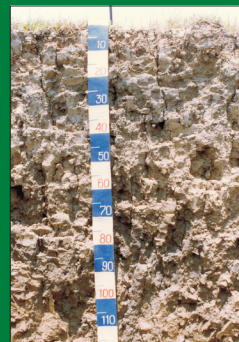# Soil Resource Information of Different Agro-Eco Subregions of India

For

Crop and Soil Carbon Modelling

National Project on Climate Change
(ICAR Network Project)

National Bureau of Soil Survey and Land Use Planning

(Indian Council of Agricultural Research)

Nagpur - 440 033, Maharashtra, India

ICAR

ICAR

Soil Resource Information of Different Agro-Eco Subregions of India

For

Crop and Soil Carbon Modelling

National Project on Climate Change
(ICAR Network Project)

National Bureau of Soil Survey and Land Use Planning

(Indian Council of Agricultural Research)

Nagpur - 440 033, Maharashtra, India

ABOUT THE NBSS&LUP

The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Nagpur, a premier Institute of the Indian Council of Agricultural Research (ICAR), was set up in the year 1976 with the objective to prepare soil resource maps at state and district level and to provide research inputs in soil resource mapping, and its applications, land evaluation, land use planning, land resource management, and database management using GIS for optimising land use on different kinds of soils in the country. The Bureau has been engaged in carrying out agro-ecological and soil degradation mapping at the country, state and district level for qualitative assessment and monitoring the soil health towards viable land use planning. The research activities have resulted in identifying the potentials and problems of soils, and the various applications of the soil surveys with the ultimate objective of sustainable agricultural development. The Bureau has the mandate to correlate and classify soils of the country and maintain a National Register of all the established soil series. The Institute is also imparting in-service training to staff of the soil survey agencies in the area of soil survey, land evaluation and soil survey interpretations for land use planning. The Bureau in collaboration with Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is running post-graduate, teaching and research programme in land resource management, leading to M.Sc. & Ph.D. degrees at Nagpur. Besides other regional centres are also directly or indirectly catering to the needs of state agricultural universities. The Bureau has been actively engaged in research work with various national and international projects. The present publication on "Soil Series Compendium (AESR-wise) for Crop Growth Model" has been prepared for the ICAR Network Project on Climate Change.

The present publication deals with detailed soil and site parameters and climatic data from selected Benchmark spots which cover all agro-ecological regions of the Country. These soils enjoy the status of many identified soils. These datasets will be useful for modellers using Roth C, Century and other Crop Growth Models viz. Info Crop Model. The source of information has been detailed in the list of references.

The first part of this document describes 117 soil series datasets in terms of morphological, physical and chemical properties. The information on crops, land use and soil data interpretation are also provided. The appendix portion details specific data requirement of the modellers for Info Crop, Roth C and Century C models.

Citation: Bhattacharyya, T., Ray, S. K., Sarkar Dipak, Balbuddhe, D. V., Dasgupta, D., Chandran, P., Tiwari, P., Pal, D. K., Mandal, C., Nimje, A. M., Deshmukh, A. S., Deshmukh, R. R., Telpande, B. A., Lokhande, M. A., Wadhai, K. N., Dongare, V. T., Thakre, S. W., Likhar, C. K., Sheikh, S. M., Aggarwal, P. K., Pathak, H., Venkateswarlu, B., Rao, V.U.M., Naresh Kumar Soora and Singh, A. K. (2011). Soil Resource Information of Different Agro-Eco Subregions of India for Crop and Soil Modelling. National Project on Climate Change (ICAR Network Project), National Bureau of Soil Survey and Land Use Planning, Nagpur, Maharashtra, p302 and 188 pages annexure.

TO OBTAIN COPIES OF THIS REPORT,

Please write to:

Director,
National Bureau of Soil Survey and Land Use Planning (NBSS&LUP),
Amravati Road, NAGPUR-440 013, India.

Phone : (0712) 2500386, 2500664, 2500545 (O)

Telefax : +91-0712-2500534

E-mail : director@nbsslup.ernet.in

ACKNOWLEDGEMENTS

CONTENTS

INDIA
BENCH MARK SPOTS

0 110 220   440 km

REFERENCES
● BENCH MARK SPOTS

PAKISTAN

NEPAL

BHUTAN

BANGLADESH

MYANMAR

Arabian Sea

Bay of Bengal

JAMMU AND KASHMIR
HIMACHAL PRADESH
PUNJAB
HARYANA
DELHI
UTTARANCHAL
UTTAR PRADESH
RAJASTHAN
GUJARAT
MADHYA PRADESH
BIHAR
JHARKHAND
WEST BENGAL
SIKKIM
ARUNACHAL PRADESH
ASSAM
MEGHALAYA
NAGALAND
MANIPUR
TRIPURA
MIZORAM
CHHATISGARH
ORISSA
MAHARASHTRA
DADRA NAGAR HAVELI
GOA
KARNATAKA
ANDHRA PRADESH
KERALA
TAMIL NADU
LAKSHADWEEP
ANDAMAN AND NICOBAR ISLAND

1.2
1.1
14.1
9.1
9.1
14.3
14.2
14.4
9.1
4.1
14.5
14.5
1.2
2.1
2.3
4.3
9.2
13.1
16.3
16.2
16.1
15.4
15.3
15.2
17.1
15.1
15.3
17.2
4.4
2.2
4.2
10.3
12.3
2.4
5.2
10.1
11.00
5.1
10.4
18.5
12.5
19.1
10.2
6.3
12.2
12.1
19.3
6.2
18.4
6.1
7.2
19.3
7.3
6.4
19.3
19.3
3.0
7.1
18.3
19.3
8.2
19.2
8.3
18.2
20.2
19.3
8.1
18.1
19.3
18.1
20.1
20.1

