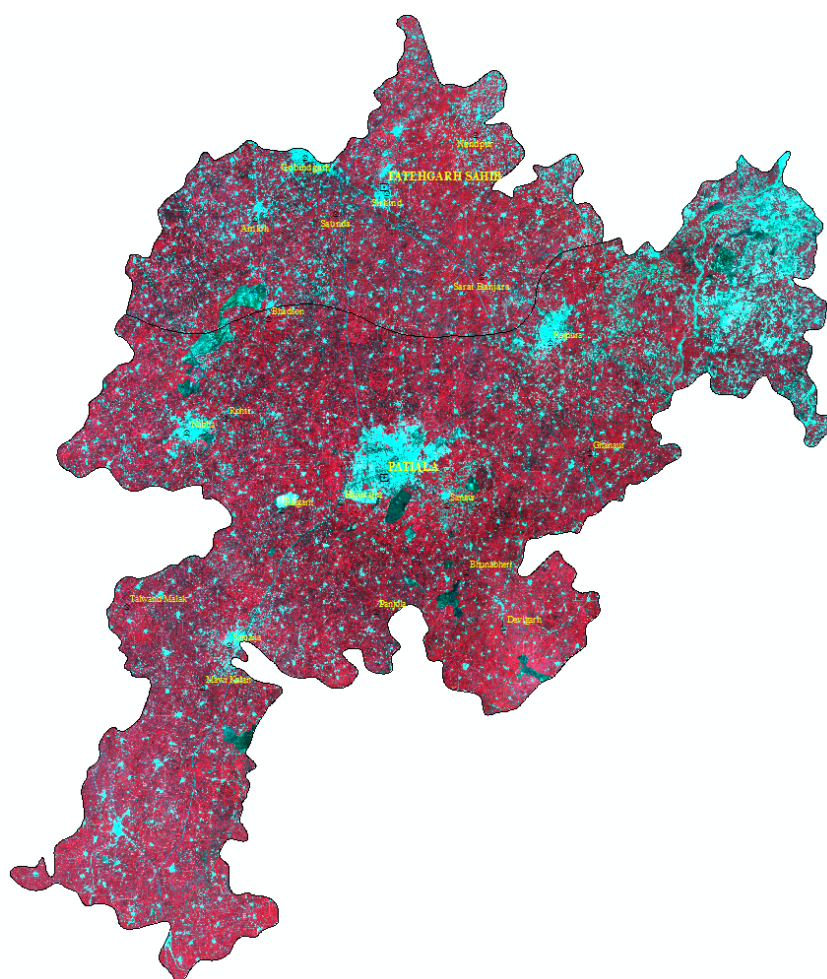


SOIL SURVEY AND LAND USE PLAN OF PATIALA DISTRICT, PUNJAB (Bifurcated into Patiala & Fatehgarh Sahib Districts)



Regional Centre, Delhi

National Bureau of Soil Survey & Land Use Planning
(Indian Council of Agricultural Research)

Nagpur - 440 033, Maharashtra, India



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Meta Data for Soil Reports of Patiala & Fatehgarh Sahib District, Panjab

S.No.	Elements	Scheme	Value
1.	Identification Information	Name of the Dataset	Soil Resource Based Land Use of Patiala & Fatehgarh Sahib District (Panjab)
		Contents	Soil Survey Reports, Maps and Imagery
		Keywords	Soil Survey Report
		Report/Map Language	English
		Map Scale	1:63,360
		Survey Year	1972 - 1974
		Imprint Year	-
		Edit Year	-
		Value-addition Year	2013
		Purpose of Value-addition	To Create Interactive Maps and Reports and Disseminate to the End-User Agencies.
		Access Constraints	Permission Required
2.	Contact Information	Generating Agency	NBSS & LUP, Nagpur
		Contact Person	Director, NBSS & LUP, Nagpur
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		Contact Email	director@nbsslup.ernet.in
3.	Spatial Domain	Bound Left	75d55'41.3750"E
		Bound Right	76d55'19.2788"E
		Bound Top	30d40'19.5629"N
		Bound Bottom	29d46'47.8197"N
		Area/Coverage	4634 Sq. Km
		Projection	UTM
		Datum	WGS 1984
		Unit	Meter
		Administrative Location	State: Punjab, District: Patiala & Fatehgarh Sahib
4.	Citation	Data Prepared By	NBSS & LUP, Delhi (Regional Centre)
		Associated Project	H.S. Shankaranarayana
		Associated Value- additions	-
		Associated Publications	-
		Coordinator Value- added Publication	-
5.	Storage	Data Format	PDF/GeoPDF
		Data File Size	48.3 MB
		Data Physical Location	\\GIST6\D:\GeoPDF Mapping Project _2013\Patiala
		Download Location	-
6.	Quicklook	Graphic file in jpg format	Y
7.	Image Data	Name of the Satellite	Landsat
		Sensor	ETM+
		Date of Image	18 March 2002 and 28 October 2002
		File Format	TIFF
		Spatial Resolution	30 m
		Image Downloaded From	http://earthexplorer.usgs.gov/
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1.

INTRODUCTION

Reconnaissance soil survey of Patiala district was conducted by the Regional Centre, Delhi of the national Bureau of Soil Survey and Land Use Planning (ICAR) with the following objectives:

- to prepare reconnaissance soil map on a scale of 1 : 63,360, characterize the soils and delineate their location and extent, evaluate their problems and potentials
- to correlate and establish the various soil series and classify them according to Soil Taxonomy
- to develop interpretations based on present land use, inherent soil properties, soil management interactions, soil and water management needs and prepare interpretive maps on soil and land resources of the district with suitable legend and obtaining experimental results from Research Stations and
- to compile small scale maps based on progressive abstraction and synthesis of significant mapping units for use by planners and Scientists at National and International levels by correlating the soils with recognised systems of soil and land suitability classification.

Soil survey was carried out by two operational units during the period November, 1972 to April, 1974. However, progressive field reviews, correlation and map checking was continued in later years up to 1976.

2.

GENERAL DESCRIPTION OF THE AREA**2.1 Location and Extent**

Patiala district is situated in Punjab between 29°50' to 30°48' N Latitudes and 75°50' to 76°57' E Longitudes. It is surrounded by districts Ambala (Haryana) in the east, Ludhiana and Sangrur (Punjab) in the west, Ropar (Punjab) in the north and Kurukshetra (Haryana) in the south. The total area of the district is 4,63,426 ha. distributed over five tehsils, Patiala, Sirhind, Rajpura, Nabha and Samana. Since, Patiala district was bifurcated into Patiala and Fatehgarh Sahib districts, the location of maps of the districts are shown in figure 1 and 1a.

2.2 Population

Total population of the district is 1238500. Tehsil wise population is presented in table No. 1. It shows an approximate male to female ratio of 54 to 46 Scheduled Castes and Scheduled Tribes constitute nearly 20.5% of the total population of the district.

Table 1: Tehsil wise population op District Patiala (Punjab)

Tehsil	Population			Scheduled Caste/Tribes population		
	Total	Male	Female	Total	Male	Female
Patiala	3,51,763	1,90,472	1,61,291	53,952	29,206	24,746
Sirhind	1,84,979	1,00,223	84,756	47,309	25,682	21,627
Nabha	2,17,997	1,18,972	99,025	54,745	29,683	25,062
Rajpura	3,00,251	1,61,860	1,38,391	59,404	32,202	27,202
Samana	1,60,110	86,356	73,754	38,538	20,778	17,760
	12,38,500	6,57,883	5,57,217	2,53,948	1,37,551	1,16,397

(Source: Patiala Statistical Hand Book 1974-75)

2.3 Physiography Relief and Drainage

Patiala District consists of six physiographical divisions namely (i) undulating old alluvial plains with scattered low dunes nearly level old flood plains on alluvial terraces (iii) old flood plains on concave relief in the west (iv) flood plains of Patialawali nadi and choa in the central part (v) nearly level flood plain of Ghaggar the east and (vi) dissected uplifted plain in the north.

The general slope of the district is from north east to south west. The highest altitude is 280 m above MSL in Rajpura in the north east and the lowest, 237 m in Samana in the North West. Major variation in relief is depicted by physiographic separation but still micro-relief variations within the above defined physiographic zones is natural. At a micro-level, geographic boundaries of each of the villages can be sub-divided into different physiographic units.

There are several choes in the northern part of the district along the Siwaliks especially in Rajpura and Sirhind Tehsils, but Patialawali nadi, choa nadi and chandigarh drain are important all draining to the river Chaggar. During rainy season, Patialawali nadi and the Ghaggar river overflow and flood the surrounding plains. The lowlying concave relief plains also get flooded during rains.

LOCATION MAP

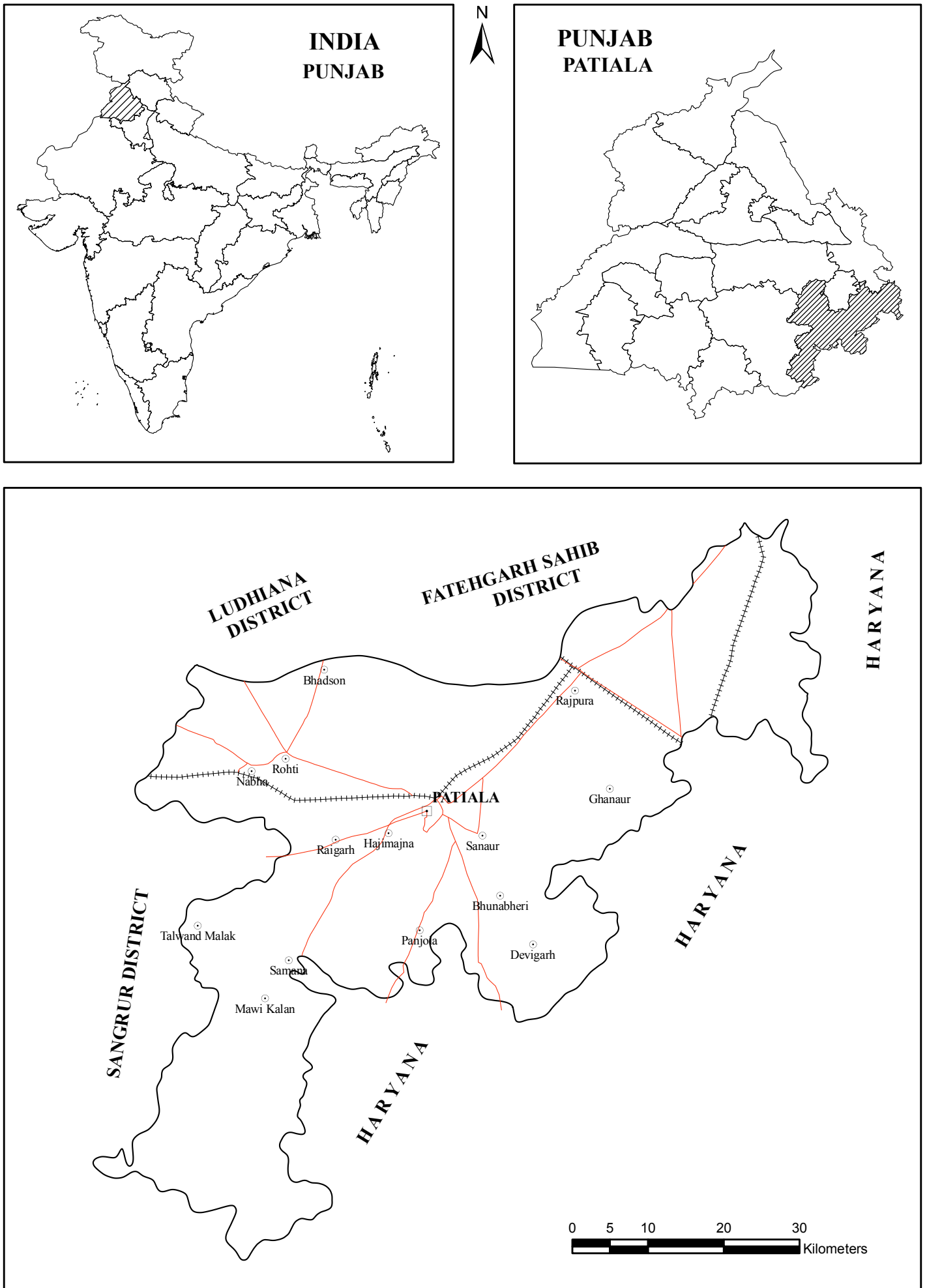


Fig. 1: Location Map (Patiala)

LOCATION MAP

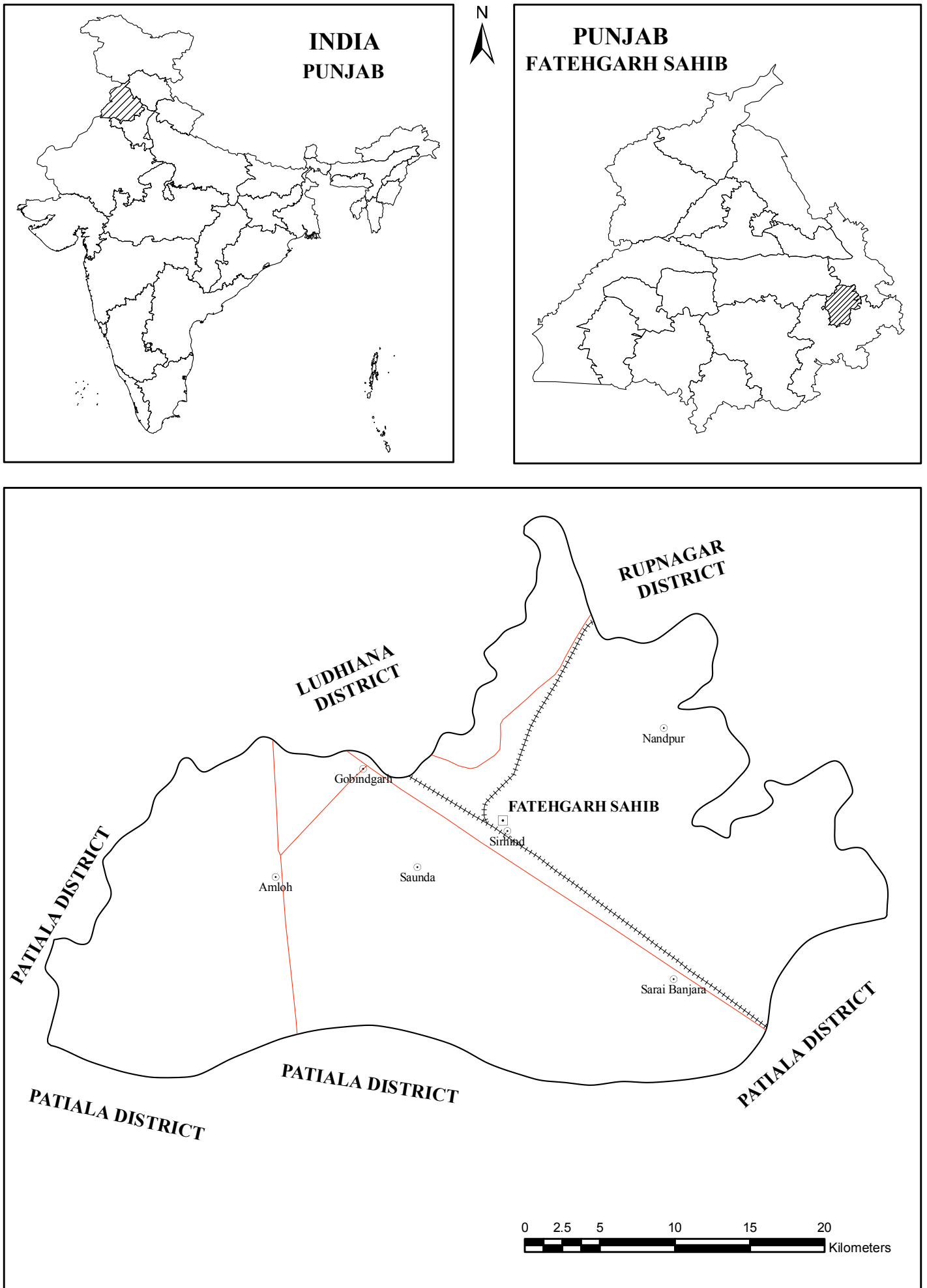


Fig. 1a: Location Map (Fatehgarh Sahib)

2.4 Climate

The climate of the area is semi-arid. Both summer and winter are severe. Dust storms are common in May and June when the day temperature exceeds 40°C. Mean annual rainfall is 700 mm based on rainfall records from 1931 to 1960. July and August are wet months.

Evaporation exceeds rainfall during the period October - April which is the period for growing *rabi* crops. Still wheat, barley and gram are grown as dry land crops to some extent.

Rainfed *kharif* crops are taken from July-August where surplus moisture is stored in the soil, climatological data are given in table 10 in chapter 6 dealing with Soil Genesis and classification.

2.5 Geology

The district largely comprises synclines or depressions formed between the Peninsular India and the Siwalik hills during the upliftment of the Himalayas. The thickness of alluvium is however not known but estimated to vary from 1,000 to 2,000 m. The recent alluvium dating from the Pleistocene is estimated to be nearly 400 m. deep.

The transport of alluvial sediments has mainly taken place through the river Systems that originate from the Himalayas. The river courses have changed considerably during the process of deposition. Even in recent times, there have been significant changes in stream channels. The large load carried by these rivers has often choked the channels thus bringing them to the level of the plains. After this the streams have formed new courses. The present inland deltas and the buried channels that are seen in the aerial photographs indicate such changes.

Most of the alluvial sediments have originated from the sedimentary beds of the Siwaliks that are of Tertiary origin. The sediments themselves consist of clay, silt and sand with boulders and coarse sand. The sediments belong to different periods.

2.6 Natural vegetation

The natural vegetation consists of trees, shrubs and herbs, common among the trees are *Dalbergia sissoo* (Shisham), *Morus alba* (Mulberry), *Azadirachta indica* (Neem), *Melia azadirachta* (Dek), *Accacia arabica* (Babool), *Picus religiose* (Peepal), *Zizyphus juluba* (Ber) and *Butea monosperma* (Dhak)

The shrubs and herbs include *canabis sativa* (Bhang), *Achyranthus aspera* (Chirdhita), *Aroimone mexicana* (Satyanashl), *Pluchea lanceolata* (Baisuri) and *Zizyphus nummalaria* (Jharberi).

Grasses and weeds are generally *Avena-tatual* (Wild Oat), *Saccharum spontaneum* (Kans), *Erianthus revanai* (Moonj), *Cynodon dactylon* (Dub), *Anaolis arvensis* (Krishan Neel), *Asynodelus unifolius* (Pyagi), *Cyperus rotundus* (Deela), *Chenopodium album* (Bathu).

2.7 Present Land Use

The total geographical area of the district is 4,63,426 ha. Nearly eighty four percent of the area is under cultivation. About ten percent (46,965 ha.) of the area in the district is affected by salinity. Three percent (14,013 ha.) of the area are lying as waste lands. Data on land use are given in Tables 2, 3, 4 and 5.

From the tables it is seen that cultivated area varies from Tehsil to Tehsil ranging between 80 and 85 percent Area under *kharif* cultivation on an average is 72.2 percent, but 61.0 percent in Sirhind and 81.5 percent in Nabha Tehsil. Area under *rabi* cultivation is as high as 90.4 percent in Patiala and 78.3 percent in Rajpura. Irrigated area in *kharif* season in the district accounts for 65.4 percent. It varies from 30.5 percent in Rajpura tehsil to percent in Sirhind tehsil. Nearly 81.2 percent of the area of the district receives irrigation for *rabi* cultivation and it varies from percent in Rajpura to 98.7 percent in Nabha. Tube wells form major source of irrigation and hence proper

Water use management on individual farms is an essential requirement.

Table 4 showing the distribution of *kharif* crops reveals that paddy, maize, groundnut and fodder crops account for 75.5 percent of the *Kharif* cropped area of which paddy alone occupies about 37.4%. Table 5 showing the distribution of *Rabi* crops reveals that wheat alone accounts for 67.4 percent of the *Rabi* area. Other important *rabi* crops are Barley, Berseem and gram. Oil seeds are grown in small areas. The variety of crops grown indicates the possibility of planning crop distribution according to soil units.

Table 2 Land Use (1974 -75)

S.No.	Land use	Tehsils					Total
		Patiala	Rajpura	Sirhind	Nabha	Samana	
(Area in ha.)							
1.	Area under cultivation	90313	97329	60061	72686	68700	389089
2.	Total area sown:						
	<i>Kharif</i>	65625	64539	42848	59266	48929	281207
	Percent	72.6	66.2	61.0	81.5	71.2	72.2
	<i>Rabi</i>	81644	76237	49650	59594	61498	328623
	Percent	90.4	73.3	82.6	81.9	89.5	84.4
3	Total area under irrigation	64459	49109	53749	56156	53517	276990
4	Total unirrigated area	22839	46927	7527	16879	15192	109364
5	Total irrigated area						
	<i>Kharif</i>	48530	19703	34876	43403	37513	184025
	Percent	73.9	30.5	81.3	73.2	76.6	65.4
	<i>Rabi</i>	71446	39076	45774	58878	51972	267146
	Percent	87.5	51.2	92.1	98.7	84.5	81.2
6	Source of irrigation:						
	Wells	2471	4281	411	749	5845	13757
	Tubewell	47473	36935	45027	32173	34643	206251
	Canals	14515	7093	8311	13234	13029	56982

(Source - D.O.'s Office, Patiala)

Table 3 Land Use

S.No.	Land use	Tehsils					Total
		Patiala	Rajpura	Sirhind	Nabha	Samana	
	(Area in ha.)						
1.	Total area according to D.C. records	111237	114430	70146	86284	81329	463426
2.	Total area under cultivation	90313	97329	10061	72686	68700	389089
3.	Waste land unfit for cultivation	840	1186	203	2222	2472	6923
4.	Culturable waste	3531	1629	159	-	1771	7090
5.	Area under pastures	87	2194	-	-	-	2231
6.	Fallow land	1507	2255	462	-	-	4304
7.	Kallar land Choa nala	13667	10493	8823	6952	7030	46965
8.	Area under forest	2749	1490	800	4375	1347	10769
9.	Area under orchard sf.	50	101	100	49	9	309
10.	Area sown more	58821	42404	27835	46443	35374	210877

(Source - D.O.'s Office, Patiala)

Table 4: Tehsil wise distribution of *kharif* crops (1974-75)

Crops	Tehsils					Total
	Patiala	Rajpura	Sirhind	Nabha	Samana	
	(Area in ha.)					
Paddy	35318	20697	16634	13780	17781	105210 (37.4)
Maize	7453	14655	9257	10515	5809	48189 (17.1)
Jowar	142	144	5	5803	163	6257 (2.2)
Bajra	393	82	65	148	3148	3836 (1.3)
Cotton	2544	1159	2192	7932	6022	19849 (7.0)
Sugarcane	2019	2975	4204	2971	1271	13440 (4.7)
Groundnut	5927	3782	1885	14185	4509	30288 (10.7)
Toria	5	X	467	18	1040	1530 (0.5)
Til	46	226	575	35	7	889 (0.3)
Guar	1116	298	518	433	536	2632 (0.9)
Mash	324	1176	557	242	7	2306 (0.8)
Moong	37	24	19	206	31	317 (0.1)
Ghari	9412	8172	4823	5803	4592	32801 (11.6)
Chari+Bajra+ Maize	164	6146	326	-	2408	9044 (3.2)
Chari+Guar					1730	1730 (0.6)
Chillies	417	4225	170	159	643	5564 (1.9)
	65125	64539	42848	59266	48929	281207

(Source - D.C.'s Office, Patiala)

Table 5 Tehsilwise distribution of *rabi* crops (1974-75)

Crops	Tehsils					Total
	Patiala	Rajpura	Sirhind	Nabha	Samana	
	(Area in ha.)					
Wheat	57521	39284	38662	45557	40227	221551 (67.4)
Barley	5842	4739	3051	6139	907	20678 (6.2)
Wheat+Barley	3002	8891	1553	1395	5900	20041 (6.3)
Wheat+Gram						
Barley+Gram						
Gram	2955	5857	1311	1032	57.19	16874 (5.1)
Masoor	934	3004	355	8	361	4662 (1.4)
Toria	1338	2013	-	-	-	3351 (1.0)
Oil Seeds (Mustard-Linseed)	373	567	234	654	453	2281 (0.7)
Berseem	6542	3634	2884	4110	4478	21648 (6.5)
Metha (chara)	585	474	321	53	1043	2476 (0.7)
Potato	490	1074	144	104	32	1844 (0.6)
	21644	76237	49650	59594	61498	328623

(Source - D.C.'s Office, Patiala)

3.

SOILS

3.1 Soil Survey Techniques

Soil mapping was done using 1:63,360 and 1:50,000 Survey of India toposheets. Other maps used were road maps and maps prepared by the Irrigation Department. Aerial photographs of 1:25,000 scale were used at the time of final field reviews.

Physiographic units were delineated using relief, drainage pattern, vegetation and other features identified in topographical maps.

Soil mapping was done tehsil-wise. After preliminary investigation, soils were examined in different physiographic units by auger holes. Major differentiating characteristics for identification of soils were texture and occurrence of CaCO_3 with the progress of field investigation, soil colour, mottling below and/or within 50 cm. depth and nodular lime concretions were included as differentiating characteristics for separating soil series.

Unit of mapping was soil series association. Observations were made generally at 1 km. distance to facilitate extrapolation of boundaries. Surface texture, slope, salinity, drainage and erosion phases within the series were identified that are needed for interpretation and preparing mapping legend for detailed soil surveys.

The series association may consist of more than two series in quite a few delineations due to variability so common in alluvial plains. In certain parts of Ghaggar flood plains more than three series occur within a delineation as the plains are highly stratified and variable in texture within short distances.

Each of the named association in the map may include some series of other associations up to about 15-20% of the delineated area, That is the reason why detailed mapping is recommended for areas where reclamation is to be done, research experiments are to be conducted and extension operations in agriculture are to be taken up on the basis of soil differences based on soil Characteristics management research studies.

Identification legend was prepared and progressively modified during mapping and field reviews using the most striking differentiating characteristics for separating soil series. Identification legend not only served as a guide to the soil surveyor for identifying and mapping soil boundaries as well as the basis for the preparation of soil legend for the report and final soil-map.

With the progress of survey, descriptive legend was prepared. It contained short descriptions of the mapping units as associations along with series differentiae followed by detailed descriptive legend consisting of soil series description. Detailed description of the soil series are given in Appendix.

Soil associations are indicated in arable numerals in the soil map. The index to the map contains physiographic units, corresponding soil series associations and salient characteristics of the soil series. The district map accompanying the report in the scale of 1:250000 is a generalized abstraction from the original 1:63,000 base.

Soils were sampled from all the identified aerie after examining the pedons to 150 cm. Besides micromonolith of representative soil series were collected. During the survey land use and socioeconomic data were collected which will be useful for land use interpretation and recommendations.

The extent of occurrence of different soil series associations was calculated and reported.

3.2 General Description of Soil Legend

Soils have been mapped as associations of soil series. The associations are of two or more soil series occurring in the same general area. Soil Series other than the named series in an association in any defined physiographic unit is common. Descriptions of the soil series associations with reference to landforms are presented below (Fig 2 and 2a). Soil legend is given in table 8.

3.2.1 Bhanra-Fatehpur Association

The general topography of this association consists of small ridges and sand dunes that have a slope range of 3 to 10 percent. Bhanra soils are sandy and occur on ridges or dune tops or upper slopes. Fatehpur soils have loamy fine sand texture and show same structural development within 60 cm. from surface. They occur on dune slopes. The soils of this association are characterized by sandy texture, low available water capacity and undulating topography. They are droughty with an estimated available moisture capacity of 2.3 to 2.6 cm. for 60 cm. and 4 to 5 cm for 100 cm profile depth.

3.2.2. Fatehpur-Samana Association

This association occurs on 1 to 5 per cent slopes. Samana soils occur on lower slopes. They are characterized by loamy fine sand to sandy loam textures. The estimated available moisture capacity of the soils ranges from 2.3 to 4.8 cm. for 60 cm and 4.0 to 8.4 cm for 100 cm. profile depth.

3.2.3 Kakra-Samana Association

This association occurs on interdunal plains with slopes varying from 0 to 5 percent. Dominant inclusion is of Fatehpur series which occurs on scattered low dunes of 1 to 2 m. height. The soils of this association are characterized by sandy loam to sandy clay loam textures with the inclusion of loamy fine sand texture. The estimated moisture capacity ranges from 4.7 to 4.8 cm for 60 cm and 8.4 to 8.7 cm for 100 cm profile depth.

3.2.4 Samana-Tulewal Association

This occurs on interdunal plains with slopes varying from 0 to 5 percent. Dominant inclusion is of Fatehpur series which occurs on scattered low dunes of 3-6 feet height. The soils of this association are characterized by sandy loam to sandy clay loam textures with the inclusion of loamy fine sand texture. The available moisture capacity ranges 4.8 to 5.2 cm for 60 cm and 8.4 to 9 cm for 100 cm profile depth.

3.2.5 Tulewal-Nabha-Kakra Association

This association occurs on nearly level to undulating interdunal plains with slopes varying from 0 to 3 percent. The soils of this association are characterized by dominantly sandy clay loam to clay loam (fine loamy) textures with small percentage of coarse loamy Kakra soils, the estimated available moisture capacity ranges from 4.7 to 5.2 cm for 60 cm and 8.7 to 17.9 cm for 100 cm soil depth.

3.2.6 Nabha-Tulewal Association

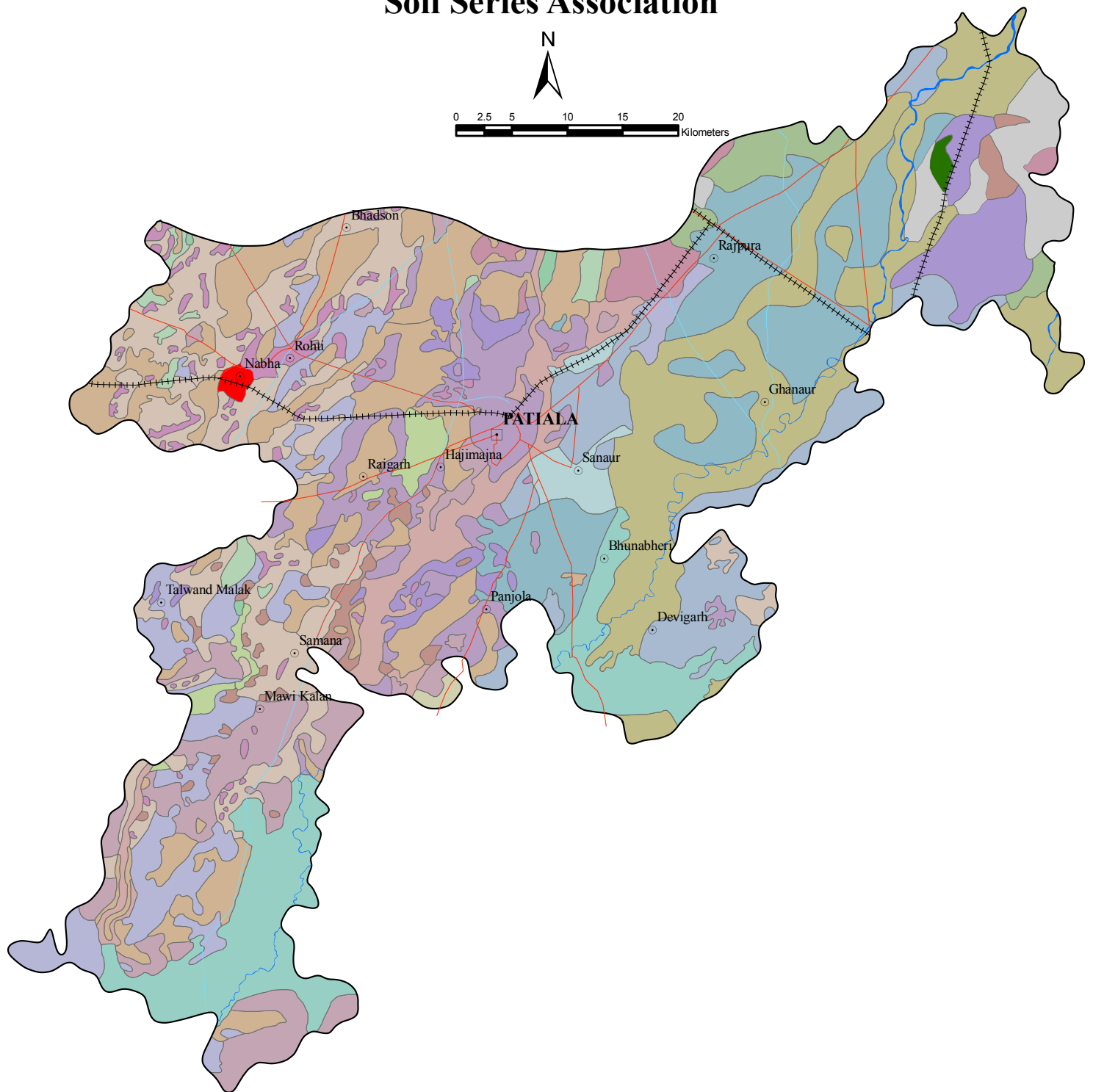
This association occurs on alluvial terraces of old flood plains with slopes varying from 0 to 3 per cent. The soils are characterized by sandy clay loam to clay loam textures. The water holding capacity is medium. The estimated available moisture capacity ranges from 5.2 to 9.2 cm for 60 cm and 9.0 to 17.9 cm for 100 cm profile depth.

3.2.7 Hissar-Nabha Association

This association occurs on alluvial terraces of old flood plains with slopes varying from 0 to 2 per cent. Soils are recognized by loam to clay loam textures. The estimated available moisture capacity ranges from 9.2 to 10.8 cm for 60 cm and 17.9 to 19.0 cm for 100 cm profile depth.

PATIALA

Soil Series Association



Legend

Bahadurgarh-Ghanaur-Patiala	Sadhu-Patiala-Jalalpur
Bhanra-Fatehpur	Samana-Tulewal
Daun-Julkan-Kapuri-Bahadurgarh-Sanaur	Sanaur-Banru
Fatehpur-Samana	Suniarheri-Rajendra
Hissar-Nabha	Todarpur-Chataihra
Kakra-Samana	Tohana-Nabha
Nabha-Tohana-Hissar	Tulewal-Nabha-Kakra
Nabha-Tulewal	Urdan-Bahadurgarh-Jalalpur
Nabha-Tulewal-Hissar	Urdan-Manakpur
Patiala-Rohar	Undifferentiated soils
Ranbirpura-Bazidpur	Forest
	Habitation

References

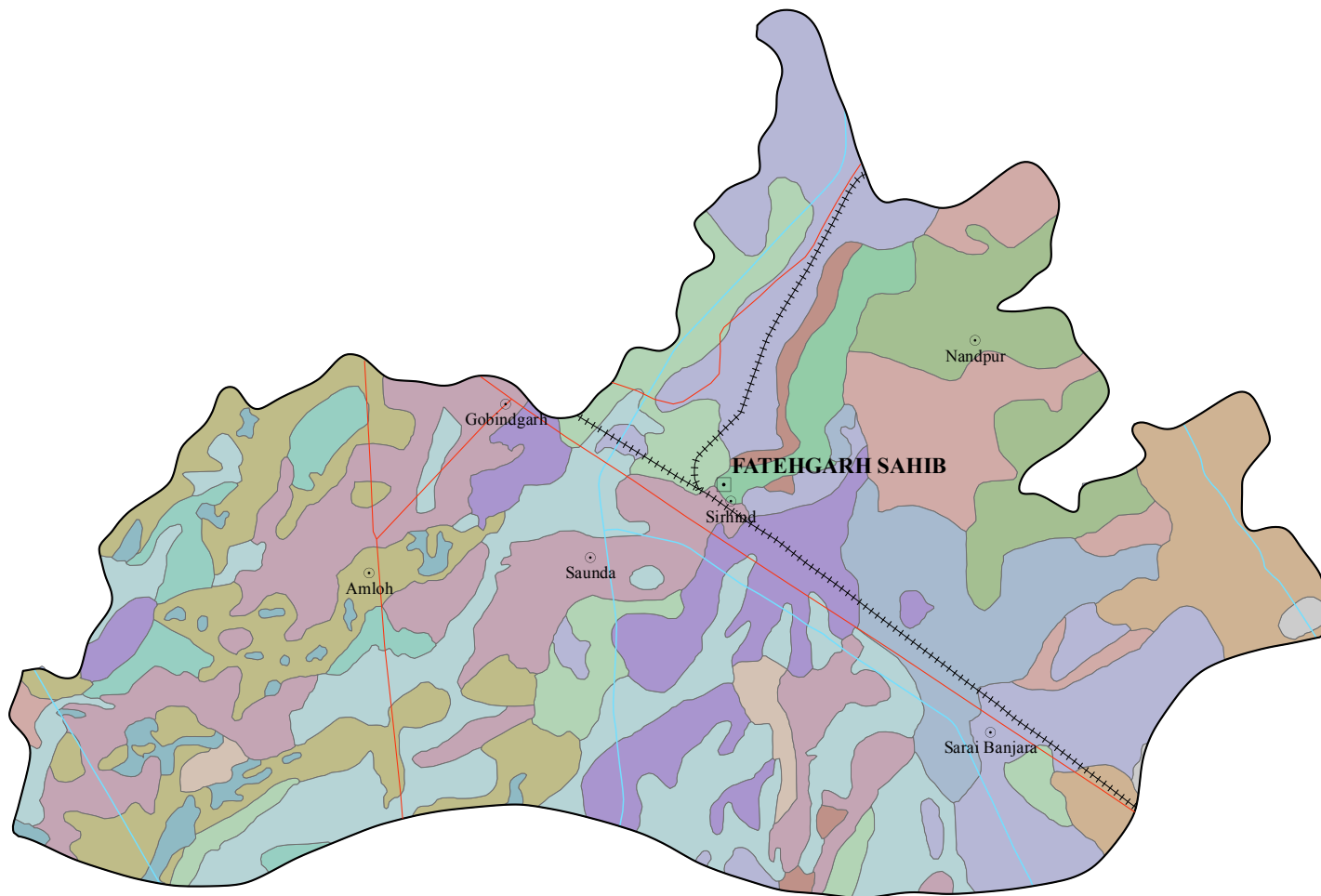
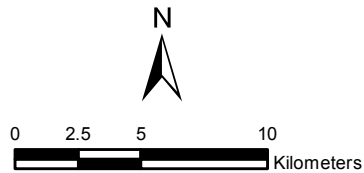
□	District HQ
○	Tehsil HQ
□	District Boundary
—	Road
+++++	Railway
—	Drainage
—	Canal
—	River



Fig. 2: Soil Series Association (Patiala)

FATEHGARH SAHIB

Soil Series Association



Legend

Bahadurgarh-Ghanaur-Patiala	Sanaur-Banru
Daun-Julkan-Kapuri-Bahadurgarh-Sanaur	Suniarheri-Rajendra
Fatehpur-Samana	Todarpur-Chataihra
Hissar-Nabha	Tulewal-Nabha-Kakra
Kakra-Samana	Urdan-Bahadurgarh-Jalapur
Nabha-Tohana-Hissar	Urdan-Manakpur
Nabha-Tulewal	Undifferentiated soils
Nabha-Tulewal-Hissar	
Patiala-Rohar	

References

□	District HQ
○	Tehsil HQ
—	District Boundary
—	Road
+++++	Railway
—	Contour
—	Drainage
—	Canal
—	Watershed Boundary



3.2.8 Nabha-Tohana-Hissar Association

This association occurs on nearly level to flat old flood plains. The soils of this association are characterized by loam to clay textures with high water holding capacity. The estimated available moisture capacity ranges from 9.2 to 17.0 cm for 60 cm and 18 to 27.0 cm for 100 cm profile depth. Nabha and Hissar soils are fine loamy. Hissar soils are calcareous and Tohana soils are clayey.

