25	9.1	0.64	0.75	41.0	8.12			43.8	23.6	32.6	C	60.53	0.189
		68-120	1.05	8.9	0.25	10.12	42.8	5.68			44.6	22.8	32.8	C	49.74	-
		120.125	1.40	8.9	0.15	15.75	39.0	4.72			41.2	24.5	39.3	C	48.44	0.568
		125-150	1.30	8.9	0.60	21.90	30.0	4.04			32.5	23.5	56.0	Scl	44.00	-
9.	**Juni –Jithardi** Karjan Vadodara	0-15	0.26	7.6	0.92	3.5	34.8	0.22	0.08	0.63	38.5	15.5	46.0	CL	-	-
		15-40	0.28	7.6	0.82	3.5	38.2	2.10	0.04	5.4	47.2	14.7	38.1	C		
		40-70	0.26	7.7	0.52	4.5	41.6	0.48	0.24	1.15	55.5	12.8	31.7	C		
		70-100	0.24	7.7	0.87	6.0	40.8	1.20	0.29	2.94	52.3	13.6	34.1	C		
		100-150	0.28	7.7	0.24	12.0	18.0	1.25	0.20	6.94	20.5	10.1	69.4	SL		
		150-180	0.30	7.9	0.39	17.25	17.0	1.09	0.21	6.41	19.7	10.7	69.6	SL		
10.	**Orwada.** Sankheda Vadodara	0-15	0.15	7.0	0.87	0.25	9.3	0.72	0.25	9.3	12.7	12.2	75.1	SL	-	-
		15-45	0.07	7.1	0.05	1.00	9.6	0.72	0.20	9.6	11.2	9.9	72.9	SL		
		45-77	0.06	7.2	0.5	1.00	6.5	0.59	0.09	9.07	9.5	8.7	81.8	SL		
		77-122	0.11	7.2	0.15	1.00	6.9	0.54	0.09	7.8	9.0	8.7	83.3	LS		
		122-162	0.15	7.1	0.45	1.5	6.2	0.52	0.09	8.2	10.1	12.7	77.2	LS		
		162-195	0.14	7.2	0.31	1.5	9.0	0.29	0.03	2.33	10.7	15.5	73.8	LS		
11.	**Wantarsa** Amod Bharuch	0-11	1.01	8.0	0.60	1.0	45.25	0.33	1.5	0.72	54.6	25.4	20.0	Sic	-	-
		11-38	1.14	8.0	0.61	0.25	48.25	0.22	0.93	0.46	57.0	22.8	20.2	C		
		38-78	1.22	8.1	0.61	0.50	52.00	0.48	1.38	0.92	59.8	24.4	15.8	C		
		78-134	1.27	7.8	0.56	1.50	55.00	0.24	1.11	0.43	60.4	24.5	15.1	C		
		134-156	1.39	8.2	0.55	18.5	31.50	0.31	0.3	0.98	31.9	48.5	19.6	SicL		
		156-180	1.27	8.2	0.24	19.0	12.70	0.37	0.1	2.9	13.6	44.6	41.8	SiL		
12.	**Dahej** Vagra. Bharuch	0-13	53.0	7.4	1.47	5.375	40.8	1.10	Nil	2.70	47.5	10.1	42.4	Clay	54.20	0.184
		13-38	39.0	7.3	1.18	6.625	40.5	7.70		19.00	43.5	18.5	38.0	Clay	56.09	-
		38-60	52.0	7.4	1.15	6.00	39.0	5.28		13.50	49.7	22.2	28.1	Clay	54.40	0.184
		60-86	52.0	7.6	1.11	6.25	42.0	7.92		18.90	51.9	21.8	26.3	Silt	47.40	-
		86-118	45.0	7.5	0.96	6.25	-	8.80		-	46.2	28.3	25.5	SL	49.90	-
		118-180	56.0	7.6	1.01	9.75	37.8	6.60		17.50	46.1	23.9	30.0	SL	51.50	-

