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Report on  
Reconnaissance Soil Survey of  
Bhiwandi Taluka, Thane District

Regional Centre  
Nagpur.

National Bureau of Soil Survey &  
Land Use Planning, Indian Council  
of Agricultural Research,  
N A G P U R -4400 06.

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REPORT ON RECONNAISSANCE SOIL SURVEY  
OF BHIVANDI TALUKA OF THANA DISTRICT

I N T R O D U C T I O N

In the master plan for Water supply and Sewage Disposal of Greater Bombay, partial treatment of Sewage and possible reuse of waste water was one of the recommendations made by one of the firms engaged by the Municipal Corporation of Greater Bombay. The National Environmental Engineering Research Institute (NEERI) was closely associated with the firms as expertise & consultants for reviewing and preparing a feasibility report on the methods of treatment and disposal of Sewage and industrial wastes of Bombay. NEERI in turn requested the National Bureau of Soil Survey and Land Use Planning (ICAR) to carry out reconnaissance Soil Survey of (Bhivandi Taluka of Thana district) part of the area to be brought under irrigation with treated water sewage. Consequently reconnaissance soil survey of Bhivandi taluka, Thana district, Maharashtra State was carried out by the Staff of the Regional Centre, Nagpur of National Bureau of Soil Survey & Land Use Planning (ICAR) during December, 1976 and Jan '77.

**I. GENERAL DESCRIPTION OF THE AREA**

**1.1. Location and Extent:**

The Surveyed area of the Bhivandi taluka is situated between latitudes  $19^{\circ}12'$  to  $19^{\circ}30'$  'N and longitudes  $73^{\circ}0'$  to  $75^{\circ}15'$  'E. It is bounded by Shahpur tahsil on the west, Bessein and Vada tahsils on the north and Thana and Kalyan tahsils on south. The total area of the Bhivandi tahsil is 69038.60 hectares.

*L. Barloah  
Tah. on  
The west*

**1.2. Physiography, Relief and drainage:**

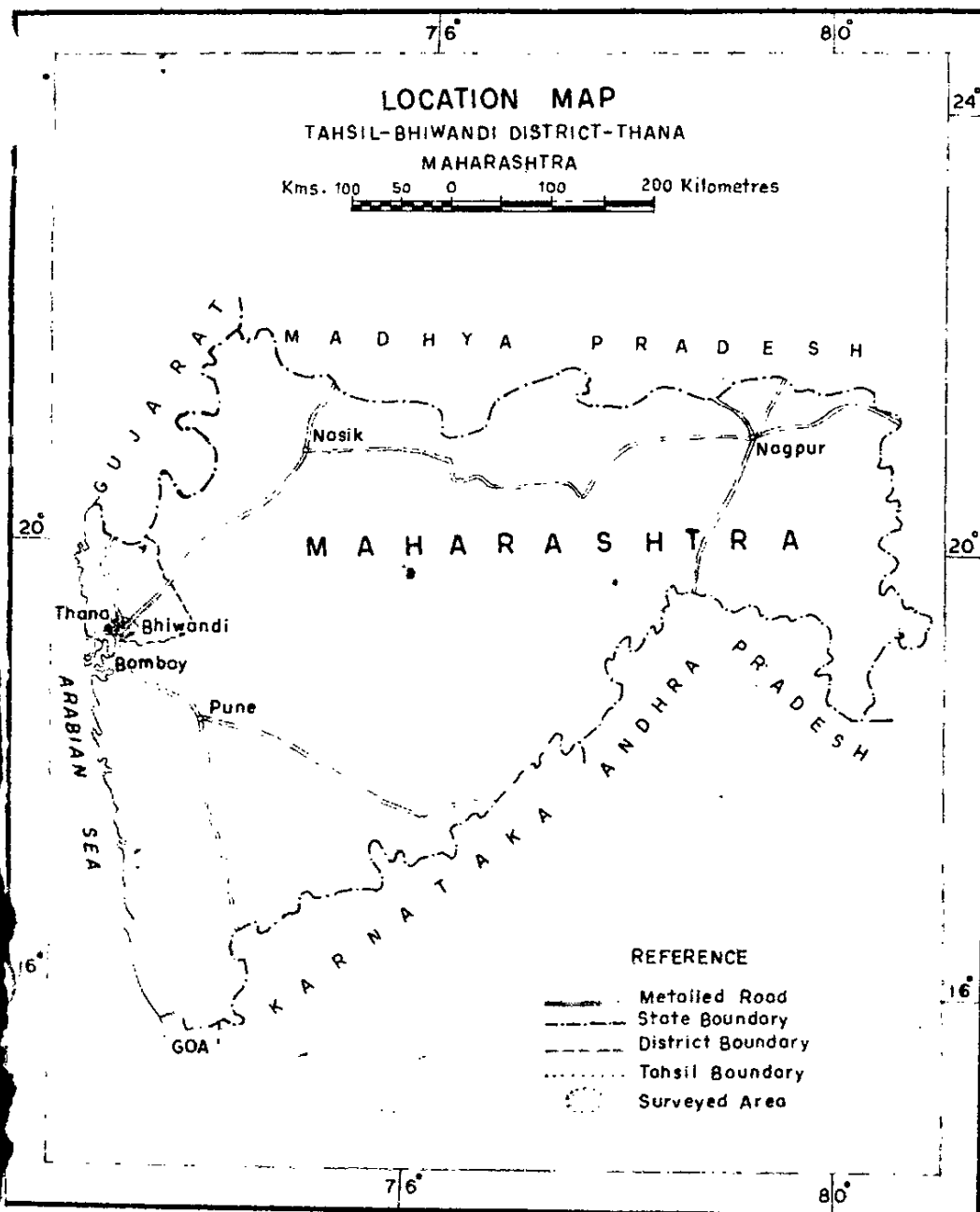
The area is situated at an elevation ranging from less than 15 M to 625 M above M.S.L. The important rivers drainage the area are Ulhas and Tansa. The following are the physiographic units.

1. Nearly level to very gently sloping intervening valley floors and flood plains.
2. Gently to moderately sloping uplands of the foothills and piedmont slopes.
3. Somewhat broken or continuous gently to strongly sloping escarpments, hills and mesas.

**1.3. Climate:**

The area has a subtropical monsoonic type of climate with three distinct seasons viz Summer (March-May) Monsoon (June-October) and winter (November-February). The average annual rainfall is about 222 cm while the maximum and minimum annual air temperatures are  $34.39^{\circ}$  and  $15.6^{\circ}$  C respectively.

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**CLIMATOLOGICAL TABLE 11**  
**METEOROLOGICAL DATA OF DHANU (1951-60)**

Station Dhanu  
(Tehsil in Thane Distt)

| Month     | Monthly mean air temp. |        | Daily mean Temp. |         | Monthly mean rainfall cm | No. of rainy days | Rainfall intensity per hour cm | R. Humidity % |
|-----------|------------------------|--------|------------------|---------|--------------------------|-------------------|--------------------------------|---------------|
|           | Highest                | Lowest | Max. °C          | Min. °C |                          |                   |                                |               |
| January   | 33.1                   | 13.7   | 27.7             | 16.8    | 0.85                     | Negligible        | Negligible                     | 68            |
| February  | 34.8                   | 13.8   | 28.2             | 17.5    | 0.04                     | -do-              | -do-                           | 67            |
| March     | 34.7                   | 17.3   | 30.3             | 21.0    | 0.01                     | -do-              | -do-                           | 60            |
| April     | 37.0                   | 20.8   | 32.0             | 23.4    | 0.01                     | -do-              | -do-                           | 78            |
| May       | 37.7                   | 20.0   | 32.9             | 26.8    | 0.85                     | 1                 | 0.035                          | 78            |
| June      | 35.1                   | 23.2   | 32.1             | 26.4    | 59.72                    | 18                | 0.14                           | 86            |
| July      | 31.7                   | 22.3   | 29.7             | 25.1    | 93.58                    | 23                | 0.17                           | 91            |
| August    | 30.3                   | 23.0   | 29.1             | 24.3    | 54.40                    | 20                | 0.12                           | 89            |
| September | 31.8                   | 22.6   | 29.6             | 24.8    | 42.65                    | 10.               | 0.18                           | 87            |
| October   | 35.1                   | 19.4   | 31.7             | 23.0    | 9.35                     | 4                 | 0.10                           | 77            |
| November  | 34.9                   | 16.8   | 31.9             | 20.0    | 0.90                     | 1                 | 0.04                           | 68            |
| December  | 33.6                   | 14.9   | 29.7             | 17.9    | 0.01                     | Negligible        | Negligible                     | 67            |

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**TABLE - 2**  
**PRESENT LAND USE OF BHIVANDI TALUKA (AREA IN HECTARES)**

| Year    | Total Geographical area. | Net area | Fallow          |               | Total | Other uncultivated land excluding fallow land | Culturable waste | Permanent pasture | Total forests | Area under barren and unculturable land | Area not available for cultivation. | Lend put under non-agri. uses. | Total | Area shown more than once |
|---------|--------------------------|----------|-----------------|---------------|-------|---|------------------|-------------------|---------------|---|-------------------------------------|--------------------------------|-------|---------------------------|
|         |                          |          | current fallows | Other fallows |       |   |                  |                   |               |   |                                     |                                |       |                           |
| 1971-72 | 69,038                   | 20,304   | 850             | 6,360         | 7,210 | -   | 7,987            | 7,987             | 24,722        | 8,209                                   | 606                                 | 8,815                          | 425   |                           |

TABLE 13  
PRESENT LAND USE AREA UNDER CROPS IN BHIVANDI TALUKA  
(area in ha.) (1972-73)

| Year    | Rice   | Regi | Wari | Total<br>Cereals | Gram | Tur | Other<br>pulses | Total<br>pulses | Total<br>good<br>grains | Condi-<br>ments<br>off<br>spices | Fruits<br>& vege-<br>tables | Total<br>food<br>grains | Fibre | Oil<br>seed | Total<br>non<br>food<br>crops | Gross<br>crop<br>area | Area<br>cro-<br>pped<br>more<br>than<br>once | Net<br>area<br>under<br>crops |
|---------|--------|------|------|------------------|------|-----|-----------------|-----------------|-------------------------|----------------------------------|-----------------------------|-------------------------|-------|-------------|-------------------------------|-----------------------|--|-------------------------------|
| 1971-72 | 18,280 | 722  | 198  | 19,200           | 245  | 89  | 464             | 798             | 19,998                  | 155                              | 316                         | 20,469                  | 87    | 173         | 260                           | 20,729                | 425  | 20,304                        |
| 1972-73 | 18,280 | 722  | 198  | 19,200           | 245  | 89  | 466             | 800             | 20,000                  | 164                              | 356                         | 20,520                  | 87    | 173         | 260                           | 20,780                | 425  | 20,355                        |

1.4. Geology:

The major rock formations consist of basic igneous rocks of extrusive nature commonly known as Basalts or Deccan Trap. Basalts are composed mainly of plagioclase feldspars, ferromagnesian minerals of pyroxene family mostly augite.