3.2.9 Tohana-Nabha Association

This association occurs on old flood plains with slopes of 0 to 2 per cent. The soils are characterized by loam to clay textures. The estimated available moisture capacity ranges from 9.2 to 17.0 cm for 60 cm and 17.9 to 27.0 cm for 100 cm profile depth.

3.2.10 Nabha-Tulewal-Hissar Association

This association occurs on old flood plains or alluvial terraces with slopes varying from 0 to 3 per cent. The soils are characterized by loam to clay loam textures. Tulewal soils are loam to sandy clay loam while Nabha and Hissar soils are loam to clay loam. Hissar soils are calcareous. The estimated available water capacity ranges from 5.2 to 10.8 cm for 60 cm and 9 to 19.0 cm for 100 cm profile depth.

3.2.11 Todapur-Chataihra Association

This association occurs in the flood plain of Patialawali nadi where the slope varies from 0 to 2 per cent. The soils are subject to flooding during monsoons. They are characterized by silt loam to silty clay loam textures. Todapur soils have iron and manganese concretions and mottles in layers below 50 cm depth. Chataihra soils are sodic in nature. The water holding capacity is medium. The estimated available water capacity ranges from 12.4 to 12.6 cm for 60 cm and 21.4 to 21.8 cm for 100 cm profile depth.

3.2.12 Sanaur-Banru Association

The soils of this association occur on levees of Ghaggar river. The slope varies from 3 to 8 per cent. Sanaur soils are loamy fine sand, while Banru are fine sandy loam in texture. Soils are calcareous. The estimated available water capacity ranges from 2.1 to 3.6 cm for 60 cm and 3.6 to 6.0 cm for 100 cm profile depth.

3.2.13 Ranbirpura-Bazidpur Association

The soils of this association occur on concave relief of old alluvial plains where the slope goes up to 1 per cent. The soils are silt loam to silty clay loam in texture and gleyed due to hydromorphic conditions. Ranbirpura soils are non-calcareous while Bazidpur soils are calcareous and have abundant lime concretions. Adverse air-water relationship due to poor drainage is the main problem. The soils are affected by salinity also.

3.2.14 Suniarheri-Rajendra Association

This association occurs on nearly level lands in old flood plains where the slope varies from 0 to 3 per cent. The soils are clay loam to clay in texture and are saline. They are characterized by the presence of nodular lime below 50 cm depth which forms 25-40 per cent of the volume. Suniarheri soils are clayey while Rajendra soils are fine loamy, vegetation is sparse and scattered and white encrustation on the surface during summer is common. These soils are lying barren and a few patches reclaimed by leaching the salts are cultivated. Hissar and Tohana soils in the general area may have saline-alkali phases.

3.2.15 Urdan-Manakpur Association

This association occurs in the upper old flood plains of Ghaggar river with slope varying from 0 to 2 per cent. The soils are characterized by reddish brown colour and silt loam to silty clay textures unlike the dark brown and

yellowish brown soils of the old flood plains in the west. Urdan soils are fine loamy while Manakpur soils are clayey. Both are non-calcareous. Water holding capacity is high. The estimated available water capacity ranges from 11.0 to 17.0 cm for 60 cm and 19.6 to 27.0 cm for 100 cm profile depth.

3.2.16 Urdan-Bahadurgarh-Jalalpur Association

This association occurs on the lower old flood plains of Ghaggar river where the slope varies from 0 to 2 per cent. The soils are characterized by reddish brown colour and silt loam to silty clay texture. Fine stratification is observed in Jalalpur soils. Water holding capacity is high and thus will cause unfavourable conditions for sensitive crops. The available moisture capacity of the soil is to 17.0 cm for 60 cm and 18.6 to 27.0 cm for 100 cm profile depth.

3.2.17 Bahadurgarh-Ghanuar-Patiala Association

This association occurs on nearly level lower old flood plains of Ghaggar river on 0 to 2 per cent slopes. The soils are reddish brown silt loam to silty clay. Bahadurgarh and Ghanuar soils are calcareous while Patiala is non calcareous. Water holding capacity is high and will cause unfavourable conditions for sensitive crops. The available moisture capacity of the soil is about 15 cm for 60 cm and 25 cm for 100 cm profile depth.

3.2.18 Patiala-Rohar Association

This association occurs on low lying old flood plains of Ghaggar river, with slopes ranging from 0 to 3 per cent. Soils are imperfectly to moderately well drained. They are characterized by reddish brown colour and silty clay loam to silty clay texture. Rohar soils have clayey reddish brown soils over yellowish brown and olive brown clay loam. The available moisture capacity of the Patiala series is about 18.8 cm for 60 cm and above 27.0 cm for 100 cm profile depth. Soil texture, soil air-water relationship and setting of the soils affect crops that are sensitive to drainage conditions.

3.2.19 Sadhu-Patiala-Jalalpur Association

The soils of this association occur in low lying old flood plains of Ghaggar river where the slope is below 1% and largely in Sirhind Tehsil. They are characterized by dark brown to reddish brown- clayey texture. Sadhu soils have more than 45 percent clay and they crack in summer. The soils are moderately well drained to imperfectly drained. The available moisture capacity of the soil is about 17.0 cm for 60 cm and about 27.0 cm for 100 cm profile depth. They pose management problem due to heavy texture and setting.

COMPLEX SOILS OF MEANDER PLAINS

3.2.20 Daun-Julkan-Kapuri-Bahadurgarh-Sanaur Association

The soils of this association occur in recent flood plains of river Ghaggar. The slope varies from 0-2 per cent. The soils are highly variable. Sanaur soils, are sandy and daun, coarse loamy occurring on levees. Jalkan and Kapuri which are stratified occur on nearly level to undulating lands in low micro-relief. The water holding capacity is low to medium. The estimated available moisture capacity ranges from 6.7 to 14.0 cm for 60 cm and 9.0 to 22.0 cm for 100 cm. profile depth.

3.2.21 Undifferentiated Soils of Uplifted Plains near Siwaliks

The soils of this association occur on uplifted dissected plains in the northern part of Rajpura tehsil adjoining the Siwaliks. The slope varies from 2-15 per cent. They are characterized by dark brown to reddish brown colour with sandy to loam textures. The soils have medium water holding capacity. They are susceptible to erosion in sloping lands.

Table 6 Soil Legend

Physiographic Unit	Soil Series Association	Description of soil series	Area (ha)	%
Sand dune	1	Bhanra – Fatehpur Bhanra: Very deep, excessively drained, pale brown to yellowish brown (10YR 6/3 - 5/4, 5/6, 5/8) sandy soils on 3-10% slopes. Patehpur: Very deep, excessively drained, pale brown to yellowish brown; (10YR 6/3 - 5/4, 5/6) 5/8) sandy over loamy fine sand within 60 cm on 3-10% slopes.	4505.60	0.97
Sand dune and Dune slopes	2	Fatehpur - Samana Patehpur: Very deep, excessively drained, pale brown to yellowish brown (10YR 6/3 - 5/4, 5/6, 5/8) sandy over loamy sand within 60 cm on 3-10% slopes. Samana: Very deep, well drained, dark brown (10YR 4/3 - 7.5YR 4/4) sandy loam soils on 0-3% slopes.	3094.48	0.67
Interdunal flats and Interdunal undulating plains	3	Kakra — Samana Kakra: Very deep, well drained, dark brown to yellowish brown (10YR 4/3, 5/3, 5/4, 5/6) sandy loam soils on 0-3% slopes. Samana: Very deep, well drained, dark brown to yellowish brown (10YR 4/3 - 7.5YR 4/4), sandy loam soils on 0-3% slopes.	54358.40	11.72
	4	Samana – Tulewal Samana: Very deep, well drained, dark brown (10YR4/3-7.5YR4/4) sandy loam soils on 0-3% slopes. Tulewal: Very deep, well drained, dark brown to yellowish brown (10YR 4/3, 3/3, 5/4, 5/6) sandy loam to sandy clay loam soils on 0-3% slopes. Tulewal - Nabha – Kakra Tulewal: Very deep, well drained, dark brown to yellowish brown (10YR 4/3, 3/3, 5/4, 5/6) sandy loam to sandy clay loam soils on 0-3% slopes.	13059.20	2.8
	5	Nabha: very deep, well drained, dark yellowish brown to yellowish brown, (10YR 4/4, 3/4, 5/4, 5/6) loam to clay loam soils on 0-3% slopes. Kakra: Very deep, well drained, dark brown to yellowish brown (10YR 4/3, 5/3, 5/4, 5/6) sandy loam soils on 0-3% slopes.	5181.44	1.12
Old flood plains	6	Nabha – Tulewal Nabha: Very deep, well drained dark yellowish brown to yellowish brown (10YR 4/4, 3/4, 5/4, 5/6) loam to clay loam soils on 0-3% slopes. Tulewal: Very deep, well drained, dark brown to yellowish brown (10YR 4/3, 3/3, 5/4, 5/6) sandy loam to sandy clay loam soils on 0-3% slopes.	14471.20	3.12
	7	Hissar – Nabha Hissar: Very deep, moderately well drained, dark brown to yellowish brown (10YR 4/3, 10YR 5/4) loam to clay loam, calcareous soils on 0-3% slopes. Nabha: Very deep, well drained, dark yellowish brown to yellowish brown (10YR 4/4, 3/4, 5/4, 5/6) loam to clay loam soils on 0-3% slopes.	12342.40	2.66

Physiographic Unit	Soil Series Association	Description of soil series	Area (ha)	%
Flood plains of Patiala-wali nadi	8	Nabha - Tohana – Hissar Nabha: Very deep, well drained, dark yellowish brown to yellowish brown (10YR 4/4, 3/4, 5/4, 5/6) loam to clay loam soils on 0-3% slopes. Tohana: very, deep, moderately well drained, dark brown to yellowish brown (10YR 4/3, 10YR 5/4) clayey soils on 0-2% slopes. Hissar: Very deep, moderately, well drained, dark brown to yellowish brown (10YR 4/3, 10YR 5/4) loam to clay loam, calcareous soils on 0-3% slopes.	42654.40	9.20
		Tohana – Nabha Tohana: Very deep, moderately well drained, dark, brown to yellowish brown (10YR 4/3, 10YR 5/4) clayey soils on 0-2% slopes.	14848.40	3.20
		Nabha: Very deep, well drained, dark yellowish brown to yellowish brown, (10 YR 4/4, 3/4; 5/4, 5/6) loam to clay loam soils on 0-3% slopes.		
	9	Nabha — Tulewal – Hissar Nabha: Very deep, well drained, dark yellowish brown to yellowish "brown, (10YR 4/4, 3/4, 5/4, 5/6) loam to clay loam soils on 0-3% slopes.	28099.36	6.06
		Tulewal: Very deep, well drained, dark brown to yellowish brown (10YR 4/3, 3/3, 5/4, 5/6) sandy loam to sandy clay loam soils on 0-3% slopes. Hissar: Very deep, moderately well drained, dark brown to yellowish brown (10YR 4/3, 10 YR 5/4) loam to clay loam, calcareous soils on 0-3% slopes.		
	11	Todarpur – Chataihra Todarpur: Very deep, moderately well drained to imperfectly drained, dark brown to reddish brown (7.5YR 4/4, 5/4, 5 YR 4/4) loam to silty clay loam calcareous soils on 0-3% slopes. Chataihra: Very deep, moderately well drained, dark brown to dark yellowish brown (10YR 4/3, 5/4) silty clay loam calcareous, sodic soils on 0-3% slopes.	7680.00	1.65
		Sanaur – Bantu Sanaur: Very deep, excessively drained, yellowish brown to dark brown (10YR 5/4, 4/3, 7.5YR 4/4) loamy sands, calcareous on 1-5% slopes.	3051.52	0.65
		Banru: Very deep, excessively drained to well drained, dark brown (7.5YR 4/4) sandy loam, calcareous soils on. 0-3% slopes.		
	12	Ranbirpura - Bazidpur Ranbirpura: very deep, imperfectly drained to poorly drained, light brownish grey to light olive brown (2.5Y 3/2 - 2.5Y 5/4), silt loam soils on 0-1% slopes, high ground water-table.	4872.80	1.03
		Bazidpur: Very deep, imperfectly to poorly drained, light brownish gray (2.5Y 6/2) to dark grayish brown (2.5Y 4/2, 10YR 4/2) on 0-1% slopes with lime concentrations, high ground water-table.		
	13	Suniarheri - Ralendra Suniarheri: Very deep, imperfectly drained, yellowish brown to light; olive brown (10YR 5/4, 2.5Y 5/4) clay loam to clay, calcareous soils on 0-1% slopes with mottles and concentrations, sodic.	73087.04	15.77
		Rajendra: Very deep, imperfectly drained, yellowish brown to light olive brown (10YR 5/4, 2.5Y 5/4) silt loam calcareous soils on.0-1% slopes, with lime nodules (25-30%), mottles.		
	14			

Physiographic Unit	Soil Series Association	Description of soil series	Area (ha)	%
Old flood plains (upper)	15	Urdan-Manakpur	12943.36	2.78
		Urdan: Very deep, well drained dark brown to reddish brown (7.5YR 4/4, 5YR 4/4) silt loam soils on 0-2% slopes. Manakpur: Very deep, well drained, dark brown to reddish brown (7.5YR 4/4, .5YR 4/4) silty Clay soils on 0-2% slopes.		
	16	Urdan - Bahadurahr- Jalalnur	25309.12	5.45
		Urdan: very deep, well drained dark brown to reddish brown (7.5YR 4/4, 5YR 4/4) silt loam soils on 0-2% slopes. Jalalpur: Very deep, well drained to moderately well drained, dark brown (7.5YR 4/4, 5YR 4/4) silt loam over silt clay, calcareous soils on 0-2% slopes, fine stratification at lower depth. Bahadurgarh: Very deep, well drained to moderately well drained, dark brown to reddish brown (7.5YR 4/4) silt loam to silty clay loam, calcareous soils on 0-2% slopes.		
Nearly level lower old flood plains	17	Bahadurahi - Chanudr – Patiala	44972.16	9.70
		Bahadurgaihi: Very deep, well drained to moderately well drained^ dark brown to reddish brown (7.5YR 4/4, 5YR 4/4) silt loamy to silty clay loam, calcareous soils on 0-2% slopes. Ghanuar: Very deep moderately well drained, dark brown to reddish brown (7.5YR 4/4, 5YR 4/4) silty clay calcareous soils on 0-3% slopes.		
	18	Patiala: Very deep/ moderately well drained, dark brown to reddish brown (7.5YR 4/4, 5YR 4/4) silty clay soils on 0-2% slopes, stratification at lower depths. Patiala – Rohar	22636.90	4.88
		Patiala: Very deep, moderately well drained, dark brown to reddish brown (7.5YR 4/4, 5YR 4/4) silty clay soils on 0-2% slopes, stratification at lower depths. Rohar: Very deep, imperfectly drained, dark brown to reddish brown (7.5YR 4/4, 5YR 4/4) silty clay loam soils over yellowish brown to olive brown (10YR 5/3, 2.5Y 5/4) loam calcareous soils with nodular lime concretions at lower depth on 0-3% slopes.		
Level old flood plains on concave relief.	19	Sadhu - Patiala — Jelalnur	5324.80	1.14
		Sadhu: Very deep, imperfectly drained, dark brown (10YR 4/3, YR 4/4), clayey soils on 0-2% slopes, deep cracks. Patiala: Very deep/ imperfectly drained, dark brown/to reddish brown (7.5YR 4/4, 5YR 4/4) silty clay soils on 0-2% slopes, stratification at lower depths.		
	20	Jalalpur: Very deep, well drained to moderately well drained, dark brown to reddish brown (7.5YR 4/4, 5YR 4/4) silt loam over silty clay, calcareous soils on 0-2% slopes, stratification at lower depths. Highly variable stratified complex soils of Ghaggar flood plains Daun-Juikan-Kapuri-Bahadur-Garh-Sanaur	5672.96	1.22
		Daun: Very deep, well drained, light brown (7.5YR 6/4), to brown (7.5YR 5/4) sandy loam, calcareous soils on 0-3% slopes. Jalkan: Very deep, moderately well drained, dark brown to reddish brown (7.5YR 4/4, 5YR 4/4) calcareous silt loam, stratified soils on 0-3% slopes.		
Recent	21	Kapuri: Very deep, moderately well drained, dark brown (7.5YR 4/4) to reddish brown (5YR 4/4); fine loamy over coarse loamy or sandy, calcareous soils on 0-2% slopes. Bahadurgarh: Very deep, well drained to moderately well drained, dark brown to reddish brown (7.5YR 4/4, 5YR 4/4) silt loam to silty clay loam, calcareous -soils on 0-2% slopes.		
		Sanaur: Very deep, excessively drained, yellowish brown to dark brown (10YR 5/4, 4/3, 7.5YR 4/4) loamy sand, calcareous soils on 1-5% slopes.		
Dissected Undifferentiated soils	21	Undifferentiated soils	5672.96	1.22

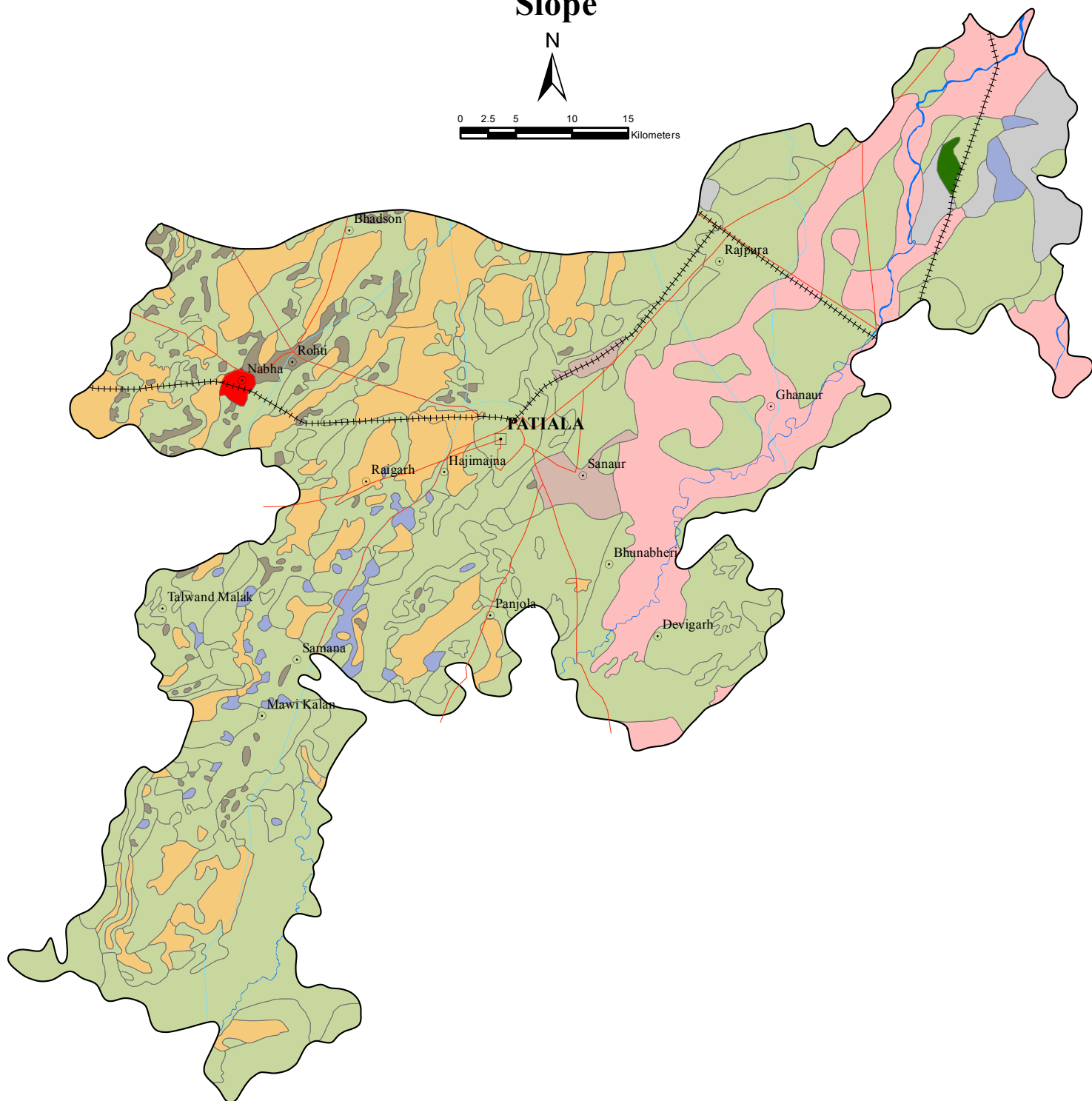
The thematic maps on slope, surface form, parent material, soil depth, surface texture, soil drainage and particle size are shown in figure 3 to 9, respectively.

PATIALA

Slope



0 2.5 5 10 15 Kilometers



Legend

- Level to nearly level
- Level to nearly level-Very gently sloping
- Level to nearly level-Gently sloping-Very gently sloping
- Level to nearly level-Very gently sloping-Level to nearly level-Gently sloping
- Gently sloping-Moderately sloping
- Gently sloping-Moderately sloping-Level to nearly level-Very gently sloping
- Undifferentiated soils
- Forest
- Habitation

References

- District HQ
- Tehsil HQ
- District Boundary
- Road
- Railway
- Drainage
- Canal
- River



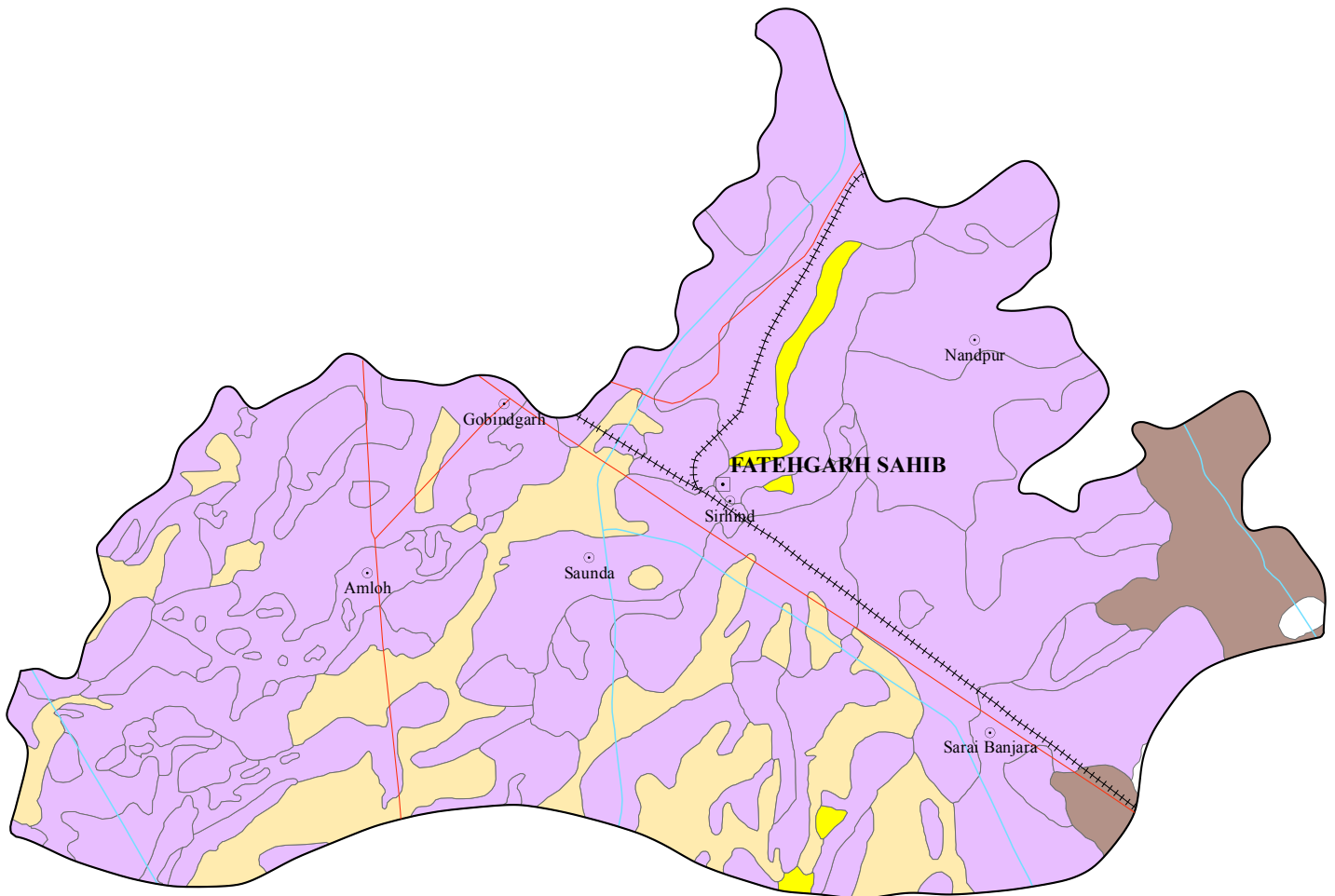
Fig. 3: Slope (Patiala)

FATEHGARH SAHIB

Slope



0 2.5 5 10
Kilometers



Legend

	Level to nearly level
	Level to nearly level-Very gently sloping
	Level to nearly level-Gently sloping-Very gently sloping
	Gently sloping-Moderately sloping-Level to nearly level-Very gently sloping
	Undifferentiated soils

References

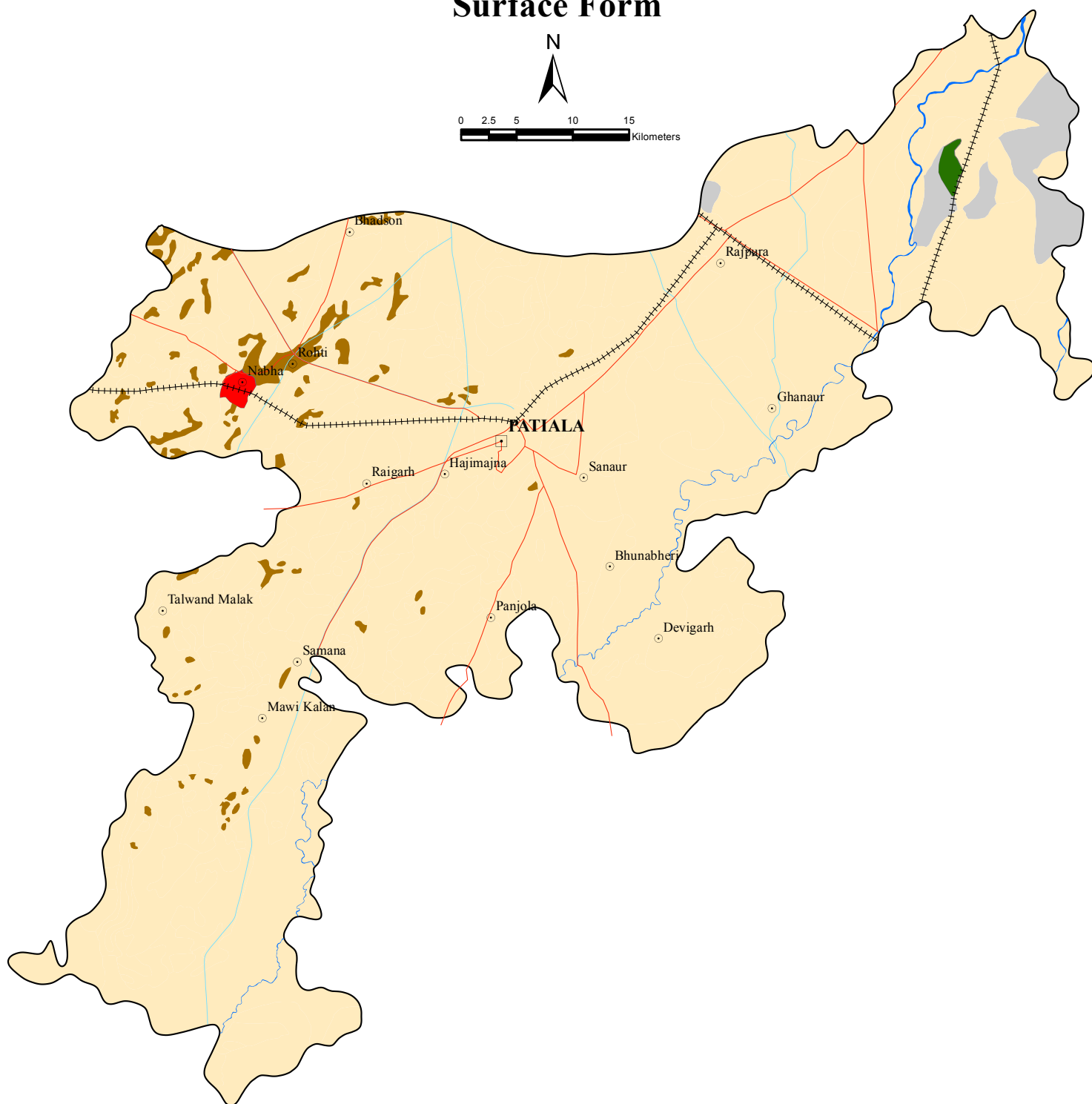
	District HQ
	Tehsil HQ
	District Boundary
	Road
	Railway
	Drainage
	Canal



Fig. 3a: Slope (Fatehgarh Sahib)

PATIALA

Surface Form



Legend

	Level
	Ridges-Undulating
	Undifferentiated soils
	Forest
	Habitation

References

<div style="position:absolute; top:-2px; left:5px; width:0; height:0; border-left:5px solid transparent; border-right:5px solid transparent; border-bottom:8px solid black;"></div>	District HQ
	Tehsil HQ
	District Boundary
	Road
	Railway
	Drainage
	Canal
	River



FATEHGARH SAHIB

Surface Form



0 2.5 5 10
Kilometers



Legend

	Level
	Undifferentiated soils

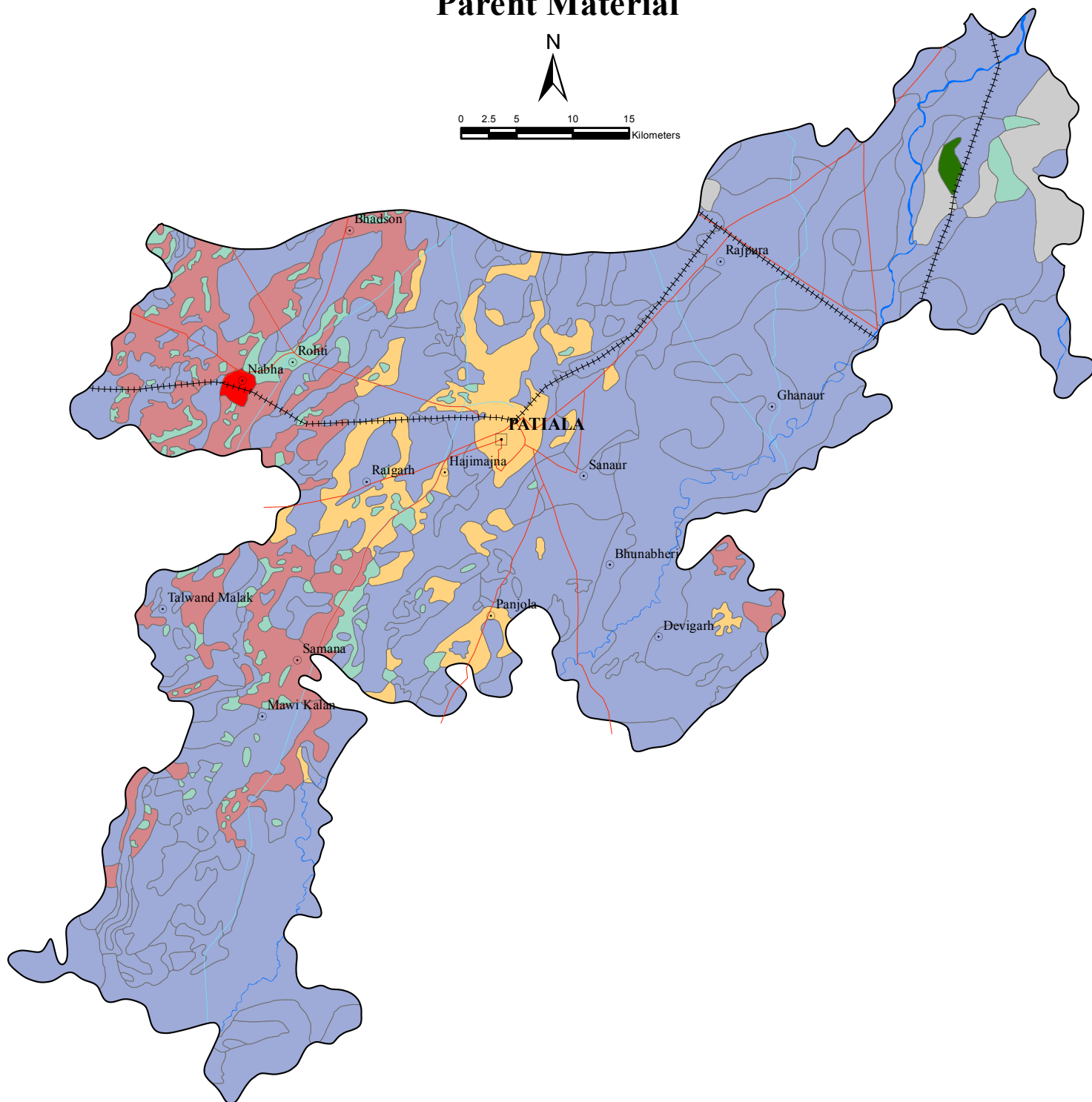
References

	District HQ
	Tehsil HQ
	District Boundary
	Road
	Railway
	Drainage
	Canal



PATIALA

Parent Material



Legend

- Aeolian
- Aeolian-Alluvium
- Alluvium
- Alluvium-Aeolian
- Undifferentiated soils
- Forest
- Habitation

References

- District HQ
- Tehsil HQ
- District Boundary
- Road
- Railway
- Drainage
- Canal
- River



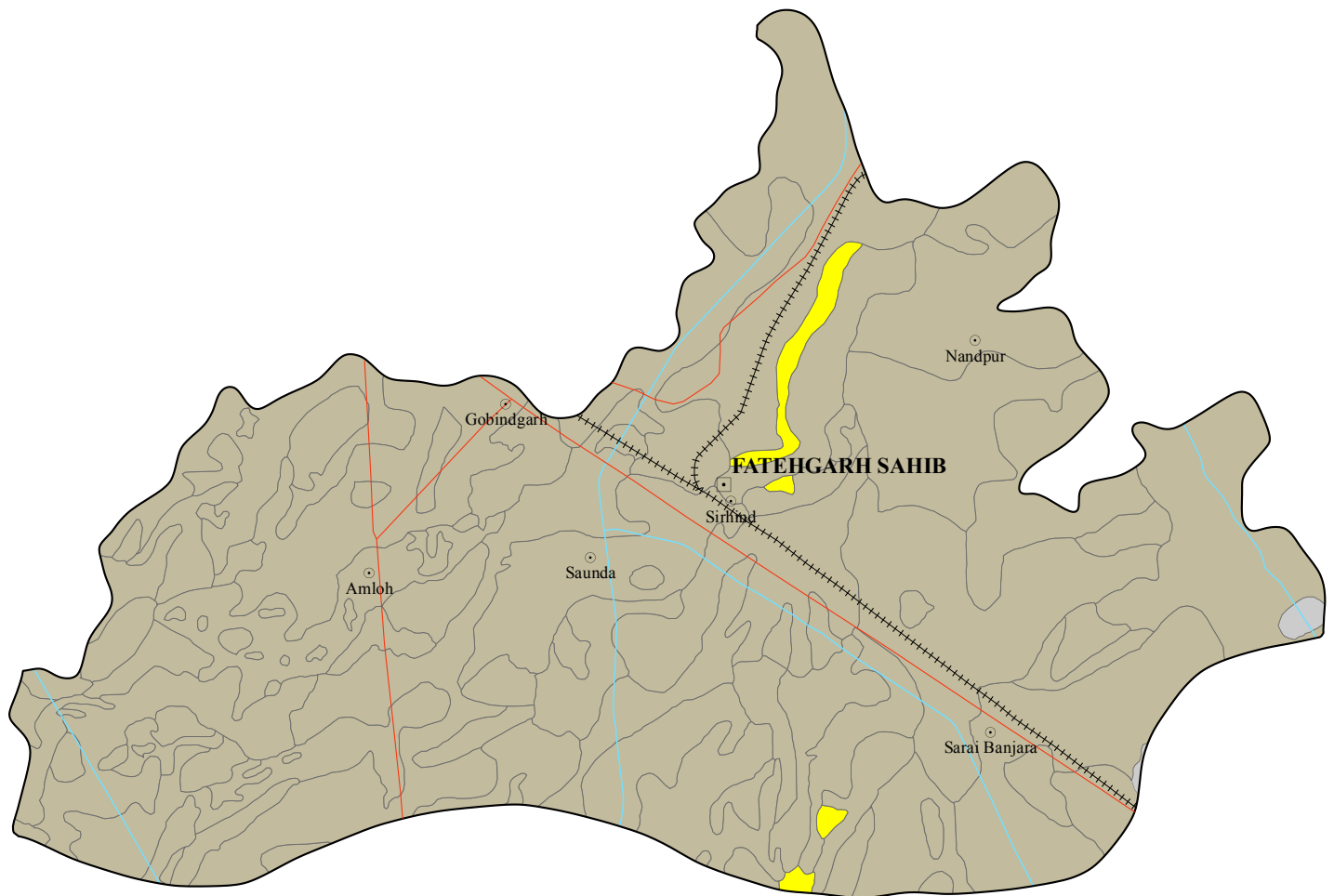
Fig. 5: Parent Material (Patiala)