INTRODUCTION

Soil datasets embedded in soil master of the Info Crop model are not adequate to run the model and also to make interpretations on the output. To fill up such gap the soil information for all the agro-ecological sub regions of NBSS&LUP (Sehgal, *et al.,* 1994; Velayuthum *et al.,* 1999) has been compiled in this document. The name of soil series and other details are shown in table1. To document this information the necessary first step was the source. Many soil datasets were not printed and documented properly. On many occasions datasets are inadequate with special reference to the requirements of different modellers and therefore we have used different pedotransfer functions to gather some missing datasets.

Soil series information, as a matter of fact provides data on landscape, morphological, physical, chemical, mineralogical and micromorphological properties of soils and associated data on environment (climate), water, vegetation and land use, crops, etc. However, for modellers, a few of these datasets are necessary to run a model although the entire datasets become essential to interpret the model output. It is in view of this we have prepared datasets for modellers in Annexure I Info Crop, Roth C and Century carbon models. The soils are described according to AESRs 1 to 60 in the following section.

Table 1. Soil information, AESR-wise

AESR No.	AESR description	Soil Series (District and State)	Soil Classification	Area ('000 ha)	Source
1.1	Eastern aspect of Ladakh Plateau, cold, hyper-arid eco- subregion (ESR) with shallow skeletal soils, very low AWC and LGP <60 days (A13Eh1)*	Ladakh II (Ladakh, Jammu & Kashmir)	Sandy, mixed (siliceous), frigid Typic Cryorthents	163	*Gawande et .al (1979)*
		Ladakh III (Ladakh, Jammu & Kashmir)	Coarse-loamy, mixed (siliceous), frigid Typic Cryorthents	164	*Gawande et .al (1979)*
1.2	Western Aspect of Ladakh Plateau and north Kashmir Himalayas, cold to cool, typic-arid ESR with shallow, loamy- skeletal soils, low AWC and LGP 60-90 days (A13Et2)	Kibber (Lahaul & Spiti, Himachal Pradesh)	Fine-loamy, mixed (calcareous), cryic Humic Cryochrepts	8,300	*Anonymus, (2002)*
2.1	Marusthali hot, hyper arid ESR with shallow and deep sandy desert soils very low AWC and LGP < 60 days (M9Eh1)	Chirai (Jodhpur, Rajasthan)	Coarse-loamy, mixed, hyperthermic Typic Camborthids	NA**	*Lal et al. (1994)*
		Pal (Jodhpur, Rajasthan)	Coarse-loamy, mixed, hyperthermic Typic Camborthids	NA	*Lal et al. (1994)*
2.2	Kachchh Peninsula (Great Rann of Kutch as inclusion), hot hyper-arid ESR with deep loamy saline and	Amliara (Kachchh, Gujrat)	Fine-loamy, mixed, hyperthermic Fluventic Comborthids	90,000	*Lal et al. (1994)*

AESR No.	AESR description	Soil Series (District and State)	Soil Classification	Area ('000 ha)	Source
	alkali soils, low AWC and LGP <60 days (L12Eh1)	Balasar (Kachchh, Gujrat)	Mixed, hyperthermic Typic Torripsamments	30,000	*Lal et al. (1994)*
2.3	Rajasthan Bagar, North Gujarat Plain and South-Western Punjab Plain, hot typic- arid ESR with deep, loamy desert soils (inclusion of saline phase), low AWC and LGP 60-90 days (M9Et2)	Hisar (Hisar, Haryana)	Fine-loamy, mixed, hyperthermic Typic Haplustepts	NA	*Lal et al. (1994)*
		Jaitaran (Pali, Rajasthan)	Coarse-loamy, mixed, hyperthermic Typic Camborthids	NA	*Lal et al. (1994)*
2.4	South Kachchh and North Kathiawar Peninsula, hot arid ESR with deep loamy saline and alkali soils, low AWC and LGP 60-90 days (L12Et2)	Bhola (Rajkot, Gujrat)	Fine, smectitic, hyperthermic Vertic Haplustepts	48,750	*Lal et al. (1994)*
		Semla (Rajkot, Gujrat)	Very fine, smectitic, hyperthermic Udic Haplusterts	62,700	*Lal et al. (1994)*
3	Karnataka Plateau (Rayalseema as inclusion), hot arid ESR with deep loamy and clayey mixed Red and Black soils, low to medium AWC and LGP 60-90 days (K6Et2)	Jamakhandi (Bijapur, Karnataka)	Fine, mixed, isohyperthermic Typic Paleustalfs	NA	*Lal et al. (1994)*
		Sollapuram (Anantapur, Andhra Pradesh)	Very fine, smectitic, isohyperthermic Sodic Haplusterts	NA	*Pal et al. (2003)*
4.1	North Punjab Plain, Ganga-Yamuna Doab and Rajasthan Upland, hot semi-arid ESR with deep loamy alluvium-derived soils (occasional saline and sodic phases), medium AWC and LGP 90-120 days (N8Dd3)	Zarifa Viran (Karnal, Haryana)	Fine-silty, mixed, hyperthermic Typic Natrustalfs	NA	*Murthy et al. (1982)*
		Shergarh (Mathura, Uttar Pradesh)	Mixed, calcareous, hyperthermic Typic Ustipsamments	12,637	*Mahapatra et al. (2010)*
4.2	North Gujarat Plain (inclusion of Aravalli range and east Rajasthan Uplands), hot dry semiarid ESR with deep loamy Gray Brown and alluvium-derived soils, medium AWC and LGP 90-120 days (P14Dd3)	Baland (Bhilwara, Rajasthan)	Fine-loamy, mixed (calcareous), hyperthermic Typic Haplustepts	1,37,862	*Singh et al. (2006); Giri et al.(2003)*
		Kajlodiya (Bhilwara, Rajasthan)	Fine-loamy, mixed, hyperthermic Typic Haplustepts	94,430	*Singh et al. (2006); Giri et al.(2003)*
4.3	Ganga Yamuna Doab, Rohilkhand and Avadah Plain, hot moist semi-arid ESR with deep, loamy alluvium-derived soils (sodic phase inclusion), medium to high AWC and LGP 120-150 days (N8Dm4)	Nagariya (Sahajahanpur, Uttar Pradesh)	Coarse-loamy, mixed, hyperthermic Typic Haplustepts	10,807	*Mahapatra et al. 2010)*
		Bijaipur (Fatehpur, Uttar Pradesh)	Fine-silty, mixed, hyperthermic Udic Haplustalfs	NA	*Murthy et al. (1982)*
4.4	Madhya Bharat Plateau and Bundelkhand Uplands, hot, moist semi-arid ESR with Deep loamy and clayey mixed Red and Black soils, medium to high AWC and LGP 90-120 days (N6Dm4)	Haripur (Banda, Uttar Pradesh)	Fine, smectitic, hyperthermic Vertic Haplustepts	NA	*Lal et al. (1994)*
		Singpura (Gwaliar, Madhya	Fine-loamy, mixed, hyperthermic Typic	NA	*Murthy et al. (1982)*