1.5. Natural vegetation:

Natural vegetation consists of the following trees:- Sagar (Bombax malabaricum), Neem (Melia azadirachta), Mango (Mangifera indica), Sag (Tectona grandis), Khair (Acacia catechu), Mohua (Bassia latifolia) Palas (Butea frondosa), Apta (Benhina racemosa), Jambhul (Engenia jambolana), Bamboo (Dandrocalamus strictus), Palm trees (Phoenix sylvestris) Grasses Heteropogon contortus, cynodon dactylon and cenchrus ciliaris.

2. Present land use, agriculture and cropping pattern:

2.1. Present land use:

Total geographical area of Bhiwandi taluka is 69038 ha. of which about 20,304 ha (29.40%) constitute the net area sown. 27,722 ha (35.80%) area is under forests; 3815 ha (12.76%) area is under waste lands; 7987 ha (11.56%) area is under pastures; 7210 ha (10.44%) area is under fallow lands. Details of present land use pattern is given in table 2.

2.2. Agriculture and cropping pattern:

In the net sown area, cereal crops occupy 19,200 ha; pulses 798 ha; oil seeds 173 ha; vegetables and spices 471 ha; Fibre crop 87 ha; confood crops 260 ha; Grain crops are paddy, Nagli and Wari. Paddy is the main crop of the area and is grown as Kharif crop only over 90% of the net area under crops. Wherever irrigation facilities are available some vegetables and fruits are grown which cover 1.5% of the net area sown. Among pulses, Gram, Urad, wal and Mung are the most common and they cover 2.3% of the net area sown. The details of different crops and fruits grown in the area are given in table-3.

3. Soils:

3.1. Soil Survey procedure and technique:

Reconnaissance soil survey of Bhiwandi taluka was carried out following the procedure given in soil survey manual published by the All India Soil and Land Use Survey



**Table 4**  
**Analytical Data of Soil Series**

| Soil Series   | Depth<br>in cm                    | Gravel<br>%                   | Soil Composition percentages |                                  |                                  |                                  | Moisture<br>equiva-<br>lent<br>% | Bulk<br>den-<br>sity<br>g/cc. | CaCO <sub>3</sub><br>%          | pH                       | Org.<br>Carbon<br>% | Nitro-<br>gen<br>%  | S.C.<br>mho/cm<br>(1:2.5)    | m.p./100 gm                      |                                  |                                 |
|---------------|-----------------------------------|-------------------------------|------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|-------------------------------|---------------------------------|--------------------------|---------------------|---------------------|------------------------------|----------------------------------|----------------------------------|---------------------------------|
|               |                                   |                               | Coarse<br>sand               | Fine<br>sand                     | Silt                             | Clay                             |                                  |                               |                                 |                          |                     |                     |                              | CEC/<br>Ex. Ca                   | Ex. Mg                           |                                 |
| 1             | 2                                 | 3                             | 4                            | 5                                | 6                                | 7                                | 8                                | 9                             | 10                              | 11                       | 12                  | 13                  | 14                           | 15                               | 16                               | 17                              |
| 1) Malkapur   | 0-16<br>16-34                     | 5.08<br>65.65                 | 3.62<br>21.26                | 12.10<br>18.03                   | 22.82<br>60.31                   | 36.16<br>19.87                   | 40.80<br>24.00                   | 1.25<br>1.28                  | 7.06<br>23.09                   | 8.3<br>8.3               | 0.47<br>-           | 0.05<br>-           | 0.20<br>0.20                 | 68.60<br>-                       | 56.61<br>-                       | 5.94<br>-                       |
| 2) Umbra      | 0-20<br>20-30                     | 40.0<br>75.0                  | 9.73<br>14.38                | 24.46<br>17.34                   | 24.89<br>28.52                   | 40.39<br>39.68                   | 32.89<br>33.10                   | 1.18<br>1.18                  | -<br>-                          | 8.1<br>8.1               | 0.25<br>-           | 0.05<br>-           | 0.25<br>0.25                 | 59.51<br>-                       | 36.21<br>40.80                   | 14.58<br>15.66                  |
| 3) Sivar      | 0-17<br>17-28                     | 26.25<br>62.30                | 3.52<br>5.62                 | 30.15<br>29.00                   | 20.74<br>30.36                   | 46.11<br>44.20                   | 34.27<br>38.40                   | 1.21<br>1.17                  | -<br>-                          | 8.1<br>8.0               | 0.16<br>-           | 0.05<br>-           | 0.20<br>0.22                 | 59.98<br>68.28                   | 31.11<br>36.21                   | 27.0<br>19.98                   |
| 4) Sivni      | 0-15                              | 20.34                         | 2.85                         | 52.67                            | 12.86                            | 29.79                            | 27.92                            | 1.39                          | nil                             | 8.3                      | 0.29                | 0.05                | 0.23                         | 50.44                            | 30.60                            | 17.55                           |
| 5) Mahbulgeon | 0-15/<br>15-37<br>37-66<br>66-107 | 4.87<br>8.33<br>5.80<br>23.25 | 6.69<br>4.67<br>4.81<br>1.76 | 18.26<br>19.14<br>15.46<br>14.62 | 20.87<br>24.81<br>22.95<br>41.13 | 50.02<br>50.30<br>55.44<br>41.22 | 36.40<br>38.62<br>43.22<br>45.45 | 1.17<br>1.22<br>1.15<br>1.20  | 6.29<br>6.98<br>6.03<br>5.37    | 7.9<br>7.9<br>7.9<br>8.0 | 0.23<br>-<br>-<br>- | 0.03<br>-<br>-<br>- | 0.35<br>0.30<br>0.30<br>0.25 | 62.75<br>56.27<br>58.53<br>62.75 | 33.14<br>29.56<br>26.54<br>44.37 | 9.13<br>12.42<br>17.02<br>17.82 |
| 6) Cuddhi     | 0-10<br>10-24<br>24-31<br>31-116  | 7.69<br>nil<br>2.65<br>46.39  | 3.15<br>9.48<br>5.55<br>5.50 | 20.61<br>10.80<br>20.72<br>20.21 | 32.90<br>32.88<br>33.85<br>30.82 | 41.40<br>47.72<br>39.19<br>39.91 | 36.75<br>38.00<br>43.78<br>28.37 | 1.33<br>1.57<br>1.48<br>1.34  | 9.97<br>10.89<br>11.27<br>10.88 | 8.1<br>8.2<br>8.0<br>8.0 | 0.25<br>-<br>-<br>- | 0.06<br>-<br>-<br>- | 0.45<br>0.30<br>0.30<br>0.25 | 67.60<br>64.30<br>64.50<br>56.05 | 47.43<br>46.41<br>44.89<br>32.61 | 9.18<br>8.10<br>9.18<br>13.50   |
| 7) Krishnagar | 0-20<br>20-32<br>32-55<br>55-75   | nil<br>2.43<br>5.17<br>60.00  | 1.38<br>1.63<br>2.62<br>2.63 | 13.44<br>17.25<br>16.40<br>18.75 | 12.79<br>14.37<br>14.81<br>21.82 | 67.99<br>67.51<br>66.85<br>51.79 | 47.19<br>45.74<br>48.37<br>38.97 | 1.43<br>1.15<br>1.12<br>1.08  | 0.46<br>2.83<br>14.86<br>16.41  | 7.9<br>8.2<br>8.2<br>8.2 | 0.36<br>-<br>-<br>- | 0.05<br>-<br>-<br>- | 0.20<br>0.30<br>0.25<br>0.30 | 92.30<br>90.61<br>88.02<br>70.20 | 73.44<br>73.44<br>69.36<br>58.14 | 5.40<br>7.01<br>7.56<br>13.50   |

Organisation, I.A.R.I. New Delhi.

Survey of India toposheets were used as base maps. Before taking up the field work the base maps were studied in detail and various physiographic units were identified on the basis of heterogeneity of terrain features. Field traverses were made on the available roads. Soil profiles, auger bores, and road cuts were studied during the traverses at frequent intervals for differentiating soil characteristics and studying the extent of soil variations. The soil profiles were exposed up to 1.5 m deep or upto parent material whichever was nearer. Soil profiles were studied for different morphological characteristics like soil depth, texture, structure, consistency, colour, effervescence, etc. Besides the pedon characteristics, the profile site characteristics i.e., slope, graveliness, stoniness, rock outcrops; past erosion hazards etc., were also noted. Soils of similar morphological characteristics were grouped into soil series and described. The soil series were named after the place near where the soil profile representative of the series was first identified and described. Profile samples were collected for laboratory analysis for characterising soil properties. While mapping appropriate soil units as series and association of series were delineated on the map and shown by symbols. The series which occurred together in a regularly repeating geographic pattern were grouped into an association. A soil association generally comprises two or three major soils with different proportions and minor inclusions of other soils.