FATEHGARH SAHIB

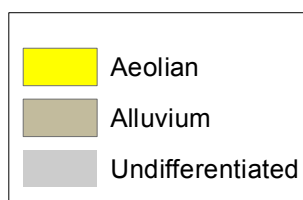
Parent Material



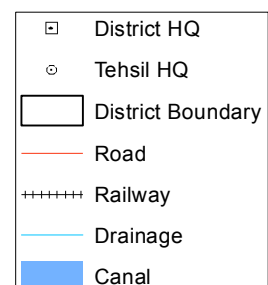
0 2.5 5 10
Kilometers



Legend

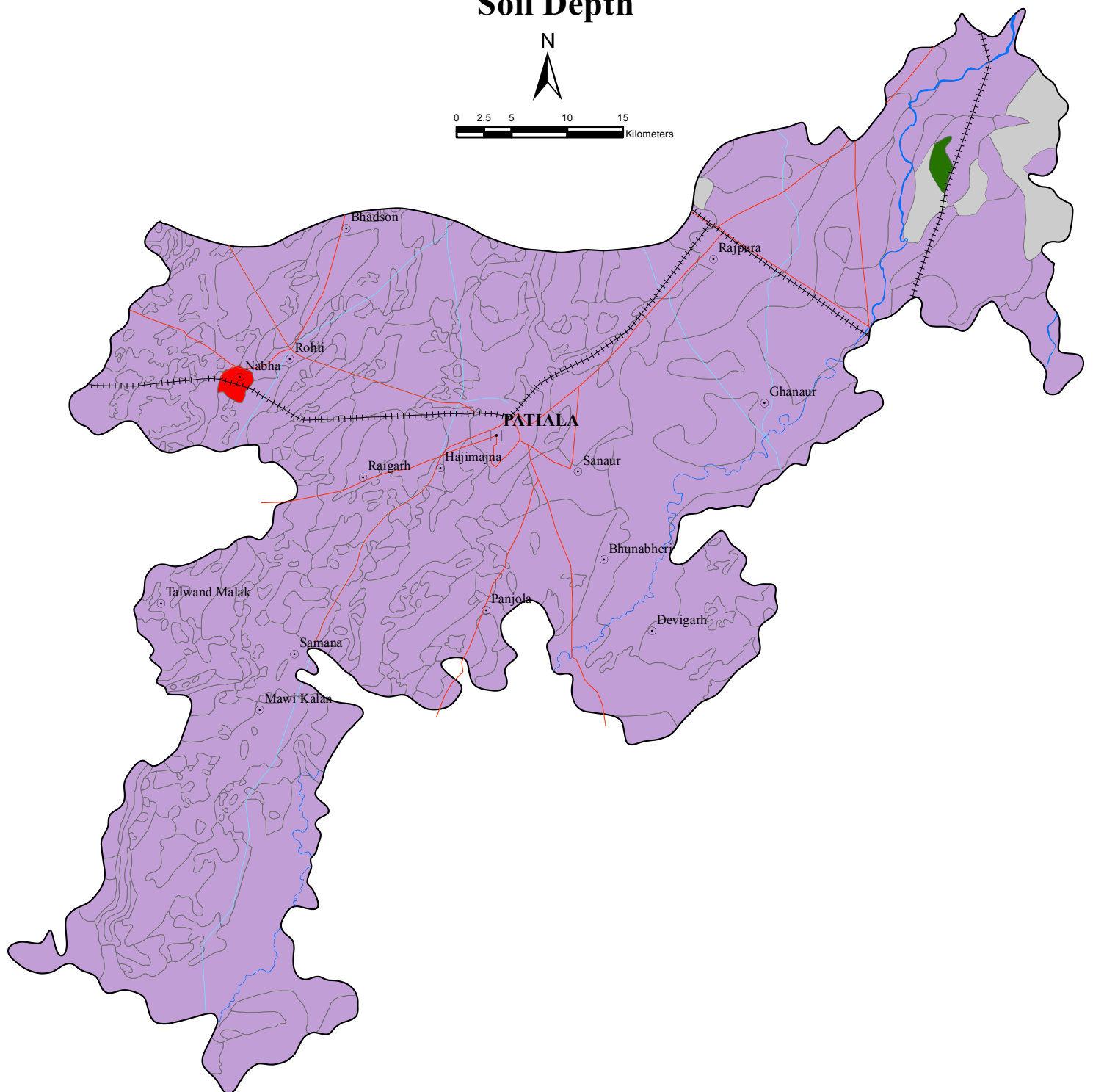


References

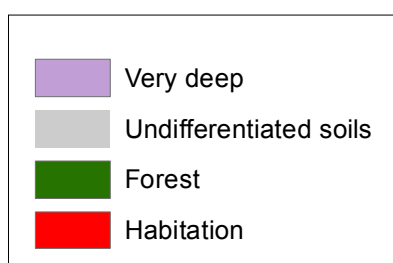


PATIALA

Soil Depth



Legend



References

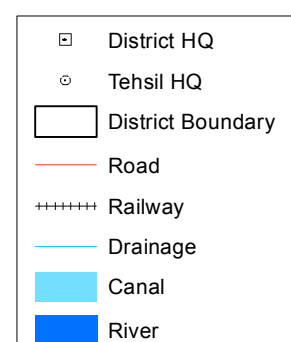


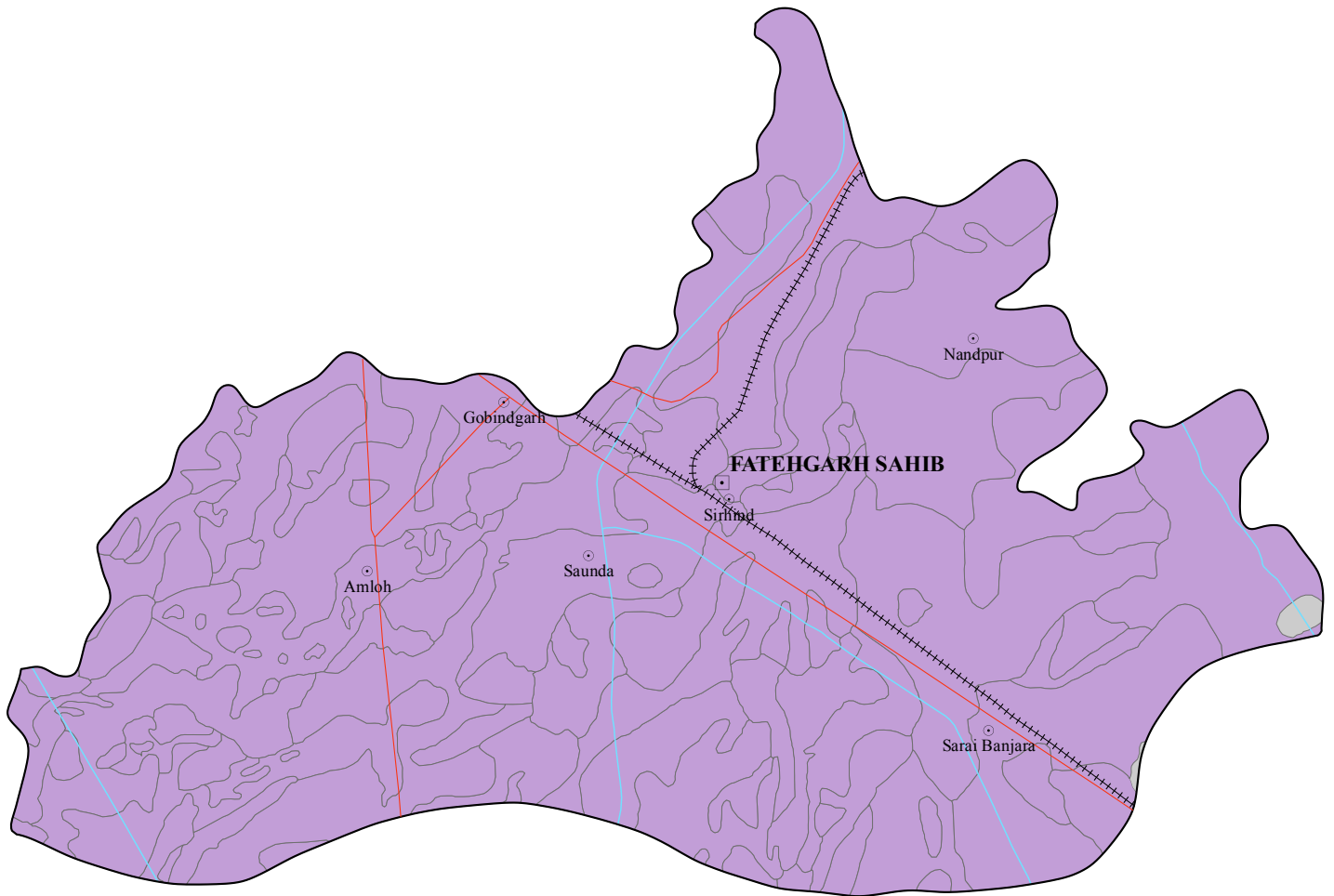
Fig. 6: Soil Depth (Patiala)

FATEHGARH SAHIB

Soil Depth



0 2.5 5 10
Kilometers



Legend

	Very deep
	Undifferentiated

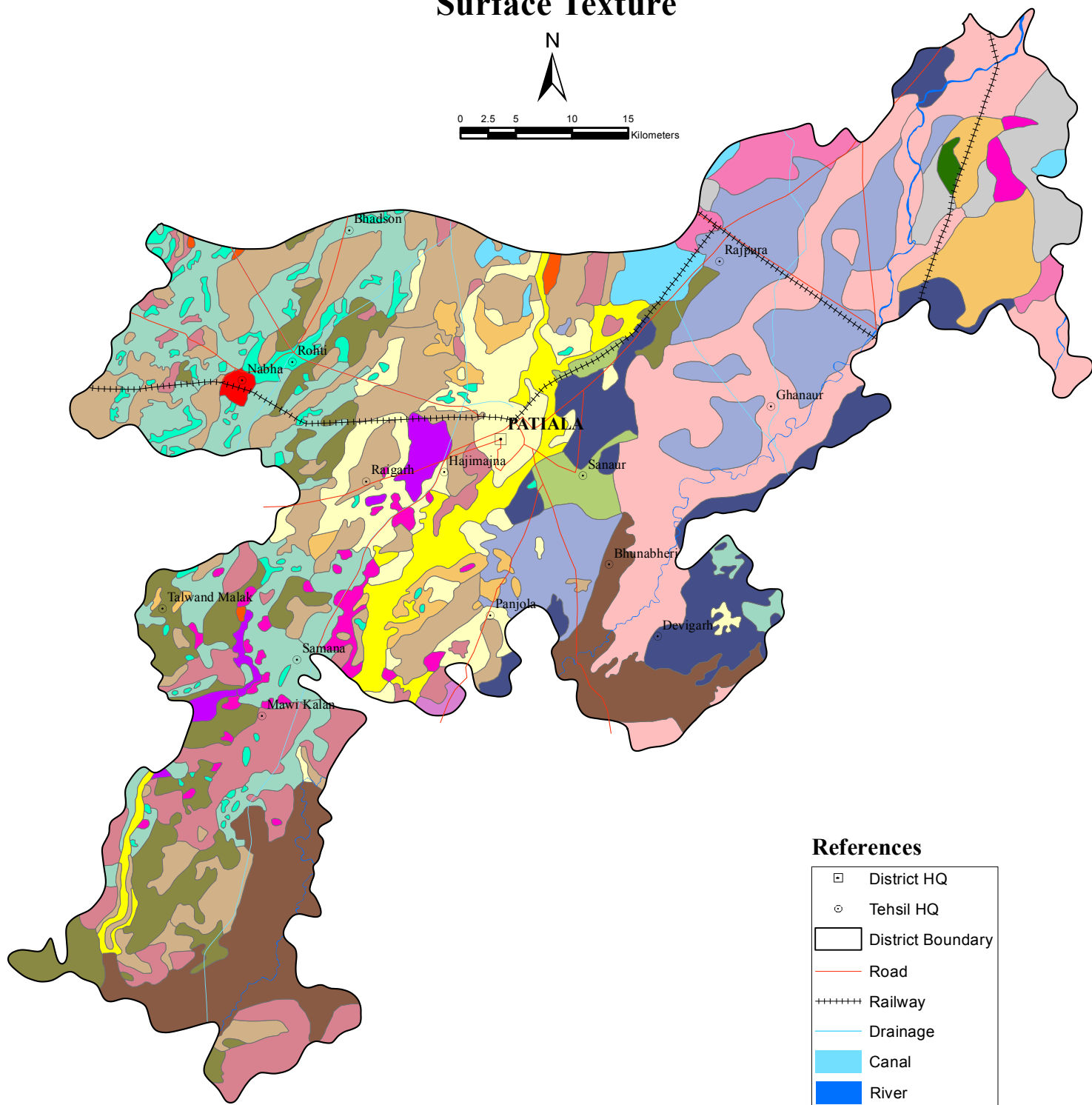
References

	District HQ
	Tehsil HQ
	District Boundary
	Road
	Railway
	Drainage
	Canal



PATIALA

Surface Texture



References

- District HQ
- Tehsil HQ
- District Boundary
- Road
- +++++ Railway
- Drainage
- Canal
- River

Legend

- | | |
|---|---|
| Clay loamy-Clayey-Silty loam | Sandy loam-Sandy clay loam |
| Clayey-Silty clay | Sandy loam-Silty-Loamy-Sandy-Silty-Sandy clay loam-Laomy sand |
| Loamy sand-Sandy loam | Sandy -Loamy |
| Loamy-Clay loamy | Silty clay loam-Loamy-Clay loam |
| Loamy-Clay loamy-Sandy loam-Sandy clay loam | Silty clay loam |
| Loamy-Clay loamy-Sandy loam-Sandy clay loam-Clayey loam | Silty clay-Loamy |
| Loamy | Silty-Loamy-Silty clay |
| Sandy -Loamy-Sandy loam | Silty-Loamy-Silty clay-Silty-Clayey |
| Sandy loam-Sandy clay loam-Clay loam | Undifferentiated soils |
| Sandy loam-Sandy clay loam-Sandy clay | Forest |
| Sandy loam | Habitation |



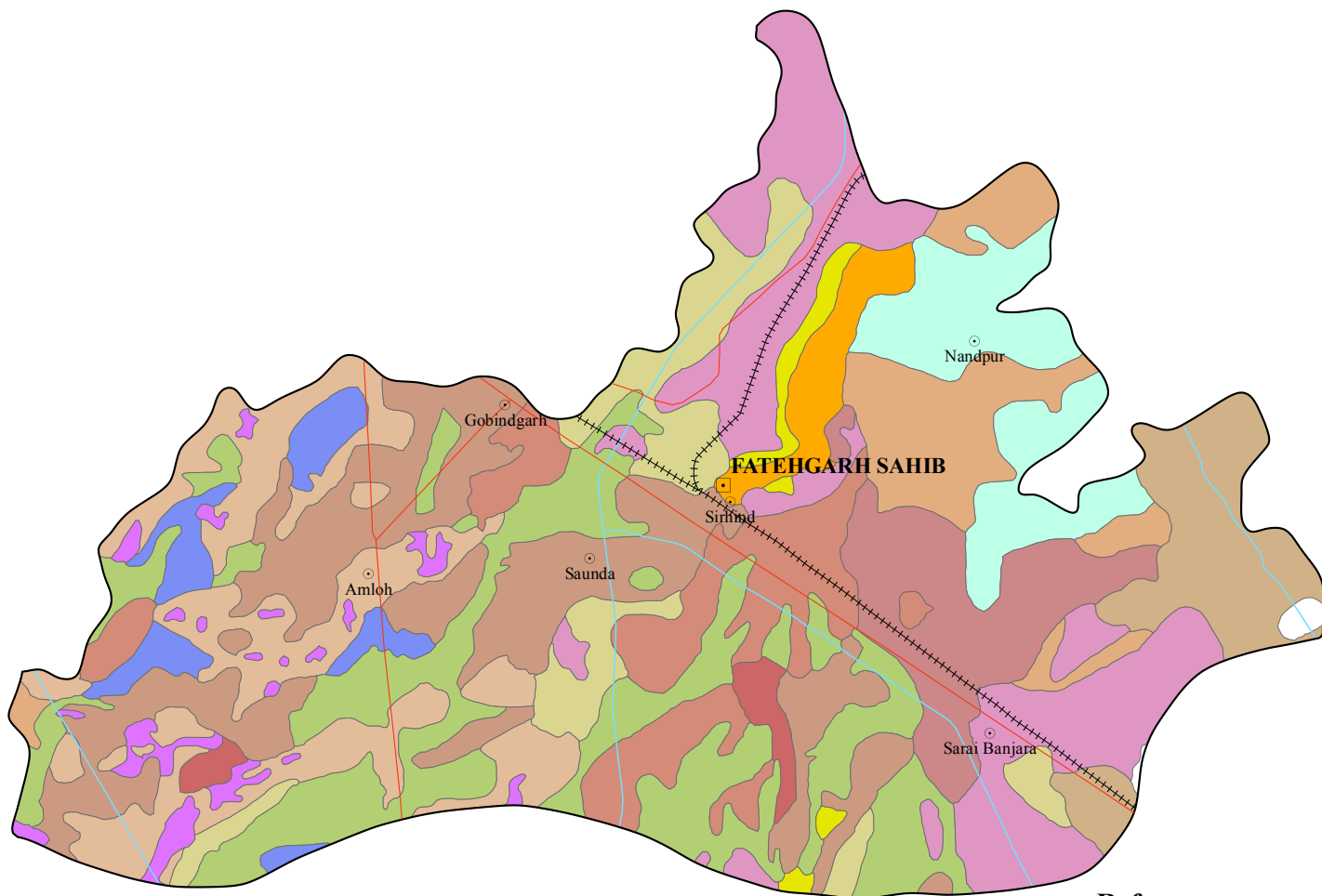
Fig. 7: Surface Texture (Patiala)

FATEHGARH SAHIB

Surface Texture



0 2.5 5 10
Kilometers



References

	District HQ
	Tehsil HQ
	District Boundary
	Road
	Railway
	Drainage
	Canal

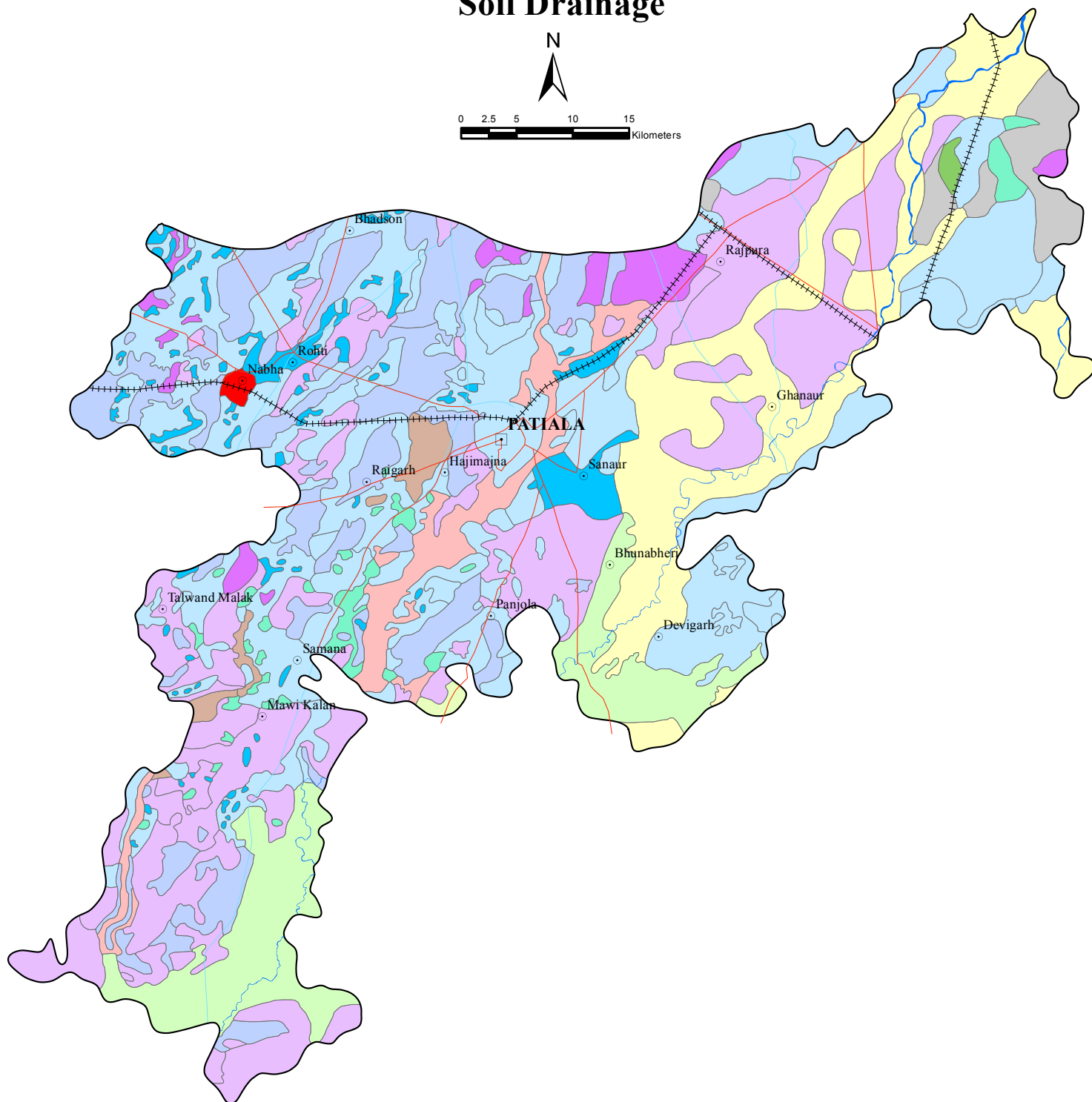
Legend

	Clay loam-Clayey-Silty loam		Sandy loam
	Loamy sand-Sandy loam		Sandy loam-Silty-Loamy-Sandy-Sandy clay-Loamy sand
	Clay loam-Clayey-Loamy-Clayey loam		Sandy-Loamy-Sandy loam
	Loamy-Clayey loam		Silty clay loam-Loamy
	Loamy-Clay loam-Sandy loam-Sandy clay loam		Silty clay loam-Silty clay loam
	Clay loam-Sandy loam-Sandy clay loam-Loamy-Clay loam		Silty-Loamy-Silty clay
	Sandy loam-Sandy clay loam-Clay loam		Silty-Loamy-Silty clay-Clayey-Silty clay
	Sandy loam-Sandy clay loam-Sandy clay		Undifferentiated Soils



Fig. 7a: Surface Texture (Fatehgarh Sahib)

PATIALA Soil Drainage



Legend

	Poor		Well- Mod well
	Imperfect		Well- Mod well-Excessive
	Imperfect-Mod well		Excessive-Well
	Mod well		Excessive
	Mod well-Imperfect		Undifferentiated soils
	Mod well-Well		Forest
	Well		Habitation

References

	District HQ
	Tehsil HQ
	District Boundary
	Road
	Railway
	Drainage
	Canal
	River



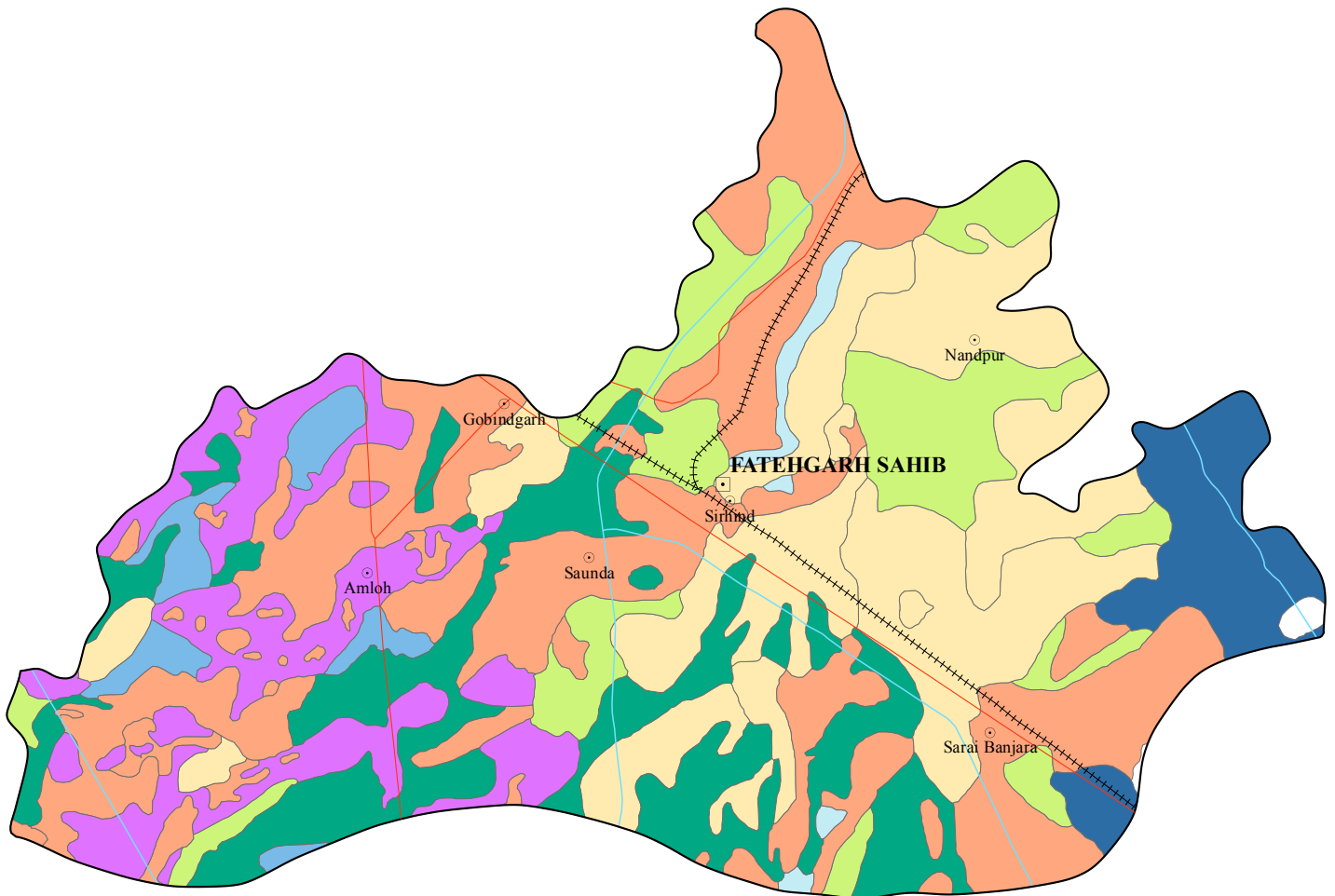
Fig. 8: Soil Drainage (Patiala)

FATEHGARH SAHIB

Soil Drainage



0 2.5 5 10
Kilometers



Legend

Imperfect	Well-Mod well
Mod well	Excessive
Mod well-Imperfect	Excessive-Well
Mod well-Well-Excessive	Undifferentiated soils
Well	

References

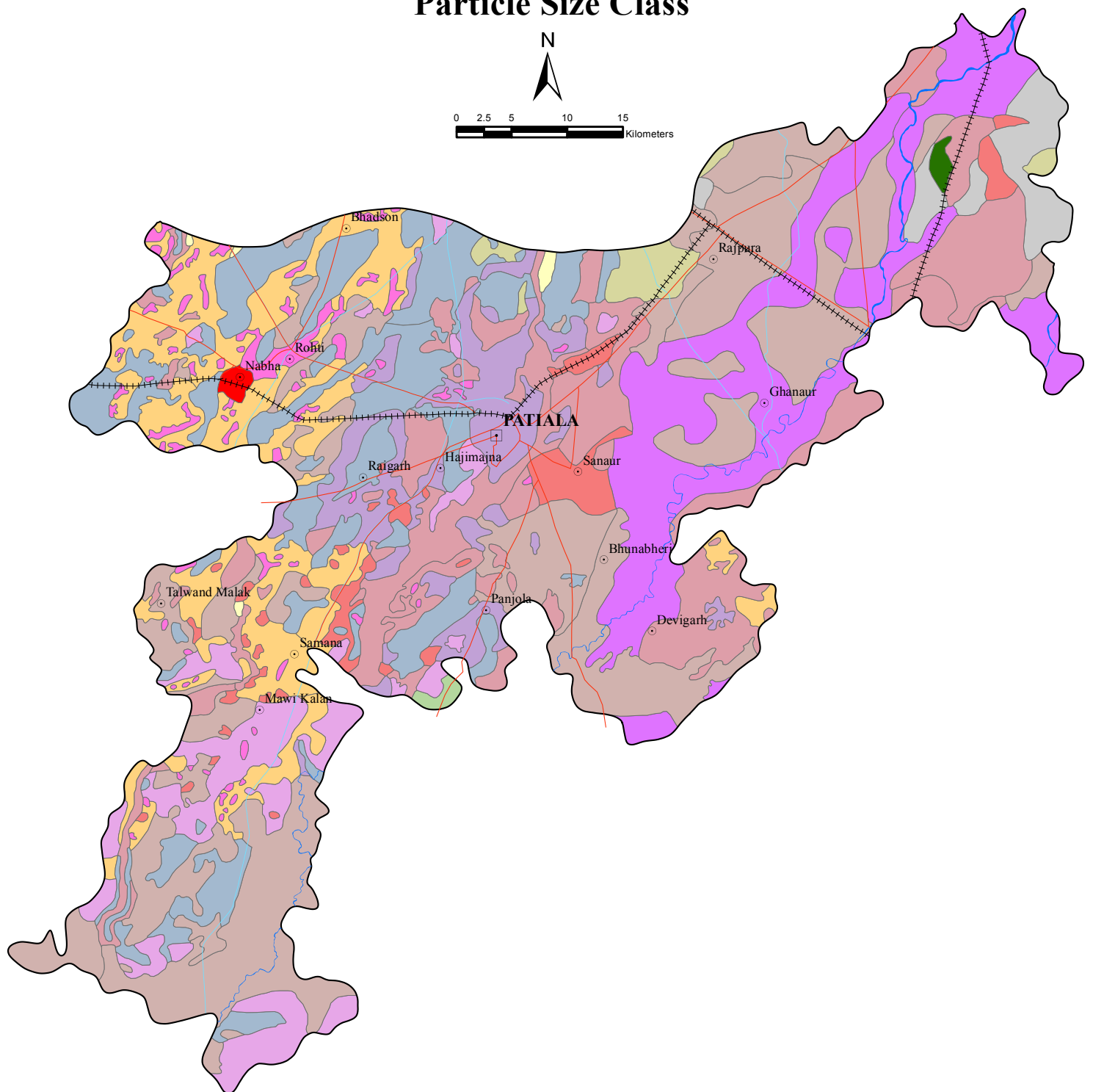
District HQ
Tehsil HQ
District Boundary
Road
Railway
Drainage
Canal



Fig. 8a: Soil Drainage (Fatehgarh Sahib)

PATIALA

Particle Size Class



Legend

Clayey-Fine loamy	Coarse loamy
Fine -Fine loamy	Coarse loamy-Coarse silty-Fine loamy-Sandy
Fine loamy	Sandy-Coarse loamy
Fine loamy- Clayey	Sandy-Sandy
Fine loamy--Fine-Clayey	Undifferentiated soils
Fine clayey-Clayey-Fine loamy	Forest
Fine loamy-Coarse loamy	Habitation
Coarse loamy-Fine loamy	

References

□	District HQ
○	Tehsil HQ
□	District Boundary
—	Road
+++++	Railway
—	Drainage
—	Canal
—	River

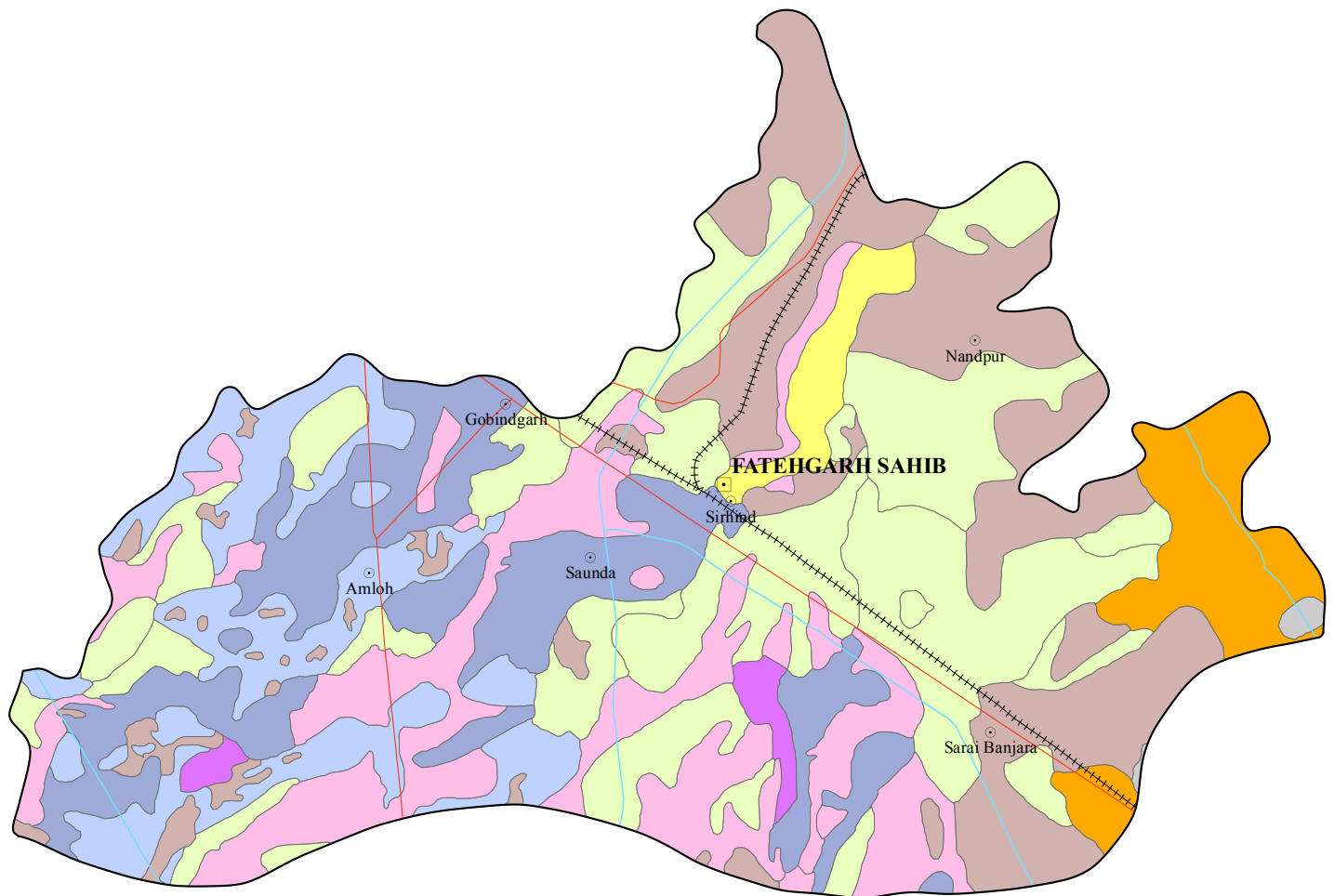


FATEHGARH SAHIB

Particle Size Class



0 2.5 5 10
Kilometers



Legend

- Clayey-Fine loamy
- Coarse loamy
- Coarse loamy-Coarse silty-Fine loamy-Sandy
- Fine loamy-Clayey
- Fine loamy-Coarse loamy
- Fine loamy
- Fine loamy-Fine-Clayey
- Sandy-Coarse loamy
- Undifferentiated

References

- District HQ
- Tehsil HQ
- District Boundary
- Road
- Railway
- Drainage
- Canal



4.

INTERPRETATIONS**4.1 Principles of Interpretations**

The soil map of the area enclosed shows delineations of soil series associations which are named but inclusion of other soils is natural in reconnaissance soil maps. Soil series are distinguished on the basis of differentiating characteristics like colour, mottles; texture and free lime, drainage. Assuming Soil mineralogy to be generally same interpretations have to be based on considerations of interactions between soil characteristics. Hence, differentiating characteristics that influence moisture and nutrient retention qualities of the soils become important to assess management responses and manipulation needed for growing crops or putting them under other uses. Therefore, the basis of interpretation should be the taxonomic unit at series level or groups of series based on differentiating characteristics. The soil map helps to ascertain the qualities and properties of different soils or locate them with reference to the interpretations that are important for intended use of the soils/land, soils are grouped according to management needs into management units with different interpretations based on the present level of knowledge and the information gathered through observations in the field.

The interpretive groupings of the soils of the district are state for land capability classification, irrigability classification based on the differentiating characteristics of the identified and mapped soils.

Table 8 gives the distribution of soil series association and miscellaneous land types in Patiala district.

4.2 Land Capability Classification

Capability classification is an interpretive grouping made primarily for agricultural purposes. Cultivable soils are grouped according to their potentialities and limitations for sustained production of the commonly cultivated crops. The crops considered are listed under presently cultivated crops. Class I to IV lands are cultivable lands and Class V to VIII are non-cultivable lands (Fig. 10).

Land capability classes are groups of soils that have the same kinds of dominant limitations for agricultural use. Four kinds of limitations at the subclass level are (e) for wind or water erosion hazard; (w) for drainage difficulties, wetness or overflow; (s) for soil limitations affecting plant growth and (c) for limitations due to climate.