13.	**Derol**	0-13	0.48	8.25	0.55	1.25	40.0	0.26	0.94	0.56	45.5	24.9	29.6	C	75.84	0.505
		13-42	0.28	7.95	0.58	1.75	41.0	0.33	0.55	0.80	45.68	16.99	37.33	C	78.82	2.636
	Bharuch	42-90	0.32	7.85	0.50	1.75	43.0	0.40	0.50	0.93	47.17	15.02	37.81	C	67.87	0.874
	Bharuch	90-130	0.33	8.05	0.31	1.75	45.0	0.44	0.42	0.97	49.74	24.59	25.67	C	64.48	1.626
		138-157	0.20	8.05	0.38	4.00	26.25	0.24	0.45	0.91	26.77	29.06	44.77	SicL	73.81	2.257
		157-190	0.22	8.1	0.28	3.5	10.0	0.48	0.23	4.8	11.26	18.02	70.72	Loam	65.51	1.541
14.	**Mangrol**	0-12	0.23	8.5	0.40	11.75	17.0	-	0.76	-	17.95	9.54	72.05	SL	42.04	0.979
		13-39	0.17	8.5	0.26	17.25	19.0		0.57		21.08	17.20	61.72	L	46.10	1.080
		39-75	0.15	8.45	0.24	11.75	19.0		0.57		24.42	16.48	59.10	CL	46.91	1.171
	Sinor	75-120	0.18	8.65	0.17	16.25	16.0		0.57		19.45	9.15	7.40	SL	43.75	1.282
	Vadodara	120-175	0.17	8.65	0.15	14.50	16.0		0.76		16.27	10.46	73.27	SL	43.97	1.862
15.	**Mota-Fofaliya**	0-10	1.54	8.0	1.01	0.25	28.0	0.242	0.049	-	30.40	19.90	49.7	CL	56.32	0.805
		10.31	0.60	8.0	0.77	0.75	27.0	0.024	0.024	0.08	33.37	18.35	48.28	CL	50.95	1.152
		31-46	0.61	8.0	0.48	0.25	33.0	0.048	0.021	0.14	29.32	17.98	42.70	C	50.61	1.278
	Sinor	46-95	0.83	8.15	0.15	0.50	25.0	0.07	0.018	.0.26	31.20	18.73	50.07	CL	56.64	0.742
	Vadodara.	94-147	1.02	8.15	0.09	1.50	22.0	0.013	0.009	0.06	18.30	9.77	71.85	SL	44.86	1.483
		147-185	1.19	8.3	0.10	2.00	25.0	0.03	0.019	0.13	17.24	10.35	72.41	SL	49.33	1.341
16.	**Kaledia**	0-9	0.072	7.0	0.64	1.09	-	0.48	0.07	-	24.9	10.5	64.6	CL	-	-
		9-27	0.054	7.2	0.67	1.09		0.84	0.07		33.5	10.9	55.6	C	41.72	2.462
		27-55	0.063	7.3	0.55	1.30		0.76	0.07		36.5	10.8	52.7	C	42.17	2.240
	Naswadi	55-75	0.081	7.4	0.45	1.30		1.08	0.07		33.6	9.8	56.6	C	44.55	1.925
	Vadodara	75-87	0.063	7.4	0.28	1.52		0.96	0.07		25.7	12.0	62.3	CL	41.00	1.577
		87+	**Weathered Basaltic Material with Lime.**													
17	**Akteshwar**	0-12	0.108	7.3	0.52	0.43	19.5	0.60	0.07	3.07	18.6	4.9	76.5	SL	28.78	7.417
		12-50	0.07	7.2	0.65	0.87	34.5	0.96	0.07	2.78	39.0	12.8	48.2	C	44.41	0.852
	Rajpipla Bharuch	50+	**Weathered Basalt Rock + Murrum.**													
18.	**Zaria**	0-18	0.07	6.8	0.80	0.98	42.0	0.29	0.29	0.69	45.67	14.40	36.93	Clay		
		18-42	0.11	6.9	0.75	0.98	40.0	0.21	0.30	0.52	43.24	18.06	38.70	Clay		
	Rajpipla	42-62	0.06	7.0	0.65	0.98	30.0	0.40	0.23	1.33	33.44	21.19	45.37	CL		
	Bharuch	62-92+	0.08	7.1	0.67	2.45	28.0	0.42	0.22	1.50	31.34	21.44	47.22	CL		

OM : Organic Matter.
C.E.C : Cation Exchange Capacity (MEQ/ 100 Gms)
EC : d/m (1:2, Soil: water)
P : Permeability (cm/hr)
Tex : Textural Class.