Soil Series associations are described below:

3.2. Mapping Units:

| <u>Map Symbols:</u> |         | <u>Description:</u>   |
|---------------------|---------|---|
| Prv.                |         | Shallow, well drained, dark reddish brown, fine loamy soils of Parivili series on strongly sloping hill slopes and escarpments.   |
| Kwk.                |         | Moderately deep, moderately well drained, moderately slowly permeable, fine loamy soils of Kawad Khurd series, on gently sloping (foot hills and mid-uplands) upper piedmont slopes.  |
| Rb                  | Dbd-Kwk | Deep, moderately drained, fine clayey soils of Jabhad series on very gently sloping foot hills; and moderately deep, moderately well drained, fine loamy soils of Kawadkhurd series on gently to very gently sloping foot hills at upper piedmont slopes. |

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| <u>Map Symbol</u> | <u>Description:</u>   |
|-------------------|---|
| Ajl-Svd           | Deep, moderately to somewhat poorly drained, slowly to very slowly permeable fine clayey soils of Arjunli series on nearly level to very gently sloping valleys; and very deep, somewhat poorly drained, very slowly permeable, fine clayey soils of Savad series on nearly level to very gently sloping valleys. |
| Akl               | Very deep, moderately to somewhat poorly drained, very slowly permeable, fine clayey alluvial soils of Akloli series on nearly level flood plains. (inclusion of moderately deep, moderately slowly permeable clayey soils of back swamp plains, Kelhar series).  |
| Akl-Svd-Ajl       | Very deep very slowly permeable, fine clayey, soils of Akloli series on nearly level flood plains and Savad series on nearly level to very gently sloping valleys; and Deep, slowly to very slowly permeable, fine clayey soils of Arjunli series on nearly level to very gently sloping valleys.                 |

4. DESCRIPTIVE LEGEND:

4.1. Strongly to moderately steep to steep excessively drained soils of Mesas and Escarpments.

These are excessively drained to well drained, moderately to severely eroded, dark reddish brown shallow soils occurring on strongly sloping hill slopes, escarpments and moderately steep to steep mesas. The soil scape presents a rugged topography with a thin grass cover amidst to steeply sloping hills covered with thick reserve forests.

These soils are mostly confined to the western portion and in patches on northern, north eastern, and south eastern sides of the surveyed area. The relief is excessive. The elevation ranges between 50 and 625 m above MSL. The soils in this unit are non-arable and under reserved forests, pastures, grass lands and waste lands. Shallow rooting depth to bed rock, moderate to severe erosion, well drained relatively low water retentive capacity, excessive runoff, frequent draught conditions, and strong to steep slopes are the limitations of these soils.

- 4.1. These soils have been mapped as Parivilli series while Kawad Khurd series occurs as inclusion.

Parivilli series contributing to 22% of the total surveyed area.

4.1.1. Parivilli Series (Prv)

Parivilli series includes shallow, well drained, dark brown to dark reddish brown clay loam soils. They are developed on weathered basaltic material and are found to occur on strongly to steeply sloping (5.25 % slopes) mesas, hills and escarpments. These are moderate to severely eroded soils with gravelly and rocky phases. The typifying pedon represents A horizon of about 9-22 cm thickness having a weakly developed subangular blocky structure, which grades to C horizon composed of dark reddish brown to brown soft murrum of weathered basalt. The inclusions are those of Kawad Khurd series developed on weathered basalt. These are moderately deep, moderately well drained, dark brown clay loam soils on gently to very gently sloping uplands.

4.2. Gently to very gently sloping moderately well drained soils on the foot hills:

These are moderately well drained brown to dark brown moderately deep and deep loamy soils that are developed on basaltic colluvium from adjoining hills and escarpments. They occur on gently to very gently sloping foot hills and piedmont slopes, mostly found in the Central, eastern and Eastern portion of the surveyed area, though they are scattered throughout the area. The elevation ranges between 20 and 75 m above MSL. The soils are mostly cultivated for Kharif crops.

All these soils have been mapped under two units, viz. i) Kawad Khurd series and ii) Dabhad-Kawadkhurd association with minor inclusions of Parivilli and Dabhad series. They occupy 40% of the total area surveyed.

4.2.1. Kawadkhurd series (Kwk)

Kawadkhurd series consists of moderately well drained, moderately deep, dark brown fine loamy soils that are developed on weathered basaltic material. They are found to occur on upper and middle portions of the gently to very gently sloping upper piedmont slopes and are mostly confined to the eastern, southern and Central portions. The elevation ranges mostly between 50 and 75 m above M.S.L. A few patches are between 50 and 20 m. Moderate to moderately slow permeability, low organic matter content, limited effective rooting depth are the limitations of these soils.

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4.2.1. The soil scape is a gently sloping piedmont slope below the foot hills.

4.2.2. Dabhad-Kawadkhurd association:

Very gently to gently sloping (1-5 % slopes), deep and moderately deep, moderately well drained, fine loamy soils of dark brown and dark yellowish brown colours. This association occupies about 33% of the surveyed area.

4.2.2.1. Dabhad Series:

Dabhad series consists of moderately well drained, deep, fine clayey soils developed on the colluvial material derived from the surrounding uplands and escarpment slopes. They are found to occur on very gently sloping foot hills, with moderate to moderately slow permeability. Moderately deep effective rooting depth and fine clayey texture are the limitations.

4.3. Nearly level to very gently sloping moderately well drained, to somewhat poorly drained, clayey soils of the valley lands flood plains.

The soils are deep to very deep, moderately well drained to somewhat poorly drained slowly to very slowly permeable clayey and cracking soils. They are developed on colluvial and alluvial material of weathered basalts and occur on the valleys and flood plains of the rivers like Ulhas, Tansa and their major tributaries like, Kamvadi, Kumbhari and Jumdala etc. They are located mostly on the northern, southern and to some extent in eastern, southern and to some extent in eastern and Central portions of the surveyed area. The elevation ranges between 15 and 50 m above MSL.

Paddy is the main crop. Three soil series forming two associations constitute 34% of the total area surveyed.

The soil scape is a valley surrounded by rugged hill and gently sloping piedmont plains and flood plains along the river courses. Slow to very slow permeability, high shrink-swell potential high water table, poor surface drainage and compact subsoil are the limitations of these soils. The association in the landscape unit is described as i) Arjuni-Saved Association ii) Akloli-Saved-Arjunli-association.

4.3.1. Arjunli-Saved Association:

Nearly level to very gently sloping (0-3%) deep to very deep, moderate to somewhat poorly drained, slow to very slowly permeable, clayey soils of dark brown and dark reddish brown

- 4.3.1. colours on valley lands. This association covers about 13% of the total area and is confined mainly in the Central portion and patches in the eastern portion. The elevation ranges between 15 to 50 m above mean sea level.

Arjunli soils are deep, dark brown to dark reddish brown and moderately to somewhat poorly drained, fine clayey on nearly level to very gently (0-3%) sloping valley lands. They have developed on weathered basalt of vesicular nature. The ground water table is between 1.5 to 5 m depth.

Savad soils are very deep, somewhat poorly drained very slowly permeable, brown to dark brown, fine clayey, cracking soils that are developed on clayey material of colluvial nature. They occur on nearly level to very gently sloping (0-3%) valley floors. The ground water table is at a depth between 1.5 and 3 meters. Slow to very slow permeability, high shrink swell potential, slight to moderate alkalinity high water table, and poor surface drainage are the problems, Paddy is the main crop.

4.3.2. Akloli-Savad-Arjunli Association:

Level to very gently sloping (0-3%) deep to very deep, moderately well drained poorly drained fine clayey soils of cracking nature. They occur on flood plains and valleys of Ulhas-Tansa and Kamvadi rivers. This association covers about 16% of the surveyed area and the soils are present mostly on the northern southern and eastern portions of the surveyed area. The elevation ranges between 15 and 35 m above MSL.

Akloli soils are very deep, somewhat poorly drained, very slowly permeable, fine clayey soils occurring on level to very gently sloping (0-3%) flood plain of river Ulhas. Tansa and other major tributaries. They have developed on silty alluvium of basaltic materials. The ground water table is between 1.5 and 3 m depth.

High water table, slow to very slow permeability, compact sub-soil slight to moderate alkalinity, high bulk density and poor surface drainage are the limitations of these soils.

4.4 Nearly level to very gently sloping moderately well drained to somewhat poorly drained. Soils of the flood plain and back swamp plain.

The soils are moderately well drained to somewhat poorly drained, moderately deep to very deep, slowly to very slowly permeable occurring on

level to very gently sloping flood plains and back swamp plains of river Ulhas around the Creek. They are located on the southern and eastern portion of the surveyed area along the river Ulhas. The elevation is 30 meters above MSL.

This unit occupies about 5% of the total area surveyed and has been mapped under Akloli series. The other associated soil series is Kalhar. The extent of Kalhar series is very insignificant and as such it has been mapped as inclusion in the Akloli series. Paddy is the main crop. High water table, slow to very slow permeability, poor surface drainage, compact subsoil are the limitations of these soils.

#### 4.4.1. Kalhar Series

Kalhar series consists of moderately deep to deep, poorly drained, slowly permeable soils that occur on nearly level to very gently sloping (0-3%) back swamp plain of Ulhas river. High exchangeable sodium, poor surface drainage and slow permeability are the limitations.

The extent of such soils is a very negligible. They are confined to the back swamp of Ulhas river.

### 5. INTERPRETATION OF THE SOIL ANALYTICAL DATA

The results of soil analysis are given in table 4 from the consideration of soil depth, the soils of the area are grouped into three depth classes viz.

- i) Very shallow to moderately deep
- ii) Moderately deep to deep and
- iii) Very deep.

The analytical data are interpreted for each of the groups separately.

#### 5.1. Shallow to moderately deep soils:

This depth class consists of Parivili and Kawad Khurd soil series. The particle size distribution indicates that gravel (2 mm) are well distributed in the profile and qualities for the gravelliness of the texture. The clay content varies from 26 to 42 percent.