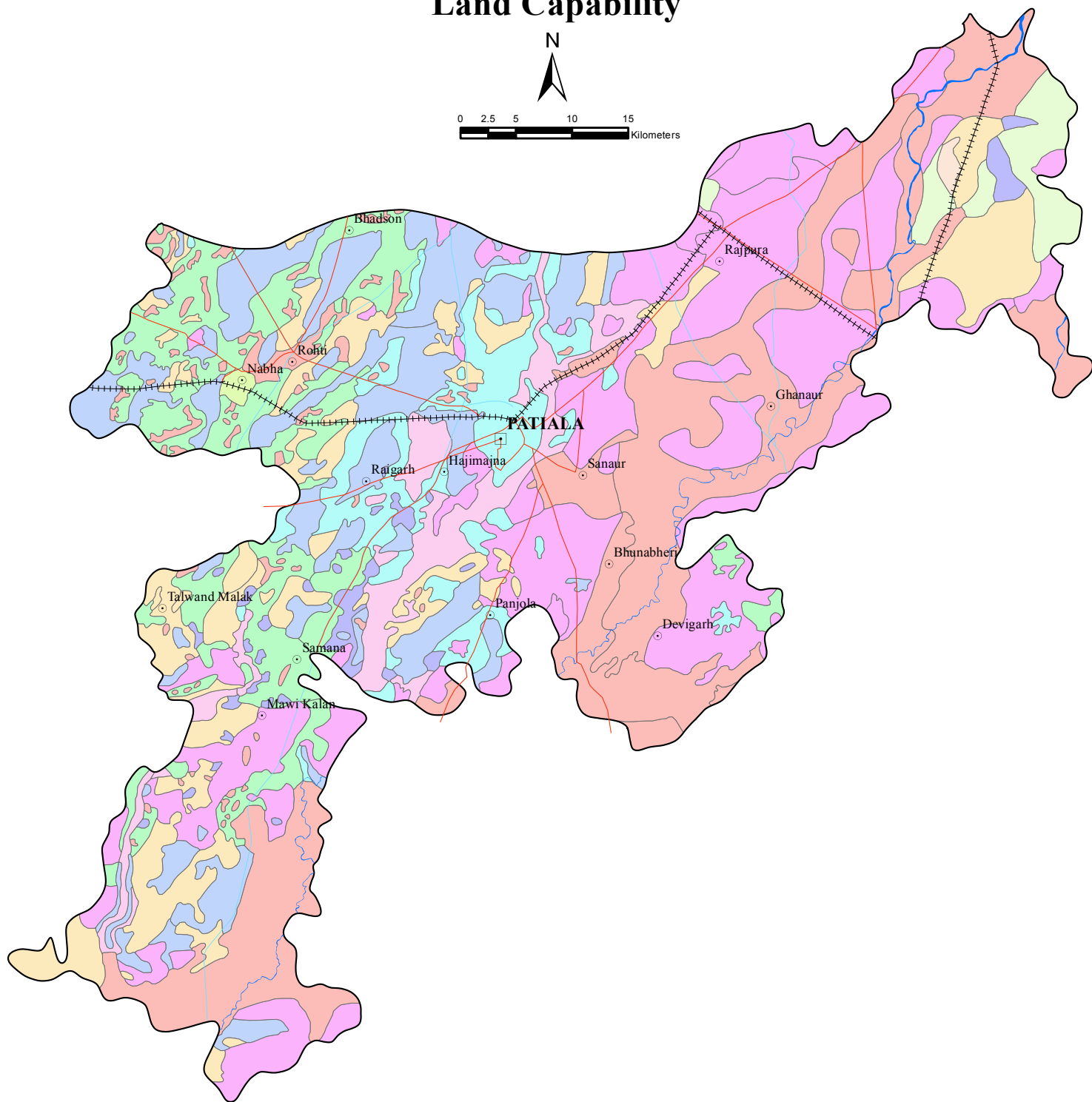
Influence of climate in land use classification has to be considered when other soil conditions are considered favourable. In the district of Patiala where rainfall during the main growing season i.e. from July-September varies from 64-90 cm. It is considered adequate for crops that mature within 120 days. Though this is considered enough to grown climatically adapted crops, rainfall is erratic and its distribution cannot be predicted. Hence, even the best soils of the area qualify for IIc only. They have no other limitations. The other limitations identified in the area are erosion soil and drainage. The delineation in the map is land capability sub-class or association of sub-class. Inclusion of other sub-classes within a named sub-class or association is natural on a small scale soil map.

4.2.1 Land Capability Sub-class IIc











Sub-class IIc are level lands having very deep, well drained fine loamy soils of loam to clay loam textures in the control section as well as at the surface. Estimated available moisture capacity ranges from 5.2 cm to 10.8 cm for 60 cm depth and from 9.0 cm to cm up to 100 cm soil profile depth. The soil can hold enough moisture from

PATIALA

Land Capability



Legend

	IIIs		IIIw
	IIc		IIIs-IIIe
	IIc-IIIs		Undifferentiated soils
	IIc-IIIs		Forest
	IIIs		Habitation

References









	District HQ
	Tehsil HQ
	District Boundary
	Road
	Railway
	Drainage
	Canal
	River



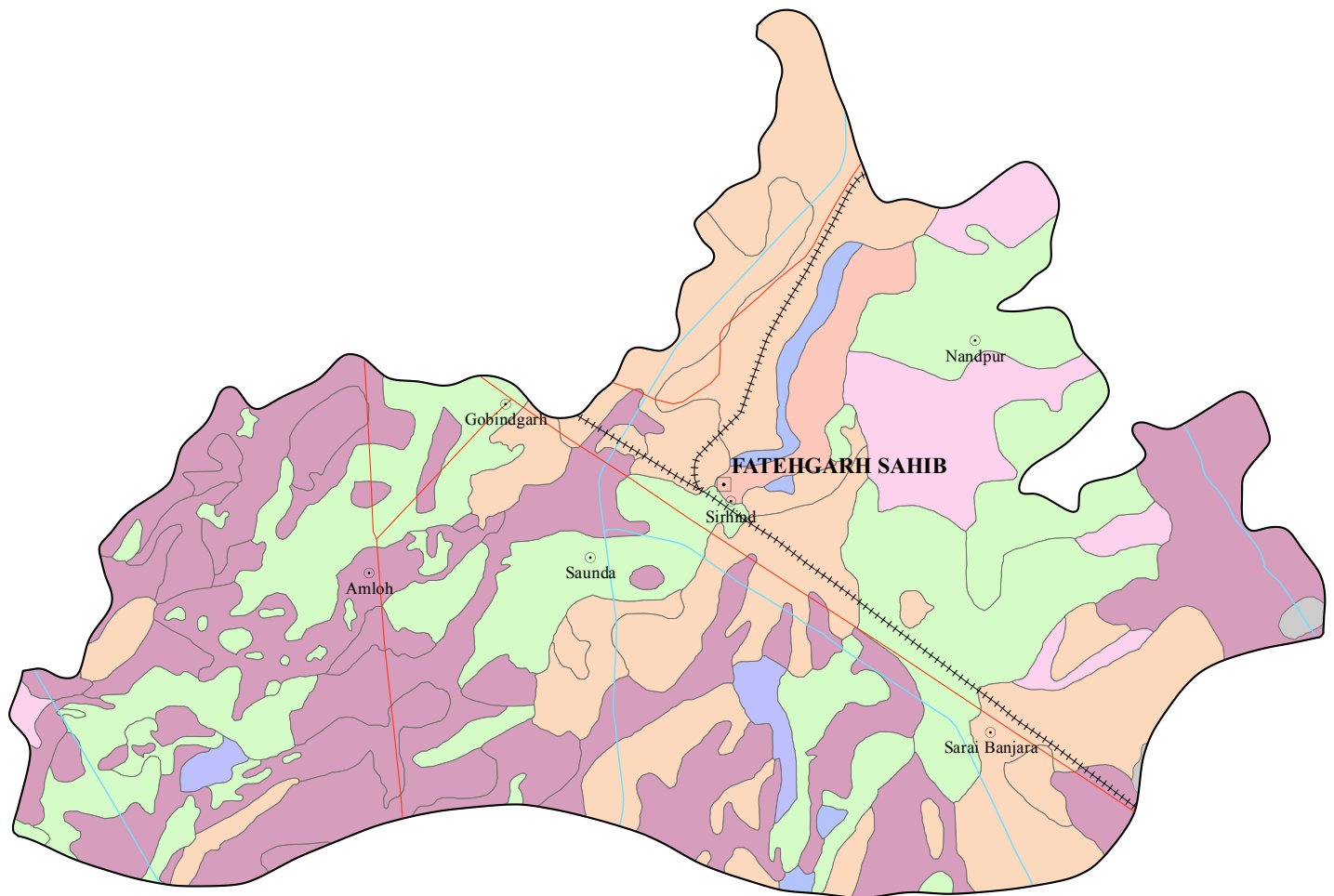
Fig. 10: Land Capability (Patiala)

FATEHGARH SAHIB

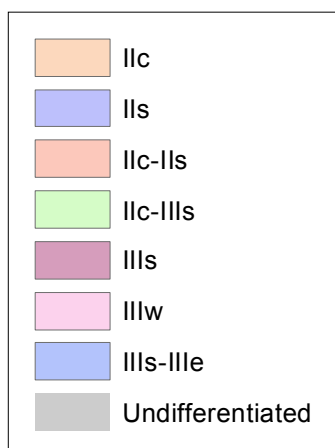
Land Capability



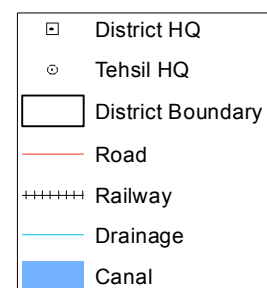
0 2.5 5 10
Kilometers



Legend



References



rainfall to support *kharif* crops. The nutrient retention capacity is good. The soils can grow climatically adapted crops of the region like jowar, bajra, maize and *kharif* legumes. Their response to alternative management is expected to be good as they are by far the most productive soils.

Mapping units grouped in lie are Associations of Nabha-Tulewal, Hissar-Nabha and Nabha-Tulewal-Hissar series associations. The sub-class association comprises 54912.96 ha i.e. 11.84% of the total area.

4.2.2 Land Capability Sub-class IIc-IIs

IIc and IIs lands include very deep well drained fine loamy and coarse loamy soils. The estimated available moisture capacity of IIc lands ranges from 5.2 to 10.3 cm for 60 cm depth and 9.0 cm to 19.0 cm for 100 cm depth and IIs lands ranges from 4.7 to 4.8 cm for 60 cm and 8.4 to 8.7 cm for 100 am profile depth. All climatically adapted crops can be grown in years of normal rainfall in He lands where as IIs lands can support maize, bajra, til, groundnut and *kharif* legumes.

Mapping units grouped in IIc and IIs sub-classes are associations of Samana-Tulewal, and Tulewal-Nabha-Kakra series. This sub-class association comprises 18240.64 ha (3.98%).

4.2.3 Land Capability Sub-class IIs

IIs lands are nearly level to gently sloping which include very deep coarse loamy soils (sandy loam to loam) with surface texture mostly sandy loam. They need leveling. Estimated available moisture capacity is 4.7 cm. to 4.8 am for 60 cm depth and 8.4 cut to 8.7 cm for 100 cm profile depth. They are suited to crops like maize, bajra, groundnut and *kharif* legumes. Mapping units grouped in IIs are association of Samana-Kakra. This sub-class comprises 54358.40 ha (11.72%).

4.2.4 Land Capability Sub-class IIc-IIIs

IIc and IIIs lands are nearly level lands which include highly potential soils with good available moisture capacity described under IIc and soils with problems of low infiltration, temporary stagnation and wet soils described under IIIs. (4.2.6). The available moisture edacity of the soils ranges from 9.2 cm to 17.0 cm for 60 cm. depth and 17.2 to about 25 cm for 100 cm profile depth. Choice of crops is restricted. Paddy and jowar are recommended. For jowar, surface drainage has to be provided.

Mapping units included in IIc-IIIs are associations of Nabha-Tohana-Hissar; Tohana-Nabha; Urdan-Manakpur; Urdan-Bahadurgarh; Bahadurgarh-Ghanaur-Patiala. This sub-class association comprises 140727.44 ha. (27.55%).

4.2.5 Land Capability Sub-Class IIs-IIIs

IIs and IIIs lands include salt affected soils like Rajendra and Suniarheri series and saline phases of other series- The differences in their response to reclamation and intensity of continued hazard of saline-alkali conditions may be largely attributed to differences in texture ranging from loam to clay. Leaching of salts, application of gypsum and growing salt resistant crops during reclamation are to be followed. The sub class association comprises an area of 73087.04 ha (15.77%).

4.2.6 Land Capability Sub-Class IIIs

IIIs lands include soils of coarse, fine and highly variable textures. The lands with coarse textures have the problem of low available moisture capacity of the soils which is 2.3 cm to 4.8 cm for 60 cm depth and 4.0 cm to 8.4 cm for 100 cm profile depth. They are susceptible to wind erosion and they cannot hold enough moisture from rain during *kharif* season to support all climatically adapted crops. They are suited to bajra, groundnut, til and *kharif* legumes during years of normal rainfall. If the rains fail in July, these lands should be preferred for *kharif* legumes. They need slight to moderate leveling.

IIIs lands have limitation of low infiltration and temporary stagnation due to heavy nature of soils thus restricting the choice of crops. Estimated available moisture capacity of the soils is about 18 cm for 60 cm depth and about 25 cm for 100 cm profile depth. The soils are not suited to *kharif* crops like bajra, maize and til but suited to paddy. With surface drainage, they can grow jowar and legumes. They may support some *rabi* crops like mustard, gram and wheat on stored moisture.

IIIs lands also include sandy loams and highly variable and stratified soils that are subject to occasional flooding, choice of crops is therefore restricted during *kharif* season.

The mapping units grouped in IIIs are associations of Bhanra- Fatehpur, Sanaur-Banra, Patiala-Rohar, Sadhu-Patiala-Jalalpur and Daun-Julkan-Kapuri-Bahadurgarh-Sanaur complex. The sub-class constitutes an area of 41455.40 ha (19.98%).

4.2.7 Land Capability Sub-Class IIIw

IIIw lands include very deep, moderately well drained to poorly drained, silt loam to silty clay loam soils. Situated on concave relief subject to temporary stagnation anchor high ground water table restricting the choice of crops. They may also be affected by saline and alkali conditions. These soils require adequate drainage and are suited to crops like paddy during *kharif*. In *rabi*, wheat and mustard may be grown depending on the level of alkalinity and ground water table.

The mapping units grouped in IIIw are associations of Todarpur-Charaihra and Ranbirpura-Bazidpur series. The sub-class association constitutes 12552.60 ha area (2.66%).

4.2.8 Land Capability Sub-Class IIIs-IIIe

IIIs and IIIe lands include very deep, droughty soils of loamy sand and sandy loam textures occurring on undulating plains with scattered low dunes. These soils have problems due to wind erosion and coarse textures. The estimated available moisture capacity is 2.3 cm to 4.8 cm for 60 cm depth and 4.0 cm to 8.4 cm for 100 cm profile depth. They are suited to bajra-groundnut and *kharif* legumes. They need slight to moderate leveling and anti-erosion measures.

Mapping unit in this sub-class- association is Fatehpur- Samana series. It comprises an area of 3092.48 ha (0.66%).

4.2.9 Land Capability Sub-Class IIe, IIIe and IVe sub-classes.

These sub-classes include very deep coarse loamy to fine loamy soils on nearly level to moderately sloping lands that are susceptible to erosion or eroded with lime nodules exposed on the surface. The lands are gullied which interfere in tillage operation. The association represents soils of undifferentiated dissected uplifted plains.

The above lands need variable treatments based on land characteristics. The moisture retention capacity of the soils varies as in the soils of IIe and IIIe land classes. This sub-class association comprises 5672.96 ha. (1.22%).

The map shows the distribution of soils according to land capability sub-classes.

4.3 Land Irrigability Classification

From the present land use, it is observed that major part of the district is under irrigation. Irrigation is through canals tube wells as well as surface wells. Tube well irrigation is a major source. Regulating irrigation according to the crop needs and selecting crops according to soil characteristics should thus be possible in a major part of the irrigated lands. Ground water quality is generally good but analysis of individual well waters will add to the efficacy of planning for individual farms.

Irrigability classification is made taking note of the fact that temperature and sunshine conditions are favourable throughout the year for climatically adapted crops. Still there are occasional frost days during January. Soil irrigability classification is made on the basis of important soil characteristics namely soil texture, depth, available water capacity of soils, inherent infiltration and permeability qualities and saline sodic conditions. Irrigability class I lands do not have any limitation and hence they are not classified into sub-groups. These include soil series that have good available moisture capacity and which do not pose problems of coarse textures drainage and salinity. The land irrigability map of Patiala and Fatehgarh Sahib districts are shown in figure 11.

Assumption made in classifying the soils are that within Irrigability subclass, soils have similar limitations.

Availability of water is assumed to be adequate. Quality of irrigation water where ground water is used is not taken into account. Such ground waters are to be considered on the basis of individual situations with respect to soil-water relationships, crop selection and management. Both canal and ground waters, however, are good in quality.

4.3.1 Irrigability Sub-class 1 Lands

These include soils which are deep with available moisture capacity from 5.2 cm to 10.8 on for 60 cm depth and from 9.0 cm to 19.0 cm for 100 cm profile depth and they can hold enough moisture from rainfall to support *kharif* crops. They are free from hazards of drainage and salinity. Under irrigation these lands can support all climatically adapted crops including horticultural plants of the region. They will respond to the recommended average irrigation schedule. The soils are expected to show most favourable interaction to management under irrigation.

Mapping units included in this class are associations of Tulewal-Nabha-Kakra, Nabha-Tulewal, Hissar-Nabha and Nabha-Tulewal- Hissar series which account for an area of 60094 ha. (13.0%).

4.3.2 Irrigability Sub-class 1-2s Lands

Include soils of Class 1 lands with good soil-moisture-air relationships and 2s sub-class lands which have problems due to heavier textures, low infiltration and other problems due to low relief that causes stagnation during rainy season. These lands limit the choice of crops and they need surface drainage during rainy season. The soils are well suited to forage crops like berseem and paddy and sugarcane under irrigation. In *rabi*, they are suited to crops like wheat, gram and mustard.

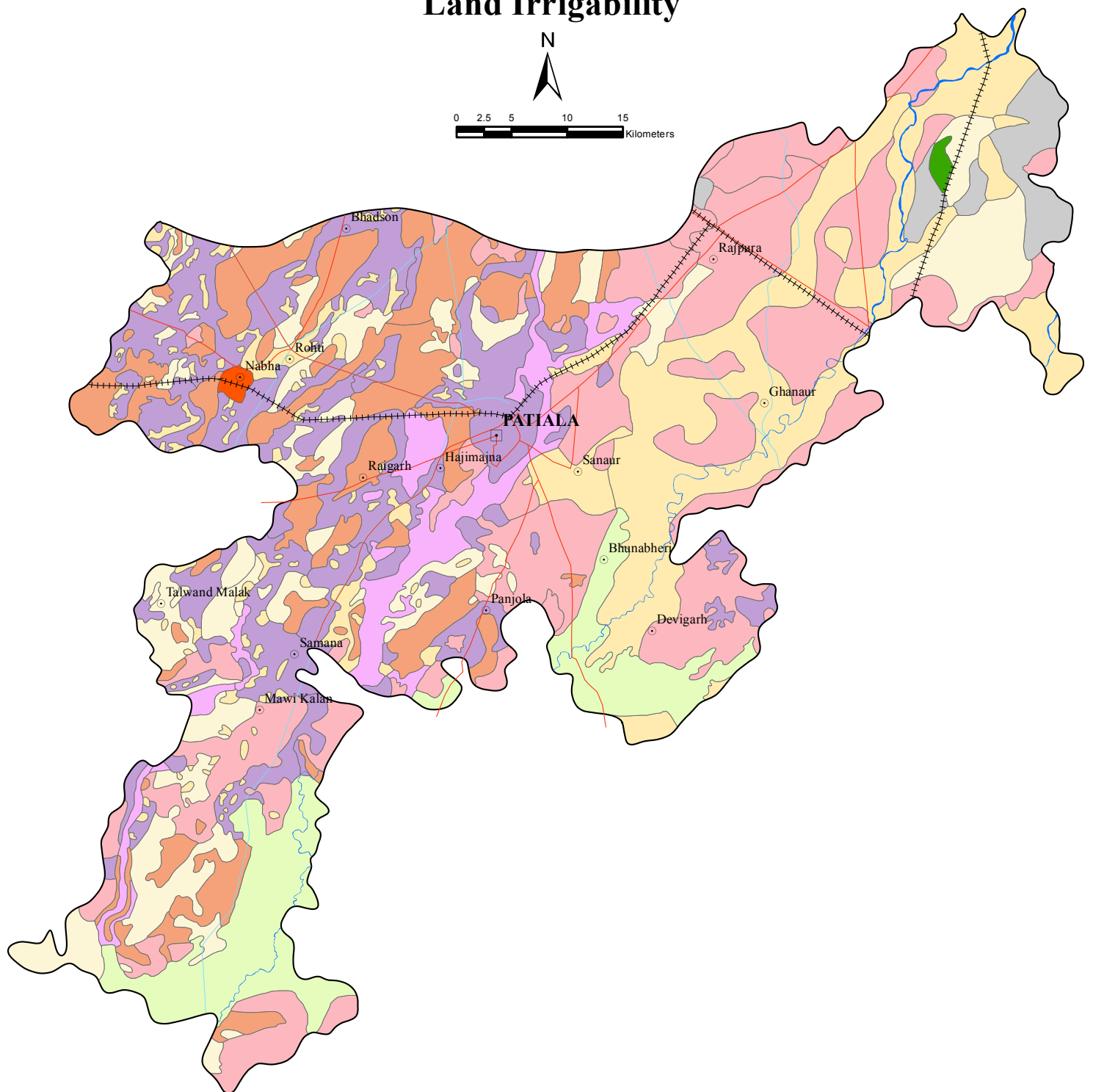
Mapping units included are associations of Nabha-Tohana-Hissar, Tohana-Nabha, Urdan-Manakpur, Bahadurgarh-Ghanaur-Patiala. Urdan-Bahadurgarh-Jalalpur series which constitute an area of 140727 ha. (30.33%).

4.3.3 Irrigability Sub-Class 2s lands

Include soils that are clayey in nature with slow permeability and susceptible to stagnation specially during monsoon. They restrict the choice of crops and the lands need proper surface drainage. The soils are well suited to paddy in *kharif* and wheat gram and mustard in *rabi*. Mapping units included in the sub-class are associations of Patiala-Rohar and Sadhu-Patiala-Jalalpur series which constitute an area of 27962.50 ha. (6.02%).

PATIALA

Land Irrigability



Legend

1	2d-3d
1-2s	2s-3s
2s	Forest
1-3s	Habitation
3s	Undifferentiated soils

References

□	District HQ
○	Tehsil HQ
□	District Boundary
—	Road
+++++	Railway
—	Drainage
—	Canal
—	River

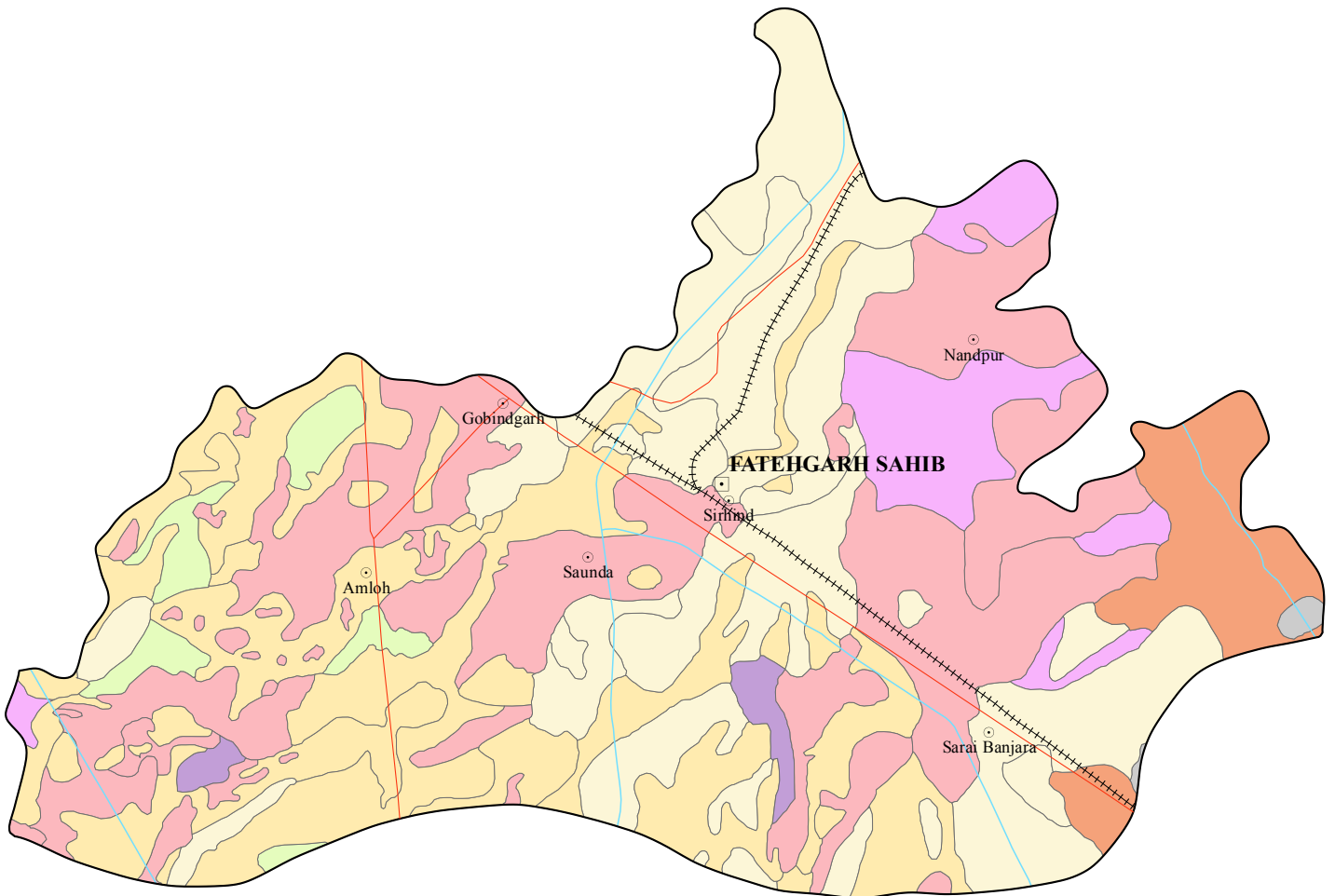


FATEHGARH SAHIB

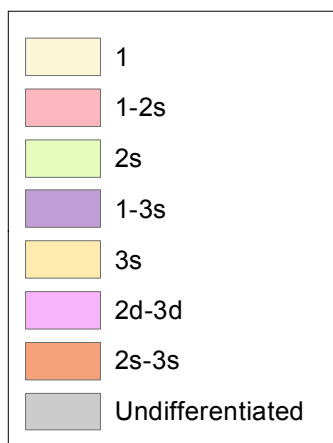
Land Irrigability



0 2.5 5 10
Kilometers



Legend



References

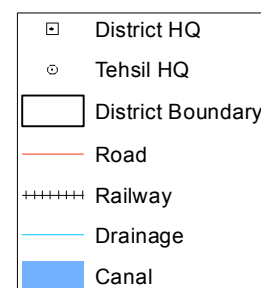


Fig. 11a: Land Irrigability (Fatehgarh Sahib)

4.3.4 Irrigability Sub-class 1-3s lands

Include soils of class 1 with good soil-moisture-air relationships in association with lands of 3s soils that are coarse textured with low available moisture capacity. The 3s soils pose the problem of water loss due to high percolation and also loss of nutrients due to leaching. They also present problems due to furrow length ratio of field area to flow for border strip or basin and flow rate of irrigation water due to coarse textures. Choice of crops for 3s lands is restricted and selection of crops to use moisture and nutrients from deeper layers of soil profile is necessary.

Mapping units included are associations of Kakra-Samana and Samana-Tulewal series, which constitute an area of 67417 ha. (14.53%).

4.3.5 Irrigability Sub-class 3s Lands

Include soils that are coarse textured with generally low available moisture capacity and also some soils of highly variable soil complex. Available moisture capacity ranges from 2.3 cm to 4.3 cm in 60 cm depth and 4.0 to 8.4 cm in 100 cm profile depth. These soils present problems due to heavy percolation losses and frequent irrigation needs. They also present problems due to shorter furrow length, ratio of field area to flow for border strip or basin and flow rate of irrigation water due to coarse textures. Low nutrient holding capacity and leaching losses of nitrogen fertilizers due to coarse textures are the major problems. Choice of crops is restricted and selecting crops that use moisture and nutrients from lower depths is necessary. Sub soils are not recommended for paddy.

Mapping units included are associations of Bhanra-Fatehpur, Fatehpur-Samana, Sanaur-Banru series and Daun-Julkan-Kapuri-Bahadurgarh- sanaur complex which occupy an area of 10649.66 ha. (2.28%).

4.3.6 Irrigability Sub-class 2d-3d Lands

Include soils that have problems due to low relief, high ground water and stagnation and overflow hazards and moderate saline-sodic conditions. The soils are fine-loamy in nature that affect infiltration and permeability. These lands need surface drainage to check overflow and rise in ground water. Crops susceptible to stagnation should be avoided.

Mapping units included are associations of Todarpur-Chataihra and Ranbirpura-Bazidpur series constituting an area of 12552.80 ha. (2.68%).

4.3.7 Irrigability Sub-Class 2s and 3s Lands

Include saline-sodic soils of fine loamy and clayey texture. Due to variation in texture efforts required to leaching salts and continuing effect of salinity hazard are expected to be different. Leaching of salts, growing salt resistant crops, and application of gypsum (based on soil test) are recommended.

Mapping unit included are association of Rajendra-Suniarheri series and saline-sodic phases of Tohana and Hissar series.

The sub-class association constitutes an area of 73087 ha. (15.77%).

4.4 Productivity and Yield Prediction

Soil productivity is the capacity of a soil in its normal environment, to produce specific crops or sequence of crops under a defined system of management. Productivity, hence, refers to the capacity of soil to produce crops and may be expressed in terms of yield.

The interpretation of soils with respect to productivity is best accomplished by gathering yield data and preparation of a table of yield estimates under alternative systems of management.

In land capability and irrigability classification, soil and land characteristics are taken into account to classify them under different categories. Productivity and yield prediction estimates may be considered as a further step for developing interpretation of soil for land use planning. In the area surveyed wheat is the most important crop. It is grown on most of the soils mapped. There is more awareness among farmers to use improved technology for obtaining better yields. Hence, a study was made to estimate productivity of different soils in respect of wheat crop under defined management levels.

Data were collected by observation of crops in the field from time to time and making enquiries from the farmers on the performance and management according to a designed questionnaire. Management as input was an important variable to estimate productivity under specific combinations of treatments. As the study was made on the basis of individual farmer's management efforts, there were several variations. Nevertheless, it was possible to classify management into three identifiable levels within the area. Following are the three levels of management defined on the basis of information collected during survey from individual farmers.

- a) Low level of management.
Use of local varieties, 0-20 kg/ha of Nitrogen 4-5 ploughing; less than optimum irrigation, no plant protection measures. (Farmers method)
- b) Medium level of management.
Use of improved varieties, 20 to 40 kg/ha of Nitrogen, 5-6 ploughings, adequate irrigation, no plant protection measures.
- c) High level of management.
Use of improved varieties, 40 to 60 kg/ha of Nitrogen, 30-40 kg/ha. phosphorus, 6-8 ploughings adequate irrigation, some plant protection measures.

Generally the farmers over irrigate when the water is available.

The yield predictions at different management levels as generated from the data and the interviews with the farmers are given in table 7. The Indications are that at low level of management coarse soils have low yield potential but compete with clayey soils at high level of management. Fine loamy soils are the best at all levels of management.

Table 7 Predicted yield of wheat on coarse loamy, Fine loamy and clayey soils (g/ha)

Level of Management	Textural family		Clayey
	Course Loamy	Fine Loamy	
Low	15-20	20-25	No data
Medium	25-30	35-40	30-33
High	35-40	40-45	37-40

Broadly speaking the differential response to management, may be attributed to differences in soil-moisture-air relationship and soil textural variations. On fine loamy soils (Nabha and Hissar series; highest yield is obtained under irrigation under assured moisture supply. Lower yields on coarse loamy soils (Samana series) is obviously due to low available moisture and nutrient holding capacity. The similar performance of coarse loamy soils and clayey soils may be explained as due to low available moisture capacity in former and adverse soil- air-plant relationship in the latter.

Table 8 gives distribution of different soils in the area surveyed in Patiala District.

Soil maps indicate distribution of soils which will help choice of adapted crops based on soil-plant-water relationships. Reconnaissance Soil map of the district has brought out distribution of different soils occurring in

the district with their salient characteristics based on this map, other namely map showing distribution of sandy and fine loamy soils, map showing dominant problem and potential soils of the district and map showing the distribution of salt affected lands are prepared and appended.

Table 8 Distribution of soils according to textural families in Patiala District

	Soil Series Association	Area (ha)	Textural family	Area (ha)	Percentage
1.	Bhanara-Fatehpur	4505.30	Sandy	4505.60	0.97
2.	a) Fatehpur-Samana	3092.48	Sandy - Coarse loamy	6144.00	1.31
	b) Sanaur-Banru	3051.52			
3.	Kakra-Samana	54358.40	Coarse loamy	54358.40	11.72
4.	a) Samana-Tulewal	13059.20	Coarse loamy Fine loamy	18240.64	3.93
	b) Tulewal-Habha-Kakra	5181.44			
5.	a) Nabha-Tulewal	14471.20	Fine loamy	54912.96	11.84
	b) Hissar-Nabha	12342.40			
	c) Nabha-Tulewal-Hissar.	28099.36			
6.	a) Ranbirpura- Bazidpur	4872.80	Fine loamy (Salt affected and high ground water table)	12552.80	2.68
	b) Todarpur- Chataihra	7680.00			
7.	Suniarheri-Rajendra.	73087.04	Fine loamy-Clayey (Salt affected)	73067.04	15.77
8.	a) Nabha-Tohana- Hissar	42654.40	Fine loamy-clayey	203814.48	30.33
	b) Tohana-Nabha	14848.40			
	c) Urdan-Manakpur	12943.36			
	d) Urdan-Bahadurgarh - Jalalpur	25309.12			
	e) Bahadurgarh- Ghanaur- Patiala	44972.15			
9.	a) Patiala-Rohar	22636.30	Clayey	27961.60	6.22
	b) Sadhu-Patiala-Jalalpur	5324.80			
10.	Daun-Julkan-Kapuri-Bahadurgarh-Sanaur	62263.60	Stratified	62263.60	13.00
11.	Undifferentiated soils			5672.96	1.22

These maps show the utility of soil maps to know soil characteristics, specific crop interaction under different levels of management and the adaptable crops that can be raised to sustain the needs of people. The information on maps clearly indicates the role of soil maps to evaluate the lands. Productivity as function of soil characteristics and management provides information to make choice of crops for better economic returns. For a planner, this provides information to plan for balanced production of different agricultural crops in the context of macro-level and micro level planning and meeting the requirements of different crops like cereals, legumes and oil seeds. A reconnaissance map is useful for macro level planning as it lacks basic units of mapping; for micro level planning detailed soil maps that show the separation of phases of basic soil classes of villages are essential.

5.

CROP AND MANAGEMENT RECOMMENDATIONS

The area is already being used for intensive agricultural production as shown by data on present land use. Soil survey has provided information on the distribution of different soils-in the area and their inherent characteristics and qualities. Based on these, land evaluation has been made for rainfed and irrigation farming. Information on productivity and prediction of yields should make it possible to choose package of practices for projected yields or to make contingency plans.

Management requirements and adapted crops are listed for various land classes. The recommendations given furnish general guidelines for cropping and management practices based on the field observations made and extension and research information particularly of Punjab Agricultural University, Ludhiana and the State Department of Agriculture, Punjab. However, these do not replace the detailed recommendations made by Extension Agronomists. The recommendations refer to the identified and mapped soil units. Adapted crops on different soil series is given in table 9 & 10.

5.1 Soils with high Groundwater

Drainage of affected lands is essential. Proper surface drainage will mitigate the problem of high ground water and/or overflow and stagnation. Paddy may be grown with supplemental irrigation followed by barley, mustard, gram and lentil. The mapping units indicate that such soils are dominantly affected by poor drainage. Onsite problems of soils of other units will have to be tackled for individual fields.

5.2 Seed bed length

Length of seed bed should not be more than 90-120 m in case of Bhanra, Fatehpur, Samana, Kakra, Sanru and Sanaur series for better distribution of irrigation water as the soils are coarse and utility of moisture is important before it percolates below the root zone.

5.3 Salt affected soils

Table 8 shows that about 18 per cent of the area is affected by saline-alkali problems. Leaching salts and reclaiming alkali soils are necessary. Salt affected soils generally do not pose problems to reclaim. Leaching may be followed by dhaincha for green manuring or paddy based on removal of salts and alkali in the upper part of the profile. With partial reclamation, mustard, barley, wheat and berseem can be grown.

In the district, the farmers are reclaiming soils through leaching of salts especially where the soils are of fine loamy nature. Where ground water is high surface and/or deep drains may be necessary. For leaching of salts or reclaiming alkali soils due consideration of soil texture is necessary. In the district the dominant salt affected lands come under fine loamy and clayey textural families.

5.4 Fertilizer and Manure

Recommended doses of fertilizers need to be used on different soils according to crops. Recommended dose, economic dose and half the recommended dose that have been worked out by the P.A.U. are expected to give good results on fine loamy soils, which are grouped under IIc land capability sub-class and Class 1 land irrigability. Lands with coarse textured soils, wet soils, soils with free lime within first 50 cm soil profile and saline sodic soils need appropriate modifications. Recommendations for marginal land holders could be modified for maximum return per unit of applied fertilizer and other inputs to keep down the cost.

5.5 Soils of High Productivity Potential for Wheat

Nabha, Hissar, Bahadurgarh, Urdan and Tulewal aeries are soils of high productive potential for wheat crop. They will respond best under different levels of management. Wheat crop was chosen to know the productive potential of soils because this crop is systematically replacing other crops like legumes and oil seeds, which are also important to fulfil pulse and oil seed requirement. Table no. 8 shows the distribution of soils under different associations with their family texture differentiae.

The distribution of soils shown on various maps should be helpful to develop the concept of area planning to meet the requirement of macro and micro level planning.

5.6 Alternate Crops

The major problems identified in alluvial plains are poor growth of maize, jowar and bajra due to excess moisture in heavy soils and deficiency of moisture in coarse textured soils.

Observations in the field revealed that such poor performance may be either due to excess rainfall in a particular season or due to nature of soils and site characteristics that encourage stagnation of water. Following suggestions are made for alternate cropping strategy.

- a) Near cites land under irrigation where maize jowar or bajra crops fail due to heavy showers in July-August alternate crops may be vegetables and potato in the succeeding months. September sown vegetable (carrot) or potato be followed by wheat sown upto mid-December.
- b) On coarse textured soils if the rains fail in August short duration *kharif* legumes and til are recommended.
- c) In similar conditions alternate crop to rainfed bajra could be toria followed by wheat with irrigation.
- d) Peas should become an important alternative crop for wheat especially on those soils that are identified as less productive for wheat. Peas, gram and/or mustard should be alternative crops for wheat under rainfed or limited irrigation. Frost injury needs to be kept in view.
- e) On salt affected lands, mustard may be an alternative crop to wheat.
- f) Mixed and relay cropping should be encouraged for complementary utilization of moisture and applied fertilizers from lower depths of soil profile. Mixed cropping should be encouraged on marginal from holding.