Table 3.12: Depth to ground water

Depth to Ground Water Range in m.	Area	%
More than 5 m	6,72,639	85.04
Between 3 & 5 m	43,960	5.56
Between 1.5 to 3 m	8,240	1.04
Within 1.5 m	280	0.03
Other Area	27,025	3.42
City, Water Bodies etc. Area	38,856	4.91
Total	**7,91,000**	**100.00**

Thus, about 86.69% area have depth to ground water below 5 metre of the surface; 4.44% area have ground water between 3 and 5 mere while 0.24% area have ground water between 1.5 to 3 meters.

4.24.3 Drainability

The outflow and outfall conditions are generally good to moderately good except in the areas in the coastal belt and in localised patches. The morphological characteristics indicate that about 13.41% of area has imperfectly drained to poorly drained soils.

Table 3.13 shows the distribution of the area in to different drainage classes (Figure 4.11).

Table 3.13: Soil Drainability

Sr. No.	Drainage Class	Area in Ha.	%
1.	Well Drained	1,06,074	13.41
2.	Moderately Well Drained	2,54,049	32.12
3.	Imperfectly to Poorly Drained	3,65,000	46.14
4.	Other Area	27,025	3.42
5.	City, Water Bodies etc. Area	38,856	4.91
Total		**7,91,000**	**100.00**