The infiltration and permeability studies indicate that the soils are moderately slow and can be put under irrigation without any appreciable deterioration in physico-chemical properties. The data further shows that the soils of Parivili series are well drained than those of Kawad Khurd series. However, because of the physiographical position, open structure due to gravelliness and better drainage, these soils may need frequent irrigation to maintain the available moisture at an optimum level. The cation exchange capacity of the soils is very

- 5.1. high indicating the presence of montmorillonitic type of clay mineral possessing high shrink swell potential.

Under moist condition to capillaries are expected to be disturbed due to swelling thus reflecting the water movement. The exchange complex is base saturated with Ca 2+ and Mg 2+ as the dominant cations. This would help to keep the soils in flocculated condition maintaining the soil structure. Moderately slow permeability and very low exchangeable Na+ content are expected to keep the soils free of alkali hazards.

The pH of the soils is neutral while the electrical conductivity is normal. From the results of analysis of saturation extract it is observed that the harmful ions such as Na +, CO<sub>3</sub>, HCO<sub>3</sub> etc., are very low. Available water capacity of the soil is moderate but the available moisture storing capacity is poor due to shallowness of the soils.

The status of organic and available P2O5 content is poor. Further shallow effective rooting depth may limit the choice of crops. However, improvement in yields is expected under assured irrigation and adequate fertilizers application without causing any adverse effect on the soil conditions.

5.2. Moderately deep to deep soils:

This depth class consists of soils mapped as Dabhad, Kalhar and Arjunli soil series having moderate effective rooting depth for the common field crops. The percentage gravel has considerably reduced while the content of silt and clay increases through depth of the profile. The clay content was found to vary from 28 to 55%. Under these conditions slight difficulty in root penetration is expected. From the distribution of clay in the profile it is observed that there is a substantial increase in clay content in the second horizon rendering compaction and resulting the rate of permeability slow. Deep ploughing should improve the physical condition of the soils. The data on accumulated intake and permeability rate of soils indicate the drainage conditions. There is also tendency for development of a clay pan in the second horizon. Deep ploughing will therefore improve the tilth as well as permeability of the soils. At places these soils will have to be provided with drainage.

The cation exchange capacity is high which is indicative of the presence of montmorillonite as the dominant clay mineral with high shrink swell potential. Exchangeable sodium in Kalhar series is about 13% while Dabhad and Arjunli series had negligible amount of Exch.Na.

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Since Kalhar series has significant amount of exchangeable Na in the exchange complex heavy irrigation is not be recommended. The Dabhad and Arjunli soils may be considered safe from the point of view of irrigation. The pH of the soils under Kalhar and Dabhad series is neutral to mildly alkaline whereas that of Arjunli soils it is mildly to moderately alkaline. The electrical conductivity is normal. The results of analysis of water extract indicates that Arjunli soils in general have higher amounts of  $\text{HCO}_3$  content. Ca and Mg are the predominations present. Low permeability and high exchangeable sodium make the Kalhar soils unfit for heavy irrigation unless adequate drainage is provided. The soils mapped as Arjunli and Dabhad series are comparatively free of salinity and alkali hazards and hence could be freely used for irrigation.

### 5.3. Very deep soils:

Soils mapped as savad and Akloli series have been included in this depth class. The soils are very deep and provide sufficient effective rooting depth for both common field crops and deep rooted crops. The gravely material is absent through out the depth and therefore high bulk density and compactness of the layers is expected. There is significant increase in clay content which varies from 39.8 to 54.4%. Due to high clay content and low organic matter status, the difficulties in tillage operations are expected. Compactness of the soil may also offer resistance to the normal root penetration. As revealed from the high cation exchange capacity, high shrink swell potential the soils seem to have montmorillonite as the dominant clay mineral. High shrink swell potential also may exert pressure on the root activity. The soils are base saturated and flocculated due to dominance of Ca and Mg. ions. Exchangeable Na percent works to about 6% and is below the critical level under normal conditions.

The lower horizons have shown slow permeability which is critical for the irrigation farming. It is also been found that the layers below 70 cm depth are very compact and impervious. This condition may lead to the formation of false water table, a condition which is conducive for the formation of alkali soils. Provision for good drainage condition is essential. pH of the soils is mildly to moderately alkaline with normal electrical conductivity and does not indicate any salinity or alkalinity hazards at this stage. Ca and Mg constitute the major bulk of the soluble cations while Na content is marginal in the soil water extract. The proportion of  $\text{HCO}_3$  and other anions to other cations also seems to be normal.

Available water capacity and available water holding capacity are very high. Organic matter and available P 205 status is low. In general it is observed that these soils are not favourable for irrigation unless drainage conditions are improved. The crops which need good drainage may not be suitable for these soils. As such paddy appears to be suitable crop.

6. INTERPRETATIVE USE OF SOILS:

This section illustrates various ways in which the soil survey information can be presented in the useable and readily understandable form. The interpretation of soil is based on field examinations and experience in the area. The soil characteristics that determine the interpretations, have been discussed in the relevant chapters. The interpretations are made in respect of the following.

- a) Soil and Land Irrigability classification
- b) Vegetative soil grouping.

6.1. Soil and Land Irrigability classification

This is the interpretative grouping of soils and lands according to their suitability for sustained use under irrigation.

6.2. Soil Irrigability classes:

Soil irrigability classes are defined in terms of soil properties indicating the degree of limitation for their suitability for sustained use under irrigation. Soil irrigability classes are established without regard to availability of irrigation water, water quality, land preparation costs, availability of drainage outlets and other non soil related factors. Criteria for classes are quantitatively defined. The most limiting property determines the classification. For example a soil may have all the properties of the most desirable class except one, but on the basis of this one undesirable property undesirable property it is assigned to a lower class.

- Class A. None to slight soil limitations for sustained use under irrigation. (None of the soils in the area comes under class A).
- Class B. Moderate soil limitations for sustained use under irrigation. (None of the soils in this area falls under Class B).
- Class C. Severe limitations for sustained use under irrigation. Soils grouped under this class are mentioned below.

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| <u>Soil Series</u>        | <u>Most limiting properties</u>   |
|---------------------------|---|
| i. Kawadkhurd-Series      | Moderately deep effective rooting depth, moderately slow permeability, somewhat moderate water retentive capacity within rooting depth.   |
| ii. Dabhad Arjunli-Series | <del>Slow to very</del> <sup>Moderately</sup> slow permeability dense clayey sub-soil, moderately deep to deep effective soil depth.      |
| iii. Arjunli-Series.      | Slow to very slow permeability, compact, clayey sub-soil which is very slowly permeable.  |
| <b>Class D</b>            | Very severe limitations for sustained use under irrigation, soils grouped under this class are mentioned below.<br>Savad, Akloli, Kalhar. |
| i. Savad-series.          | Slow to very slowly permeable, compact, sub-soil.   |
| ii. Akloli-Series         | Dense, clayey very slowly permeable with impervious sub-soil.   |
| iii. Kalhar-Series.       | Shallow effective rooting depth, moderately slow permeability.  |
| <b>Class E</b>            | Non irrigible soil class. It includes parivili series which is shallow, eroded, on strongly and moderately steep to steep slopes.         |

### 6.3. Land Irrigability classes and sub-classes.

The suitability of land for irrigation depends on the site characteristics as appraised from soil survey information viz., slope, permeability of sub-soil and sub-strata, available drainage outlets, depth to bed rock, seasonal fluctuation of water table, salinity etc., as given in soil survey Manual Re. Ed. 1970 of the All India Soil and Land Use Survey Organisation. On the basis of specifications defined, land classes are defined as follows.

|                 |  |
|-----------------|--|
| <b>Class 1</b>  | Land have few limitations for sustained use under irrigation. These are, nearly level soils having deep effective rooting depth, favourable texture, good tilt and optimum A.W.C.        |
| <b>Class 2.</b> | Lands have moderate limitations. These lands are very gently sloping with less than ideal soil depth, texture, permeability and somewhat unfavourable topography or drainage conditions. |
| <b>Class 3.</b> | Lands that have severe limitations for sustained use under irrigation  |

Lands of this class have severe limitations of either soil, topography or drainage when used for irrigation. Limitations may include singly or in combination with the effects of

1) Gentle slopes, 2) unfavourable Soil depth, textures permeability or other soil properties, 3) moderately severe salinity or alkali when in equilibrium with the irrigation water, 4) unfavourable topography or unfavourable drainage conditions. The soils grouped under class 3 are mentioned below.

Soil Series

Limiting Factors

- |                |   |
|----------------|---|
| i) Kawad Khurd | Very gently to gently sloping with moderate to moderately slow permeability.              |
| ii) Dabhad     | Moderately slow permeability, moderately drained, unfavourable texture, high water table. |
| iii) Arjunli   | Unfavourable texture, slow to very slow permeability, drainage and high water table.      |

**Class 4.** These lands are marginal for sustained use under irrigation due to very severe limitations of either soil, topography, or drainage when used for irrigation. Limitations may include singly or in combination with the effects of moderately steep slopes; very unfavourable soil depth, texture, permeability or other soil properties; severe salinity or alkali when in equilibrium with irrigation; very unfavourable topography or drainage conditions. The soils grouped under this class are given below.

Soil Series

Limiting Factors:

- |             |   |
|-------------|---|
| i) Savad    | Very deep, unfavourable texture, very slow permeability, poor drainage, high water table and poor tilth.                          |
| ii) Akloli  | Unfavourable soil texture, very slow to impermeable sub-soil, poor drainage, high water table.                                    |
| iii) Kalhar | Shallow effective rooting depth, unfavourable sub-soil texture poor drainage, slow permeability high exchangeable sodium content. |

**Class 6** These lands are not suitable for sustained use under irrigation. This class of lands does not meet the minimum requirement for lands of other classes or are not

Susceptible to delivery of irrigation water. The soils grouped under this class are.

Soil Series: Limiting Factor.

Parivili Strongly and moderately steep to steeply sloping mesas, hills and escarpments.

Sub Classes:

- S : Soil Limitations  
t : Topographic limitations.  
d : Drainage limitations.