AESR No.	AESR description	Soil Series (District and State)	Soil Classification	Area ('000 ha)	Source
		Pradesh)	Haplustalfs		
5.1	Central Kathiawar Peninsula, hot, dry semiarid ESR with shallow and medium loamy to clayey black soils (deep black soils as inclusion) medium AWC and LGP 120-150 days (L4Dd3)	Gondal (Rajkot, Gujarat)	Clayey, smectitic, hyperthermic Lithic Ustorthents	1,36,000	*Lal et al. (1994)*
		Kagwad (Rajkot, Gujarat)	Clayey, smectitic (calcareous), hyperthermic Vertic Haplustepts	87,200	*Lal et al. (1994)*
5.2	Madhya Bharat Plateau, Western Malwa Plateau, Eastern Gujarat Plain, Vindhyan and Satpura range and Narmada Valley, hot moist semi-arid ESR with medium and deep, clayey Black soils (shallow black soils as inclusions), medium to high AWC and LGP 120-150 days (I5Dm4)	Haldhar (Bharuch, Gujrat)	Fine, smectitic, hyperthermic Chromic Haplusterts	NA	*Lal et al. (1994)*
		Jalalpur (Vadodara, Gujrat)	Very fine, smectitic, hyperthermic Typic Haplusterts	NA	*Lal et al. (1994)*
5.3	Coastal Kathiawar Peninsula, hot moist semi-arid ESR with deep loamy coastal alluvium-derived soils (saline/phases inclusion), low to medium AWC and LGP 120-150 days (L7Dm4)	Khuntwada (Bhavnagar, Gujarat)	Fine, smectitic (calcareous), hyperthermic Typic Haplusterts	67,670	*Sharma et al. (2006)*
		Lilvan (Bhavnagar, Gujarat)	Very fine, smectitic (calcareous), hyperthermic Vertic Haplustepts	21,750	*Sharma et al. (2006)*
6.1	South Western Maharashtra and North Karnataka Plateau, hot dry semi-arid ESR with shallow and medium loamy Black soils (deep clayey Black soils as inclusion), medium to high AWC and LGP 90-120 days (K4Dd3)	Talegaon (Ahmednagar, Maharashtra)	Fine, smectitic, isohyperthermic Leptic Haplusterts	50,000	*Lal et al. (1994)*
		Sirasgaon (Pune, Maharashtra)	Fine, smectitic, isohyperthermic Typic Haplusterts	NA	*Lal et al. (1994)*
6.2	Central and Western Maharashtra Plateau and North Karnataka Plateau and North Western Telangana Plateau, hot moist semi-arid ESR with shallow and medium loamy to clayey Black soils (medium land deep clayey Black soils as inclusion), medium to high AWC and LGP 120-150 days (K4Dm4)	Annapur (Ahmednagar, Maharashtra)	Fine-loamy, smectitic, isohyperthermic Fluventic Haplustepts	NA	*Lal et al. (1994)*
		Torkewadi (Ahmednagar, Maharashtra)	Clayey-skeletal, mixed, isohyperthermic Lithic Ustorthents	1,10,000	*Lal et al. (1994)*
6.3	Eastern Maharashtra Plateau, hot moist semi-arid ESR with medium land deep clayey Black soils (shallow loamy to clayey Black soils as inclusion), medium to high AWC and LGP 120-150 days (K5Dm4)	Jambha (Amravati, Maharashtra)	Very fine, smectitic, hyperthermic Typic Haplusterts	NA	*Lal et al. (1994)*
		Loni (Yeotmal, Maharashtra)	Very fine, smectitic, hyperthermic Typic Haplusterts	NA	*Pal et al. (2003)*