TABLE 9. CROP ADAPTABILITY TABLE FOR DIFFERENT SOILS

Soil Series association and textural family		Available moisture capacity cm/60 cm. depth.	Kharif		Rabi	
			Unirrigated	Irrigated	Unirrigated	Irrigated
	1	2	3	4	5	6
1.	Bhanra-Fatehpur (Sandy)	2.3 to 2.6	Guar, Moong, til, Castor	Bajra, Moong, groundnut	Fallow, taramira, barley	Barley, sunflower
2.	Fatehpur-Sahana-Sanaur-Banru (Sandy-Coarse loamy)	2.3 to 4.8	Guar, moong, til, castor	Bajra, guar, moong, groundnut	Fallow, barley, gram, mustard, taramira	Barley, mustard, sunflower, turnip
3.	Kakra-Samana (Coarse loamy)	4.7 to 4.8	Barja-arhar guar, moong	Bajra, improved arhar, guar, moong, maize, tomato, brinjal, cucurbits and potato.	Fallow-barley, mustard, gram	Barley, wheat, mustard, toria, sunflower, pea, carrot, raddish.
4.	a) Tulewal-Nabha-Kakra	4.8 to 9.2	Bajra, arhar, moong, guar	Bajra, improved arhar, guar, moong, maize, cotton, tomato, brinjal, cucurbits and potato.	Mustard, barley grain	Wheat, potato, pea carrot, onion, toria, garlic, sunflower
	b) Samana-Tulewal (Coarse loamy fine loamy)	4.7 to 5.2				
5.	a) Nabha-Tulewal b) Hissar-Nabha c) Nabha-Tulewal-Hissar (fine loamy)	5.2 to 10.8	Chari, jowar, dhaincha, urd	Chari, jowar, maize, cotton, paddy-sugarcane, moong, urd, tomato, brinjal, onion, bhindi and chillies.	Barley, gram	Wheat, onion, peas, cauliflower, chillies
6.	a) Tohana-Nabha b) Urdan-Manakpur c) Urdan-Bahadur-garh-Jalalpur d) Bahadurgarh-Ghanaur-Patiala (Fine loamy clayey)	9.2 to 17.0	Chari jowar, dhaincha	Paddy, sugarcane, jowar, masur, cotton	Gram, lentil	Wheat, berseen, lentil
7.	a) Patiala-Rohar b) Sadhu-Patiala (Clayey)	17.0	Chari-jowar, dhaincha	Paddy	Gram-lentil	Wheat-berseem, lentil, gram
8.	a) Ranbirpura-Bazidpur b) Todarpur-Chataihra c) Patiala-Rohar (Fine loamy-clayey)	-	Dhaincha, Green-gram, chari	Paddy, chari berseem	Barley, gram, lentil	Wheat, berseem, lentil, gram
9.	Suniarheri-Rajendra	-	Dhaincha	Dhinch-a-roads, grass. Atter primary reclamation, paddy berseem	Barley, Mustard	Barley-berseem, mustard
10.	Daun-Jalkan-Kapuri-Bahadur-garh-Sanaur. Highly variable stratified	6.7 to 14.0	Chari-jowar	Summer vegetables, early, chillies, chari, maize, jowar	Barley, toria	Barley, wheat mustard, peas, cauliflower, chillies, summer vegetables
11.	Undifferentiated	5 to 8	Bajra, Arhar, Guar, Cowpea, Sunhemp	Maize, Moong, Bajra, Moong	Gram, Barley, Taramira	Wheat, Mastard

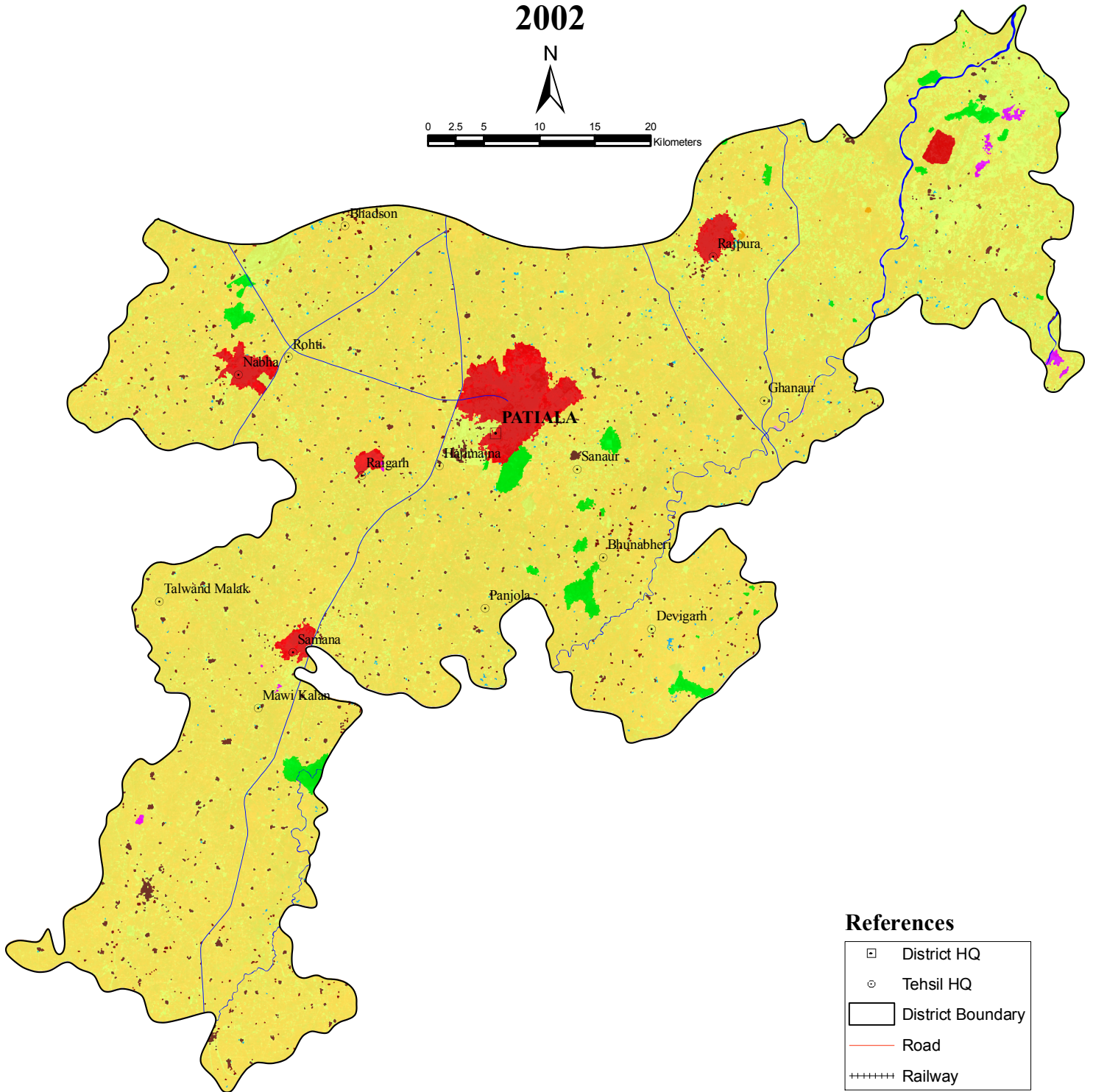
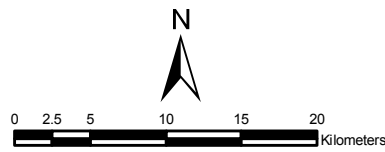
5.7 On-site problems

On-site problems of stagnation due to construction of roads and embankments are to be tackled on individual field basis. Provision of surface drainage may become on-site or specific crop requirement. Land Use/Land Cover map of Patiala and Fategarh Sahib districts are shown in figure 12 and 12a.

PATIALA

Land Use/Land Cover

2002

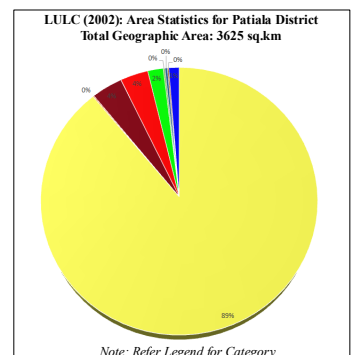


References

	District HQ
	Tehsil HQ
	District Boundary
	Road
	Railway

Legend

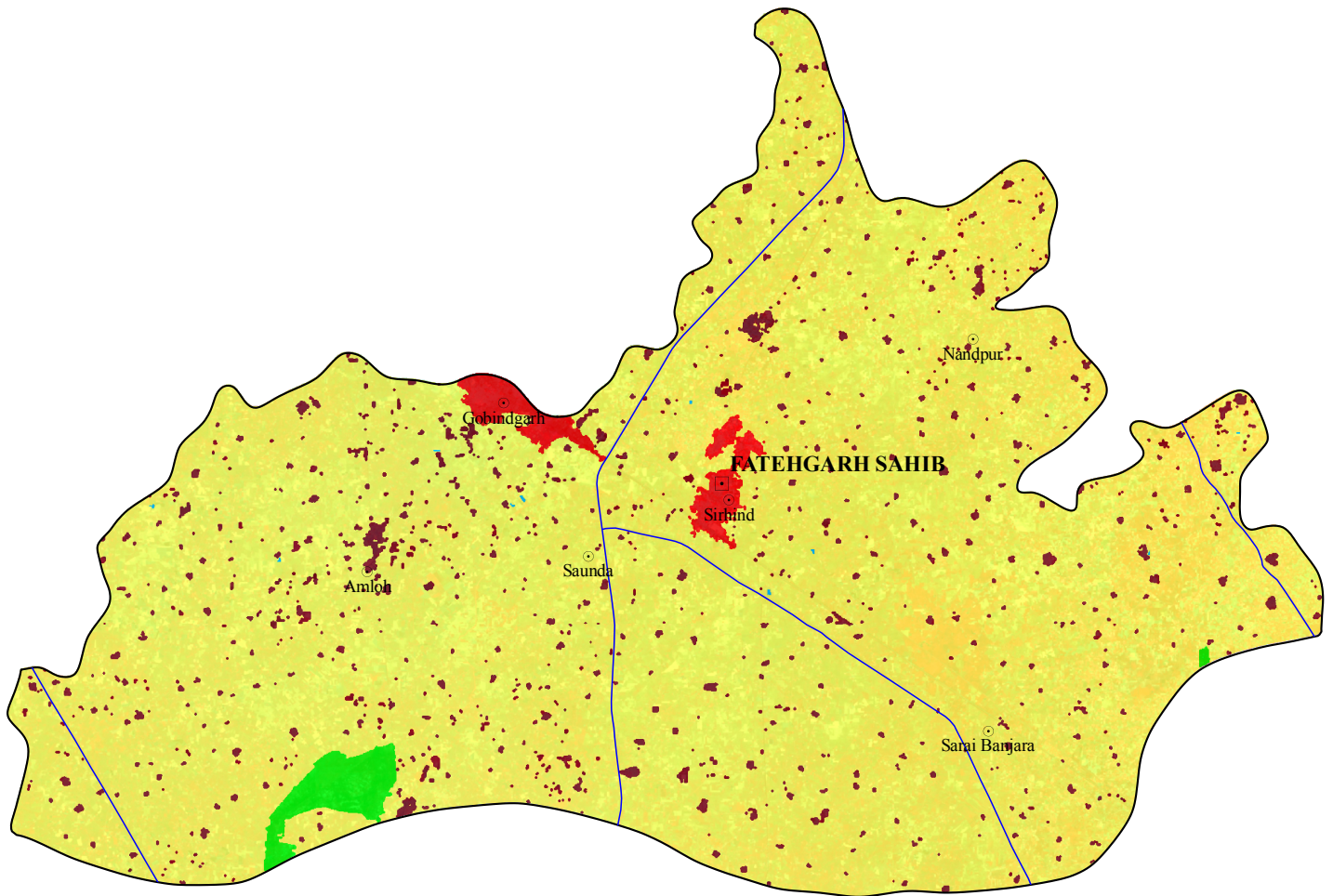
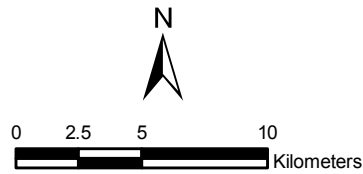
Classes	Area [sq.km]	Classes	Area [sq.km]
Agriculture		Uncultivable	5
Agriculture, Cropland	3225	Barren/Uncultivable/Gullied/Ravinous Land	7
Agriculture, Plantation	5	Barren/Uncultivable/Wastelands/Sandy Area	11
Builtup		Water	
Built-up, Rural	136	Wetlands/Water Bodies, Reservoir/Lakes/Ponds	6
Built-up, Urban	122	Wetlands/Water Bodies, River/Stream/Canals	45
Forest			
Forest, Deciduous	68		



Data Source: Landsat ETM+ Satellite data of Kharif (2002) and Rabi (2002), SRTM DEM, Existing Soil Maps & Reports (NBSS & LUP), and other Statistical Data

Fig. 12: Land Use/Land Cover (Patiala)

FATEHGARH SAHIB Land Use/Land Cover 2002

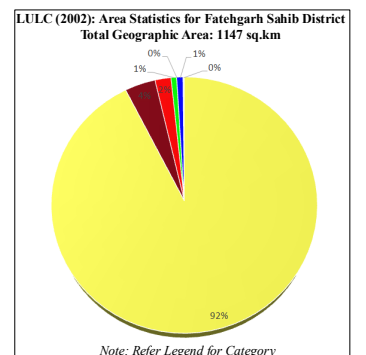


References

	District HQ
	Tehsil HQ
	District Boundary
	Road
	Railway

Legend

Classes	Area [sq.km]	Classes	Area [sq.km]
Agriculture		Water	
Agriculture, Cropland	1061	Wetlands/Water Bodies, Reservoir/Lakes/Ponds	0.19
Builtup		Wetlands/Water Bodies, River/Stream/Canals	9
Built-up, Rural	44	Others	1.81
Built-up, Urban	23		
Forest			
Forest, Deciduous	8		



Data Source: Landsat ETM+ Satellite data of Kharif (2002) and Rabi (2002), SRTM DEM, Existing Soil Maps & Reports (NBSS & LUP), and other Statistical Data

Fig. 12a: Land Use/Land Cover (Fatehgarh Sahib)

6.

MORPHOLOGY GENESIS AND CLASSIFICATION OF SOILS

Any identified soil can be explained in relation to its environment. Each soil exhibits certain characteristics as determined by climate and living organisms operating over period of time on soil forming materials and on landscapes of varying relief. Thus the environment in which an individual soil is formed is related to interaction of climate vegetation Soil forming material, relief and drainage and the length of time. However, soil characteristics which are observable or measurable are the basis for their classification.

6.1 Climate

The climate of the district is semi-arid and both summer and winter are severe. June is the hottest and January the coldest month. Mean maximum and mean minimum summer air temperatures are 38.3°C and 23.3°C, respectively. Mean maximum and mean minimum winter air temperatures are 22.5°C and 10.1°C. The mean summer air temperature is 31°C and the mean winter air temperature is 16.3°C. The mean annual air temperature is 24.5°C and the difference between mean summer and mean winter temperature is more than 5°C. Hence the districts come under hyperthermic temperature regime.

Climatological data are given in table 10.

Dust storms are common in May and June when the dry temperature exceeds 40°C. Wind modification of the soils is observed in the area resulting in the formation of scattered sand dunes on which soil aeries like Bhanra/Fatehpur are found to occur. Frost occurs during January which however, is not common.

The rains start in the month of June and continue up to September. It is in its peak in the month of July and August. More than 75% of precipitation is received during these months.

There are light showers during winter months of December, January and February. On an average 5 to 7 cm of rainfall is received in these months.

Potential evaporation (PE)

The PE data indicates that April, May and June are the months of which potential evaporation. PE is highest in the month of June which is 216.4 mm. PE starts decreasing from October and reaches a minimum of 47 mm in the month of December. Precipitation is higher than PE in the months of July and August. Surplus moisture in August is possibly carried through September in the soils for utilization by dry crops.

Effects of overhead climatic environment may be considered same for the district as a whole.

6.2 Physiography, Relief and Drainage

The district may be separated into following physiographic regions namely undulating plains with scattered low sand dunes, nearly level old flood plains or alluvial terraces, old flood plains on concave relief in the west, flood plains of Patialawali nadi and chao in the middle and nearly level old flood plains, low lying old flood plains, recent flood plains and old meander plains of Ghagggar in the east and dissected uplifted plains in the north.

Table 10 Climatological data of Patiala
(Based on observations 1931 to 1960)

Month	Temperature in °C			Relative humidity %	Potential evaporation (mm)	Average precipitation (mm)
	Max	Min	Mean			
January	1 11	20.2	7.1	13.8	81 55	47.7 20.4
February	1 11	24.2	9.3	16.7	69	75.9 28.3
March	1 11	29.4	13.8	21.6	59 34	121.5 10.6
April	1 11	36.0	19.2	27.6	40 20	168.7 3.0
May	1 11	40.2	24.0	32.1	36 20	211.7 13.6
June	1 11	40.4	26.7	33.5	51 31	216.4 87.0
July	1 11	35.2	26.4	30.8	77 60	157.6 237.0
August	1 11	33.5	24.5	29.5	83 67	131.9 215.6
September	1 11	34.4	23.8	29.1	76 58	134.0 47.1
October	1 11	32.4	17.8	25.1	66 47	111.1 19.6
November	1 11	28.2	10.6	19.4	62 45	67.6 2.0
December	1 11	23.1	7.3	15.2	78 50	46.4 16.6
Total/Mean		31.4	17.6	26.5	—	1491.0 730.8

(Source - India Meteorological Department, Scientific Report No.136, February, 1971).

6.2.1 Undulating old plains with scattered low dunes

Major area of the unit is in Nabha and Samana tehsils and is characterized by lands with slopes of 2-10% covered with light textured soils. Soils are mostly well drained with moderate to rapid permeability. Soil series namely Bhanra, Fatehpur, Samana, Kakra and Tulewal are found to occur in this physiographic unit.

6.2.2 Nearly level Old Flood Plains or Alluvial Terraces

This unit is found to occur in Nabha, Samana and part of Patiala tehsils and is characterized by very gently to gently sloping lands (0-3% slopes) covered with fine loamy and clayey soils. They are well to moderately well drained and mostly belong to Nabha, Tulewal, Hissar and Tohana series.

6.2.3 Old Flood Plains of Concave Relief

(a) With high groundwater table

This unit is found to occur on the old river channels and low lands where water stagnates during rainy season. This may be considered as the drainage way from the area of the above mentioned units. Soils are fine loamy and have gleyed colours where ground water is within one meter. Soil series like Ranbirpura and Bazidpur are found in this physiographic unit.

(b) With low groundwater table

This unit is also on concave relief with moderate to imperfect drainage where the soils are saline sodic but groundwater is lower than in the unit (a). Stagnation of water during monsoon is common. Rajendra and Suniarheri are the soils in this setting.

6.2.4 Flood Plains of Patialawali Nadi

It represents level land of concave relief which is subject to flooding every year and found to occur along the Patialawali Nadi. The soils are silt loam to silty clay loam in texture, soil series, Todarpur, and Chataihra are found to occur in this situation.

6.2.5 Flood Plains of Ghos Nadi

This unit comprises flat to concave relief, moderately well drained to imperfectly drained lands, which are subject to flooding every year. It is found to occur along the Ghos Nadi. The soils are silt loam to silty clay loam in texture. Low relief has affected the drainage condition.

6.2.6 Ghaggar Flood Plain

Ghaggar river and its attendant tributaries of the Siwaliks have formed this plain, ghaggar plain occupies the whole of Rajpura and part of Sirhind, Patiala and Santana tehsil is the sediments brought by this river are characteristically or redioisn material. The flood plains can be further divided into:

(a) Upper Old Flood Plain

It comprises nearly level to level lands well drained to moderately well drained silty clay loam to silty clay soil forming materials of 7.5 YR to 5 YR hue. They are mostly found to occur away from the river Ghaggar and are not subject to flooding. Soil series occurring in this plain are Manakpur, Urdan, Ghanaur, Bahadurgaih, Jalalpur and Patiala.

(b) Low Lying Old Flood Plain

The plain in almost level to flat land and moderately well to imperfectly drained. They are clayey or silty clay soils of 7.5 YR and S YR hue, subject to seasonal flooding. Some soils have cracking properties. Sadhu. Rohar. Jalalpur and Patiala series occur on the plain.

(c) Old Meander Plain

Meander plains are commonly formed by changing of river courses viz. Ghaggar and its tributaries. The soil material is highly variable and stratified. Soil series like Jalkan, Kapuri, Duan and Sanaur are found to occur in this situation.

6.2.7 Dissected (Uplifted) Plain

It is a part of lower siwaliks and is severely dissected. It is thought that in the first instance, this was an upliftment and then became dissected. It is found to occur north of the Rajpura Tehsil which is adjoining Chandigarh. Several choes of ephermal nature drain this plain.

In the general area, physiography as a factor of the soil environment has its effect on the setting and drainage characteristics of soils. In the western and mid-western part of the district saline sodic conditions are also due to relief and landscape setting under the existing climatic conditions.

6.3 Vegetation and Biotic Activity

Vegetation and biotic activity as a factor in the soil environment have been identified in the area.

Natural vegetation is greatly altered due to human activity. Still differential/preferential occurrence of some shrubs and grasses may be observed yet the effect of natural vegetation and biotic factor are not dominant as environmental factors of soli formation.

Natural vegetation consists of trees like Babool (*Rccada arabica*), Sisam (*Dalberoa sissoo*), Shahtoot (*Morns alba*), Neem (*Asadirachta indica*), Ber (*Zizyphus jujuba*), Peepai (*Ficus relioiosa*), Dhak (*Butea monosperma*), Dek (*Meija azadirachta*), Khajur (*Phoenix dactvlifera*), Barota (*Ficus indica*), Siras (*Albezia lebbeck*), Faras (*Tamarix anhvlla*), Jammun (*Svzvoium cummuni*). Herbs and shrubs like Jherberi (*Zizvohus numalaria*). Karil (*Caonaris linin*). Aak (*Calitraole procera*), Moonj (*Erianthus ravenae*) Khair (*Accacia Catechu*), Gugal (*Balsam odenetron mukul*), Dela (*Cyprus rotendus*). Pyagi (*Asohodelus tunifolius*), Hirannkhuri (*Convolvulus arvensls*)/ Bathu (*Chinonodium album*), Kans (*Saccharum spontaniuml*).

6.4 Soil forming material

The soil forming material is derived largely from the alluvial sediments originated from the unconsolidated sedimentary rocks of Siwaliks of Tertiary origin. In the south-western and western parts, the alluvium is modified by wind activity resulting in dunes. The sediments may also come from Choa Nala, Patiala wall nadi and Ghaggar and its tributaries.

Whereas, the sediments of Ghaggar are of 7.5 YR due, other soil forming sediments are of 10 YR hue. When the variation within different kind of alluvium is considered texture becomes an important differentiating characteristics. Besides, the occurrence of free and nodular lime further distinguishes the soils of the area. The mineralogy of the soils can be defined as mixed.

These plains are considered to be the formations of the latest Himalayan system of upheaval due to folding Siwalik sediments have high dips and some degree of induration both of which are absent in the alluvium deposited on the plains. The Siwaliks are represented by the unconsolidated material of varying colour in 10 YR, 7.5 YR and 5 YR hues and texture composition of the sediments that are sand silt loam clay loams, clays and conglomerate.

Soil forming material variability in the plains is not only due to the variability's in the Siwaliks but also due to geometry of stream depositions in the plain and to some extent to local wind modifications.

6.5 Time

Soils of the district are related to different periods of the Pleistocene age. Those of the old flood plains are older than the soils of Ghaggar plains and the sand dunes covering the older alluvium. Still this is a factor of soil formation.

6.6 Morphology and Classification

Morphology is distinguished by the nature of the soil forming material which varies from sand to clay within the soil series control section. This is besides the two major alluviums on which the soils are formed in the district i.e., one brought by Ghaggar and other by Uhoa Nala. Other characteristics of dominant morphological differentiation are stratification of soil forming materials; drainage differentiates as indicated by mottles or high water table, relief and presence of free and nodular lime. Not much difference in soil structure is observed.

Soil classification and mapping are based on morphology as influenced by the various environmental factors described. Soil series has been the fundamental unit of classification and the delineations of series associations are shown on the map. The soil series is a group of soils having soil horizons similar in differentiating characteristics and arrangement in the profile and developed from the same parent material. The soils within a series are essentially homogeneous in all characteristics except in texture of the surface horizon, slope, erosion and topographic position when these factors do not modify greatly the kind of arrangement of horizons.

In view of the importance of textures the soil series are identified as textural families as the series differentiae are defined. Similarly, lime in the soils profiles is taken to differentiate either as series characteristics or as family differentiae.

With the knowledge of moisture regime through meteorological and soil morphological data and the laboratory

analysis soil classification at higher category level is made through proper keying out of the soil series according to soil taxonomy.

Soils of the Patiala and Fatehgarh Sahib districts have been classified according Taxonomy (Fig 13 and 13a).

In this district the epipedon is mostly ochric and sub-surface diagnostic horizon is cambic. Three orders viz. Entisol, Inceptisol and Alfisol have been recognized. Detailed classification is presented in Table 11.

6.6.1 Entisols

Entisols are the soils that lack diagnostic horizon other than an ochric epipedon. They are found on recent geomorphic surfaces or slopes that are undergoing active erosion. Three sub-orders are identified:

6.6.1.1 Psammments are the soils that have textures of loamy fine sand or coarser typic sub-group of Ustipsammments was identified. Bhanra, Fatehpur and Sanaur Series come under this sub-group.

6.6.1.2 Fluvents are the soils that have textures of loamy very fine sand or finer in some sub-surface horizon and the organic carbon content decreases irregularly with depth or remains above 0.2 per cent at a depth of 1.25 m. Typic sub-group of Ustifluvents was identified, Baun, Julkan, Rajehdra and Kapuri come under this sub-group.

6.6.1.3 Orthents are the soils that have textures of loamy very fine sand or finer below Ap in some sub-horizon and organic matter content decreasing regularly with depth. Typic sub-group of Ustorthents was identified. Banru series comes under this sub-group.

6.6.2 Inceptisois

Inceptisois are developed over alluvium. They include soils that have a cambic horizon that may be formed due to leaching, gleying or removal of carbonates etc. Two sub-orders, Aquepts and Ochrepts are identified.

6.6.2.1 Aquepts

Soils which are saturated with water or have strong greying within 50 cm.

Halaquepts: Soils that have sodium saturation of more than 15 per cent in some part of the upper 50 cm and decreasing with depth below 50 cm. Aerie Halaquepts are the soils with lighter chromas than Typic. Suniarheri is classified under this sub-group.

Haplaquepts: Soils that have ochric epipedon and organic matter content decreasing with depth. They are lighter in colour. Aerie Haplaquepts are the soils with lighter chromas than Typic Haplaquepts. Ranbirpura series is classified under this sub-group. Bazidpur series is classified under Typic Haplaquepts.

6.6.2.2 Ochrepts

Soils with an ochric epipedon and a cambic horizon. The colours are in the shades of brown and yellow.

Ustochrepts are Ochrepts that are calcareous at shallow depth and have lime or calcic horizon. The following sub-groups of Ustochrepts were identified.

Typic Ustochrepts: Soils which show regular decrease in organic matter content, lact cracking, mottling and characteristics associated with wetness. Kakra, Longowai, Tulewal, Urdan, Hissar and Bahadurgarh series come under this sub-group.

Fluentic Ustochrepts: Ustochrepts with an irregular decrease of organic matter content with depth or organic carbon remains more than 0.2 per cent at depth of 1.25 m. Ghanaur, Manakpur, Patiala, Tohana, Jalalpur and Rohar series come under this sub-group.

Vertic Ustochrepts: Ustochrepts that have more than 35 per cent clay and cracks at some period in most years. Sadhu series come under this group.

Udic Ustochrepts: Ustochrepts free from carbonates or the carbonates are in deeper layers. They are otherwise like Typic Ustochrepts. Sanana and Nabha series come under this sub-group.

6.6.3 Alfisols

6.6.3.1 Haplustalfs: Alfisols with an argillic horizon lacking characteristics defined for other Ustalfs. Typic Haplustalfs are Haplustalfs having a calcic horizon or soft powdery secondary lime at moderate depths, Chataihra series comes under this sub-group.

Table 11. Soil Classification

Order	Suborder	Great group	Sub-Group	Family	Series
Entisols	Psamments	Ustipaamments	Typic	Sandy	Bhanra, Fatehpur, Sanaur
			ustipsamments		
	Fluvents	Ustifluvents	Typic	Coarseloamy, calcareous, coarse silty, calcareous. Fine silty over coarse loamy calcareous	Daun, Julkan, Kapuri
			ustifluventa	Fine loamy	Todarpur
				Fine loamy, calcareous	Rajendra
				Coarse loamy, calcareous	Banru
	Orthents	Ustorthenta	Typic	Coarse loamy, calcareous	
			Ustorthents		
	Inceptisols	Aquepts	Typic	Fine loamy, calcareous	Bazidpur
			Halaquapts		
		Haplaquepts	Aerie	Fine loamy, non acid	Ranbirpura
			Haplaquepts		
		Halaquepts	Typic	Fine loamy, calcareous	Suniarheri
			Halaquepts		
	Ochrepts	Ustrochrepts	Udic	Coarse loamy, non acid	Samana, Kakra
			Ustochrepts	Fine loamy, nonacid	Tulewal, Nabha,Urdan.
			Typic	Fine loamy, calcareous	Hissar, Bahadurgarh,Choa
			Ustochrepts		
			Fluventic	Clayey, calcareous	Ghanaur,Manakpur
			Ustoch- repts		
				Fine silty over clayey calcareous	Jalalour
				Clayey over Fine loamy	Rohar
				Clayey	Patiala, Tohana
			Vertic	Clayey	Sadhu
Alfisols	Ustalfs	Heplustalfs	Typic	Fine silty, calcareous	Chataihra
			Haplustalfs		

PATIALA

Soil Taxonomy

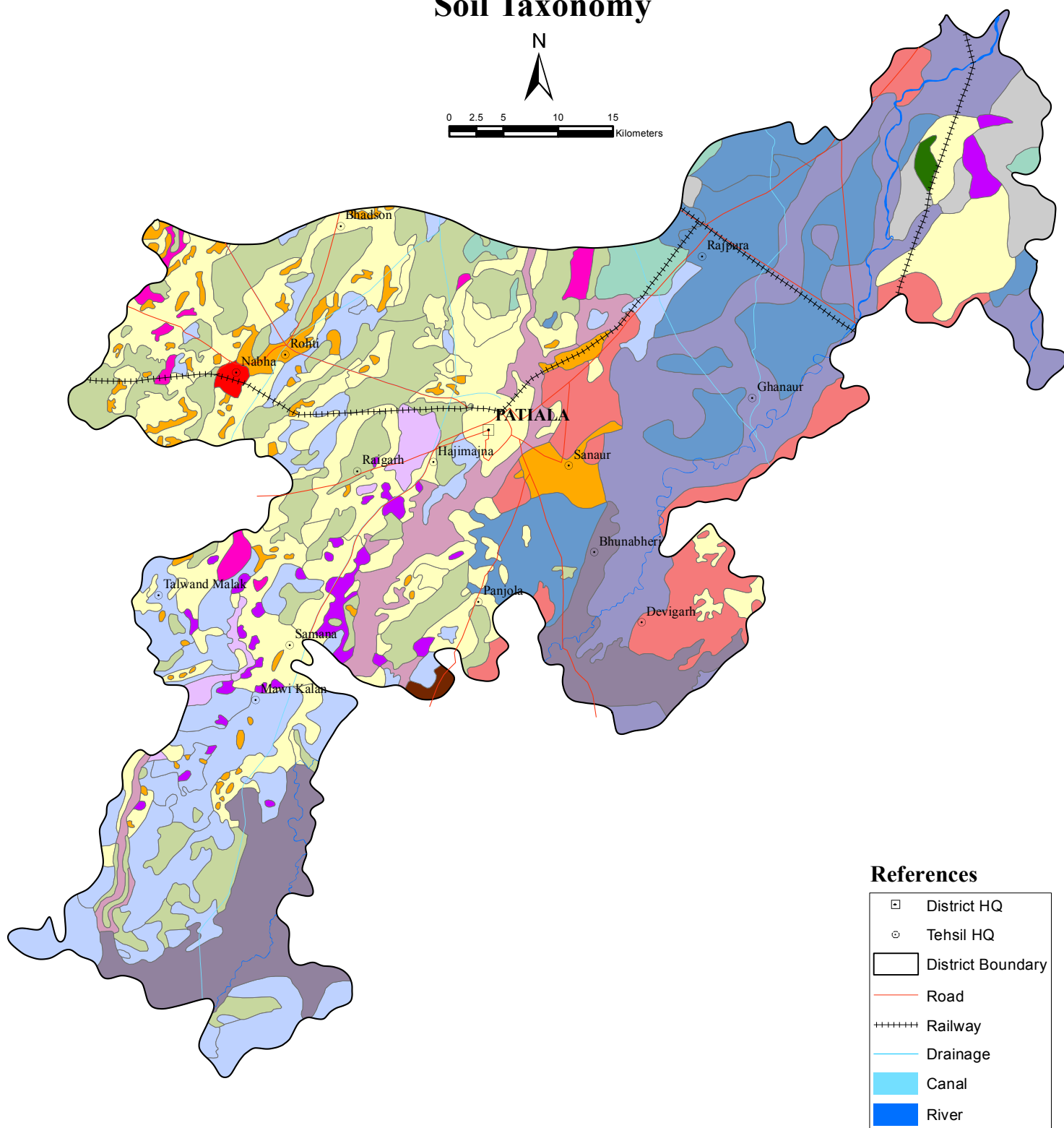


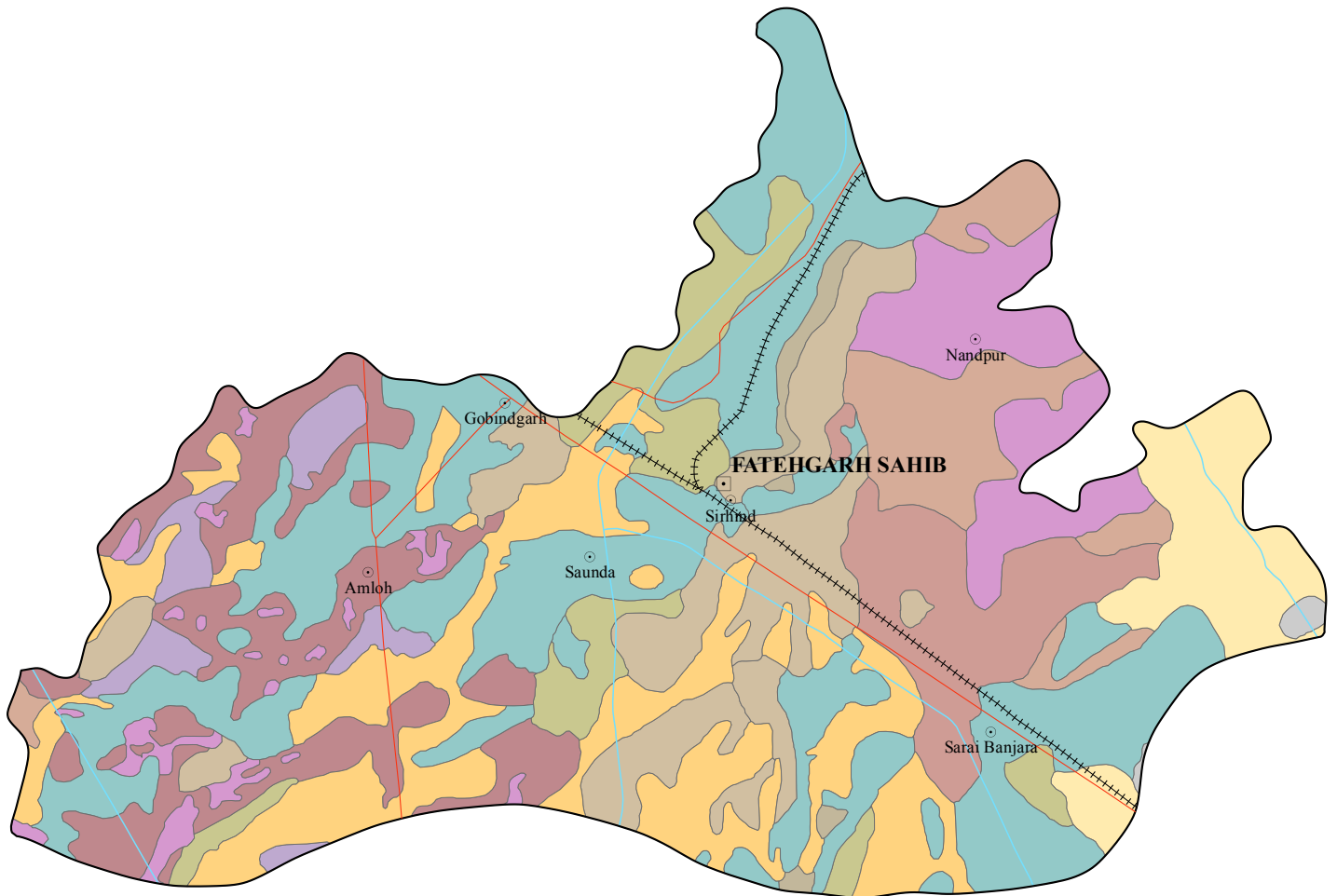
Fig. 13: Soil Taxonomy (Patiala)

FATEHGARH SAHIB

Soil Taxonomy



0 2.5 5 10
Kilometers



References

	District HQ
	Tehsil HQ
	District Boundary
	Road
	Railway
	Drainage
	Canal

Legend

	Fluentic Ustochrepts		Typic Ustochrepts-Fluentic Ustochrepts
	Typic Hapluquepts-Typic Ustifluvents		Typic Ustochrepts-Typic Ustipsamments-Fluentic Ustochrepts
	Typic Ustifluent-Typic Haplustalfs		Typic Ustochrepts-Udic Ustochrepts
	Typic Ustifluent-Typic Ustochrepta-Typic Ustipsamments		Udic Ustochrepts-Fluentic Ustochrepts-Typic Ustochrepts
	Typic Ustipsamments		Udic Ustochrepts
	Typic Ustipsamments-Udic Ustochrepts		Undifferentiated



BHANRA SERIES

The Bhanra series comprises excessively drained, non-calcareous, sandy soils of yellowish brown colour. They occur on strongly undulating dune topography ranging up to 10 percent slopes. They have been formed in wind deposited fine sands in the semi-arid parts of Punjab and Haryana. The climate is semi-arid with mean annual temperature more than 22°C and mean annual rainfall of 570 to 900 mm.

Principal associated soils are the Fatehpur series.

Bhanra series is a member of mixed, hyperthermic family of Typic Ustipsamments.