6.4. VEGETATIVE SOIL GROUPS

Definition: A vegetative soil group consists of soils with similar properties that characterize it from a plant growing point of view. Each plant has definite requirements and tolerance. Soil characteristics used in such groupings include.

- 1) Effective depth. 2) surface texture
- 3) Sub-soil permeability 4) Drainage class
- 5) Salinity or alkali 6) Available water holding capacity 7) erosion class and 8) reaction

The soil series mapped in the area have been grouped into vegetative groups C.D and J. The descriptions are given below:

GROUP C: Deep to very deep, well to somewhat poorly drained, fine loamy to clayey soils with moderately slow to very slow permeability. These soils are subject to wide and deep cracking during dry period every year. Choice of plants limited by

FINE TEXTURE: The soil series included in this group are, Kawad Khurd, Dabhad, Arjunli, Savad and Akloli series.

GROUP D: Soil are moderately deep, moderately drained, moderately slow to slowly permeable. Choice of the plants limited by SLOWLY PERMEABLE SUB-SOIL. The series included in this group is Kalhar.

GROUP J: Choice of plants DEPENDS UPON ON SITE INVESTIGATION. Soils included ARE THOSE IN THE MISCELLANEOUS NON-Arable category, such as river wash,

TABLE - 5  
INTERPRETIVE GROUPINGS

| Srl. No. | Series description   | Soil irrigability class | Land irrigability class | Land irrigability sub-class | Vegetative grouping. |
|----------|--|-------------------------|-------------------------|-----------------------------|----------------------|
| Prv      | Parivili, gravelly clay loam, shallow, on 5-25% slope, moderately to severely eroded.                                  | E                       | 6                       | 6st                         | J                    |
| Kwk      | Kawad Khurd, clay loam, moderately deep to deep, well drained, moderately slowly permeable, on 1 to 5% slope.          | C                       | 3                       | 3a                          | C                    |
| Dhd      | Dabhad, clay loam, deep, moderate to moderately well drained, moderately slowly permeable on 1 to 5% slope.            | C                       | 3                       | 3a                          | C                    |
| Ajl      | Arjunli, clay, deep, moderately well drained to somewhat poorly drained, slow to very slowly permeable, on 0-3% slope. | C                       | 3                       | 3e                          | C                    |
| Svl      | Saved, clay, very deep, poorly drained, very slowly permeable, on 0-3% slope.  | D                       | 4                       | 4a                          | C                    |
| Akl      | Akloli, silty clay, very deep, moderately to somewhat poorly drained, very slowly permeable, on 0 to 3% slope.         | D                       | 4                       | 4a                          | C                    |
| Klh      | Kalhar, silty clay loam, moderately deep to deep, slowly permeable on 1 to 3% slope.                                   | D                       | 4                       | 4a                          | D                    |

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TABLE - 6  
CLASSIFICATION OF SOILS OF BHIVANDI TANSIL THANA DISTRICT

| Sl. No. | Order       | Sub-order | Great group | Sub-group             | Family                                   | Series      |
|---------|-------------|-----------|-------------|-----------------------|--|-------------|
| 1.      | Entisol     | Orthent   | Ustorthent  | Troptic Ustorthent    | Fine loamy, mixed isohyperthermic        | Parivili    |
| 2.      | Inceptisol  | Tropepts  | Ustropepts  | Vertic Ustropepts     | Fine, montmorillonitic, isohyperthermic. | Kawad Khurd |
| 3.      | Inceptisol  | Tropepts  | Ustropepts  | Typic Ustropepts      | Fine, montmorillonitic, isohyperthermic. | Dabhad      |
| 4.      | Inceptisol  | Tropepts  | Ustropepts  | Vertic Ustropepts     | Fine, montmorillonitic isohyperthermic.  | Arjunli     |
| 5.      | Vertisol    | Ustert    | Chromustert | Typic Chromustert     | Fine, montmorillonitic, isohyperthermic. | Saved       |
| 6.      | Inceptisols | Tropepts  | Ustropepts  | Vertic ustropepts     | Fine, montmorillonitic, isohyperthermic. | Akloli      |
| 7.      | Inceptisols | Eropepts  | Ustropepts  | Paralithic Ustropepts | Fine, mixed, isohyperthermic.            | Kalhar.     |

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stony or rocky upland, etc. The soils included in this group are those of parivili series. They are shallow, moderately to severely eroded soils on strongly and moderately steep to steep sloping mesas, hills and escarpments.

7. DESCRIPTION OF SOIL SERIES:

Parivili series includes well to excessively drained, eroded, shallow soils of gravelly nature. They occur on strongly to moderately steep to steep slopes of escarpments, mesas and hills and are formed over basalts. A profile of the soil pedon exhibits dark brown to dark reddish brown gravelly clay loam A horizon overlying brown to dark reddish brown weathered basalt mixed with loamy material. The principal associated soils are those of Kawad Khurd and Dabhad Series which are moderately deep and deep inceptisols at foot hills.

Parivili series comprises members of fine loamy, mixed, isohyperthermic shallow family of Tropic Ustorthents.

Typifying pedon: Parivili gravelly clay loam grass land.

(Colours are for dry soils unless otherwise noted)

|            |   |
|------------|---|
| A1 0-12 cm | Dark brown (7.5 YR 4/4 D & M) gravelly clay loam; weak medium subangular blocky dry slightly hard, moist friable, wet slightly sticky and non-plastic; plenty fine roots common, fine inped and exped pores; rapid permeability; clear irregular boundary; slightly acidic (pH 6.2) (9 to 22 cm thick). |
| C 12-38 cm | Weathered basalt in the matrix of loamy material.   |

Range in Characteristics:

The depth of the soil to paralithic contact ranges from 9 to 22 cms. The colour of the soil in A horizon is in the hue of 7.5 YR and 5 YR with values and chroma 3 and 4 both for dry and moist soils.

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The texture is usually gravelly clay loam to clay loam. The structure varies from weak to moderate sub-angular blocky. The weathered material is of dark reddish brown colour in the hue of 5 YR and sometimes of brown colour in hue of 7.5 YR and 10 YR.

Drainage and permeability: Well drained, excessive surface runoff and moderate permeability.

Use and vegetation: Most of the area is under forest grasses and pastures and at places rugged waste lands to extract building and road materials. Sag, Neem are the dominant natural vegetation.

Topography: Strongly sloping and moderately steep to steep sloping mesas, hills and escarpments ranging from 5 to 25% slopes.

Type location: Parivili village near Angaon temple hillock on the left side of the Chivandi Vada Road.

#### 7.2. Kawad Khurd Series (Kwk)

Kawad Khurd series includes moderately well drained, moderately deep, dark brown soils. They occur on gently to very gently sloping foot hills and are developed over weathered basaltic material. The soil pedon exhibits dark brown clay loam A horizon grading into dark brown clay B horizon overlying the C horizon of weathered basalt. The principal associated soils are those of Dabhad and parivili series which are deep Inceptisols and shallow Entisols respectively. Kawad Khurd series comprises members of the fine, montmorillonitic, isohyperthermic moderately deep family of Vertic Ustropepts.

Typifying pedon: Kawad Khurd clay loam-fallow after paddy.

(Colours are for dry soils unless otherwise noted)

Ap 0-15 cm Dark brown (10 YR 3/3 D & M) clay loam, strong coarse subangular blocky; dry hard, moist firm, wet sticky and plastic; few fine roots; common very fine impeded and exp. pores; 0.5 to 1.0 cm wide cracks; moderately slow permeability; clear and smooth boundary; mildly alkaline (pH 7.8) (12 to 16 cm thick).

B2

B2 15-41 cm Dark brown (10 YR 3/3 D & M) clay loam; strong coarse subangular blocky peds with shiny pressure faces; dry hard, moist firm, wet sticky and plastic; very few fine impeded and exp. roots; common fine impeded and exp. pores; slow permeability; clear smooth boundary; neutral reaction (pH 7.3) (22 to 28 cm thick)



C 41 to 45 cm + Weathered basalt.

Range in characteristics:

The thickness of the solum ranges from 35 to 44 cms. The dominant surface textures are clay loam to gravelly clay loam grading to clay loam to clay in sub-surface horizons. The clay percentage of the A horizon is more than 30 percent. The clay content in B horizon is around 40 percent. The dry colour in the solum is in the hue of 10 YR and 7.5 YR with values and chromes 3,4,5 and 2,3,4 respectively. The moist colour ranges in the hue of 10 YR and 7.5 with values and chromes 3,4 and 2,3 respectively. The ground water table ranges from 2.5 to 3.5 m of the surface. The surface cracks 0.5 to 1.0 cm wide extend upto 30 cms. Quartz and basalt pieces are present in the lower part of the solum.

Competing series and their differentiae:

Soils Dabhad series are moderate to moderately well drained deep soils developed on colluvial material derived from the adjoining mesas and escarpments.

Drainage and permeability:

Moderately well drained soils with moderate slow permeability.

Use and vegetation:

These soils are generally cultivated for paddy crop. Neem, Mango, Babar, Karanj form the natural vegetation.

Topography:

Very gently to gently sloping upper piedmont slopes.

Type location:

Village Kawad Khurd (Pit No.8) on Kawad Khurd Koliveli Road on right hand side, near Mango tree.

7.3. Dabhad Series (Ubd)

Dabhad series consists of moderately well drained, deep dark brown soils developed on colluvial material derived from adjoining mesas and escarpments. They are found to occur on the lower portions of the very gently sloping foot hills. The soil pedon exhibits dark brown (10 YR 4/3) clay loam A horizon grading to dark brown (7.5 YR 3/2) clayey B horizon overlying the C horizon of colluvial material mixed with weathered basalt. The principal associated soils are those of Kawad Khurd and Parivili series which are moderately deep inceptisols and shallow entisols respectively.

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Dabhad series comprises members of fine montmorillonitic isohyperthermic deep family of Typic Ustropepts.