AESR No.	AESR description	Soil Series (District and State)	Soil Classification	Area ('000 ha)	Source
6.4	North Sahyadris and Western Karnataka Plateau, hot dry subhumid ESR (K4Cd5)	Achmatti (Dharwad, Karnataka)	Very fine, smectitic, isohyperthermic Sodic Haplusterts	NA	*Lal et al. (1994)*
		Nimone (Pune, Maharashtra)	Fine, smectitic, isohyperthermic Typic Haplusterts	NA	*Lal et al. (1994)*
7.1	South Telangana Plateau (Rayalseema) and Eastern Ghat, hot dry semi-arid ESR with deep loamy to clayey mixed Red and Black soils, medium AWC and LGP 90-120 days (K6Dd3)	Rayadurg (Cuddapah, Andhra Pradesh)	Loamy, skeletal, mixed (calcareous), isohyperthermic Ustic Haplargids	1,35,342	*Reddy et al. (2005)*
		Kurnool (Kurnool, Andhra Pradesh)	Fine, smectitic (calcareous), isohyperthermic Vertic Haplustepts	20,34,944	*Reddy et al. (2005)*
7.2	North Telangana Plateau, hot moist semi-arid ESR with deep loamy and clayey mixed Red and Black soils, medium to very high AWC and LGP 120-150 days (K6Dm4)	Kasireddipalli (Medak, Andhra Pradesh)	Fine, smectitic, isohyperthermic Sodic Haplusterts	86,306	*Pal et al. (2003)*
		Chitkul (Medak, Andhra Pradesh)	Fine, smectitic, active isohyperthermic Vertic Haplustepts	86,304	*Reddy et al. (2005a); Reddy et al. (2005b)*
7.3	Eastern Ghat (South), hot moist semi-arid/dry subhumid ESR with medium to deep, loamy to clayey mixed Red and Black soils, medium AWC and LGP 150-180 days (H6Dm/Cd5)	Peddapuram (West Godavari, Andhra Pradesh)	Fine, mixed, subactive, isohyperthermic Rhodic Paleustalfs	5,12,579	*Reddy et al. (2005)*
		Nuzvid (Krishna, Andhra Pradesh)	Fine, mixed, semiactive, isohyperthermic Typic Paleustalfs	2,50,161	*Reddy et al. (2005)*
8.1	Tamil Nadu Uplands and Leeward Flanks of South Sahyadris, hot dry semi-arid ESR with moderately deep to deep, loamy to clayey, mixed Red and Black soils, medium AWC and LGP 90-120 days (H6Dd3)	Coimbatore (Coimbatore, Tamil Nadu)	Fine, smectitic, isohyperthermic Vertic Haplustepts	NA	*Lal et al. (1994)*
		Kovilpatti (Toothokudi, Tamil Nadu)	Very fine, smectitic, isohyperthermic Gypsic Haplusterts	NA	*Pal et al. (2003)*
8.2	Central Karnataka Plateau, hot moist semi-arid ESR with medium to deep Red loamy soils, low AWC and LGP 120-150 days (K1Dm4)	Tyamagondalu (Bangalore, Karnataka)	Fine, mixed, isohyperthermic Kandic Paleustalfs	NA	*Lal et al. (1994)*
		Channasandra (Bangalore, Karnataka)	Clayey-skeletal, mixed, isohyperthermic Kanhaplic Haplustalfs	NA	*Lal et al. (1994)*
8.3	Tamil Nadu Uplands and Plains, hot moist semi-arid ESR with deep red loamy soils, low AWC and LGP 120-150 days (H1Dm4)	Sivagangai (Shivangangai, Tamil Nadu)	Clayey-skeletal, mixed, isohyperthermic Rhodic Paleustalfs	NA	*Natarajan et al. (2006)*