Typifying Pedon: Bhanra sand on dune top

- A Light yellowish brown (10 YR 6/4 D), yellowish brown (10 YR 5/6 M); sand, single grain; loose; gradual and smooth boundary.
- C1 Yellowish brown (10 YR 5/6 M) fine sand; single grain; loose; gradual and smooth boundary.
- C2 Yellowish brown (10 YR 5/6 M) fine sand; single grain, loose.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
A	0-20	46.50	44.90	3.10	<1	8.00
C1	20-66	41.52	49.22	2.40	<1	6.74
C2	66-150	39.72	49.41	3.39	<1	6.68

Physico-chemical Properties

Depth (cm)	PH (1:2.5)	E.C.(1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100gm soil	Exchangeable cations meq/100 gm soil			
						Ca	Mg	Na	K
0-20	7.60	0.20	Nil	0.11	1.09	1.20	0.80	0.26	0.15
20-66	7.50	0.20	„	0.08	1.31	1.60	0.80	0.17	0.10
66-150	7.60	0.20	„	0.08	1.09	1.20	0.80	0.35	0.15

RANGE IN CHARACTERISTICS:

Colours of the Soil varies from pale brown to yellowish brown. Texture is sandy and structure single grain. The soils are low in available moisture capacity and are droughty. Available moisture capacity of the soil is estimate at 2.6 cm for 60 cm and 4.4 cm for 100 cm profile depth.

DRAINAGE AND PERMEABILITY: Excessively drained with rapid permeability.

USE AND VEGETATION: Some areas are cultivated for groundnut, bajra and til. *Zizyphus jujuba* and *zizyphus numalaria* are the common vegetation.

DISTRIBUTION AND EXTENT: Extensive in the States of Punjab and Haryana.

TYPE LOCATION: About half a kilometer from the canal to the right of the Ghaggar canal towards Mathas village.

SERIES PROPOSED: Originally proposed by the Punjab Regional Pilot project for Soil and Water management (Patiala) 1969

FATEHPUR SERIES

The Fatehpur series consists of very deep, excessively drained non-calcareous loamy sand, soils of yellowish brown colours. It occurs on dune slopes upto 10 per cent. The soils have been formed in wind deposited loamy sands in the semi-arid tracts of Punjab and Haryana. The climate is semi-arid with mean annual temperature of more than 22°C and means annual rainfall of 570 to 900 mm. Principal associated soils are Bhanra and Samana. The Bhanra Soils are sandy and Samana soils are coarse loamy. Fatehpur series is a member of mixed hyperthermic family of Typic Ustipsamments.

Typifying Pedon: Fatehpur sand.

- Ap Very pale brown (10 YR 7/4 D), light yellowish brown (10 YR 6/4 M) sand, single grain, loose, non-sticky and non-plastic; many medium continuous roots, micro pores, diffuse and smooth boundary.
- A12 Very pale brown (10 YR 7/4 D), brownish yellow (10 YR 6/6 M), loamy fine sand, single grain, loose, non-sticky and non-plastic, many medium continuous roots, micro pores, clear and wavy boundary.
- C1 Light yellowish brown (10 YR 6/4 D), brownish yellow (10 YR 6/6 M): loamy fine sand, weak fine subangular blocky; loose, non-sticky and non-plastic many medium continuous roots; micro pores; clear and smooth boundary.
- C2 Brown (7.5 YR 4/4 M); loamy fine sand, weak, fine subangular blocky; slightly hard; friable; many medium few continuous roots; few fine discontinuous pores; non-calcareous.

Particle Size Distribution

Horizon	Depth(cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
Ap	3-20	36.50	55.00	3.60	2.30	2.33
A12	20-50	25.25	56.00	7.75	5.38	5.25
C1	50-90	21.00	59.40	9.20	5.50	4.75
C2	90-160	18.25	60.75	11.00	6.45	4.00

Physico-chemical Properties

Depth (cm)	PH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100 gm soil	Exchangeable cations meq/100 gm soil			
						Ca	Mg	Na	K
Ap	8.1	0.2	Nil	0.13	5.43	3.25	1.25	0.86	0.13
A12	7.6	0.2	„	0.17	7.60	4.75	1.00	0.10	0.13
C1	8.0	0.2	„	0.07	8.69	4.50	1.75	0.21	0.07
C2	8.0	0.2	„	0.03	8.69	2.50	3.75	0.10	0.07

RANGE IN CHARACTERISTICS:

Colour of the surface soils varies from very pale brown (10 YR 7/3) to light yellowish brown (10 YR 6/4). The texture of surface soil, ranges from loamy sand to sandy loam and structure is single grain to subangular blocky. The colour of the sub-soil varies from yellowish brown (10 YR 5/4, 5/6) to strong brown. Available moisture capacity of the soil is estimated at 2.3 cm for 60 cm and 4.0 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIATE: The closely associated series are Bhanra and Samana which are sandy and sandy loam respectively.

USE AND VEGETATION: Mostly cultivated for groundnut, *zizyphus jujuba*, *Dalbergia sissoo*, are the commonest vegetation and *zyzyphus numalaria*, *Erianthus revanae*, *saccharum spontanium* are common vegetation.

DISTRIBUTION AND EXTENT: Extensive areas occur in district Patiala; this series may occur in parts of Rajasthan and part of Uttar Pradesh.

SERIES PROPOSED BY: Originally proposed by Pilot Project, Patiala.

TYPE AND LOCATION: Kahangarh to Bishanpura Road, middle of both village, Samana- Patiala (Punjab).

SAMANA SERIES

Samana aeries consists of very deep well drained, non-calcareous sandy loam soils of dark brown to strong brown (7.5 YR hue) colours. Samana series occur on gently sloping dunes in interdunal area of about 1 to 3 per cent slopes. These have been developed over aeoline of light textured material in the semi-arid tract of Punjab (about 225meter above mean see level). The climate is semi-arid with MAT more than 24.5 u and means annual rainfall is 570 to 900 mm.

Principal associated soils are Fatehpur and Kakra. The Fatehpur soils are sandy and Kakra soils are coarse loamy. Samana series is a member of coarse loamy mixed hyperthermic family of udic Ustochrepts.

Typifying pedon: Sandy loam - cultivated.

- A Dark yellowish brown (10 YR 4/4 D), brown to dark brown (7.5 YR 4/4 D), sandy loam; weak-medium-crumb, slightly hard, then dry, friable when moist, slightly sticky and non-plastic, fine to medium plentiful continuous roots; fine common pores; fine roots channel; non-calcareous; clear smooth boundary.
- B1 Dark yellowish brown (10 YR 4/4 D), brown to dark brown (7.5 YR 4/4 M), sandy loam; weak-medium-crumb or sub-angular blocky, slightly hard when dry, friable when moist, slightly sticky and non-plastic, non-calcareous, fine to medium many continuous roots; fine to medium few pores, clear smooth boundary.
- B21 Dark yellowish brown (10 YR 4/4 D), brown to dark brown (7.5 YR 4/4 M), sandy loam, weak medium crumb, slightly sticky and non-elastic, non-calcareous, fine to medium many roots, fine to medium few pores, gradual smooth boundary.
- B22 Dark yellowish brown (10 YR 4/4 D) brown to dark brown (7.5 YR 4/4 M), sandy loam; weak, medium crumb, slightly hard when dry-friable when moist, slightly sticky and non-plastic, non-calcareous, fine many but medium few roots, fine to medium few pores.

Particle Size Distribution

Horizon	Depth(cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
AP	0-22	34.37	38.65	6.21	9.02	11.65
B1	22-54	37.16	38.72	5.69	6.15	12.82
B21	54-100	30.08	42.51	6.64	5.27	16.52
B22	100-152	32.56	39.04	7.68	5.25	15.75

Physico-Chemical Properties

Horizon	PH (1:2.5)	E.C. 1:2 mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100gm soil			
						Ca	Mg	Na	K
AP	7.5	0.25	Nil	0.27	7.00	4.75	2.00	0.11	0.19
B1	7.3	0.20	„	0.12	6.95	4.25	1.50	0.11	0.13
B21	7.2	0.20	„	0.10	9.10	6.75	1.75	0.27	0.13
B22	7.2	0.20	„	0.10	9.00	7.25	1.25	0.22	0.13

RANGE IN CHARACTERISTICS:

The surface colour ranges from very pale brown to light yellowish brown (10 YR 7/4, 6/4, 6/3 B) and yellowish brown to dark brown (10 YR 5/6, 5/4 and 7.5 YR 5/6, 4/4, M). The texture varies, from loamy sand to sandy loam; structure is weak, fine to medium crumb at surface. The sub-soil colours range from yellowish brown (10 YR 5/8 M) to brown to strong brown (7.5 YR 4/4, 5/8 M). The texture is sandy loam and sometimes loam and structure is weak-medium to sub angular blocky. The difference between mean summer and mean winter temperature is 16.4°C.

Available moisture capacity of the soil is estimated at 4.8 cm for 60 cm and 8.4 cm for 100 cm profile depth from

the surface.

COMPETING SERIES AND THEIR DIFFERENTIALS: The competing series is Kakra which is sandy loam to loam in texture having the colours of 10 YR hue.

USE AND VEGETATION: These soils are intensively cultivated under irrigation. Maize, cotton, wheat, bajra are important crops. *Aceacia sp.*, *Dalbergia sisso*, *Morus Alba*, *Zizyphus jujuba*, *psidium guava*, *Mangifera indica*, *Azadirachta indica*, are main trees; *Zizyphus numularia*, *Argemone mexicana*, *Erianthus revanue*, *Chinopodium album* constitute the natural vegetation.

DRAINAGE AND PERMEABILITY: Well drained and mod rapid permeability.

DISTRIBUTION AND EXTENT: Extensively spread in Samana and Nabha Tehsils.

TYPE AND LOCATION: Right side on Nabha-Sangrur Road near bifurcation of Canal.

SERIES PROPOSED BY: Pilot Project, Patiala (Punjab)

KAKRA SERIES

Kakra series comprises very deep, well drained, yellowish brown to dark yellowish brown soils of sandy loam to loam textures. They have develop on wind modified alluvium in the semi-arid part of Punjab (about 225 m above mean sea level). Kakra series occur on nearly level to gently sloping lands with 1 to 3 percent slopes. They are non-calcareous. The climate is semi-arid with mean annual temperature more than 24.5°C and mean annual rainfall of 570 to 900 mm. Principal associated soils are Samana and Tulewal. The Samana soils are coarse loamy of strong brown colour whereas tulewal are fine loamy. Kakra series is member of coarse loamy, mixed, hyperthermic family of udic Ustochrepts.

Typifying Pedon: Kakra sandy loam-cultivated

- Ap Brown (10 YR 5/3 D), dark brown (10 YR 4/3, 3/3 M) sandy loamy weak, fine crumb structure, loose when dry, many medium roots, few fine discontinuous pores, clear and smooth boundary.
- B1 Brown (10 YR5/3D), dark brown (7.5 YR 4/4M), sandy loamy, weak fine granular, loose when dry, slightly sticky; many medium roots, few fine discontinuous pores, clear and smooth boundary.
- B2 Dark yellowish (10 YR 4/4 M); sandy loam; moderate, medium granular; loose when dry, friable when moist slightly sticky and slightly plastic; few medium roots; few fine continuous pores; few medium Krotovinas; gradual and smooth boundary.
- C Dark brown (7.5 YR 4/4 H); sandy loam; moderate medium granular; friable when moist, slightly sticky and slightly plastic; few fine roots; few fine continuous so as; common medium ferromanganese concretions.

Particle size Distribution

Horizon	Depth(cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay%
Ap	0-18	39.78	35.70	9.84	11.99	3.40
B1	18-35	47.43	23.82	8.31	5.41	10.03
B2	35-80	42.59	24.58	8.31	8.30	16.07
C	80-152	41.57	23.43	9.54	10.15	14.87

Physico-Chemical Properties

Horizon	pH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100gm soil			
						Ca	Mg	Na	K
Ap	8.5	0.35	Nil	0.33	3.81	4.5	1.2	0.4	0.5
B1	7.8	0.35	„	0.18	4.32	4.5	1.2	0.4	0.2
B2	7.8	0.20	„	0.17	7.31	7.5	1.2	0.4	0.1
C	7.7	0.20	„	0.15	8.15	9.7	-	0.4	0.1

RANGE IN CHARACTERISTICS:

The colour of surface soil varies from light yellowish brown (10 YR 6/4) to dark brown (10 YR 4/4, 3/3). The texture varies from loamy sand to sandy loam. The structure varies from weak fine to medium crumb to granular, colour of the sub-soil ranges from darn yellowish brown (10 YR 4/4) to dark brown (7.5 YR 4/4). The texture of subsoil varies from sandy loam to loam. The structure ranges from weak to moderate, fine to medium crumb to angular blocky (occasionally). Available moisture capacity of the soil is estimated at 4.7 cm for 60 cm and 8.7 cm for 100 cm profile depth. Competing series is Samana. Samana has colours of 7.5 YR hue.

USE AND VEGETATION: These soils are intensively cultivated. Irrigation is common. Maize, cotton, wheat and sugarcane are important crops. Trees of *Accacia* Sp. *Azadirachta indica*, *Hangifera indica* are common vegetation.

DISTRIBUTION AND EXTENT: Extensive in the tehsils Nabha and Samana in Patiala district, Kakra series is likely to occur in other adjoining areas of Punjab and Haryana.

DRAINAGE AKO PERMEABILITY: Well drained with moderately rapid permeability

TYPE LOCATION: Near village Kheri on the left side of the tract going to kheri District Patiala, Punjab.

SERIES PROPOSED: Regional Center Delhi. National Bureau or Soil Survey and Land Use Planning.

TULEWAL SERIES

Tulewal series comprises of very deep, well drained, sandy loam to loam soils of dark brown to yellowish brown colour. They have developed in the interdunal plains in the semi-arid tract of Punjab and Haryana. The clay percentage in the soil profile is more than 18 per cent and less than 35 per cent.

Tulewal soils occur on nearly level interdunal plains on 0-3 percent slope. The climate is semi-arid with mean annual temperature more than 22°C and means annual rainfall is 570 to 900 mm.

Principal associated soils are fine loamy Nabha, Hissar which have low content of sand and coarse loamy Kakra and Samana.

Tulewal series is a member of fine loamy mixed hyperthermic family of Udic Ustochrepts.

Typifying Pedon: Tulewal loamy sand cultivated.

- Ap Light brownish gray (10 YR 3/2 D), yellowish brown (10 YR 5/4 M); sandy loam, fine weak sub-angular blocky structure; slightly hard, friable, non-sticky and non-plastic; common fine roots; clear and smooth boundary.
- B21 Light yellowish brown (10 YR 6/4 D), dark yellowish brown (10 YR 4/4 M); sandy loam; medium moderate angular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; clear and smooth boundary.
- B22 Yellowish brown (10 YR 5/4 D), dark yellowish brown (10 YR 4/4 M) sandy loam medium moderate sub angular blocky structure, slightly hard, friable slightly sticky and slightly plastic, clear and smooth boundary.
- B Yellowish brown (10 YR 5/4 D), dark yellowish brown (10 YR 4/4 M) sandy loam, medium moderate angular blocky structure, slightly hard, friable slightly sticky and slightly plastic, clear and smooth boundary.
- Cl Yellowish brown (10 YR 5/4 D), dark yellowish brown (10 YR 4/4 M), sandy loam, moderate medium sub-angular blocky; slightly hard friable slightly sticky and slightly plastic.

Particle Size Distribution

Horizon	Depth(cm)	Coarse sand%	Fine sand %	Coarse silt %	Fine silt %	Clay %
Ap	0-23	44.52	25.05	17.05	4.47	8.28
B21	23-68.5	39.11	23.41	11.91	7.82	17.14
B22	68.5-94	36.18	20.12	12.25	12.03	20.20
B23	94-129.5	32.24	23.96	11.90	13.19	18.69
Cl	129.5-145	32.16	20.25	13.66	15.35	19.67

Physico-Chemical Properties

Horizon	pH (1:2.5)	E.C.(1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100 gm soil			
						Ca	Mg	Na	K
Ap	8.4	<0.2	0.95	0.15	4.90	2.00	1.50	0.75	0.35
B21	7.8	<0.2	Nil	0.12	9.79	5.25	3.25	0.55	0.40
B22	7.1	<0.2	„	0.09	10.88	7.00	1.50	1.25	0.75
B23	6.5	<0.2	„	0.13	10.38	7.50	1.25	0.75	0.55
Cl	7.2	0.6	„	0.13	10.61	9.00	1.50	0.06	0.04

RANGE IN CHARACTERISTICS:

The colour of the surface soils varies from dark brown to light yellowish brown (10 YR 4/3, 6/4). The surface texture ranges from loamy sand to loam. The colour of the sub-soil varies from dark brown (7.5 YR 4/4) yellowish brown (10 YR 5/6). The texture ranges from loam to sandy clay loam. Available moisture capacity of the soil is estimated at 5.2 cm for 60 cm and 9.0 cm for 100 cm profile depth from the surface.

COMPETING SERIES AND THEIR DIFFERENTIALS: Competing series are Nabha, Hissar, Kakra and Samana. Nabha and Hissar have dominantly loam to clay loam texture. Kakra and Samana are coarse loamy and have less than 18 per cent clay.

DRAINAGE AND PERMEABILITY: Well drained with moderately rapid permeability.

USE AND VEGETATION: Generally used for Bajra, Jowar, Wheat; *Accacia Sp.* *Dalbergia sissoo* are some of the common vegetation.

DISTRIBUTION AND EXTENT: Occur in Patiala district of Punjab.

TYPE LOCATION: In village Jassuwal-Patiala-Sirhind road, Tehsil Patiala (Punjab).

ESTABLISHED BY: Pilot Project Patiala (Punjab).

NABHA SERIES

Nabha series comprises very deep, well drained loam to clay loam soils of dark yellowish brown to yellowish brown colours. They have developed on alluvium in the semi-arid part of Punjab and Haryana States. The clay percentage in the soil profile is more than 18 percent and less than 35 percent. Roils occur on nearly level to very gently sloping lands upto 3 percent slope. The climate is semi-arid with mean annual temperature more than 22°C and mean annual rainfall of 570 to 900 mm. Principal associated soils are Hissar and Tulewal. The Hissar soils are fine loamy calcareous whereas Tulewal soils are also fine loamy of yellowish crown colour. Nabha series is a member of fine loamy, mixed hyperthermic family of Udic Ustochrepts.

Typifying Pedon: Nabha sandy loam cultivated.

- Ap Yellowish brown (10 YR 5-4 D) dark yellowish brown (10 YR 4/4 M) sandy loam; medium moderate angular blocky structure; slightly hard, slightly firm, slightly sticky and slightly plastic; clear and smooth boundary.
- B1 Dark yellowish brown to yellowish brown (10 YR 4.5/4 D), dark brown (10 YR 4/3 M), sandy clay loam; medium moderate angular blocky structure; slightly hard, slightly firm, slightly sticky and slightly plastic, clear and smooth boundary.
- B21 Dark brown (10 YR 5/3 M), loam, medium moderate angular blocky structure; slightly firm, slightly sticky and slightly plastic; clear and smooth boundary.
- B22 Dark brown (10 YR 3.5/3 M), clay loam; medium moderate angular blocky structure; slightly firm, slightly sticky and slightly plastic; Fe-Mn concretions, clear and smooth boundary.
- B3 Dark brown (10 YR 3.5/3 M).clay loam; medium moderate angular blocky structure; slightly firm, slightly sticky and slightly, plastic; Fe-Mn concretions, clear and smooth boundary.
- Cl Dark brown HO YR 3.5/3 M)-clay loam; medium moderate angular blocky structure; slightly firm, slightly sticky and plastic, common many taint iron mottles

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand%	Fine sand%	Coarse silt %	Fine silt %	Clay%
Ap	0-17	7.10	50.80	13.60	10.90	18.30
B1	17-39	5.37	48.09	12.50	10.16	22.66
B21	39-30	5.40	38.00	12.70	19.80	24.40
B22	50-89	3.80	36.70	14.70	12.60	33.10
B23	89-101	3.00	36.30	14.50	14.50	33.00
Cl	101-130	3.00	35.09	12.05	17.25	31.76

Physico-chemical Properties

Horizon	pH (1:2.5)	E.C.(1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100gm soil	Exchangeable cations meq/100 gm soil			
						Ca	Mg	Na	K
Ap	8.9	0.45	Nil	0.28	4.35	3.00		0.37	0.75
B1	8.7	0.30	„	0.18	5.52	3.00		0.37	0.71
B21	8.3	0.23	„	0.18	7.61	9.0		0.51	0.41
B22	8.3	0.27	„	0.18	10.87	10.0		1.01	0.41
B23	8.5	0.35	„	0.18	10.87	10.0		1.01	0.51
Cl	8.3	0.36	„	0.18	10.87	10.0		1.01	0.51

RANGE IN CHARACTERISTICS:

The colours of the surface soil vary from light yellowish brown to dark yellowish brown or dark brown in 10 YR hue. The surface texture ranges from sandy loam to clay loam. Structure is angular blocky. The colour of the sub-soil varies from dark brown (10 YR 3/3) to yellowish brown (10 YR 3/4, 5/6) and texture from loam to clay loam. Structure is dominantly angular blocky. Available moisture capacity of the soil is estimated at 9.2 cm for 60 cm and 17.9 cm for 100 cm profile depth from the surface. Nabha soils have good available moisture capacity and potential fertility.

COMPETING SERIES AND THEIR DIFFERENTIALS: Competing series in Hissar, Urdan, Bahadurgarh and Tulewal. Tulewal soils have in percentage. Hissar soils differ from Nabha being calcareous. Urban and Bahadurgarh soils are dark brown to reddish brown developed on Ghaggar alluvium.

DRAINAGE AND PERMEABILITY: Well drained with moderate permeability.

USE AND VEGETATION: Maize, bajra, jowar, arhar, Sugarcane and wheat are some of the important crops. Nabha soils are highly productive and are adapted to a variety of climatically suited crops. *Accacia sp*, *Butea monosperma* and *Dalbergia sissoo* constitute the main vegetation.

DISTRIBUTION AND EXTENT: Occur in district Patiala, Sangrur and surrounding areas.

TYPE LOCATION: Patran - Hissar road, 1 km. from Patran in tehsil Samana, District Patiala, Punjab.

HISSAR SERIES

Hissar series consists of very deep, well drained pale brown to light yellowish brown to dark yellowish brown soils of loam to clay loam textures. They have developed over alluvium of clay loam or silty clay loam material in the semi-arid tract of Haryana and Punjab (about 225 m above MSL). Hissar soils occur on nearly level lands of usually less than 1 per cent slopes. They are calcareous. The climate is semi- arid with MAT more than 22°C and annual rainfall is 570 to 900 mm.

The principal associated soils are Nabha and Tohana. Nabha soils are fine loamy and Tohana are clayey, non-calcareous.

Hissar series is a member of fine loamy mixed, hyperthermic family of Typic Ustochrepts.

Typifying Pedon: Hissar loam cultivated

- Ap Light yellowish, brown (10 YR 5/4 D), dark yellowish brown (10 YR 4/4 M); loam; moderate-medium subangular blocky structure; hard, firm, sticky and plastic; strong effervescence with dilute acid; medium common roots, few fine pores; clear and smooth boundary.
- B21 Light yellowish brown (10 YR 6/4 D), dark yellowish brown (10 YR 4/4 M); loam; moderate medium angular blocky structure; hard, firm, sticky and plastic; strong effervescence with dilute acid, medium common roots; few fine pores; gradual and smooth boundary.
- B22 Light yellowish brown (10 YR 6/4 D), dark yellowish brown (10 YR 4/4 M) loam; moderate coarse, angular blocky structure, hard, firm, sticky and plastic, strong effervescence with dilute acid; few fine faint mottles; medium common roots; common fine pores; clear and smooth boundary.
- B23 Dark brown (10 YR 4/3 M) clay loam; moderately medium angular blocky structure; firm, sticky and plastic; strong effervescence with dilute acid; many fine faint mottles; fine few roots; fine many pores; gradual and smooth boundary.
- B24 Dark brown (10 YR 3/3 M); loam; moderate medium sub angular blocky structure, firm, sticky and plastic; strong effervescence with dilute acid; fine few roots; fine to medium many pores.

Particle Size Distribution

Horizon	Depth(cm)	Coarse sand %	Fine sand %	Coarse Silt %	Fine silt %	Clay%
Ap	0-1.8	17.75	23.25	20.75	26.68	11.20
621	18-36	18.00	22.25	17.15	22.67	18.58
B22	36-69	16.35	21.35	14.15	25.95	22.93
B23	69-102	15.50	21.75	15.35	19.45	28.30
B24	102-160	14.50	23.25	18.10	18.33	25.05

Physico-Chemical Properties

Depth (cm)	pH (1:2.5)	E.C.(1:2) mmhos/cm	CaCO ₃ %	O.C.%	C.E.C. meq/100 gm soil	Exchangeable cations meq/100gm soil			
						Ca	Mg	Na	K
0-18	8.3	0.30	1.18	0.525	11.42	7.75	3.00	0.65	0.45
18-36	8.2	0.25	0.23	0.255	13.60	8.25	2.75	0.65	0.32
36-69	8.9	0.20	1.50	0.255	16.86	9.25	6.00	0.76	0.26
69-102	7.9	0.23	2.00	0.210	17.95	12.25	3.75	0.76	0.26
102-160	7.9	0.23	2.00	0.186	15.32	11.50	2.50	0.81	0.19

RANGE IN CHARACTERISTICS:

Surface colour ranges from light gray to light brownish gray (10 YR 7/2, 7/3, S/3 D) and yellowish brown to dark brown (10 YR 4/3, 4/4, 5/4 M). The texture varies from loam to clay loam and structure ranges from crumb to

subangular blocky. The colour of subsoil is light yellowish brown (10 YR 5/4 D) and yellowish brown to dark brown (10 YR 4/4, 4/3, 3/3, 5/S M). The structure is sub angular blocky to angular blocky. Few fines to medium lime and ferromanganese concretions below 75 cm depth are found some times. Available moisture capacity of the soil is estimated at 10.8 cm for 60 cm and 19.0 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIAE: The Competing series is Nabha which is non-calcareous.

USE AND VEGETATION: Cotton, maize, sorghum, chillies, wheat, barley, berseem are important crops grown on these soils.

Accacia sp. Dalbergia sissoo, Moius alba, Mangifera indica, Butea monosperma, Zizyphus jujuba are trees *Zizyphus numalaria, cynodon dactylon, Chinopodium album* are common shrubs that constitute the natural vegetation.

DISTRIBUTION AND EXTENT: Extensively occurring in Nabha Patiala and Samana Tehsils.

TYPE AND LOCATION: Bathalthuia to Naraingarh village road right side near Nucleus seed production farm at Narain garh.

SERIES PROPOSED BY: Regional Centre Delhi, National Bureau of Soil-Survey and Land Use Planning I.A.R.I.Campus New Delhi-12.

TOHANA SERIES

Tohana series comprises very deep, moderately well drained, fine textured soils of pale brown to dark brown colours. They have developed on alluvium in the semi-arid part of the States, Haryana and Punjab. Tohana soils occur on low level old flood plains on Concave slope ranging upto 1 per cent. The climate is semi-arid with mean annual temperature more than 22°C and mean annual rainfall of 570 to 900 mm. Principal associated soil series are Hissar and Nabha which are clay loam to silty clay loam. Tohana soil is a member of fine, illitic, hyperthermic family of Fluventic Ustochrepts.

Typifying Pedon: Tohana silty clay loam-cultivated.

- Ap Pale brown (10 YR 6/3, D), dark brown (10 YR 4/3, M); silty clay loamy coarse moderate angular blocky structure, hard, very firm, sticky and plastic, medium plentiful roots, many fine pores, clear and smooth boundary.
- B1 Dark brown (10 YR 3/3)M) silty clay coarse strong angular blocky structure very firm, sticky and plastic common fine roots many fine pores clear and smooth boundary.
- B21 Dark grayish brown (10 YR 4/2 M) silty clay; coarse strong angular blocky; very firm, sticky and plastic few fine roots; fine many pores; slight effervescence with dilute acid, clear and smooth boundary
- B22 Dark brown (10 YR 4/3); silty clay; coarse strong angular blocky structure; very firm, sticky and plastic; few fine roots and many fine pores; clear and smooth boundary.
- B3 Dark brown (10 YR 4/3 M), silty clay; coarse strong angular blocky structure; very firm, sticky and plastic; few fine roots, fine many pores.

Particle Size Distribution

Horizon	Depth(cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
Ap	0-15	1.43	4.52	16.73	36.44	40.06
B1	15-47	1.02	2.26	9.35	39.56	47.79
B21	47-77	1.25	2.20	7.44	39.30	49.79
B22	77-104	2.67	1.84	6.67	39.32	49.40
B3	104-151	2.20	1.50	6.10	45.00	44.30

Physico-Chemical Properties

Horizon	pH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100 gm soil	Exchangeable cations meq/100gm soil			
						Ca	Mg	Na	K
Ap	6.8	0.2	Nil	0.70	12.83	7.25	4.75	0.44	0.51
B1	7.6	0.3	„	0.47	13.91	7.14	5.25	0.65	0.45
B21	8.0	0.3	1.1	0.41	13.00	7.00	4.25	0.76	0.45
B22	8.0	0.3	0.8	0.29	13.00	7.25	4.25	0.87	0.45
B3	8.1	0.3	0.5	0.29	10.33	6.75	2.10	1.08	0.38

RANGE IN CHARACTERISTICS:

Colour of the surface soil ranges from light gray to dark yellowish brown (10 YR 7/2-4/4). Also includes 10-15% soils of 7.5 YR colours. Texture varies from loam to clay loam and structure from moderate to strong medium subangular blocky to angular blocky. The colour of the sub-soil ranges from light brownish gray to dark yellowish brown (10 YR 6/2 to 3/4) and texture from silty clay loam to silty clay. Structure ranges from strong medium to coarse subangular blocky to angular blocky. Available moisture capacity of the soil is estimated at 17 cm and 27 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIAE: These include the associated Hissar series which is fine loamy and Sangrur series which is fine clayey, calcareous in the control section for lime.

DRAINAGE AND PERMEABILITY: The soils are subject to stagnation during' monsoon due to topography. Permeability is slow to moderate.

USE AND VEGETATION: These soils are generally under cultivation. Paddy, wheat and gram are the main crops. *Aceacia sp.* and *Dalbergia sissoo* and *saccharum spontanium* are common in uncultivated areas.

DISTRIBUTION AND EXTENT: Extensive in Tehsil Hissar (Haryana and Sangrur and Patiala Tehsils (Punjab).

SERIES PROPOSED BY: Regional Centre Delhi, National Bureau of Soil Survey and Land Use Planning, 1971.

TODARPUR SERIES

Todarpur series comprises very deep, moderately well drained to imperfectly drain dark brown to reddish brown soil of fine loamy texture. They have developed over alluvium of silty clay in the semi- arid tract of Punjab State (about 225 meter above M.S.L.). They are found to occur on level to almost flat land usually less than 1 per cent slope in the flood plain of Patiala wali nadi. The climate is semi-arid with mean annual air temperature more than 22°C and means annual rainfall is 570 to 900 mm.

They are variably saline sodic soils and are associated with Chhataira soils.

Todarpur series is a member of fine loamy, mixed, hyperthermic family of Typic Ustifluvents.

Typifying Pedon: Todarpur silty clay-loam cultivated.

- All Brown (10 YR 5/3, 7.5 YR 5/4 D & M); clay loam, moderate medium, angular blocky structure, hard, firm sticky and plastic; few fine faint mottles, common fine pores; clear and smooth boundary.
- A12 Reddish brown (5 YR 4/4 M) ; clay loam, moderate medium subangular blocky structure; slightly firm-sticky and plastic, common fine faint mottles, coarse and fine plentiful roots; clear and wavy boundary.
- IIC1 Brown (7.5 YR 5/4 M); loam; moderate medium angular blocky structure; slightly firm, sticky and plastic; few fine roots; clear and smooth boundary.
- IIC2 Brown (7.5 YR 5/4 M) loam; moderate medium angular blocky structure; slightly firm, sticky and plastic; slightly calcareous with dil HCl; few fine roots; clear and smooth boundary.
- IIC3 Brown (7.5 YR 5/4 M), loam; moderate medium angular blocky structure; slightly firm sticky and plastic, common fine to coarse faint mottles, slightly calcareous with dilute HCl; Ferro-manganese concretions; fine stratification, few fine roots, clear and smooth boundary.
- IIIC4 Reddish brown (5 YR 4/4 M); silty clay loam; moderate coarse angular blocky structure; firm, sticky and plastic; slightly calcareous with dilute HCl, few fine faint mottles; ferromanganese concretions; irregular blocky.
- IIIC5 Brown (7.5 YR 5/4 M); clay loam; moderate coarse angular blocky structure; firm sticky and plastic; slightly calcareous with dilute HCl; ferromanganese concretions.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay%
All	0-13	3.99	15.59	13.12	32.97	33.95
A12	13-35	5.90	26.75	20.94	16.75	28.93
IIC1	35-50	1.37	34.43	24.06	15.10	24.03
IIC2	50-68	2.21	24.52	23.60	22.25	24.87
IIC3	68-85	2.01	30.38	24.86	16.27	23.73
IIIC4	85-100	2.22	1.37	22.70	31.51	37.76
IIIC5	100-115	5.89	16.40	21.59	19.86	36.37

Physico-Chemical Properties

Horizon	pH (1:2.5)	E.C.(1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100gm soil	Exchangeable cations meq/100gm soil			
						Ca	Mg	Na	K
All	6.5	9.0	Nil	0.21	14.96	13.00	1.50	0.25	0.33
A12	6.1	2.45	„	0.19	14.14	6.75	5.00	1.00	0.80
IIC1	8.6	2.8	„	0.90	8.73	6.50	1.50	0.49	0.23
IIC2	8.9	4.5	„	0.24	10.34	8.00	1.00	1.20	0.21
IIC3	8.4	5.5	„	0.19	10.34	4.25	3.25	1.00	1.00
IIIC4	8.7	6.0	„	0.21	14.14	8.00	3.75	1.39	0.90
IIIC5	8.7	5.5	„	0.29	18.30	15.00	2.50	0.90	0.10

RANGE IN CHARACTERISTICS:

The colour of the surface soil varies from light grey (10 YR 7/2 D) and brown (10 YR 5/3 M) to pinkish grey (7.5 YR 6/2 D) and dark brown (7.5 YR 4/2 M). The texture ranges from silt loam to silty clay loam and structure is massive and cloddy with weak, fine platy to medium angular blocky.

The colour of the sub-surface soil is mainly dark brown (7.5 YR 4/2, 3/2 M). The texture is dominantly silty clay and structure mainly angular blocky. Available moisture capacity of the soil is estimated at 12.4 and for 60 cm and 21.4 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIALS: The carpeting series is Rohar which is characterized by having fine stratification and have pale brown to grayish brown color below 45cm depth.

DRAINAGE AND PERMEABILITY: Moderately well to imperfectly drained with slow to very slow permeability.

USE AND VEGETATION: Mainly used for pasture. Sometime cultivated for paddy. *Cynodon dactylon* is the natural vegetation.

DISTRIBUTION AND EXTENT: Not extensive and found mainly along the bank of Patiala wali nadi.

TYPE LOCATION: Near Patialawali nadi village Mair, district Patiala (Punjab).

SERIES PROPOSED BY: Pilot Project Patiala (Punjab).

CHATAIHRA SERIES

Chataihra series comprises very deep, moderately well drained, brown to dark yellowish brown soils of silt loam to silty clay loam texture. They have developed over alluvium of silt loam material of calcareous nature in semi-arid tract of Punjab (about 225 m above M.S.L.). They are found to occur on level to nearly level lands of usually less than 1 percent slope in the flood plains of Patiala wali nadi. The climate is semi-arid with mean annual air temperature more than 22°C and means annual rainfall is 570 to 900 mm. They are subject to flooding periodically during rainy season. They are saline-sodic. Chataihra series is tentatively classified as a member of fine loamy, mixed, hyperthermic family of Typic Haplustalfs.

Typifying Pedon: Chataihra silt loam, cultivated

- Ap Very pale brown (10 YR 8/3 D), dark yellowish brown (10 YR 4/4 M); loamy medium weak sub angular blocky to coarse moderate platy structure; very hard, firm, slightly sticky and slightly plastic; strong effervescence; clear and smooth boundary.
- B1 Dark yellowish brown (10 YR 3/4 M); silt loam; medium to coarse moderate angular blocky; firm, sticky and plastic; strong effervescence; gradual smooth boundary.
- B21t Dark brown (10 YR 4/3 M), silty clay loam, medium moderate angular blocky; firm, sticky and plastic; strong effervescence, many fine CaCO₃ concretions, patchy clay films, gradual and smooth boundary.
- B22t Dark yellowish brown (10 YR 4/4 M), silty clay loam, medium moderate angular blocky, firm, sticky and plastic, moderate effervescence, many fine CaCO₃ concretions, many fine distinct reddish brown (5 YR 5/4) iron mottles, patches of thin clay films, clear and wavy boundary.
- B3 Dark yellowish brown (10 YR 4/4 M), loam, medium weak subangular blocky, friable, slightly sticky and slightly plastic, moderate effervescence, many fine distinct reddish brown (5 YR 5/4) iron mottles.

Particle Size Distribution

Horizon	Depth(cm)	Sand %	Silt %	Clay %
Ap	0-12	55.63	23.27	21.10
B1	12-30	48.43	19.72	29.64
B21t	30-67	46.2	25.8	27.0
B22t	67-109	46.7	27.5	26.4
B3	109-147	64.2	22.1	13.5

Physico-Chemical Properties

Depth (cm)	pH(1:2.5)	E.C.(1:2) mmhos/cm	CaCO ₃ %	O.C.%	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100gm soil			
						Ca	Mg	Na	K
0-12	8.8	1.00	1.77	0.35	11.1	6.6	1.1	2.76	0.44
12-30	9.8	1.85	1.92	0.23	14.9	5.6	1.0	7.60	0.43
30-67	9.9	1.90	1.12	0.12	15.1	5.3	0.5	8.65	0.46
67-109	9.9	1.90	0.95	0.18	12.2	2.0	1.1	8.04	0.47
109-147	10.0	1.95	0.70	0.17	10.5	4.1	1.5	4.27	0.27

RANGE IN CHARACTERISTICS:

The colours of the surface soil ranges from very pale brown (10 YR 8/3 D) and dark yellowish brown (10 YR 4/4 M) to light yellowish brown (10 YR 5/4, 5/6 M). The texture ranges from fine sandy loam to silt loam and structure is platy to weak sub-angular blocky.

The colour of the sub-surface soil varies from dark yellowish brown (10 YR 4/4, 3/4 M) to dark brown (10 YR 4/3 M). The texture is generally silt loam and structure varies from subangular blocky to angular blocky.