Typifying pedon: Dabhad clay loam, fallow after paddy. (Colours are for dry soils unless otherwise noted)

DESCRIPTION

- Ap 0-11 cm Dark brown (10 YR 4/3) clay loam, dark brown (7.5 YR 3/2) when moist; moderate medium subangular blocky; dry hard, moist friable, wet sticky and plastic; few fine roots; very fine impeded and exped pores, moderately slow permeability; clear smooth boundary; neutral (pH 6.9) (10 - 15 cm thick)
- B1 11-28 Dark brown (7.5 YR 3/2 D & M) clay; moderate medium subangular blocky; dry hard, moist friable, wet sticky and plastic; very few fine roots, common very fine impeded and exped pores; moderately slow permeability; clear smooth boundary; mildly alkalinity (pH 7-8) (15 YR to 20 cm thick).
- B2 28-51 Dark brown (10 YR 3/3 M) clay; weak medium subangular blocky breaking into granular; moist friable, wet sticky and plastic; very few fine roots; common very fine impeded and exped pores; moderately slow permeability; clear and smooth boundary; mildly alkaline (pH 7.7) (22 to 25 cm thick).
- C 51-55 + Soft murum of weathered basalt.

Range in characteristics:

The thickness of the solum ranges from 45 to 60 cms. The colour of the A horizon is in the hue of 10 YR and 7.5 YR with values 3 and 4 and chroma 2, 3 and 4 both for dry and moist soils. The texture of the surface soil is clay loam with clay content ranging from 32 to 36 percent. The texture of the subsoil is clay and the clay content ranges from 38 to 42 percent. The structure varies from medium moderate subangular blocky to medium weak subangular blocky. The ground water table ranges between 2.5 to 3.5 m of the surface.

The competing series and their differentiae:

The associated Kawad Khurd series, which is vermic Ustochrept is the competing series. These are cracking soils and the cracks extend upto 30 cms depth. Kawad Khurd soils are comparatively better drained than Dabhad soils.

Drainage and permeability:

Moderate to moderately well drained soils with moderately slow permeability.

Use and vegetation:

These soils are generally cultivated for paddy crops. Sabar Nam, and khend are the natural vegetation.

Topography:

Very gently sloping foot hills, (1 to 5% slope)

Type location:

Village Dabhad on Khambale Dabhad Road nearly one furlong away from the pipe line and one furlong south of Dabhad village.

7.4. Arjunli Series (A1)

Arjunli series includes moderate to some what poorly drained deep soils that occur on nearly level to very gently sloping (0-3 % slope) valleys. They have developed over weathered basalts of vesicular type. The soil pedon exhibits A horizon of dark brown subangular blocky clay grading to dark brown clay B horizon of angular blocky peds with shiny pressure faces overlying weathered basalt. The principal associated soils are those of Savad series which are very deep some what poorly drained Vertisols.

Arjunli series comprises members of fine montmorillonitic isohyperthermic, deep family of Vertic Entisols.

Typifying pedon: Arjunli clay, fallow after paddy. (Colours are for dry soils unless otherwise noted)

Depth in cms:

- |            |  |
|------------|--|
| Ap 0-8 cms | Dark brown (10 YR 3/3) clay; dark brown (7.5 YR 3/2) when moist; moderate coarse subangular blocky; dry very hard; moist firm, wet sticky and plastic; expd pores; 0.5 to 1.5 cm wide cracks; moderate permeability, mildly alkaline (pH 7.4) (8 to 22 cms thick).   |
| B1 8-26    | Dark brown (7.5 YR 3/2 D & M) clay; moderate coarse subangular blocky; dry very hard; moist firm, wet sticky and plastic; few fine roots; very few very fine lined pores; 0.8 to 1.5 cm wide cracks, moderately slow permeability, clear smooth boundary; moderately alkaline (pH 7.9); (8 to 29 cm thick) |

- B21 26-44      Dark brown (7.5 YR 3/3 D & M) clay; medium moderate angular blocky peds with shiny pressure faces; dry very hard, moist very firm, wet very sticky and very plastic; very few, very fine roots; very few very fine expd pores; 1.2 cm wide cracks, slow permeability; gradual smooth boundary; moderately alkaline (pH 8.1) ; (18-30) cms thick)
- B22 44-56      Dark brown (7.5 YR 3/2 M) clay; moderate medium angular blocky peds with shiny pressure faces moist very firm, wet very sticky and very plastic; very few very fine roots; very few very fine expd pores; 1.2 cm wide cracks; very slow permeability gradual and smooth boundary; moderately alkaline (pH 8.2) (10-15 cm thick)
- C 56-92 +      Weathered basalt.

Range in characteristics:

The thickness of the solum ranges from 56 to 72 cms. The colour of the surface and subsoil horizons is in the hue of 10 YR and 7.5 YR with value and chroma 3 and 2 for dry and moist soils. The colour of the subsoil in some cases may also be in the hue of 5 YR with values and chromas 3 and 2 respectively. The texture of the surface soil varies from clay loam to clay. The subsoil texture varies from clay to silty clay with clay content ranging between 40 to 46%. The surface structure is mostly coarse subangular blocky while it grades to medium angular blocky peds with shiny pressure faces in the subsoil. 1 to 3 cm wide cracks of polygon nature occur on the surface and they extend upto 60 cms depth. The ground water table ranges between 1.5 to 3 m of the surface.

Competing series and their differentials:

Associated Savad series which is very deep, very slowly permeable & poorly drained in the competing series.

Drainage and permeability:

Moderate to some what poorly drained with slow to very slow permeability.

Use and Vegetation:

These soils are used for rainfed paddy crop mainly. Neem, mango, Bhend, Sabar, form the natural vegetation.

Topography:

Nearly level to very gently sloping valleys  
( 0-3 % slopes)

Type location:

Bhivandi Wada Road right side, about 1/2 km.  
south of Arjunli village.

7.5 Savad Series (Svd):

Savad series includes very deep, some what poorly drained, cracking soils occurring on nearly level to very gently sloping (0 to 3 %) valleys. These have been formed on the clayey alluvium of basaltic origin. The surface soil is dark brown to dark yellowish brown clay of strong subangular blocky structure characterised by wide cracks extending through depth. The sub-soil is dark brown clay with prominent intersecting slickensides breaking into angular blocky peds with shiny pressure faces. Slickensides are prominent between 40 and 75 cm depth. The principal associated soils are those of Arjunli and Akloli series which are deep and very deep inceptisols respectively. Savad series comprises members of fine montmorillonitic isohyperthermic family of Typic chromusterts.

Typifying pedon: Savad clay-fallow after paddy  
(Colours are for dry soils unless otherwise noted)

- |              |   |
|--------------|---|
| Ap 0-15 cm   | Dark brown (7.5 YR 3/2 D & M) clay; strong coarse subangular blocky; dry very hard, moist very firm, wet very sticky and very plastic; 1 cm wide cracks; few fine roots; few very fine pores; slow permeability clear smooth boundary; mildly alk,aline (pH 7.6) (12 to 18 cm thick)  |
| A12 15-40 cm | Dark brown (7.5 3/2 M) clay; moderate medium angular blocky; moist very firm, wet very sticky and very plastic; 1.5 cm wide cracks; few very fine roots. Very few very fine pores; very slow permeability; clear and smooth boundary; moderately alkaline (pH 8.0) (23 to 30 cm thick)                                      |
| A12 40-78 cm | Dark brown (7.5 YR 3/2) clay; intersecting slickensides with axes tilted at about 45° from horizontal; moderate medium angular blocky peds with shiny pressure faces; moist very firm, wet very sticky and very plastic; 1.0 cm wide cracks present, very slow permeability, very few fine roots; very few very fine pores; |

gradual smooth boundary; neutral reaction (pH 7.3) (22 to 48 cm thick).

- A14 78-118 cm Dark brown (7.5 YR 3/2 M) clay; medium intersecting slickensides with axes tilted at about 45° from horizontal; moderate angular blocky peds with shiny pressure faces; moist very firm, wet very sticky and very plastic; 1.0 cm wide cracks; very few very fine roots; very few very fine pores; very slow permeability; gradual and smooth boundary; mildly alkaline (pH 7.4) (40-55 cm thick)
- A15 118-165 cm Dark brown (7.5 YR 3/2 M) clay; medium intersecting slicken sides; moderate angular blocky peds with shiny pressure faces; moist very firm; wet very sticky and very plastic; 0.5 cm wide cracks; very slow permeability; ~~very fine very few permeability~~; very fine very few pores; neutral reaction (pH 7.2).

#### Range in Characteristics:

The thickness of the solon is more than 1 M. Particles coarser than 2 mm range from 5 to 15 %. The surface texture is dominantly clay. The surface structure is medium to coarse subangular blocky. The surface colours are in the hue of 7.5 YR, 10 YR and in some times 5 YR with values 3, 4 and 5 and chromas 2, 3, and 4 for dry soils and chromas 2 and 3 for moist soils. The colours of the subsoils, are dominantly in the hue of 7.5 YR with value 8 and 4 chroma 2. They may range in the hue of 10 YR with values 3, 4 and 5 and chroma 3. Texture of the subsoil is dominantly clay and ranges to silty clay also. The sub-soil structure is dominantly moderate angular blocky with shiny pressure faces starting at the depth of about 20 cm. The surface is characterised by polygonal cracks of width ranging from 2 to 4 cms and the longer axes ranges between 30 to 50 cm. The ground water table ranges between 1.5 to 3 m from the surface.

#### Competing series and their differentials:

Associated Arjunli series which is vertic ustropept in the competing series. It is deep, comparatively better drained without any intersecting slicken sides. The cracks are limited to the depth of about 60 cms. Shiny pressure faces are limited upto a depth of 50 cms only.

#### Drainage and Permeability:

Some what poorly drained with very slow permeability.

Use and Vegetation:

These soils are generally used for rainfed paddy crops. Mango, Neem, Sabar, Shend and Chinch are the natural vegetations.

Topography:

Nearly level to very gently sloping valleys (0-3 % slope).

Type location:

Village Saved on the Anne Saved Road.