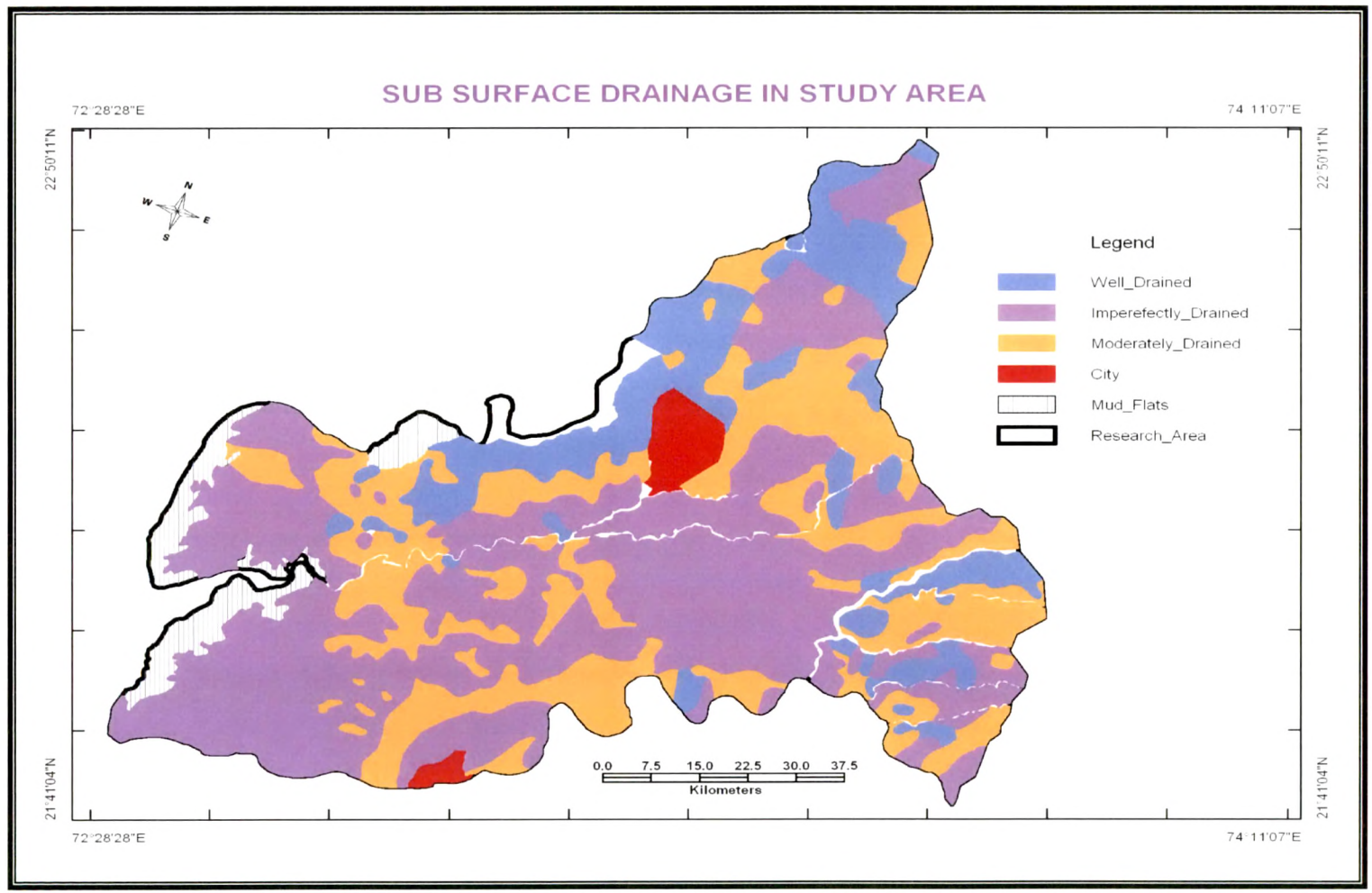

SUB SURFACE DRAINAGE IN STUDY AREA
72°28'28"E
74°11'07"E
22°50'11"N
21°41'04"N
N
W
E
S
Legend
Well_Drained
Imperefectly_Drained
Moderately_Drained
City
Mud_Flats
Research_Area
0.0 7.5 15.0 22.5 30.0 37.5
Kilometers

Figure 4.12

4.24.3 Land Irrigability Classification

The land Irrigability appraisal have been carried out on the basis of physico chemical properties of the soils and considering land parameters as per the criteria laid down in the soil survey manual I.A.R.I. 1970 FOR Phase – I area.

Table 4.14 gives the Land Irrigability appraisal picture of the surveyed area.

Table 4.14: Land Irrigability Class

Land Irrigability Class	Area in ha.	%
1.	10,439	1.32
2.	2,67,489	33.82
3.	3,73,902	47.27
4.	51,496	6.51
5.	-	-
6.	21,793	2.75
Other Area	27,025	3.42
City, Water Bodies etc. Area	38,856	4.91
Total	**7,91,000**	**100.00**

The land Irrigability classes defined by soil survey manual I.A.R.I. 1970 are as under.

L.I. Class – 1: The lands that have few limitations for their sustained use under Irrigation.

L.I. Class – 2: The lands that have moderate limitations for their sustained use Under Irrigation.

L.I. Class – 3: The lands that have severe limitation for their sustained use under Irrigation,

L.I. Class – 4: The lands that have very severe limitation for their sustained use Under Irrigation.

L.I. Class - 5: Lands that are temporarily classed as not suitable for sustained Use under irrigation pending further investigation.

L.I. Class – 6: Lands that are not suitable for sustained use under irrigation.

It can be seen from the table 4.14 that most of the surveyed area i.e., 33.82% and 47.27% have been classified under land class 2 & 3 respectively while small area i.e. 1.32%, 6.5% and 2.75% areas have been classified under land classes 1,4 and 6 respectively. The areas under land class 1 to 4 are classified suitable for irrigation with different degrees of limitations while class 6 is classified as unsuitable for irrigation.

The limitations for sustained use under irrigation include singly or jointly the effect of factors related to (i) soils (inadequate soil depth A.W.H.C. unfavorable texture, soil susceptibility to erosion, salinity and alkalinity) (ii) Land factors like unfavorable topography. (iii) Lack of adequate external or internal drainage in soils, presence of layers that may impede water table or susceptibility of rise in water table etc. these limitations if any for individuals soil sites have been identified so that remedial can be contemplated undertaken.