AESR No.	AESR description	Soil Series (District and State)	Soil Classification	Area ('000 ha)	Source
		Salur (Shivagangai, Tamil Nadu)	Fine, smectitic, isohyperthermic Vertic Haplustepts	NA	*Natarajan et al. (2006)*
9.1	Punjab and Rohilkhand Plains, hot dry/moist subhumid transitional ESR with deep, loamy to clayey alluvium-derived (inclusion of saline and sodic phases) soils, medium AWC and LGP 120-150 days (N8Cm/Cd4)	Berpura (Ambala, Haryana)	Fine-loamy, mixed, hyperthermic Udic Haplustepts	NA	*Lal et al. (1994)*
		Shahazadpur (Ambala, Haryana)	Fine-loamy, mixed, hyperthermic Typic Haplustalfs	NA	*Lal et al. (1994)*
9.2	Rohilkhand, Avadh and south Bihar Plains, hot dry subhumid ESR with deep loamy alluvium-derived soils, medium to high AWC and LGP 150-180 days (N8Cd5)	Basiaram (Azamgarh, Uttar Pradesh)	Fine-silty, mixed, hyperthermic Sodic Haplustalfs	NA	*Lal et al. (1994)*
		Sarthua (Bhojpur, Bihar)	Fine, mixed, hyperthermic Vertic Endoaqualfs	NA	*Pal et al. (2010)*
10.1	Malwa Plateau, Vindhyan Scarpland and Narmada Valley, hot dry subhumid ESR with medium and deep clayey Black soils (shallow loamy Black soils as inclusion), high AWC and LGP 150-180 days (15Cd5)	Kheri (Jabalpur, Madhya Pradesh)	Very fine, montmorillonitic, hyperthermic Typic Haplusterts	NA	*Pal et al. (2003)*
		Jamra (Sagar, Madhya Pradesh)	Fine, montmorillonitic, hyperthermic Chromic Haplusterts	NA	*Lal et al. (1994)*
10.2	Satpura and Eastern Maharashtra Plateau, hot dry subhumid ESR with shallow and medium loamy to clayey Black soils (deep clayey Black soils as inclusion), medium to high AWC and LGP 150-180 days (K4Cd5)	Linga (Nagpur, Maharashtra)	Very fine, montmorillonitic, hyperthermic Typic Haplusterts	NA	*Lal et al. (1994)*
		Sukali (Nagpur, Maharashtra)	Fine-loamy, mixed, hyperthermic Typic Haplustepts	NA	*Lal et al. (1994)*
10.3	Vindhyan Scarpland and Bundelkhand Plateau, hot dry subhumid ESR with deep loamy to clayey mixed Red and Black soils, medium to high AWC and LGP 150-180 days (I6Cd5)	Sundra (Panna, Madhya Pradesh)	Very fine, montmorillonitic, hyperthermic Chromic Haplusterts	NA	*Lal et al. (1994)*
		Marha (Chattarpur, Madhya Pradesh)	Fine, montmorillonitic, hyperthermic Chromic Haplusterts	NA	*Lal et al. (1994)*
10.4	Satpura range and Wainganga Valley, hot moist subhumid ESR with shallow to deep loamy to clayey mixed Red and Black soils, low to medium AWC and LGP 180-210 days (K6Cm6)	Sagar (Seoni, Madhya Pradesh)	Fine, mixed, hyperthermic Vertic Haplustepts	NA	*Tamgadge et al. (2008)*
		Gondatola (Seoni, Madhya Pradesh)	Fine, mixed, hyperthermic Typic Rhodustalfs	NA	*Tamgadge et al. (2008)*
11	Moderately to gently sloping Chattisgarh/Mahanadi Basin, hot moist/dry subhumid transitional	Bichanpur (Bilaspur, Chattisgarh)	Fine, montmorillonitic (cal.), hyperthermic Chromic Haplusterts	86,583	*Tamgadge et al. (2002)*

AESR No.	AESR description	Soil Series (District and State)	Soil Classification	Area ('000 ha)	Source
	ESR with deep loamy to clayey Red and Yellow soils, medium AWC and LGP 150-180 days (J3Cd/Cm5)	Hitekusa (Durg, Chattisgarh)	Fine-loamy, kaolinitic, isohyperthermic Typic Haplustalfs	95,780	*Tamgadge et al. (2002)*
12.1	Garjat Hills, Dandakaranya and Eastern Ghats, hot moist subhumid ESR with deep loamy Red and Lateritic soils, low to medium AWC and LGP 180-210 days (J2Cm6)	Gadchiroli (Gadchiroli, Maharashtra)	Fine-loamy, mixed, hyperthermic Typic Haplustoll	2,32,100	*Challa et al.(1999)*
		Bawanpuri (Bastar, Chattisgarh)	Fine, mixed, isohyperthermic Chromic Haplusterts	1,89,799	*Tamgadge et al. (2002)*
12.2	Eastern Ghats, hot moist subhumid ESR with medium to deep loamy Red and Lateritic soils, medium AWC and LGP 180-210 days (H2Cm6)	Bhubaneswar (Puri, Orissa)	Fine-loamy, mixed, isohyperthermic Typic Haplustults	NA	*Murthy et al. (1982)*
		Motto (Balasore, Orissa)	Fine, mixed, hyperthermic Vertic Halaquepts	NA	*Murthy et al. (1982)*
12.3	Chhotanagpur Plateau and Garjat Hills, hot, dry subhumid ESR with moderately deep to deep loamy to clayey Red and Lateritic soils, medium AWC and LGP of 150-180 days (J2Cd5)	Pusaro (Santal Paraganas, Bihar)	Fine-loamy, mixed, hyperthermic Typic Paleustalfs	NA	*Lal et al. (1994)*
		Phulkusma (Bankura, West Bengal)	Fine, mixed, hyperthermic Typic Haplustalfs	15,000	*Lal et al. (1994)*
13.1	North Bihar and Avadh Plains, hot dry to moist subhumid transitional ESR with deep, loamy alluvium-derived soils, low to medium AWC and LGP 180-210 days (O8Cd/Cm6)	Baratol (Madhubani, Bihar)	Fine-loamy, mixed, hyperthermic Typic Haplustepts	30,417	*Sarkar et al.(1999)*
		Hirapatti (Madhubani, Bihar)	Fine-loamy, mixed, hyperthermic Fluventic Haplustepts	47,232	*Sarkar et al.(1999)*
13.2	Foothills of Central Himalayas, warm to hot moist subhumid ESR with deep loamy to clayey Tarai soils, high AWC and LGP 180-210 days (B10Cm6)	Bahraich (Bahraich, Uttar Pradesh)	Fine-loamy (calcareous), mixed, hyperthermic Typic Udifluvents	65.38	*NBSS&LUP Staff (1984)*
		Kesarganj (Bahraich, Uttar Pradesh)	Coarse-loamy (calcareous), hyperthermic Typic Udifluvents	152.84	*NBSS&LUP Staff (1984)*
14.1	South Kashmir and Punjab Himalayas, cold and warm by dry semi-arid/dry subhumid ESR with shallow to medium deep loamy Brown Forest and Podzolic soils, low to medium AWC and LGP 90-120 days (A15Dd/Cd3)	Bathal (Lahaul & Spiti, Himachal Pradesh)	Medium deep, loamy-skeletal, mixed, calcareous, cryic Typic Cryorthents	2,82,000	*Anonymus, (2002)*
		Kalpa (Kinnaur, Himachal Pradesh)	Deep, fine- loamy, mixed, thermic Typic Dystrudepts	13,000	*Anonymus, (2002)*
14.2	South Kashmir and Kumaun Himalayas, warm moist to dry subhumid transitional ESR with	Ropri (Bilaspur, Himachal Pradesh)	Coarse-loamy, mixed, hyperthermic Typic Haplustepts	23,598	*Walia et al.(1998)*