7.6 Akloli Series (Ak1)

Akloli series includes very deep, moderate to some what poorly drained, very slowly permeable, fine clayey cracking, non-calcareous soils that occur on nearly level to very gently sloping (0-3 %) flood plains of River Ulhas, & Tansa and their major tributaries. They have been formed from the fine alluvium of silty nature. The pedon exhibits A horizon of dark brown clay grading to dark brown clay B horizon slickensides are present below 30 cm depth and they are prominent below 70 cm depth. Few faint mottles of dark yellowish brown colour may be present below 75 cm depth. The principal associated soils are those of Saved, Arjunli and Kalhar series. Arjunli Kalhar and Saved soils are deep and very deep Inceptisols and Vertisols respectively. Akloli series comprises members of fine, montmorillonitic, isohyperthermic family of Vertic Ustropepts.

Typifying Pedon: Akloli silty clay-fallow after paddy (Colours are for dry soils unless otherwise noted)

- |                |  |
|----------------|--|
| Ap 0-15 cm     | Dark brown (10 YR 3/3) clay, dark brown (7.5 YR 3/2) when moist; strong coarse subangular blocky; dry hard, moist firm wet sticky and plastic; 1.0. cm wide cracks; common fine roots; few very fine impad and expad pores; moderate permeability; clear smooth boundary moderately alkaline (pH 8.1) (10 - 15 cm thick) |
| B21 15-42 cm   | Dark brown (7.5 YR 3/2 H) clay; moderate medium angular blocky; moist firm, wet sticky and plastic; 0.7 cm wide cracks; fine roots; few very fine pores; slow permeability; no effervescence; few calcinated gravels; clear smooth boundary; moderately alkaline (pH 8.0) (20 to 30 cms thick)                           |
| B22 42-75 cms. | Dark brown (7.5 YR 3/2 H) clay; moderate angular blocky p ds with shiny pr ssure faces and medium slickensides; moist firm, wet.   |

- Sticky and plastic; 0.8 cm wide cracks- few very fine roots; no effervescence; fine calcinated gravels; gradual and smooth boundary, slow permeability moderately alkaline (pH 8.1) (30-45 cm thick).
- B23 75-125 cm Dark brown (7.5 YR 3/2 M) clay; few faint mottles of dark yellowish brown (10 YR 4/4); colour; moderate angular blocky peds with shiny pressure faces and medium slickensides, moist firm, wet sticky and plastic; 0.6 cm wide cracks; very few very fine roots; very few very fine pores; soil non-calcareous; few calcinated gravels, impervious; clear and smooth boundary; neutral (pH 7.3) (42 to 50 cm thick).
- B2 125-156 cm Dark brown (10 YR 3/3 M) silty clay; few faint mottles of dark yellowish brown colour (10 YR 4/4); moderate angular blocky shiny peds with medium slickensides; moist firm, wet sticky and plastic; 0.6 cm wide cracks; very few very fine roots; very few very fine pores; no effervescence, few calcinated gravels; impervious moderately alkaline (pH 8.3) (30 cm and above.)

Range in characteristics:

The thickness of the solum is more than 1 m depth. The texture of the surface soil ranges from clay loam to silty clay. The structure ranges from moderate subangular blocky to strong subangular blocky where as the subsoil structure is moderate medium angular blocky. The subsoil texture ranges from clayey to silty clay. The colour of the surface soil is in the hue of 10 YR and 7.5 with YR with values 3 and chroma 3 and 2 for dry and moist soils. The subsoil colour is in the hue of 7.5 YR and 10 YR with values 3 and chromas 2 and 3 respectively, for moist soils. Cracks are present throughout the depth of the profile and they narrow down with the depth. Shiny pressure faces and slickensides start below 30 cm. Few faint mottlings with dark yellowish brown colour in the hue of 10 YR and value and chroma 4 are present below the depth of 70 cm. The ground water table ranges between 1.5 to 2.5 m of the surface.

Competing series and their differentiae:

Arjunli and Savad series are the competing series. Arjunli series is comparatively better drained slowly permeable deep vertic ustropept with cracks upto 50 cm depth where as Savad series is very deep slowly permeable vertisol.



Drainage and permeability:

Moderate to somewhat poorly drained with slow permeability.

Use and vegetation:

These soils are used mostly for rainfed paddy crop and also vegetables where well-irrigation facilities are available. Mango, Sabar, Bhedd, for the natural vegetations.

Topography:

Nearly level to very gently sloping flood plains (0-3%).

Type location:

Village Kone, on the bank of Ulhas river.

7.7 Kalhar Series (Klh)

Kalhar series includes moderately deep, moderately drained soils occurring on level to very gently sloping, back swamp areas of Ulhas river. The pedon exhibits brown to dark brown silty clay loam in A horizon grading to dark brown clay B horizon underlain by gravelly C horizon. The principal associated soils are those of Akloli series which includes very deep Inceptisol. Kalhar series comprises members of fine loamy, mixed isohyperthermic, moderately deep family of Paralithic Ustropente.

Typifying pedon: Kalhar silty clay loam-Fallow after paddy.

(Colours are for dry soils unless otherwise noted).

|    |           |  |
|----|-----------|--|
| Ap | 0-13 cm   | Dark brown (10 YR 4/3) silty clay loam, dark brown (10 YR 3/3) when moist moderate medium subangular blocky; dry hard, moist friable, wet tacky and slightly plastic; few fine roots; moderately slow permeability; clear smooth boundary; neutral (pH 7.2) (10 to 15 cm thick). |
| B2 | 13-25 cm  | Dark brown (10 YR 3/3 D & M) clay; weak medium subangular blocky breaking into granular, dry slightly hard, moist firm, wet tacky; moderate permeability, clear smooth boundary; mildly alkaline (pH 7.6) (10-15 cm thick).  |
| C  | 25-40 cms | +Layer of gravels, coarse fragments, quartz particles.   |

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ANALYTICAL DATA FILE-4A

| Sta. No.     | Well Series | Horizon | Depth in m | % gravel by wt. | Particle size distribution |         |      |       | Moist. Equiv. | Org. Carbon % | Total Nitrogen % | pH  | Intake rate ml/hr | Extractions Meq./100g |      |      |      | C.E.C |
|--------------|-------------|---------|------------|-----------------|----------------------------|---------|------|-------|---------------|---------------|------------------|-----|-------------------|-----------------------|------|------|------|-------|
|              |             |         |            |                 | Gravel                     | F. Sand | Silt | Clay  |               |               |                  |     |                   | Ca                    | Mg   | K    | Na   |       |
| 1. Pass-vill | A           | D-12    | N.D        | 30.0            | 19.5                       | 23.0    | 28.5 | 32.93 | 2.97          | 0.55          | 0.012-0.12       | 6.2 | 0.38              | 25.0                  | 25.0 | 2.08 | 0.20 | 54.08 |
| 2.           |             | 12-35*  | N.D        | 39.0            | 15.0                       | 21.8    | 38.2 | 30.49 | 3.95          | 0.08          | 0.02 - 0.06      | 7.0 | 0.08              | 27.0                  | 24.0 | 2.43 | 0.19 | 56.90 |
| 3. Kaned     | A           | D-15    | 3.7        | 20.0            | 25.6                       | 24.5    | 30.0 | 24.76 | 2.79          | 0.14          | 0.075            | 7.8 | 0.65              | 23.0                  | 17.0 | 2.95 | 0.11 | 46.08 |
| 4. Chured    | B2          | 15-41   | 7.0        | 14.0            | 23.0                       | 23.3    | 39.7 | 26.93 | 4.27          | -             | 0.031            | 7.8 | 0.25              | 28.0                  | 20.0 | 3.33 | 0.24 | 54.19 |
| 5. Grader    | C           | 47-65   | -          | -               | -                          | -       | -    | -     | -             | -             | -                | -   | -                 | -                     | -    | -    | -    | -     |
| 6. Uthab     | A           | D-11    | 9.5        | 20.4            | 32.0                       | 31.5    | 36.1 | 27.03 | 2.4-2.0       | 0.69          | 0.03-0.12        | 6.9 | 0.63-2.5          | 21.0                  | 17.0 | 3.36 | 0.61 | 45.42 |
| 7. "         | B1          | 11-28   | 5.0        | 20.0            | 13.9                       | 23.7    | 42.3 | 26.79 | 3.6-4.3       | 0.36          | -                | 7.6 | 0.23-0.75         | 28.0                  | 21.0 | 2.17 | 0.61 | 53.66 |
| 8. "         | B2          | 28-51   | 1.72       | 22.0            | 14.2                       | 23.17   | 39.7 | 20.38 | -             | 0.25          | -                | 7.7 | -                 | 39.0                  | 12.0 | 4.42 | 0.46 | 51.24 |
| 9. "         | C           | 51-65 + | -          | -               | -                          | -       | -    | 22.45 | -             | 0.13          | -                | 6.0 | -                 | 23.0                  | 17.0 | 2.95 | 0.11 | 46.08 |
| 10. Junia    | A           | D-8     | 1.01       | 9.0             | 24.8                       | 21.3    | 44.0 | 26.99 | 1.62          | 0.64          | 0.09-0.14        | 7.4 | 2.5               | 30.0                  | 17.0 | 2.52 | 0.20 | 52.07 |
| 11. "        | B1          | D-26    | 4.52       | 9.7             | 22.7                       | 22.6    | 45.0 | 27.22 | 3.68          | 0.39          | -                | 7.0 | 2.5               | 31.0                  | 19.0 | 3.02 | 0.30 | 54.91 |
| 12. "        | B21         | 26-44   | N.D        | 10.2            | 27.0                       | 26.8    | 46.0 | 27.01 | 4.08          | 0.45          | -                | 8.1 | 0.13              | 20.0                  | 19.0 | 3.30 | 0.20 | 53.40 |
| 13. "        | B22         | 38-90   | N.D        | 18.0            | 35.0                       | 14.5    | 38.5 | 30.25 | 2.93          | 0.63          | -                | 8.2 | 0.16              | 29.0                  | 20.0 | 2.52 | 0.23 | 54.40 |
| 14. "        | C           | 98-90   | N.D        | -               | -                          | -       | -    | -     | -             | 0.43          | -                | 8.3 | -                 | 29.0                  | 5.0  | 2.43 | 0.06 | 36.28 |
| 15. Javed    | Ap          | D-15    | N.D        | 8.0             | 22.8                       | 21.2    | 48.0 | 30.66 | 3.59          | 0.18          | 0.09-0.14        | 7.6 | -                 | 35.0                  | 19.0 | 4.26 | 0.24 | 59.08 |
| 16. "        | A12         | 15-40   | N.D        | 6.0             | 42.0                       | 16.2    | 40.0 | 30.92 | 5.72          | 0.15          | -                | 8.0 | -                 | 29.0                  | 16.0 | 6.52 | 0.19 | 62.40 |
| 17. "        | A13         | 40-78   | N.D        | 6.0             | 26.6                       | 19.0    | 48.5 | 31.35 | 8.84          | 0.10          | -                | 8.3 | -                 | 39.0                  | 19.0 | 1.78 | 1.23 | 62.63 |
| 18. "        | A14         | 78-115  | N.D        | 2.5             | 20.7                       | 23.0    | 53.8 | 32.06 | 9.93          | 0.07          | -                | 7.4 | -                 | 37.0                  | 20.0 | 1.91 | 0.32 | 60.84 |
| 19. "        | A15         | 118-165 | N.D        | 2.9             | 21.9                       | 21.2    | 54.5 | N.D   | 11.32         | 0.17          | -                | 7.2 | -                 | 31.0                  | 23.0 | 2.21 | 0.17 | 57.8  |
| 20. Moloi    | Ap          | D-15    | 2.9        | 15.7            | 16.3                       | 27.8    | 41.2 | 27.99 | 3.16          | 0.46          | 0.07-0.09        | 8.1 | 2.25              | 28.0                  | 18.0 | 3.13 | 0.25 | 52.76 |
| 21. "        | B21         | 15-42   | N.D        | 2.0             | 24.0                       | 27.6    | 45.0 | 28.72 | 5.83          | 0.31          | -                | 8.0 | 0.25              | 34.0                  | 23.0 | 3.47 | 0.12 | 61.56 |
| 22. "        | B22         | 42-75   | N.D        | 5.1             | 24.4                       | 25.0    | 42.5 | 31.66 | 7.88          | 0.27          | -                | 8.1 | N.D               | 30.0                  | 21.0 | 2.0  | 0.21 | 56.56 |
| 23. "        | D23         | 75-125  | 2.1        | 16.0            | 0.2                        | 30.0    | 49.5 | 35.76 | 13.47         | 0.23          | -                | 7.3 | N.D               | 31.0                  | 20.0 | 2.73 | 0.28 | 64.39 |
| 24. "        | B3          | 125-156 | N.D        | 4.5             | 30.0                       | 22.5    | 43.0 | 35.92 | -             | 0.39          | -                | 8.3 | -                 | 31.0                  | 23.0 | 3.82 | 0.26 | 60.98 |
| 25. Walher   | A           | D-13    | 11.6       | 21.0            | 15.4                       | 43.3    | 30.3 | 24.69 | 2.41          | 0.34          | 0.09             | 7.2 | 0.66              | 12.0                  | 0.0  | 4.86 | 0.41 | 27.45 |
| 26. "        | B           | 13-25   | N.D.       | 16.0            | 14.3                       | 24.7    | 45.0 | 23.27 | 2.10          | 0.31          | 0.07             | 7.6 | -                 | 20.0                  | 0.0  | 4.36 | 0.12 | 34.61 |
| 27. "        | C           | 25-40   | -          | -               | -                          | -       | -    | -     | -             | -             | -                | -   | -                 | -                     | -    | -    | -    | -     |