Available moisture capacity of the soil is estimated at 12.6 cm for 60 cm and 21.8 cm for 100 cm profile depth.

DRAINAGE AND PERMEABILITY: Moderately well drained with very slow permeability.

USE AND VEGETATION: Cultivated mainly for paddy and wheat. The natural, vegetation consists of *Accacia arabica* and *Agrotia* spp.

SERIES PROPOSED: Pilot Project Patiala (Punjab)

TYPE LOCATION: Village Jalalpur in tehsil. Samana, district Patiala (Punjab).

RANBIRPURA SERIES

Ranbirpura series comprises very deep, poorly drained, fine loamy non-calcareous soils of light brownish gray colour. These are hydromorphic soils. They occur near Bhakra Canal in the surrounding low lying areas of village Ranbirpura on Patiala-Sangrur road. The climate is semi-arid with mean annual temperature of more than 22°C and means rainfall of 570 to 900 mm. Principal associated soil is Bazidpur which is also hydromorphic but calcareous. Ranbirpura series is a member of fine loamy, mixed hyperthermic family of Aerie Haplaquepts.

Typifying Pedon: Ranbirpura loam-cultivated

- Ap Light brownish gray (2.5 Y 5/2 D), grayish brown (2.5 Yh 5/2 M); loam; moderate medium angular blocky structure, hard, firm, sticky and slightly plastic; clear and smooth boundary.
- B1 Light brownish gray (2.5 Y 5/2 D), grayish brown (2.5 Y. 5/2 M), silty loam, moderate medium, angular blocky structure, hard, firm, sticky and slightly plastic, clear and smooth boundary.
- B21 Light brownish gray (2.5 Y 3/2 D) grayish brown (2.5 Y 5/2 M); silty clay loam; moderate medium angular blocky structure, hard firm, sticky and slightly plastic, clear and smooth boundary B22 88-126
- B22 Light brownish gray to light yellowish brown (2.5 Y 6/3 D), grayish brown (2.5 Y. 5/2 H), to (2.5 Y 5/3)) clay loam; moderate medium angular, blocky structure, hard, firm, sticky and slightly plastic, many fine to medium distinct yellowish brown ferruginous mottles clear and smooth boundary.
- B3 Light yellowish brown (2.5 Y 5/4 D), light olive brown (2.5 Y 5/4 M) clay loam, moderate medium angular blocky structure hard, firm, sticky and slightly plastic.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
Ap	0-18	4.40	29.35	22.25	23.70	18.50
B1	18-58	3.85	21.60	20.05	30.38	23.25
B21	58-88	4.00	16.35	18.05	33.18	29.00
B22	88-126	2.50	18.00	16.40	29.32	33.00
B3	126-141	2.00	19.00	18.35	25.50	33.95

Physico-chemical Properties

Depth (cm)	pH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100gm soil			
						Ca	Mg	Na	K
0-18	8.6	0.35	-	0.60	11.96	10.00		0.65	0.42
18-58	8.3	0.20	-	0.33	11.65	10.25		0.65	0.49
58-88	8.1	0.20	-	0.35	15.22	14.00		0.76	0.51
88-126	8.1	0.20	-	0.22	15.30	14.00		0.87	0.45
126-141	7.8	3.32	-	0.12	15.30	14.25		1.09	0.47

RANGE IN CHARACTERISTICS: Colour of the soil varies from light brownish gray (2.5 Y 5/2) to light olive brownish (2.5 Y 5/4). Texture of the solum varies from loam to silty clay loam or clay loam. Gleyed mottles occur below 25 cm from the surface.

COMPETING SERIES AND THEIR DIFFERENTIALS: These include Bazidpur Series which is poorly drained and calcareous.

DRAINAGE AND PERMEABILITY: Poorly drained with slow permeability.

USE AND VEGETATION: The soils are generally under cultivation. Paddy is the important crop.

DISTRIBUTION AND EXTENT: Extensive area occurs near village Ranbirpura on Patiala-Sangrur road after crossing Bhakra Canal.

TYPE LOCATION: Patiala-Sangrur road after crossing Bhakra canal two furlongs towards Ranbirpura on the left side of the main road.

SERIES PROPOSED BY: Regional Centre, Delhi-National Bureau of Soil Survey and Land Use Planning.

BAZIDPUR SERIES

Bazidpur series comprises very deep, poorly drained, fine loamy calcareous soils of grayish brown colour. They are hydromorphic soils occurring near Bhakra Canal in the surrounding low-lying areas of village Ranbirpura and Bazidpur on Patiala-Sangrur road.

Principal associated soil is Ranbirpura which is also hydromorphic but non-calcareous.

Wazidpur series is a member of fine loamy, mixed (calcareous) hyperthermic family of Typic Halaquepts.

Typifying Pedon: Bazidpur loam cultivated

- Ap** Light brownish gray (2.5 Y 6/2 D), dark grayish brownish to grayish brown (2.5 Y 4.5/2 R); loams; strong, coarse, sub-angular blocky structure, very hard, very firm, sticky and plastic, moderate effervescence with dilute acid, common fine and medium roots, clear and smooth boundary.
- B1** Grayish brown (2.5 Y 5/2 D), dark grayish brown to grayish brown (2.5 Y_i 4.5/2 R) loam; strong, coarse, angular blocky structure; very hard, very firm, sticky and plastic; strong effervescence with dilute acid; few fine roots; clear and smooth boundary.
- B21** Grayish brown (2.5 Y 5/2 D), dark grayish brown (2.5 Y 4/2 M); loam; moderate, medium angular blocky structure; hard, firm, sticky and plastic; violent effervescence with dilute acid, few fine faint yellowish brown (10 YR 5/4); iron mottles, few fine roots; clear and smooth boundary.
- B22** Grayish brown (2.5 Y 5/2 M); clay loam; moderate medium angular blocky structure; firm, sticky and plastic; slight effervescence-with dilute acid; soft iron and manganese concretions of 3 to 8 mm size; common fine distinct yellowish brown (10 YR 5/4); iron mottles, gradual and smooth boundary.
- B3Ca** Light yellowish brown (2.5 Y 5/4 M); loam; moderate, medium, sub angular blocky structure; firm, sticky and plastic; violent effervescence with dilute acid, 45- 50 % calcium carbonate concretions of 5 to 30 mm size; diffuse boundary.
- Cca** Yellowish brown (10 YR 5.5/4 M), loam; moderate, medium subangular blocky structure; firm, sticky and plastic violent effervescence with dilute acid, 45-50% calcium carbonate concretions of 5 to 30 mm size.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay%
Ap	0-16	6.75	28.85	20.30	29.25	15.00
B1	16-31	10.15	27.50	23.85	24.20	13.55
B21	31-58	7.90	27.00	22.10	22.83	19.05
B22	58-94	5.75	24.00	17.55	26.07	26.56
B3Ca	94-116	15.80	13.70	7.00	35.85	25.90
Cca	116-135	16.50	11.70	5.30	42.50	24.50

Physico-Chemical Properties

Depth (cm)	PH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100gm soil		
						Ca+Mg	Na	K
0-16	9.2	0.95	1.18	0.35	11.96	3.25	8.29	0.42
16-31	9.9	0.30	3.25	0.22	9.61	0.75	8.48	0.31
31-58	9.5	1.30	0.89	0.12	13.04	3.00	9.51	0.42
58-94	9.5	0.50	0.59	0.11	14.13	2.75	10.88	0.50
94-116	9.6	0.95	19.77	0.11	10.87	1.75	8.81	0.30
116-135	9.7	0.82	22.13	0.11	10.87	1.25	9.33	0.30

RANGE IN CHARACTERISTICS: Colour of the soil varies from light brownish gray (2.5 Y 6.2) to dark grayish brown (2.5 Y 4/2, 10 YR 4/2). Texture varies from loam to clay loam or silty clay loam.

COMPETING SERIES AND THEIR DIFFERENTIAE: These include the associated Ranbirpura Series which is non-calcareous.

DRAINAGE AND PERMEABILITY: Poorly drained with stow permeability.

USE AND VEGETATION: Generally under cultivation; paddy is the main crop.

DISTRIBUTION AND EXTENT: Extensive near village Ranbirpura and Bazidpur on Patiala-Sangrur road after crpsing Bhakra Canal.

SERIES PROPOSED BY: Regional centre, Delhi - National Bureau of Soil Survey and Land Use Planning.

SUNIARHERI SERIES

Suniarheri series comprises very deep, imperfectly drained, clayey soils of grayish brown to dark grayish brown colours. They have developed over alluvium in the semi-arid parts of Punjab and Haryana. The clay content in the soil profile is more than 35 percent. Nodular lime concretions (25-40%) by volume occur in layers below 50 cm depth. The soils occur on nearly level to slightly undulating lands ranging up to 3 per cent slope. The climate is semi-arid with mean annual temperature more than 22°C and mean annual rainfall of 570 to 900 mm. The principal associated soil is Rajendra which is fine loamy salt affected. Suniarheri series is tentatively classified as a member of clayey, calcareous, mixed, hyperthermic family of Typic Halaquepts.

Typifying Pedon: Suniarheri loam, cultivated.

- Ap** Light brownish gray (10 YR 6/2 D), grayish brown (10 YR 5/2 M), loam, medium, moderate, angular blocky structure, hard, firm sticky and plastic, violent effervescence with dilute acid, abundant in ped and some ex-ped pores, many fine roots, clear and smooth boundary.
- B21** Dark grayish brown to grayish brown (10 YR 4.5/2 M), silty clay loam, medium, strong, angular blocky structure firm, sticky and plastic, organic coatings and salt cutans; violent effervescence with dilute acid, abundant discontinuous in ped and some ex-ped pores, common fine roots; 5% calcium concretions; fine stratifications; fine clear and smooth boundary.
- B22** Dark grayish brown (10 YR 4/2 M), silty clay, medium, strong, angular blocky structure; firm sticky and plastic; violent effervescence with dilute acid; common fine roots; 10% calcium carbonate concretions; fine stratification; gradual smooth boundary.
- Cl** Brown (10 YR 5/3 M); silty clay loam; medium, moderate, angular blocky structure firm, sticky and plastic; violent effervescence with dilute acid; few fine roots; abundant faint iron mottles of yellowish brown colour; 20-25% nodular lime concretions; plentiful free lime in pockets; gradual and wavy boundary.
- C2** Grayish brown (10 YR 5/2 M), silty clay loam; medium, moderate, angular blocky structure; firm, sticky and plastic; violent effervescence with dilute acid; 40-50 percent nodular shaped lime concretions.

Particle size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
Ap	0-16	6.1	19.3	20.9	27.6	24.4
B21	16-45	4.8	14.6	14.4	35.8	31.5
B22	45-79	4.3	14.0	11.6	31.0	39.5
Cl	79-113	4.6	13.0	13.8	32.2	37.5
C2	113-155	4.8	11.2	33.6	22.0	29.8

Physico-Chemical Properties

Horizon	Depth (cm)	pH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100gm soil		
							Ca+Mg	Na	K
Ap	0-16	9.8	1.0	1.73	0.23	7.15	4.25	2.72	0.97
B21	16-45	10.3	1.9	1.98	0.17	8.45	0.75	6.52	1.33
B22	45-79	10.2	1.6	2.00	0.19	9.78	0.75	7.46	1.23
Cl	79-113	10.0	1.55	2.70	0.13	9.15	2.25	5.98	1.02
C2	113-155	9.6	0.65	20.0	0.10	7.70	5.00	2.17	0.41

RANGE IN CHARACTERISTICS: The colour of the surface soil ranges from brown (10 YR 4/3) to light brownish gray (10 YR 6/2) or dark greyish brown to grayish brown (10 YR 4/2, 5/2). The texture varies from loam to silty clay loam and structure is angular blocky. The colours of the sub-soil vary from dark grayish brown (10 YR 4/2) to olive brown (2.5 Y 4/4). The texture varies from clay loam to silty clay or clay. There are abundant nodular lime concretions below 50 cm depth and a layer of concretions (about 40-50% concretions) between 75-125 cm depth.

COMPETING SERIES AND THEIR DIFFERENTIALS: Competing series is Rajendra which is fine loamy.

DRAINAGE AND PERMEABILITY: Imperfectly drained with slow permeability.

USE AND VEGETATION: Large areas are lying uncultivated. In recently reclaimed soils paddy is generally grown. *Calotropis prosera*, *Butea monosperma* and *Accacia* sp. are some of the common vegetation.

DISTRIBUTION AND EXTENT: Extensive in Sangrur and Patiala districts of Punjab.

TYPE LOCATION: The profile is situated, mile east of village Latur, tehsil Sirhind, district-Patiala (Punjab).

SERIES PROPOSED BY: Regional Centre, Delhi - National Bureau of Soil Survey and Land Use Planning.

Note: These soils are very compact, difficult to dig with spade. Abundant, calcium carbonate concretions have caused restricted downward water movement. Grasses, aak and dhak grow well, Scattered patches of strongly saline soils with white encrustation on the surface are come across.

RAJENDRA SERIES

Rajendra series comprises very deep, imperfectly drained silt loam soils of yellowish brown to dark grayish brown colours. They have developed over alluvium in the semi-arid tract of Punjab and Haryana. The clay percentage in the soil profile is more than 18. There is a nodular lime concretions (25-40%) layer below 50 cm depth. Rajendra soils occur on nearly level lands of less than 2% slopes. The climate is semi-arid with mean annual temperature more than 22°C and mean rainfall of 570 to 900 mm. Principal associated soil is Suniarheri which is clayey. Rajendra series is a member of fine loamy, calcareous mixed hyperthermic family of Typic Ustifluvents.

Typifying Pedon: Rajendra loam uncultivated.

- A1 Light yellowish brown (10 YR 3/4 M); silt loam; weak, thin, platy structure; soft, friable, slightly sticky and slightly plastic, strongly calcareous; few fine to medium roots; many fine pores; clear and smooth boundary.
- B21 Light yellowish brown (10 YR 3/4 M), y silt loam; moderate, medium, subangular blocky; hard, firm sticky and plastic; strongly calcareous; about 5% soft lime nodules by volume and few ferromanganese concretions; fine to medium few roots; many fine pores, gradual smooth boundary. Paper thin stratification.
- B22 Yellowish brown (10 YR 5/4 M), silt loamy moderate, medium subangular blocky; hard, firm sticky and plastic; strongly calcareous; fine to medium few root, many fine pores; gradual smooth boundary.
- ClCa Light yellowish brown (10 YR 6/4 M); silty loam; moderate, medium, subangular blocky; breaking into granular; very hard; friable sticky and plastic; strongly calcareous; about 20% lime concretions by volume, more diffuse lime (Powdery form) becomes very hard when dry, fine few roots; many fine pores.

Particle size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
A1	0-12	4.71	21.28	35.78	23.77	18.52
B21	12-43	5.22	21.56	28.32	22.27	24.12
B22	43-91	6.05	18.43	28.46	22.20	24.90
ClCa	91-120	7.34	31.31	27.83	20.05	16.87

Physico-Chemical Properties

Depth (cm)	pH(1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100gm soil			
						Ca	Mg	Na	K
0-12	10.45	9.00	3.81	0.22	7.41	2.25	0.73	3.37	1.15
12-43	10.50	5.00	3.53	0.15	8.70	2.50	1.00	3.80	0.33
43-91	10.20	1.40	5.99	0.22	10.38	2.50	1.75	5.76	0.59
91-120	10.00	0.80	24.81	0.30	8.16	2.00	2.50	3.25	1.09

RANGE IN CHARACTERISTICS: The colours of the surface soils ranges from light yellowish brown (10 YR 6/4) to dark grayish brown (10 YR 4/2). The texture varies from sandy loam to silt loam and structure is sub-angular blocky to angular blocky. The colour of the subsoil varies from yellowish brown (10 YR 5/4) to dark brown (10 YR 4/3) or sometimes olive brown (2.5 Y 4/4). The texture varies from loam to silt loam or silty clay loam, structure varies from sub-angular blocky to angular blocky. Pressure cutan, Salt and Organic Coatings are common in the subsoil. There are abundant nodular-shaped lime concretions below 50 cm depth and a layer of concentration having 25-30 % nodular shaped lime concretions between 73- 125 cm depth. Paper thin stratification also observed in some profiles.

COMPETING SERIES AND THEIR DIFFERENTIALS: Competing series is Suniarheri which is clayey.

DRAINAGE AND PERMEABILITY: Imperfectly drained, with slow permeability.

USE AND VEGETATION: Large areas are lying uncultivated. In recently reclaimed soils paddy is generally grown. *Calotropis procera*, *Butea monosperma* and *Accacia sp.* are some of the common vegetation.

DISTRIBUTION AND EXTENT: Extensive area is Patiala and Sangrur districts of Punjab.

TYPE LOCATION: This profile is situated in waste land near village Mund Khera, towards Kalyan village about 1 km.

SERIES PROPOSED BY: Regional Centre. Delhi - National Bureau of Soil Survey and Land Use Planning.

URDAN SERIES

Urdan series comprises very deep, well drained fine loamy non- calcareous soils of dark brown to reddish brown colour. They have developed on alluvium of the Ghaggar flood plains in the semi arid part of Punjab. Urdan soils occur on nearly level lands. The climate is semi-arid with mean annual temperature of more than 22°C and mean rainfall of 570 to 900 mm.

Principal associated series are clayey Patiala, Manipur and jalalpur and fine loamy Bahadurgarh series which is calcareous.

Urdan series is a member of fine loamy, mixed, hyperthermic family of Typic Ustochrepts.

Typifying Pedon: Urdan loam - cultivated.

- Ap Light reddish brown (YR 5/3 D), reddish brown (5 YR 4/3 M) loam; medium, moderate, angular blocky structure, hard, friable, slightly sticky and slightly plastic, fine to very fine, discontinuous abundant pores, many fine roots, gradual and smooth boundary.
- B1 Light reddish brown (5 YR 5/3 D), reddish brown (5 YR 4/3 M), silt loam, medium, moderate, angular blocky structure, slightly firm, slightly sticky and slightly plastic fine to very fine discontinuous abundant pores with few fine roots, gradual and smooth boundary.
- B2 Light reddish brown (5 YR 6/3 D); reddish brown (5 YR4/3 M); silt loam; medium, moderate, angular blocky structure; slightly firm, slightly sticky and slightly plastic fine to very fine, discontinuous, abundant cores with many fine roots; few, fine, soft iron-manganese concretions; gradual and smooth boundary.
- B3 Reddish brown (5 YR 5/3 D), dark reddish brown (5 YR3/3 M); loam; medium, moderate, angular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; fine to very fine, discontinuous, abundant pores; few weak, dark coloured, soft, iron manganese concretions; gradual and smooth boundary.
- Cl Reddish brown (5 YR 5/4 D), reddish brown (5 YR 4/4 M); loam; medium, moderate angular blocky structure; friable, slightly sticky and slightly plastic; fine to very fine discontinuous abundant pores; many, dark brown soft iron, manganese concretions.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt%	Fine silt %	Clay %
Ap	0-15	1.15	28.96	33.95	15.21	20.70
B1	15-42	0.35	23.47	32.22	24.64	19.31
B2	42-72	0.23	16.44	30.70	30.70	21.00
B3	72-120	0.51	26.61	27.77	22.43	21.17
Cl	120-160	2.46	28.62	31.16	19.47	16.23

Physico-Chemical Properties

Depth (cm)	pH (1:2.5)	E.C.(1:2) mmhos/cm	CaCO ₃ %	O.C.%	C.E.C. meq/100gm soil	Exchangeable cations meq/100gm soil		
						Ca+Mg	Na	K
0-15	8.4	0.90	0.50	0.65	6.52	5.44	0.59	0.49
15-42	8.6	1.10	0.50	0.32	9.24	8.02	1.04	0.18
42-72	8.7	2.20	0.15	0.28	11.69	10.05	1.49	0.15
72-120	8.3	1.80	0.15	0.18	10.05	8.71	1.19	0.15
120-160	8.2	1.40	0.60	0.17	8.70	7.99	0.56	0.15

RANGE IN CHARACTERISTICS: The colours of the surface soil range from light brown (7.5 YR 6/4) to light reddish brown (5 YR 6/3). The surface texture ranges from sandy loam to silt loam. Structure is generally medium moderate angular blocky. The colour of the sub-soil varies from dark brown (7.5 YR 4/4) to reddish brown (5 YR 4/3) and texture from loam to silt loam; structure is medium to coarse, angular blocky with moderate to strong grades. Available moisture capacity of the soil is estimated at 11.0 cm for 60 cm and 18.6 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIALS: Bahadurgarh series which is calcareous.

DRAINAGE AND PERMEABILITY: Well drained with moderate permeability.

USE AND VEGETATION: The soils are generally under cultivation. Maize, Chillies, Jowar, Wheat, Gram, Berseem and Sugarcane are important crops. *Morus alba*, *Acacia sp* *Dalbergia sissoo* are common natural vegetation.

TYPE LOCATION: Along Rajpura - Patiala road to the right, opposite of Khanpur village in Tehsil Rajpura.

SERIES PROPOSED BY: Regional Centre, Delhi - National Bureau of Soil Survey and Land Use Planning.

MANAKPUR SERIES

Manakpur series comprises very deep, well drained, clayey, non-calcareous soils of dark brown to reddish brown colours. They have developed on alluvium of the Ghaggar flood plains in the upper portion of the semi-arid part of Punjab. Manakpur soils occur on nearly level to very gently sloping lands ranging upto 3 percent slopes. The climate is semi-arid with mean annual temperature of more than 22°C and means rainfall of 570 to 900 mm. Principal associated series are Jalalpur and Ghanaur which are calcareous and fine loamy, Manakpur series is a member of clayey, mixed hyperthermic family of Fluventic Ustochrepts.

Typifying Pedon: Manakpur silty clay loam. cultivated.

A	Reddish brown (5 YR 4/4 M); silty clay loam; medium, moderate, angular blocky structure; firm, sticky and plastic; plentiful fine and medium roots; clear and smooth boundary.
B21	Reddish brown (5 YR 4/4 M), silty clay; medium, moderate, angular blocky structure; firm, sticky and plastic; common fine roots; clear and smooth boundary.
B22	Dark reddish brown (5 YR 3/4 M), silty clay; medium, moderate, angular blocky structure; firm, sticky and plastic; few fine roots; clear and smooth boundary.
B3	Dark reddish brown (5 YR 3/4 M), silty clay loamy medium/ moderate/angular, blocky structure; firm, sticky and plastic; clear and smooth boundary.
Cl	Dark reddish brown (5 YR 3/4 M) silty clay loam; medium, moderate, angular blocky structure; firm sticky and plastic.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse Silt %	Fine Silt %	Clay%
Ap	0-20	0.40	4.90	31.45	32.00	31.25
B21	20-48	0.73	2.77	12.75	39.75	44.00
B22	48-75	0.94	1.18	7.63	45.25	45.00
B3	75-107	1.44	0.51	10.80	51.75	35.50
Cl	107-150	1.87	1.04	10.85	50.75	35.50

Physico-chemical Properties

Depth (cm)	pH (1:2.5)	E.C.(1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100gm soil		
						Ca+Mg	Na	K
0-20	7.10	1.01	-	0.40	11.96	14.75	1.65	0.44
20-48	7.50	0.60	-	0.24	11.65	15.75	1.87	0.39
48-75	7.80	0.70	-	0.25	15.22	17.25	2.09	0.34
75-107	8.80	0.65	-	0.12	15.30	13.50	2.20	0.34
107-150	8.65	0.35	-	0.20	15.30	12.75	2.31	0.27

RANGE IN CHARACTERISTICS: Colour of the surface soil ranges from dark brown (7.5YR 4/4) to reddish brown (5 YR 4/4) and texture from loam to silty clay loam. Structure is angular blocky, colours of the sub-soil range from reddish brown (5 YR 4/4) to dark reddish brown (5 YR 3/4). Texture ranges from silty clay loam to silty clay. Structure is generally angular blocky. Available moisture capacity of the soil is estimated at 20.0 oh for 60 cm and 34.7 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIALS: Competing series are Patiala, Jalalpur, Ghanaur and Rohar. Patiala soils are clayey, non-calcareous, and are finely stratified. Jalalpur and Ghanaur soils are calcareous. Tohar soils are reddish brown to grayish brown clayey over fine loamy.

DRAINAGE AND PERMEABILITY: Well drained with slow permeability.

USE AND VEGETATION: The soils are generally under cultivation. Paddy, Jowar, Wheat, Gram, Sugarcane

and Berseem are among the important crops. *Accacia sp.*, *Dalbergia sissoo*, *Zizyphus jujuba* are the cannon vegetation.

TYPE LOCATION: Along the Canal 3/4 km from the village Chamarheri on Patiala - Rajpura road.

SERIES PROPOSED BY: Regional Centre, Delhi - National Bureau of Soil Survey and Land Use Planning.

JALALPUR SERIES

Jalalpur series comprises of very deep, moderately well drained, clayey, calcareous soils of dark brown to reddish brown colours. They have developed over alluvium of Ghaggar flood plains in the semi-arid tract of Punjab. Jalalpur soils occur on nearly, level lands of concave slopes of 0-2 percent. The climate is semi-arid with mean annual temperature more than 22°C and means rainfall is 570 to 900 mm.

Principal associated soils are clayey Patiala which is non- calcareous and fine loamy Bahadurgarh and urdan which are calcareous and non-calcareous respectively.

Jalalpur series is a member of fine loamy over clayey mixed hyperthermic family of Fluventic Ustochrepts.

Typifying Pedon: Jalalpur silt loam - cultivated.

Ap	Brown (7.5 YR 5/4 D); dark brown (7.5 YR 4/4 M); silt loam; medium, moderate, subangular blocky structure; hard, firm, sticky and plastic; common fine and medium roots; violent effervescence with dilute acid; clear and smooth boundary.
B2	bark brown (7.5 YR 4/4 M); silt loam; medium, moderate, angular blocky to platy structure; firm, sticky and plastic; few fine roots; violent effervescence with dilute acid; clear and smooth boundary.
IIC1	Dark reddish brown (5 YR 3/3 M), silty clay, coarse, moderate, angular blocky structure, firm, sticky and plastic few fine roots. Fe and Mn concretions, fine stratification, violent effervescence with dilute acid, clear and smooth boundary.
IIC2	Dark reddish brown (5 YR 3/3 M); silty clay, coarse, moderate, angular blocky structure, firm, sticky and plastic, Fe and Mn concretions, strong effervescence with dilute acid, clear and smooth boundary.
IIC3	Dark reddish brown (5 YR 3/3 M), silty clay, coarse, moderate, angular blocky structure, firm sticky and plastic, Fe and Mn concretions, slight effervescence with dil. HCl.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
Ap	0-18	0.95	4.40	16.50	52.75	24.82
B2	18-60	1.25	1.65	7.90	63.62	25.95
IIC1	60-85	0.46	4.17	8.65	35.71	52.03
IIC2	85-118	0.55	7.45	10.15	33.67	47.15
IIC3	118-150	1.02	7.72	13.09	34.12	44.02

Physico-Chemical Properties

Depth (cm)	pH (1:2.5)	E.C.(1:2) mmhos/cm	CaCO ₃ %	O.C.%	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100gm soil			
						Ca	Mg	Na	K
0-18	7.9	0.45	0.75	0.45	18.00	11.5	1.5	1.30	0.42
18-60	8.0	0.35	0.75	0.24	19.00	12.0	3.0	1.41	0.76
60-85	7.9	0.60	0.80	0.38	26.43	16.0	5.0	2.81	0.49
85-118	8.0	0.80	1.15	0.33	25.47	13.5	4.5	4.30	0.49
118-150	8.1	1.30	2.00	0.35	24.12	10.5	5.0	5.87	0.44

RANGE IN CHARACTERISTICS: Colours of the surface soils range from brown to dark brown (7.5 YR 5/4, 4/4). The surface texture ranges from loam to silty clay loam, structure is generally medium, moderate angular blocky. The colour of the sub-soil varies from dark brown to dark reddish brown (7.5 YR 4/4, 5 YR 3/3). The texture varies from silt loam to silty clay. Structure varies from medium to coarse angular blocky with moderate to strong grade. The soils are calcareous. There are fine stratification within 100 cm depth, mottles occur below 60 cm. depth. Strata of loamy sand or sandy loam may occur below 100 cm depth. Available moisture capacity of the soil is estimated to be about 17 on for 60 cm and 27 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIAE: These include the associated Patiala and Sadhu Series. Patiala is clayey non-calcareous and Sadhu is clayey but cracks.

DRAINAGE AND PERMEABILITY: Moderately well drained with moderately slow permeability. Moderately slow permeability is generally occur below 60 cm depth.

USE AND VEGETATION: These soils are generally under cultivation, Wheat, Barely, Toria, Paddy are the main crops. *Accacia sp.*, *Dalbergia sissoo* and *Saccharum ap.* are common natural vegetation in uncultivated areas.

DISTRIBUTION AND EXTENT: Extensive area occurs south of Tehsil Patiala.

TYPE LOCATION: Bhunerheri - Devigarh road 1 km. from village Mirapur towards right side.

SERIES PROPOSED BY: Regional Centre, Delhi - Rational Bureau of Soil Survey and Land Use Planning.

BAHADURGARH SERIES

Bahadurgarh series comprises very deep, moderately well drained, fine loamy, calcareous soils of dark brown to reddish brown colours. They have developed on alluvium of Ghaggar flood plains in the semi-arid part of Punjab. Bahadurgarh soils occur on nearly level land & of concave slopes ranging up to 2 percent. The climate is semi-arid with mean annual temperature more than 22°C and mean annual rainfall of 570 to 900 mm.

Principal associated soils are fine loamy-Urdan which is non-calcareous, clayey. Patiala which is non-calcareous and clayey Jalalpur which is calcareous.

Bahadurgarh series is a member of fine loamy, mixed hyperthermic family of Typic Ustochrepts.

Typifying Pedon: Bahadurgarh silt, loam-cultivated.

Ap	Light reddish brown (5 YR 6/4 dry), Reddish brown (5 YR 5/4 moist), silt loam, medium, moderate, angular blocky structure, hard, slightly firm, sticky and plastic, violent effervescence with dilute acid, plentiful roots, clear and smooth boundary.
B1	Reddish brown (5 YR 5/4 dry), (5 YR 4/4 moist), silt loam; medium, moderate, angular blocky structure, hard slightly firm, sticky and plastic, violent effervescence with dilute acid, common fine roots, clear and smooth boundary.
B2	Reddish brown (5 YR 5/3 dry), dark reddish brown (5 YR 3/4, moist); silt loam; medium, moderate, angular blocky, hard, slightly firm, sticky and plastic; violent effervescence with dilute acid, few fine roots, 5 % lime concretions, clear and smooth boundary.
C1	Reddish brown (5 YR 5/3 dry), dark reddish brown (5 YR 3/4 moist); silt loam, medium, moderate, angular blocky structure, hard, slightly firm, sticky and plastic, violent effervescence with dilute acid, few fine roots, 5% lime concretions, fine stratification, clear and smooth boundary.
C2	Dark reddish brown (5 YR 3/4 moist), silty clay loam, medium, moderate, angular blocky structure, firm, sticky and plastic, violent effervescence with dilute acid, 5% lime concretions, fine stratification, clear and smooth boundary.
IIC3	Dark reddish brown to reddish brown, (5 YR 3/4, 4/4 moist); silty clay, medium, moderate, angular blocky structure firm, sticky and plastic, violent effervescence with dilute acid, fine stratification clear and smooth boundary.
IIC4	Reddish brown (5 YR 4/3, moist), silty clay loam, medium moderate, angular blocky structure, firm sticky and plastic, violent effervescence with dilute acid, fine stratification.

Particle Size Distribution

Horizon	Depth(cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
Ap	0-14	4.85	22.65	25.70	29.48	16.97
B1	14-46	4.10	14.75	23.00	33.23	25.77
B2	46-67	1.70	13.45	27.65	32.60	24.70
C1	67-103	1.80	10.20	26.67	39.77	22.55
C2	103-124	1.55	5.40	9.55	52.60	29.52
IIC3	124-159	2.20	5.10	4.40	43.90	43.02
IIC4	159-185	4.40	15.50	14.50	32.67	34.05

Physico-Chemical Properties

Depth (cm)	pH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100 gm soil	Exchangeable cation meq/100 gm soil			
						Ca	Mg	Na	K
0-14	7.8	0.45	1.00	0.58	11.40	4.50	4.00	0.65	0.40
14-46	7.9	0.45	1.70	0.25	13.57	5.00	5.00	0.87	0.37
46-67	8.0	0.45	2.80	0.21	14.11	5.25	5.00	1.09	0.23
67-103	8.2	0.35	4.00	0.18	13.03	4.50	4.50	1.52	0.19
103-124	8.5	0.60	4.00	0.19	18.46	5.00	5.00	4.13	0.24
124-159	8.6	0.45	2.60	0.16	18.46	6.00	4.50	5.65	0.30

RANGE IN CHARACTERISTICS: Colour of the surface soils ranges from light brown (7.5 YR 6/4) to reddish brown (5 YR 5/4). The surface texture ranges from loam to silt loam or clay loam. Structure of the surface soils is generally medium moderate angular blocky. Colour of the sub-soil varies from brown (7.5 YR 5/4) to reddish brown (5 YR 5/3). Texture of sub-soil varies from silt loam to silty clay loam, structure varies from medium to coarse blocky of medium to strong grades. The soils are calcareous. Fine stratifications are visible below 60 cm depth. Available moisture capacity of the soil is estimated at 14.7 cm for 60 cm and 25.6 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIALS: These include associated Urdan Series which is non-calcareous and fine loamy and Patiala and Jalalpur Series which are clayey.

DRAINAGE AND PERMEABILITY: Moderately well drained with, moderately slow permeability.

USE AND VEGETATION: These soils are generally under cultivation; wheat, barley, and jowar are the main crops. *Accacia sp.* and *Dalbergia sp.* are common natural trees in the cultivated areas.

DISTRIBUTION AND EXTENT: Extensive areas in district Patiala.

TYPE LOCATION: Village Bahai, Patiala, Punjab.

SERIES PROPOSED BY: Regional centre, Delhi - National Bureau of Soil Survey and Land Use Planning.

SANAUR SERIES

Sanuar series comprises of very deep, excessively drained sandy, calcareous soils of yellowish brown to dark brown colours. They are developed over sandy alluvium of Ghaggar flood plains in the semi-arid tract of Punjab. Sanaur soils occur on gently to moderately sloping old levees. The climate is semi-arid with mean annual temperature more than 22°C and mean rainfall is 570 to 900 mm.

Principal associated soils are coarse loamy Daun and Banru.

Sanaur series is a member of sandy calcareous mixed hyperthermic family of Typic Ustipsamments.

Typifying Pedon: Sanaur loamy sand uncultivated.

All	Yellowish brown (10 YR 5/4 moist), loamy sand, single grain, structure friable, non-sticky and non-plastic, plentiful roots, stratified, strong effervescence, clear and smooth boundary.
A12	Yellowish brown (10 YR 5/4moist), loamy sand, single grain structure, friable, non-sticky and non-plastic, plentiful roots, stratified, strong effervescence, clear and smooth boundary.
C1	Yellowish brown (10 YR 5/4 moist), loamy sand, single grain structure; friable, non-sticky and non-plastic; common roots, stratified, strong effervescence, clear and smooth boundary.
C2	Yellowish brown (10 YR 5/4 moist), loamy sand, single grain structure, friable, non-sticky and non-plastic, few roots, stratified, strong effervescence, clear and smooth boundary.
C3	Yellowish brown (7.5 YR 5/4 D); loamy sand, single grain, loose friable, non-sticky and non-plastic; strong effervescence, clear and smooth boundary.
C4	Yellowish brown (10 YR 5/4 moist), loamy sand, single grain structure, friable, non-sticky and non-plastic, strong effervescence.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand%	Fine sand %	Coarse silt %	Fine silt %	Clay %
All	0-20	11.75	68.75	9.94	2.65	6.85
A12	20-45	14.75	64.75	12.90	1.60	6.05
C1	45-70	24.50	51.50	16.10	1.43	5.90
C2	70-95	14.00	67.00	9.30	2.52	7.08
C3	95-150	14.25	69.25	8.40	2.11	5.99

Physico-Chemical Properties

Depth (cm)	pH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100 gm soil	Exchangeable cation meq/100 gm soil			
						Ca	Mg	Na	K
1-20	8.2	0.15	0.45	0.07	2.44	1.40	0.70	0.19	0.15
20-45	8.4	0.15	0.45	0.06	2.17	1.30	0.50	0.19	0.11
45-70	0.9	0.20	0.60	0.06	2.17	1.30	0.05	0.19	0.15
70-95	8.0	0.20	0.50	0.06	2.30	1.50	0.50	0.19	0.12
95-150	2.1	0.20	0.70	0.06	2.10	1.25	0.50	0.19	0.12

RANGE IN CHARACTERISTICS: Colours of the surface soils vary from yellowish brown to, dark brown, dominantly yellowish brown in 10 YR hue. The surface texture ranges from sand to loamy sand. Structure is single grain to weakly granular; sub-soil texture dominantly loamy sand and texture control section is sandy. Structure is single grain. The soils are calcareous. The soils are stratified throughout profile depth.

Available moisture capacity of the soil is 2.1 cm for 60 cm and 3.6 cm for 100 cm profile depth.

DRAINAGE AND PERMEABILITY: Excessively drained, with rapid permeability.

USE AND VEGETATION: Some area is cultivated, important crops grown are bajra, gram and mustard. *Accacia sp.*, *Zizyphus sp.* are most common natural vegetation in uncultivated areas.

DISTRIBUTION AND EXTENT: Occur in old flood plain of Ghaggar district Patiala (Punjab).

TYPE LOCATION: Profile is located near village Sanaur tehsil Patiala district - Patiala (Punjab).

SERIES PROPOSED BY: Regional Centre, Delhi - National Bureau of Soil Survey and Land Use Planning.

KAPURI SERIES

Kapuri series comprises very deep, moderately well drained, fine loamy over coarse loamy or sandy, calcareous soils of dark brown to reddish brown colours. They have developed over alluvium of Ghaggar flood plains in the semi-arid tract of Punjab. Kapuri soils occur on nearly level lands of slopes of 0-2 percent. The climate is semi-arid with mean annual temperature more than 22 C and mean rainfall is 570 to 900 mm. Principal associated soils are coarse silty stratified Julkan, coarse loamy Daun, and fine loamy Bahadurgarh and clayey stratified, Devigarh. These soils are calcareous. Kapuri series is a member of fine loamy over coarse loamy calcareous, mixed, hyperthermic family of Typic Ustifluvents.

Typifying Pedon: Kapuri silt loam cultivated.