AESR No.	AESR description	Soil Series (District and State)	Soil Classification	Area ('000 ha)	Source
	medium to deep loamy to clayey Brown Forest and Podzolic soils, medium AWC and LGP 150-210 days (A15Cd/Cm6)	Dehra (Bilaspur, Himachal Pradesh)	Fine-loamy, mixed, hyperthermic Typic Haplustalfs	2,012	*Walia et al.(1998)*
14.3	Punjab Himalayas, warm humid to perhumid transitional ESR with shallow to medium deep loamy brown forest and podzolic soils, low to medium AWC and LGP 270-300+ days (A15BA9)	Mataur (Kangra, Himachal Pradesh)	Fine-loamy, mixed, thermic Dystric Eutrochrepts;	NA	*Lal et al. (1994)*
		Rajpura (Kangra, Himachal Pradesh)	Fine-silty, mixed, thermic Typic Paleudalfs.	NA	*Lal et al. (1994)*
14.4	Kumaun Himalayas, warm humid to perhumid transitional ESR with shallow to medium deep loamy Red and Yellow soils, low AWC and LGP 270-300+ days (A3B/A9)	Gajeli (Tehri Garhwal, Uttarakhand)	Loamy-skeletal, mixed, thermic Typic Dystrudepts	NA	*NBSS&LUP Staff (2003)*
		Tayari (Tehri Garhwal, Uttarakhand)	Loamy-skeletal, mixed, thermic Typic Udorthents.	NA	*NBSS&LUP Staff (2003)*
14.5	Foothills of Kumaun Himalayas (Subdued), warm moist subhumid ESR with medium to deep, loamy tarai soils, medium AWC and LGP 270-300 days (A10A9)	Haldi (Nainital, Uttarakhand)	Coarse-loamy, mixed, hyperthermic Typic Hapludolls	NA	*Lal et al. (1994)*
		Nainital (Nainital, Uttarakhand)	Fine-loamy, mixed, hyperthermic Typic Endoaquoll.	NA	*Deshpande et al. (1971)*
15.1	Bengal basin and North Bihar Plain, hot moist subhumid ESR with deep loamy to clayey alluvium-derived soils, medium to high AWC and LGP 210-240 days (08Cm7)	Amarpur (Hooghly, West Bengal)	Fine-silty, mixed, hyperthermic Typic Haplustalfs	NA	*Lal et al. (1994)*
		Anantpur (Barddhaman, West Bengal)	Fine, mixed, hyperthermic Typic Endoaqualfs	12,000	*Lal et al. (1994)*
15.2	Middle Brahmaputra Plain, hot humid ESR with deep, loamy to clayey alluvium-derived soils, medium AWC and LGP 240-270 days (Q8B8)	Morigaon (Morigaon, Assam)	Fine-loamy, mixed, hyperthermic Typic Fluvaquents	NA	*Vadivelu et al.(2004)*
		Barbhagia (Morigaon, Assam)	Fine-loamy, mixed, hyperthermic Typic Epiaquents	NA	*Vadivelu et al.(2004)*
15.3	Teesta, lower Brahmaputra Plain and Barak Valley, hot moist humid to perhumid ESR with deep, loamy to clayey alluvium- derived soils, medium AWC and LGP 270-300 days (Q8A9)	Bongaigaon (Bongaigaon, Assam)	Coarse-loamy, mixed, hyperthermic Typic Endoaquepts	26,425	*Vadivelu et al.(2004)*
		Jogighopa (Bongaigaon, Assam)	Mixed, hyperthermic Typic Psammaquents	8,617	*Vadivelu et al.(2004)*
15.4	Upper Brahmaputra Plain, warm to hot perhumid ESR with moderately deep to deep loamy, alluvium-derived soils, medium AWC and LGP 300 days (Q8A10)	Sonari (Sibsagar, Assam)	Fine-loamy, mixed, hyperthermic Oxyaquic Dystrudepts	NA	*NBSS&LUP Staff (1995)*
		Amguri	Fine-loamy, mixed, hyperthermic Dystric	36,217	*NBSS&LUP Staff (1995)*