**ANALYTICAL DATA - TABLE 14B**  
**ANALYSIS OF SOIL WATER EXTRACT OF THE SOIL OF BULVANDI AREA**

| Sl. No. | Soil Series  | Horizon | Depth in cm | Ec mehos/cm (1:2) | I R O N S        |                  |                 |                | M E c/100 g |      |                 |
|---------|--------------|---------|-------------|-------------------|------------------|------------------|-----------------|----------------|-------------|------|-----------------|
|         |              |         |             |                   | Ca <sup>++</sup> | Mg <sup>++</sup> | Na <sup>+</sup> | K <sup>+</sup> | NEO3        | Cl   | SO <sub>4</sub> |
| 1.      | Parivili     | A       | 0-12        | 0.180             | 0.20             | 0.11             | 0.07            | 0.007          | 0.20        | 0.10 | 0.09            |
| 2.      |              |         | 12-38+      | 0.080             | 0.12             | 0.06             | 0.01            | 0.001          | 0.10        | 0.06 | 0.04            |
| 3.      | Khawad Khurd | A       | 0-15        | 0.125             | 0.18             | 0.12             | 0.08            | 0.003          | 0.18        | 0.07 | 0.12            |
| 4.      | "            | B2      | 15-41       | 0.149             | 0.10             | 0.10             | 0.00            | 0.004          | 0.14        | 0.10 | 0.19            |
| 5.      | "            | C       | 41-65       | -                 | -                | -                | -               | -              | -           | -    | -               |
| 6.      | Dobhad       | A       | 0-11        | 0.230             | 0.32             | 0.23             | 0.07            | 0.032          | 0.40        | 0.11 | 0.10            |
| 7.      | "            | B1      | 11-25       | 0.190             | 0.17             | 0.15             | 0.09            | 0.009          | 0.27        | 0.09 | 0.07            |
| 8.      | "            | B3      | 25-51       | 0.110             | 0.13             | 0.10             | 0.06            | 0.002          | 0.16        | 0.03 | 0.03            |
| 9.      | "            | C       | 51-85 +     | 0.090             | 0.12             | 0.07             | 0.04            | 0.003          | 0.12        | 0.03 | 0.04            |
| 10.     | Arjunli      | A       | 0-8         | 0.120             | 0.14             | 0.10             | 0.04            | 0.007          | 0.18        | 0.07 | 0.07            |
| 11.     | "            | B1      | 8-26        | 0.185             | 0.20             | 0.14             | 0.05            | 0.005          | 0.25        | 0.08 | 0.01            |
| 12.     | "            | B2      | 26-44       | 0.120             | 0.14             | 0.10             | 0.07            | 0.003          | 0.22        | 0.06 | 0.06            |
| 13.     | "            | B22     | 44-56       | 0.140             | 0.18             | 0.13             | 0.03            | 0.002          | 0.22        | 0.06 | 0.07            |
| 14.     | "            | C       | 56-90       | 0.120             | 0.14             | 0.10             | 0.09            | 0.002          | 0.16        | 0.13 | 0.06            |
| 15.     | Savad        | Ap      | 0-15        | 0.280             | 0.37             | 0.22             | 0.08            | 0.006          | 0.42        | 0.16 | 0.09            |
| 16.     | "            | A12     | 15-40       | 0.210             | 0.25             | 0.18             | 0.05            | 0.004          | 0.27        | 0.12 | 0.08            |
| 17.     | "            | A13     | 40-78       | 0.300             | 0.54             | 0.38             | 0.12            | 0.003          | 0.26        | 0.20 | 0.16            |
| 18.     | "            | A14     | 78-118      | 0.850             | 0.96             | 0.77             | 0.18            | 0.05           | 1.52        | 0.21 | 0.20            |
| 19.     | "            | A15     | 118-165     | 0.875             | 0.99             | 0.79             | 0.18            | 0.05           | 1.60        | 0.20 | 0.26            |
| 20.     | Akholi       | Ap      | 0-15        | 0.500             | 0.56             | 0.49             | 0.12            | 0.01           | 0.86        | 0.16 | 0.13            |
| 21.     | "            | B21     | 15-42       | 0.550             | 0.59             | 0.48             | 0.14            | 0.02           | 0.87        | 0.19 | 0.15            |
| 22.     | "            | B22     | 42-75       | 0.500             | 0.55             | 0.48             | 0.14            | 0.20           | 0.87        | 0.15 | 0.19            |
| 23.     | "            | B23     | 75-125      | 0.550             | 0.59             | 0.48             | 0.15            | 0.10           | 0.88        | 0.19 | 0.16            |
| 24.     | "            | B2      | 125-166     | 0.315             | 0.47             | 0.35             | 0.09            | 0.006          | 0.85        | 0.10 | 0.17            |
| 25.     | Kalhor       | A       | 0-13        | 0.520             | 0.53             | 0.44             | 0.13            | 0.01           | 0.82        | 0.15 | 0.12            |
| 26.     | "            | B       | 13-25       | 0.270             | 0.36             | 0.30             | 0.08            | 0.08           | 0.56        | 0.12 | 0.09            |
| 27.     | "            | C       | 25-40       | -                 | -                | -                | -               | -              | -           | -    | -               |

Drainage and permeability:

Moderately drained with moderately slow permeability.

Use and vegetation:

Generally used for paddy. Shad, Katarwar, Sabar form the natural vegetation.

Topography:

Nearly level to very gently sloping back swamp areas of River Ulhas.

Type location:

Village-Kalhar on the Shivandi Thana Road, left side.

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Contribution in the Project

|                                       |  |
|---------------------------------------|--|
| Project Leader                        | Shri J.C. Bhattacharjee  |
| Field Leader                          | Shri K.P.C. Rana   |
| Party Leader.                         | Shri G.S. Vaidya<br>Shri G.S. Yodam<br>Shri R.G. Lanjewar.                               |
| Field intake and<br>laboratory leader | Dr.A.R.Kalbade<br>Sh. N.Y. Parhad<br>Shri S.G. Shende<br>Shri S.L. Durga<br>Shri M.Ahmad |
| Cartography<br>leader.                | Shri J.M. Sahrawat<br>Shri K.B. Mandhakar  |

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