Ap	Light reddish brown (5 YR 6/3 dry), reddish brown (5 YR 4/4 moist); silt loam; coarse, strong, angular blocky structure; hard, firm, sticky and plastic; plentiful roots; violent effervescence with dilute acid; clear and smooth boundary.
A3	Light reddish brown (5 YR 6/3 dry); reddish brown (5 YR 4/4 moist); silt loam; coarse, strong, angular blocky structure; hard, firm, sticky and plastic; plentiful roots; violent effervescence with dilute acid clear and smooth boundary.
IIC1	Dark brown (7.5 YR 4/4 moist); silt loam with sand layers; weak, medium, angular blocky structure; friable, fine roots; violent effervescence with dilute acid, clear and wavy boundary.
IIC2	Dark brown (7.5 YR 4/4 moist); silt loam; stratified; moderate, medium, granular structure; friable; slightly sticky; fine roots; violent effervescence; clear and wavy boundary.
IIIC3	Reddish brown (5 YR 4/4 moist), silt loam; mixed with sand layers; medium, weak, angular blocky structure; slightly friable; slightly sticky and slightly plastic fine roots; pocket of sand in between stratified; violent effervescence with dilute acid; clear wavy boundary.
IVC4	Brown (7.5 YR 5/4 moist); sandy loam; weak, fine granular structure; friable, violent effervescence with dilute acid; clear and wavy boundary.
VC5	Reddish brown (5 YR 4/4 moist); silt loam; medium, moderate, angular blocky structure; slightly firm, slightly sticky and slightly plastic, stratified, violent effervescence with dilute acid; clear and wavy boundary.
VIC6	Light yellowish brown (10 YR 6/4 moist); sandy loam mixed with sand; weak, medium, granular structure; friable, violent effervescence with dilute acid; clear and wavy boundary.
VIC7	Reddish brown (5 YR 4/4 moist); silt loam; coarse, strong, angular blocky structure; firm sticky and plastic; violent effervescence with dilute acid; clear and wavy boundary.
VIIIC8	Dark brown (7.5 YR 4/4, moist); loam; medium, weak, angular, blocky structure; friable, violent effervescence with dilute acid; clear and wavy boundary.
VIHC9	Reddish brown (5 YR 4/4, moist); silt loam; coarse; strong, angular blocky structure; firm, sticky and plastic; violent effervescence with dilute acid, abundant medium distinct iron mottles.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
Ap	0-13	1.31	8.52	18.39	42.13	29.12
A3	13-32	1.00	13.75	22.20	38.18	25.10
IIC1	32-53	0.50	24.25	39.25	25.23	9.90
IIC2	53-72	0.50	23.10	29.85	30.20	17.33
IIIC3	72-96	0.50	18.50	34.50	36.43	8.40
IVC4	96-105	0.50	64.00	26.85	3.12	4.68
VC 5	105-117	0.50	2.15	60.30	27.02	8.63
VIC6	117-137	1.00	61.00	24.25	6.55	6.45
VIIC7	137-150	0.50	10.60	10.70	67.45	11.58
VIIIC8	150-160	0.50	43.75	35.45	11.37	7.20
VIIIC9	160-170	0.50	11.50	50.20	28.17	9.63

Physico-Chemical Properties

Depth (cm)	pH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100 gm soil	Exchangeable cation meq/100 gm soil			
						Ca	Mg	Na	K
0-13	7.6	0.40	1.55	0.51	14.37	7.75	3.00	0.87	0.63
13-32	7.8	0.20	1.50	0.30	13.29	7.00	1.50	0.87	0.58
32-53	7.8	0.20	1.75	0.18	4.50	2.25	1.25	0.65	0.33
53-72	7.9	0.20	1.80	0.12	7.48	4.25	1.75	0.68	0.23
72-96	7.9	0.20	2.45	0.10	4.90	2.00	1.00	1.58	0.30
96-105	7.8	0.30	1.00	0.07	2.60	1.25	0.50	0.65	1.13
105-117	8.00	0.15	2.45	0.12	4.86	2.50	1.00	0.60	0.27
117-137	8.0	0.15	1.20	0.09	3.60	2.25	0.50	0.43	0.13
137-150	7.9	0.20	2.15	0.18	4.0	3.25	1.75	0.79	0.43
150-160	7.9	0.15	1.45	0.09	4.0	2.25	1.00	0.49	0.09
160-170	7.7	0.25	3.45	0.19	5.0	2.75	1.25	0.57	0.25

RANGE IN CHARACTERISTICS: Colours of the surface soils range from dark brown to reddish brown. Texture varies from silt loam to silty clay loam with clay more than 25%. Structure varies from moderate to strong angular blocky. Thickness of the 'A' horizon varies from 32 to 50 cm. Colours of the sub-soil vary from dark brown to reddish brown or brown in 7.5 YR, 5 YR and 10 YR hues. Texture varies from sandy loam to silt loam mixed with sandy layer and sand pocket; the sub-soil is highly stratified with layers of variable textures. Structure varies from single grain to moderate blocky. Available moisture capacity of the soil is estimated at 13.8 cm for 60 cm and 20.7 cm for 100 cm profile depth.

DRAINAGE AND PERMEABILITY: Moderately well drained with moderate to moderately rapid permeability.

USE AND VEGETATION: These soils are generally under cultivation, maize, chilies, wheat, gram, sugarcane are the main crops. *Accacia sp.*, *Dalbergia sissoo* are common natural vegetation in uncultivated area.

DISTRIBUTION AND EXTENT: Extensive area occurs south of Patiala city along old river coarse and recent flood plain of river Ghaggar.

TYPE LOCATION: Village F.No. 12/6, Kapuri, District Patiala Punjab).

SERIES PROPOSED BY: Regional Centre, Delhi - National Bureau of Soil Survey and Land Use Planning.

JULKAN SERIES

Julkan series comprises very deep, moderately well drained, stratified calcareous silt loam soils of brown to dark brown colours. They have developed over alluvium of Ghaggar plains in the semi-arid tract of Punjab. Julkan soils occur on nearly level lands of slopes 2 per cent on recent flood plains of Ghaggar. The climate is semi-arid with mean annual temperature more than 22°C and means rainfall is 570 to 900 mm. Principal associated soils are coarse loamy Daun, fine loamy over coarse loamy Kapuri, fine loamy Bahadurgarh and clayey stratified Devlgarh. Julkan series is a member of coarse silty, calcareous, mixed hyperthermic family of Typic Ustifluvents.

Typifying Pedon: Julkan silt loam cultivated.

Ap	Brown (7.5 YR 5/4 dry), dark brown (7.5 YR 4/4 moist), silt loamy medium, moderate, angular blocky structure, hard, slightly firm, sticky and plastic, plentiful roots, violent effervescence with dilute acid, clear and smooth boundary.
A3	Yellowish brown (10 YR 5/4 moist), silt loam, medium, weak, angular blocky structure; friable, slightly sticky and slightly plastic; common roots, violent effervescence with dilute acid, clear and wavy boundary.
C1	Reddish brown (5 YR 4/4 moist); silt loamy coarse, strong, angular blocky structure; firm, sticky and plastic; common roots; violent effervescence with dilute acid; clear and wavy boundary.
C2	Brown (7.5 YR 5/4 moist); silt loam; medium, weak, angular blocky structure; friable; slightly sticky and slightly plastic; common roots; stratified; violent effervescence with dilute acid; clear and wavy boundary.
C3	Reddish brown (5 YR 4/4 moist); silty clay loam; medium, moderate, angular blocky structure; slightly firm; sticky and plastic; few roots; stratified, violent effervescence with dilute acid; clear and wavy boundary.
IIC4	Yellowish brown (10YR 5/4 moist); silt loam; medium, weak, angular blocky structure; friable, few roots; stratified; violent effervescence with dilute acid; acid and wavy boundary.
IIIC5	Reddish brown (5 YR 4/4 moist) silty clay loam; medium, moderate, angular blocky structure; slightly firm, sticky and plastic; few roots; violent effervescence with dilute acid; stratified; clear and wavy boundary.
IVC6	Yellowish brown (5 YR 4/4 moist); sandy loam; medium, moderate, angular blocky structure slightly firm; sticky and plastic; few roots; violent effervescence with dilute acid; stratified; clear and wavy boundary.
VC7	Yellowish brown (10 YR 5/4 moist); sandy loam; single grain structure; friable; slightly sticky and non- plastic; stratified; strong effervescence with dilute acid.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
Ap	0-14	0.50	22.50	25.70	35.37	16.90
A3	14-40	0.50	13.60	25.40	45.92	15.15
C1	40-57	0.50	26.85	34.65	26.87	10.83
C2	57-79	0.50	13.50	18.00	52.49	14.03
C3	79-90	0.50	24.75	35.85	25.30	12.50
IIC4	90-114	0.50	5.40	21.10	50.84	21.88
IIC5	114-127	0.50	37.40	42.10	11.39	8.58
IVC6	127-144	0.50	9.25	19.25	50.62	19.98
VC7	144-160	0.50	51.85	30.15	9.74	7.73

Physico-Chemical Properties

Depth (cm)	pH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100 gm soil	Exchangeable cation meq/100 gm soil			
						Ca	Mg	Na	K
0-14	7.8	0.60	2.45	0.36	10.65	5.75	2.5	1.30	0.35
14-40	7.8	0.20	2.55	0.24	10.10	5.00	2.5	1.30	0.35
40-57	7.9	0.20	2.40	0.13	6.50	6.00	1.2	0.65	0.19
57-79	7.9	0.25	3.00	0.22	9.50	5.50	2.2	0.70	0.13
79-90	7.9	0.20	2.20	0.13	7.76	3.50	2.3	0.57	0.28
90-114	7.8	0.25	3.40	0.27	20.85	11.25	4.0	0.92	0.28
114-127	7.9	0.20	2.25	0.08	5.69	3.75	0.7	0.65	0.11
127-144	8.1	0.25	2.95	0.16	12.50	7.75	3.0	0.88	0.22
144-160	8.0	0.20	1.35	0.07	6.00	2.50	1.0	0.98	0.09

RANGE IN CHARACTERISTICS: Colours of the surface soils range from brown to dark brown or reddish brown. Texture varies from loam to silt loam. Structure is medium moderate angular blocky.

Colour of the sub-soils range from dark brown to reddish brown with inclusion of some 10 YR hue colour soil horizon. Texture varies from silt loam to silty clay loam with thin sand pockets or thin sandy horizon, stratified. Structure varies from weak to strong angular blocky. The soils are calcareous. Available moisture capacity of the soil is estimated to be 12.2 cm for 60 cm and 22.8 cm for 100 cm profile depth.

DRAINAGE AND PERMEABILITY: Well drained with moderate to moderately rapid permeability.

USE AND VEGETATION: These soils are generally under cultivation, maize, chilies, wheat and vegetable crops are grown on these soils. *Accacia sp.* and *zizyphus sp.* are common natural vegetation in uncultivated areas.

DISTRIBUTION AND EXTENT: Extensive area occurs south of city Patiala along old river coarse and recent flood plain of river Ghaggar.

TYPE LOCATION: F.No. B 13/14, village - Kapuri district - Patiala (Punjab).

SERIES PROPOSED BY: Regional Centre, Delhi — National Bureau of Soil Survey and Land Use Planning.

DAUN SERIES

Daun series comprises very deep, well drained, sandy loam calcareous soils of dark brown colours. They have developed over alluvium of Ghaggar flood plains in the semi-arid tract of Punjab. Daun soils occur on 0-3 per cent slopes. The climate is semi-arid with mean annual temperature more than 22°C and means rainfall is 570 to 900 mm. Principal associated soils are sandy Sanaur, coarse loamy Banru and coarse silty stratified Julkan and fine loamy over coarse loamy, stratified Kapuri. Daun series is a member of coarse loamy, calcareous, mixed, hyperthermic family of Typic Ustifluvents.

Typifying Pedon: Daun loam-cultivated.

Ap	Dark brown (7.5 YR 4/4 moist), silt loam, medium, weak, angular, blocky structure, friable, slightly sticky and slightly plastic, plentiful medium and coarse roots, strong effervescence with dilute acid, clear and smooth boundary.
A3	Dark brown (7.5 YR 4/4 moist), silt loam; medium, weak, angular blocky structure, friable, slightly sticky and slightly plastic, common fine and medium roots, strong effervescence with dilute acid, clear and smooth boundary.
IIC1	Dark brown (7.5 YR 4/4 moist), silt loam, medium, weak, angular blocky structure friable, slightly sticky and slightly plastic, common fine and medium roots, strong effervescence with dilute acid, clear and wavy boundary.
IIC2	Dark brown (7.5 YR 4/4 moist), sandy loam, weak, medium, granular structure, friable, Common fine roots, stratified, strong effervescence with dilute acid, clear and wavy boundary.
IIC3	Dark brown (7.5 YR 4/4 moist), sandy loam, weak, medium, granular structure, friable, common fine roots, stratified, strong effervescence with dilute acid, clear and wavy boundary.
IIIC4	Reddish brown (5 YR 4/4 moist), silty clay loam, coarse, strong, angular blocky structure, firm sticky and plastic, strong effervescence with dilute acid.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse Silt %	Fine Silt %	Clay %
Ap	0-17	0.50	37.75	41.00	11.30	8.53
A3	17-42	0.75	25.25	39.50	24.83	10.21
IIC1	42-60	0.75	37.75	37.10	13.23	10.88
IIC2	60-86	0.75	50.50	33.20	9.75	5.18
IIC3	86-118	0.75	59.50	28.50	5.80	5.08
IIIC4	118-160	0.75	1.75	13.10	55.92	27.93

Physico-Chemical Properties

Depth (cm)	pH (1:2.5)	E.C. (1:2)mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100 gm soil	Exchangeable cation meq/100 gm soil			
						Ca	Mg	Na	K
0-17	8.0	0.20	0.90	0.33	4.25	3.00	0.50	0.33	0.18
17-42	8.1	0.15	2.50	0.22	5.15	3.50	0.75	0.54	0.11
42-60	8.2	0.15	1.70	0.12	5.20	3.50	1.00	0.43	0.10
60-86	8.2	0.15	1.80	0.07	2.50	1.25	0.25	0.43	0.08
86-118	8.2	0.15	1.40	0.04	2.50	1.25	0.50	0.43	0.04
118-160	8.1	0.30	2.60	0.40	16.25	10.50	3.50	1.25	0.25

RANGE IN CHARACTERISTICS: Colour of the surface soils vary from yellowish brown to dark brown dominantly dark brown in 7.5 YR hue. The surface texture ranges from loamy sand to loam. Structure is weak to medium angular blocky. Colours of the subsoils are generally dark brown; texture is sandy loam to loam. Structure is generally weak blocky. The soils are calcareous There is stratification below 60 cm depth. Horizon of silty clay loam texture may occur below 100 cm depth. Available moisture capacity of the soil is estimated at 6.7 cm for 60 cm and 9.0 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIALS: These include the associated Banru series which is sandy loam in texture.

DRAINAGE AND PERMEABILITY: Well drained with moderately rapid permeability.

USE AND VEGETATION: These soils are generally under cultivation. Maize, bajra, guar, toria, mustard and vegetables are the main crops. *Accacia* sp. *zizyphus* sp. is most common natural vegetation in uncultivated area.

DISTRIBUTION AND EXTENT: Extensive areas occur near old course and recent course of Ghaggar river.

TYPE LOCATION: F.NO. B 1J/12, village Kapuri, district Patiala (Punjab).

SERIES PROPOSED BY: Regional Centre, Delhi - National Bureau of Soil Survey and Land Use Planning.

BANRU SERIES

Banru series comprises very deep, well drained sandy loam/ calcareous soils of light brown colours. The have developed over alluvium of Ghaggar flood plains in the semi-arid tract of Punjab. These soils occur on old levees of up to 3 per cent slopes. The climate is semi-arid with mean annual temperature more than 22°C and means rainfall is 570.to 900 mm. Principal associated soils are coarse loamy Daun which is stratified, coarse silty stratified Julkan, fine loamy over coarse loamy stratified Kapuri and sandy Sanaur. These soils are calcareous. Banru series is tentatively classified as a member of coarse loamy, calcareous, mixed, hyperthermic family of Typic Ustorthents.

Typifying Pedon: Banru sandy loam cultivated.

Ap	Light brown (7.5 YR 6/4 dry), brown (7.5 YR 5/2 moist), sandy loamy medium, weak angular blocky structure, slightly hard, friable, non-sticky and slightly plastic, plentiful roots, strong effervescence with dilute acid, clear and smooth boundary.
A3	Light brown(7.5 YR6/4 dry), brown (7.5YR 5/2 moist), sandy loam, medium, weak, angular blocky structure, lightly hard, friable, non-sticky and slightly plastic, plentiful roots, strong effervescence with dilute HCL, clear and smooth boundary.
C1	Light brown (7.5 YR 5/4 dry), brown (7.5 YR 5/2 moist), sandy loam moderated, weak, angular blocky structure, slightly hard, friable; common roots; strong effervescence with dilute acid clear and smooth boundary.
C2	Brown (7.5 YR 5/4 dry), dark yellowish brown (10YR4/4 moist), sandy loam; medium, weak, angular blocky structure; slightly hard, friable, common roots; strong effervescence with dilute acid; clear smooth boundary.
C3	Brown (7.5 YR 5/4 dry) dark yellowish brown (10 YR 4/4 M) sandy loam medium weak angular blocky structure, slightly hard, friable, common roots, and strong effervescence with dilute acid, clear and smooth boundary.
C5	Brown (7.5 YR 5/4 dry), dark yellowish brown (10 YR 4/4 moist), loamy single grains structure, slightly hard; friable, strong effervescence with dilute acid, clear and smooth boundary.
C6	Brown (7.5 YR 5/4 dry) dark yellowish brown (10 YR 4/4 moist), sandy loam mixed with pockets of silt loam, single grain, slightly hard, friable, non-sticky and non-plastic, strong effervescence with dilute acid.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse Silt %	Fine Silt %	Clay %
Ap	0-15	7.25	59.00	19.76	5.20	8.73
A3	15-28	8.25	57.75	19.82	5.82	8.28
C1	28-55	7.75	69.00	12.13	4.17	6.93
C2	55-65	1.75	56.25	26.71	7.62	7.63
C3	65-78	4.25	67.75	18.00	3.95	6.00
C4	78-94	4.75	48.50	27.08	11.10	8.55
C5	94-140	7.25	77.75	6.00	3.43	5.60
C6	140-160	21.75	52.50	15.57	3.02	5.89

Physico-chemical Properties

Depth (cm)	pH (1:2.5)	E.C. 1:2 mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cation meq/100gm soil			
						Ca	Mg	Na	K
0-15	7.6	0.25	0.60	0.21	2.98	1.60	1.00	0.33	0.13
15-26	8.1	0.20	0.60	0.16	2.71	1.15	1.00	0.33	0.13
29-55	8.2	0.20	0.35	0.07	2.21	1.50	0.3	0.27	0.13
55-65	8.3	0.20	1.50	0.07	2.25	1.25	0.5	0.38	0.13
65-78	8.3	0.20	1.00	0.06	2.25	1.15	0.5	0.43	0.13
78-94	8.2	0.20	4.90	0.06	2.25	1.00	0.5	0.52	0.19
94-140	8.4	0.15	0.85	0.04	2.10	1.20	0.5	0.27	0.39
140-160	8.5	0.15	1.00	0.06	2.40	1.20	0.8	0.27	0.39

RANGE IN CHARACTERISTICS: Colour of the surface soils vary from light brown to dark brown (7.5 YR 6/4, 5/2). The surface texture varies from sandy loam to loam. Structure is wash blocky.

Colours of the sub-soil vary from brown to dark yellowish brown (7.5 YR 6/4, 5/2, 4/4). Texture is generally sandy loam; lower depth texture may be sandy. Structure varies from weak blocky to single grain. The soils are calcareous and stratified.

Available moisture capacity of the soil is estimated at 3.4 cm for 60 cm and 6.0 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIALS: These include the associated soil Daun which is loam in texture and Julkan which is coarse silty.

DRAINAGE AND PERMEABILITY: Well drained with rapid permeability.

USE AND VEGETATION: Bajra, mustard and vegetable crops are cultivated. *Accacia sp.* and *zizyphus sp.* are common natural vegetation in cultivated areas.

DISTRIBUTION AND EXTENT: Occur in Patiala and Rajpura Tehsils.

TYPE LOCATION: Field No. 117/3, village Sanaur, District Patiala, (Punjab).

SADHU SERIES

Sadhu series comprises very deep, imperfectly drained, clayey calcareous soils of very dark grayish brown to dark brown colours. They have developed on alluvium of Ghaggar old flood plain in the semi-arid part of Punjab. Sadhu soils occur on nearly level to flatlands usually less than 1 per cent slopes. The climate is semi-arid with mean annual temperature more than 22°C and mean rainfall of 570 to 900 cm. Hexagonal cracks 2-4 cm wide on the surface. Both horizontal and vertical cracks are present. Horizontal cracks are found throughout the profile depth whereas vertical cracks are present up to 30 cm depth. Principal associated soils are clayey Patiala and Jalalpur which do not crack. Sadhu series is tentatively classified as a member of fine clayey, mixed, hyperthermic family of Vertic Ustochrepts.

Typifying pedon: Sadhu silty clay loam - cultivated.

- A1 Dark brown (7.5 YR 4/2, D, M), silt loam; strong, medium, angular blocky structure; very hard, very firm, sticky and plastic; slight effervescence with dilute acid; clear and smooth boundary.
- B2 Dark grayish brown (10YR 4/2 D), dark brown (10 YR 4/3 M); clay; strong, coarse, angular blocky structure; very hard, very firm, sticky and plastic; slight effervescence with dilute acid; few fine roots; cracks, clear and smooth boundary.
- B3 Very dark grayish brown to dark brown (10 YU 3/1.5 M), clay, strong, coarse, angular blocky structure, very firm, sticky and plastic, few fine roots, few fine distinct iron mottles (7.5 YR 4/4), slight effervescence with dilute acid, diffuse boundary.
- C1 Very dark grayish brown to dark brown (10 YR 3/2.5), clay, strong, coarse, angular blocky structure, firm, sticky and plastic, few fine faint iron mottles, 5-10% calcium carbonate concretion, clear and wavy boundary.
- C2 Very dark grayish brown to dark brown (10 YR 1/1.5), clay, strong, coarse, angular blocky structure, firm sticky and plastic, few fine faint iron mottles 5-10% calcium carbonate concretions, clear and wavy boundary.
- C3 Dark brown (10 YR 3/3 M), silty clay, moderate, medium, angular blocky structure, firm, sticky and plastic, common medium distinct iron mottles. (7.5 YR 5/6), 30-40% calcium carbonate concretions mixed with (7.5YR 5/6) colour, soil in pockets violent effervescence with dilute acid.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse Silt %	Fine Silt %	Clay %
A1	0-12	5.50	17.20	16.15	35.70	26.25
B2	12-45	2.50	12.55	3.70	24.83	56.25
B3	45-75	1.55	10.70	4.65	25.58	58.25
C1	75-100	1.60	6.70	5.70	25.50	59.00
C1	100-120	2.00	6.35	6.45	25.80	58.78
C3	120-168	7.05	8.75	12.20	28.12	43.50

Physico-chemical Properties

Depth (cm)	pH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100 gm soil	Exchangeable cation meq/100gm soil		
						Ca+Mg	Na	K
0-12	9.60	0.75	0.54	0.13	11.96	3.0	8.0	0.96
12-45	8.65	0.25	0.65	0.39	33.35	25.0	6.2	1.93
45-75	8.75	0.40	1.24	0.38	33.15	25.0	6.8	1.33
75-100	8.80	0.48	1.08	0.38	34.78	25.0	8.5	1.28
100-120	9.00	0.55	2.16	0.38	33.15	23.5	8.5	1.33

RANGE IN CHARACTERISTICS: Colours of the surface soil vary from brown to dark brown. The surface texture varies from silty clay loam to silty clay.

Colours of the sub-soil vary from brown to dark grayish brown (10 YR 5/3, 4/3 to 10 YR 3/2 and 2.5 YR 3/2 M). Texture is generally silty clay. Structure is angular blocky. Lime concretions are met in lower depth soil horizon. Available moisture capacity of the soil is estimated 17 cm. for 60 cm and 27 cm for 100 cm profile depth.

COMPETING SERIES AND THEIR DIFFERENTIAE: These include the associated Patiala and Jalalpur series which do not crack during summer.

DRAINAGE AND PERMEABILITY: Moderately well drained with moderately slow permeability.

USE AND VEGETATION: These soils are generally under cultivation. Paddy, wheat and gram are the important crops. *Accacia sp.* is only the natural vegetation.

DISTRIBUTION AND EXTENT: Extensive area occurs near village sadhugarh - Boras of tehsil Sirhind, Punjab.

TYPE LOCATION: East of village Sadhargarh, Tehsil Sirhind; District Patiala (Punjab).

REMARKS: This soil cracks during summer season.

SERIES PROPOSED BY: Regional Centre; Delhi - National Bureau of Soil Survey and Land Use Planning.

PATIALA SERIES

Patiala series comprises very deep, moderately well drained, clayey, non-calcareous soils of dark brown to reddish brown colours. They have developed on alluvium of the Ghaggar flood plains in the semi- arid part of Punjab. Patiala soils occur on nearly level lands of concave slopes ranging upto 2 percent. The climate is semi-arid with mean annual temperature of more than 22°C and means rainfall of 570 to 900 cm. Principal associated soil series are clayey Jalalpur which are calcareous and fine loamy, Bahadurgarh and Urdan which are calcareous and non-calcareous respectively. Patiala series is a member of clayey, mixed hyperthermic family of Fluventic Ustochrepts.

Typifying Pedon : Patiala silty clay cultivated.

Ap	Light reddish brown (5 YR 6/4 dry), reddish brown (5 YR 4/4 moist), silty clay; coarse, strong, angular blocky structure, hard, firm, sticky and plastic, common roots, clear and smooth boundary.
B1	Reddish brown (5 YR 4/4y moist), silty clay, coarse, strong, angular blocky structure, firm, sticky and plastic, common roots, gradual and smooth boundary.
B	Reddish brown (5YR4/3 moist), silty clay loam, coarse, strong, angular blocky structure; firm, sticky and plastic, few roots, diffuse boundary.
B3	Reddish brown(5YR 4/3, 4/4 moist), silty clay, coarse, strong, angular blocky structure, firm, sticky and plastic, few fine faint mottles, clear and smooth boundary.
C1	Reddish brown (5 YR 4/4 moist); silty clay; coarse, strong, angular blocky structure; firm, vary sticky and vary plastic; few fine faint mottles; slight effervescent with dilute acid; clear and smooth boundary.
C2	Dark reddish gray to reddish brown (5 YR 4/2,4/4 rubbed) silty clay loam; coarse, strong, angular blocky structure; firm, very sticky and very plastic, few fine faint mottles; alight effervescence with dilute acid; clear and smooth boundary.
C3	Dark reddish gray to reddish brown (5 YR 4/2, 4/4 rubbed) silty clay loam; coarse, strong, angular blocky structure; firm vary sticky and very plastic; slight effervescence.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse Silt %	Fine Silt %	Clay %
Ap	0-18	2.25	7.00	12.70	34.60	41.70
B1	18-47	2.75	7.25	12.35	33.87	42.70
B2	47-66	3.60	8.95	12.00	37.18	36.67
B3	66-86	1.65	6.50	8.31	38.70	44.00
C1	86-116	2.10	6.93	6.93	43.95	40.12
C2	116-146	3.60	11.10	9.30	38.85	35.90
C3	146-174	3.60	10.30	9.40	41.75	34.70

Physico-Chemical Properties

Depth (cm)	pH (1:2.5)	E.C. 1:2 mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cation meq/100 gm soil			
						Ca	Mg	Na	K
0-18	7.5	0.75	—	0.83	19.20	12.50	5.00	0.98	0.72
18-47	7.5	0.25	—	0.38	16.83	11.25	4.2	0.76	0.57
47-66	7.5	—	—	0.36	17.24	12.00	4.0	0.72	0.52
66-86	7.5	0.20	—	0.33	20.73	14.50	5.0	0.71	0.52
86-116	7.6	0.25	0.90	0.29	19.13	13.50	4.5	0.71	0.42
116-146	7.3	0.20	0.50	0.25	15.19	10.75	3.5	0.54	0.40
146-174	7.5	0.25	0.70	0.21	16.44	11.50	4.0	0.57	0.37

RANGE IN CHARACTERISTICS: Colour of the surface soils range from brown (7.5 YR 5/4) to reddish brown

(5 YR 5/4). The surface texture ranges from silt loam to silty clay. Structure varies from medium to coarse angular blocky with moderate to strong grades. Colour of the sub-soil varies from dark Brown (7.5 YR 4/4) to reddish brown (5 YR 4/4). Texture varies from silty clay loam to silty clay. Structure varies from medium to coarse angular blocky with moderate to strong grades. The soils are generally non-calcareous. Pine stratifications are visible within the profile. Mottles occur at various depths. Soil may be calcareous below 60 cm depth. Available moisture capacity of the soil is estimated to be 17 cm for 60 cm and 27 cm for 100 profile depth.

COMPETING SERIES AND THEIR DIFFERENTIALS: These include the associated Jalalpur series which is clayey and calcareous and Urdan. Bahadurgarh series which are fine loamy, non-calcareous and calcareous respectively.

DRAINAGE AND PERMEABILITY: Moderately well drained with moderately slow permeability.

USE AND VEGETATION: The soils are generally under cultivation. Paddy, wheat, berseem and gram are among the important crops. *Accacia sp.*, *Dalbergia sissoo* and *Saccharum sp.* are common vegetation observed in uncultivated lands.

DISTRIBUTION AND EXTENT: Extensive area in the southern part Patiala Tehsil.

TYPE LOCATION: Bahal, Patiala, Punjab.

SERIES PROPOSED BY: Regional Centre, Delhi - National Bureau of Soil Survey and Land Use Planning, 1976.

ROHAR SERIES

Rohar series comprises very deep, moderately well drained fine loamy calcareous soils of reddish brown to brown colour. Generally sub-soil colour varies from dark yellowish brown to olive brown. These soils are developed on alluvium of the Ghaggar flood plains in the semi-arid part of Punjab. These soils are sodic below about 45 on depth. Fine paper thin stratifications are present. The climate is semi-arid with mean annual temperature more than 22°C and mean annual rainfall of 570 to 900 mm. Associated series are Patiala, Jalalpur which are clayey and Bahadurgarh which is fine loamy and calcareous. Rohar series is a member of clayey over fine loamy, calcareous, mixed hyperthermic family of Fluventic Ustochrepts.

Typifying Pedon: Rohar silty clay loam, cultivated.

Ap	Light reddish brown (5 YR 6/3 D), reddish brown (5 YR 4/3 M), silty clay loamy strong, coarse, angular blocky structure; very firm, sticky and plastic; slight effervescence with dilute acid, common fine roots; clear and smooth boundary.
B2	Reddish brown (5 YR 5/3 D), (5 YR 4/3 M), silt clay, strong, coarse, angular blocky structure very hard, very firm, sticky and plastic, slight effervescence with dilute acid; clear and smooth boundary.
B3	Reddish brown (5 YR 5/3 D), (5 YR 4/3 M); silty loam, moderate, medium, angular blocky structure; very hard, very firm, sticky and plastic, moderate effervescence with dilute acid, clear and smooth boundary.
IIC1	Pale brown (10 YR 6/3 D) brown (10 YR 5/3 M) loam; moderate, medium, angular blocky structure, very hard; very fine, sticky and plastic; strong effervescence with dilute acid; plentiful concretions clear and smooth boundary.
IIC2	Pale brown (10 YR 6/3 D), yellowish brown (10 YR 5/4 M); loam; moderate, medium, angular blocky structure; very hard, very firm, sticky and plastic; slight effervescence with dilute acid; plentiful concretions; few fine faint iron mottles; clear and smooth boundary.
IIC3	Brown to pale brown (10 YR 5.5/3 D) grayish brown (10 YR 5/2 M); clay loam, moderate, medium, angular blocky structure; very hard, very firm, sticky and plastic; very slight effervescence with dil. acid; plentiful concretions; common fine faint iron mottles; clear and smooth boundary.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse Silt %	Fine Silt %	Clay %
Ap	0-12	0.8	8.3	19.0	37.8	35.0
B2	12-25	0.8	7.7	15.8	35.8	40.0
B3	25-45	2.1	11.2	18.5	38.6	29.8
IIC1	45-76	3.7	21.8	20.0	28.3	26.3
IIC2	76-91	3.7	21.2	19.2	28.1	27.2
IIC3	91-125	4.2	21.1	21.7	34.4	30.3

Physico-Chemical Properties

Depth (cm)	pH (1:2.5)	E.C. (1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/100 gm soil	Exchangeable cation meq/100gm soil			
						Ca	Mg	Na	K
0-12	7.8	1.4	Nil	1.06	17.39	10.25	3.50	3.57	0.77
12-25	8.5	0.9	„	1.53	17.41	11.00	2.25	4.46	0.64
25-45	9.2	3.4	0.38	0.54	16.95	13.00	0.25	3.57	0.58
45-76	10.0	2.4	0.74	0.39	15.78	3.50	1.50	10.78	0.58
76-91	10.0	1.6	0.74	0.51	15.53	3.25	0.75	11.00	0.64
91-125	9.8	1.4	0.12	0.45	14.69	2.00	1.25	11.04	0.60

RANGE IN CHARACTERISTICS: The colour of the surface soil varies from dark brown (7.5 YR 4/4) to reddish brown (5 YR 4/3). Surface texture varies from silty clay loam to silty clay. Sub-soil colour varies from pale brown to yellowish brown (10 YR 6/3, 5/3, 4/4) and olive brown to light olive brown (2.5 Y 5/4, 4/4). Texture varies from loam to clay loam. In Some cases there are 15-25% calcium carbonate concretions below 67-100 cm depth.

COMPETING SERIES AND THEIR DIFFERENTIAE: These include associated Patiala-Jalalpur series which are of 7.5 YR hue throughout the profile.

DRAINAGE AND PERMEABILITY: Moderately well drained with moderately slow permeability.

USE AND VEGETATION: These soils are generally in cultivation of wheat, paddy and gram. *Accacia sp.*, *Dalbergia sp.*, *Saccharum sp.* and *Eucalyptus* are common vegetation in forest areas.

DISTRIBUTION AND EXTNET: Extensive areas occur south of Patiala, tehsil in Bunerheri forest area.

TYPE LOCATION: Profile is located at Bunerheri forest.

SERIES PROPOSED: Regional Centre, Delhi - National Bureau of Soil Survey and Land Use Planning

GHANUAR SERIES

Ghanuar series comprises very deep, moderately well drained, clayey, calcareous, soils of dark brown to reddish brown colour. They have developed on the alluvium of Ghaggar flood plains in the semi- arid part of Punjab. The soils occur on nearly level lands of usually less than 1 per cent slope. The climate is semi-arid with mean annual temperature of more than 22 °C and means annual rainfall of 570 to 900 cm. Principal associated soils are Bahadurgarh which is fine loamy, calcareous. Ghanuar is a member of clayey, mixed, calcareous hyperthermic family of Fluventic Ustochrepts.

Typifying Pedon: Ghanuar silty clay loam - cultivated.

Ap	Light brown (7.5 YR 6/4 D), brown (7.5 YR 5/4 M), silty clay loamy moderate, medium, subangular blocky structure, hard, sticky and plastic many-medium roots many very fine pores, clear and smooth boundary.
A12	Light brown (7.5 YR 5/4 D), brown (7.5 YR 5/4 M), silty, clay loamy strong, medium-angular blocky structure, hard firm, sticky and plastic many medium roots; many very fine pores; clear and smooth boundary.
B21	Brown (7.5 YR 5/4 D), reddish brown (5 YR 4/3 M), silty clay loamy strong, medium to coarse, angular blocky structure; very hard, very firm, sticky and plastic; few fine roots; many very fine pores; strong effervescence with dilute acid: gradual and smooth boundary.
B22	Reddish brown (5 YR 4/3 M), silty clay, strong, medium to coarse angular blocky structure, hard, very firm, sticky and plastic, few fine roots, few fine pores, gradual and smooth boundary.
B3	Brown to dark brown (5 YR 4/4 M), silty clay loam, strong, medium to coarse angular blocky structure, hard, very firm, sticky and plastic, few fine roots, few fine pores, gradual and smooth boundary.
C	Brown to dark brown (5 YR 4/4 M), silt loam, moderate, medium, angular blocky structure, hark, very firm, sticky and plastic, few fine roots; few fine pores.

Particle Size Distribution

Horizon	Depth (cm)	Coarse sand %	Fine sand %	Coarse silt %	Fine silt %	Clay %
Ap	0-9	0.9	7.9	18.1	37.5	33.8
A12	9-22	0.9	7.6	13.5	45.6	32.0
B21	22-52	0.9	6.3	11.6	46.6	35.4
B22	52-85	0.9	2.0	2.4	51.5	41.0
B3	85-124	0.8	3.7	10.6	45.3	37.3
C	124-156	0.8	9.2	20.1	42.5	24.8

Physico-chemical Properties

Depth (cm)	pH (1:2.5)	E.C.(1:2) mmhos/cm	CaCO ₃ %	O.C. %	C.E.C. meq/ 100 gm soil	Exchangeable cations meq/100gm soil			
						Ca	Mg	Na	K
0-9	9.4	0.7	Nil	0.24	10.33	2.50	3.25	4.67	0.26
9-22	9.4	0.8	Nil	0.32	14.14	3.00	2.50	4.89	0.26
22-52	9.3	1.0	Nil	0.35	17.95	5.25	3.00	4.89	0.32
52-85	8.4	2.2	1.00	0.15	21.76	11.50	5.00	4.35	9.32
85-124	8.6	0.8	Nil	0.26	18.49	8.75	3.00	1.63	3.32
124-156	7.4	1.3	Nil	0.30	11.70	5.00	4.25	2.17	3.32

RANGE IN CHARACTERISTICS: Colour of the surface soils ranges from light brown to brown (7.5 YR 6/4, 5/4) and surface texture varies from silty clay loam to clay loam. Structure of surface soil varies from moderate medium to coarse subangular blocky. Colour of the sub-soil varies from brown (7.5 YR 5/4) to dark reddish brown (5 YR 3/4). Texture varies from silty clay loam to silty clay or clay and structure from moderate to strong, medium to coarse subangular blocky to angular blocky.

COMPETING SERIES AND THEIR DIFFERENTIALS: Competing series are Manakpur and Tohana. Manakpur is non- calcareous and Tohana also non-calcareous but has 10 YR colours.

DRAINAGE AND PERMEABILITY: Moderately well drained with slow permeability.

USE AND VEGETATION: The soils are under cultivation. Paddy, sugarcane, wheat, gram, jowar and berseem are the main crops. Trees of *Accacia sp*, *Dalbergia sissoo*, *Zizyphus jujuba*, are found growing.

DISTRIBUTION AND EXTENT: South east and Central parts of the Tehsil near Ghaauar and Rajapura towns.

TYPE LOCATION: 1 km. from Bathuria village to the left of the Kaccha road.

SERIES PROPOSED BY: Regional Centre, Delhi - National Bureau of Soil Survey and Land Use Planning.