AESR No.	AESR description	Soil Series (District and State)	Soil Classification	Area ('000 ha)	Source
		(Sibsagar, Assam)	Eutrudepts		
16.1	Foot-hills of Eastern Himalayas (Bhutan foot-hills), warm to hot perhumid ESR with shallow to medium, loamy-skeletal to loamy Tarai soils, low to medium AWC and LGP 270-300 days (C10A9)	Darrang (Darrang, Assam)	Fine-loamy, mixed, hyperthermic Typic Endoaquepts	20,706	*Vadivelu et al.(2004)*
		Dhansiri (Darrang, Assam)	Mixed, hyoerthermic Typic Psammaquents	18,781	*Vadivelu et al.(2004)*
16.2	Darjeeling and Sikkim Himalayas, warm perhumid ESR with shallow to medium deep loamy Brown and Red Hill soils, low to medium AWC and LGP 300 days (C11A10)	Rayong (South Sikkim, Sikkim)	Fine-loamy, mixed, thermic Mollic Hapludalfs	9,937	*Das et al. (2003)*
		Maniram (South Sikkim, Sikkim)	Loamy-skeletal, mixed, thermic Typic Hapludolls	3,449	*Das et al. (2003)*
16.3	Arunachal Pradesh (Subdued Eastern Himalayas), warm to hot perhumid ESR with deep, loamy to clayey Red Loamy soils, low to medium AWC and LGP 300 days (C1A10)	Longsom (Tirap, Arunachal Pradesh)	Fine-loamy, mixed, hyperthermic Typic Dystrudepts	8054	*Chamuah et al. (1984)*
		Wakka (Tirap, Arunachal Pradesh)	Coarse-loamy, mixed, hyperthermic Lithic Udorthents	8,373	*Chamuah et al. (1984)*
17.1	Meghalaya Plateau land Nagaland Hill, warm to hot moist humid to perhumid ESR with medium to deep loamy to clayey Red and Lateritic soils, medium AWC and LGP 270-300+ days (D2A9)	Mawlyndair (East Khasi Hills, Meghalaya)	Loamy-skeletal, kaolinitic, thermic Humic Dystrochrepts	NA	*Nair et al. (1992)*
		Lailad (East Khasi Hills, Meghalaya)	Fine, kaolinitic, thermic Typic Kanhaplohumult	NA	*Nair et al. (1992)*
17.2	Purvachal (Eastern Range), warm to hot perhumid ESR with medium to deep loamy Red and Yellow soils, low to medium AWC and LGP 300 days (D3A10)	Longol-5 (Imphal, Manipur)	Fine, mixed, hyperthermic Typic Dystrudepts	10.07	*Sarkar et al. (2005)*
		Longol-6 (Imphal, Manipur)	Fine, mixed, hyperthermic Typic Kandiudults	6.17	*Sarkar et al. (2005)*
18.2	North Tamil Nadu Plains (Coastal), hot moist semi-arid ESR with deep, clayey and cracking Coastal land Deltaic alluvium- derived soils, high AWC and LGP 120-150 days (S7Dm4)	Kalathur (Thanjavur, Tamil Nadu)	Fine, montmorillonitic, isohyperthermic Sodic Haplusterts.	NA	*Lal et al. (1994)*
		Thirunallar (Puducherry, U. T.)	Fine, montmorillonitic, isohyperthermic Typic Haplusterts.	NA	*Vadivelu et al. (2008)*
18.3	Andhra Plain, hot dry subhumid ESR with deep, clayey Coastal and Deltaic alluvium-derived soils, low to medium AWC and LGP 150-180 days (S7Cd5)	Kovvur (Nellore, Andhra Pradesh)	Fine, mixed, active, isohyperthermic Aquic Haplustepts	76,896	*Reddy et al. (2005)*
		Kaveli (Nellore, Andhra Pradesh)	Mixed, isohyperthermic Typic Ustipsamments	71,658	*Reddy et al. (2005)*
18.4	Utkal Plain and East Godavari Delta, hot dry subhumid ESR with deep,	Srikakulam (Khammam,	Fine, mixed, isohyperthermic Typic	4,73,118	*Reddy et al. (2005)*

AESR No.	AESR description	Soil Series (District and State)	Soil Classification	Area ('000 ha)	Source
	loamy to clayey Coastal and deltaic alluvium- derived soils, medium AWC and LGP 180-210 days (S7Cd6)	Andhra Pradesh)	Haplustalfs		
		Suryapet (Medak, Andhra Pradesh)	Fine-loamy, mixed, isohyperthermic Inceptic Haplustalfs	5,22,629	*Reddy et al. (2005)*
18.5	Gangetic Delta, hot moist subhumid to humid ESR with deep, loamy to clayey Coastal and deltaic alluvium-derived soils, medium AWC and LGP 240-270 days (S7Cm7)	Rantrapur (Balasore, Orissa)	Fine-loamy, mixed, hyperthermic Typic Haplustalfs	137.51	*Sarkar et al. (2005a)*
		Sagar Island (24-Paragans, West Bengal)	Fine, mixed isohyperthermic Vertic Endoaquepts	NA	*Pal et al. (2010)*
19.1	North Sahyadris and Konkan Coast, hot humid ESR with medium to deep loamy to clayey mixed Red and Black soils, medium to high AWC and LGP 210-240 days (E6B8)	Pati (Dadra&Nagar Haveli, U. T.)	Clayey-skeletal, smectitic, isohyperthermic Lithic Haplustepts	5,498	*Challa, O. (2008)*
		Tinoda (Dadra&Nagar Haveli, U. T.)	Clayey-skeletal, smectitic, isohyperthermic Typic Haplustepts	4,678	*Challa, O. (2008)*
19.2	Central and South Sahyadris, hot moist subhumid to humid transitional ESR with deep, loamy to clayey Red and Lateritic soils, low to medium AWC and LGP 210-270 days (E2Cm/ B7(9)	Chimpukkad (Palakkad, Kerla)	Fine-loamy, mixed, isohyperthermic Ultic Haplustalfs	1,044	*Nair et al. (2006)*
		Karinganthode (Palakkad, Kerla)	Fine, mixed, isohyperthermic Ultic Paleustlfs	2692	*Nair et al. (2006)*
19.3	Konkan, Karnataka and Kerala Coastal plain, hot humid to per humid transitional ESR with deep, clayey to loamy acidic coastal alluvium-derived soils, low AWC and LGP 240-270 days (R7A(B8(7)	Palghar (Thane, Maharashtra)	Fine, montmorillonitic (cal.), isohyperthermic Vertic Halaquepts	90,000	*Challa et al.(1999)*
		Virthan (Thane, Maharashtra)	Fine, montmorillonitic (cal.), isohyperthermic Entic Haplusterts	63,040	*Challa et al.(1999)*
20.1	Andaman and Nicobar group of Islands, hot perhumid ESR with shallow to medium deep, loamy to clayey Red and Yellow and Red Loamy soils, low to medium AWC and LGP 300 days (T3A10)	Basanthipur (Andaman & Nicobar Island)	Fine-loamy, mixed, isohyperthermic Typic Tropudalfs	NA	*Anonymous*
		Govindpur (Andaman & Nicobar Island)	Fine-loamy, mixed, hyperthermic Typic Hapludalfs	NA	*Anonymous*
20.2	Level Lakshadweep and group of Island, hot humid ESR with shallow to medium deep loamy to sandy Black, sandy and Littoral soils, low to medium AWC and LGP 240-270 days (U16B8)	Kavaratti (Kavaratti Island, Lakshdweep)	Carbonic, isohyperthermic Typic Ustipsamments	NA	*Krishnan et al. (1997)*
		Andrott (Andrott Island, Lakshdweep)	Coarse-loamy, carbonic, isohyperthermic Typic Ustorthents	NA	*Krishnan et al. (1997)*

*For full descriptions of ESR codes please see Sehgal *et al.* (1994) and Velayutham *et al.* (1999); **NA – Not available

Soil Series Description

2.1 Soil Series: AESR 1.1

Eastern aspect of Ladakh Plateau, cold, hyper-arid eco- subregion (ESR) with shallow skeletal soils, very low AWC and LGP <60 days (A13Eh1)

2.1.1 LADAKH (II) SERIES

Ladakh (II) series is a member of the sandy, (siliceous) mixed*, frigid family of Typic Cryorthents. Typically Ladakh (II) soils have dark brown and pale brown, moderately alkaline, sandy loam A horizon and dark grayish brown to grey, moderately alkaline, gravelly loamy sand to sandy C horizons.

Water balance diagram
Leh, J.&K.
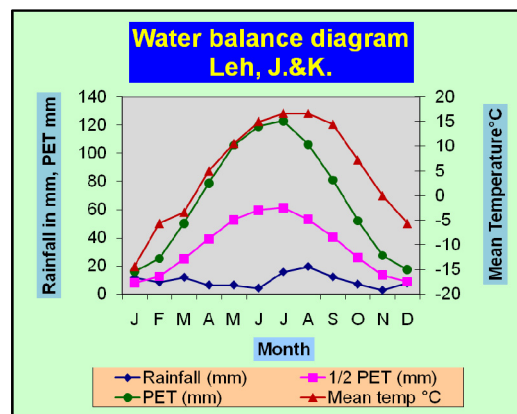
(*) In view of the fact that clay CEC of these soils are above 16 cmol(p+)kg^{-1} (soil control section) and moreover it is not confirmed whether the sand fraction contains weatherable minerals like biotite (from granite-gneiss parent material), siliceous mineralogy class may not be used; instead, mixed may be used.

Typifying pedon: Ladakh II sandy loam

A   0-10 cm -- Dark brown (10 YR 4/3M) and pale brown (10 YR 6/3 D) sandy loam; structureless; loose, non-sticky and non-plastic; strong effervescence; strongly alkaline (pH 8.6); clear smooth boundary.

IIC 1   10-28 cm -- Dark greyish brown (10 YR 4/2M) and light brownish grey (10 YR 6/1 D) gravelly loamy sand; structureless; loose, non-sticky and non-plastic; strong effervescence; strongly alkaline (pH 8.6); abrupt wavy boundary.

IIIC 1   28-52 cm -- Grey (2.5 Y 6/0M) and light grey (2.5 Y 7/2 D) gravelly sand; single grained; loose, non-sticky and non-plastic; no effervescence; strongly alkaline (pH 8.8); clear smooth boundary.

IIIC 2   52-75 cm -- Grey (2.5 Y 6/0M) and light grey (2.5 Y 7/2 D) sand; loose, non-sticky and non-plastic; no effervescence; strongly alkaline (pH 8.9); abrupt wavy boundary.

IIIC 3   75-90 cm -- Olive brown (2.5 Y 4/4M) and light grey (2.5 Y 7/2 D); sand; structureless; loose, non-sticky and non-plastic; strong effervescence with acid; strongly alkaline (pH 8.8); abrupt smooth boundary.

IIIC 4   90-150 cm -- Grey (2.5 Y 6/0M) and light grey (2.5 Y 7/2 D) gravelly sand; single grained; loose, non-sticky and non-plastic; no effervescence; strongly alkaline (pH 8.8).

Geographic setting: Ladakh (II) soils are developed in the alluvium of granite gneiss and Indus river and occur on 1 to10 percent slopes at an elevation ranging from 3500 to 6000 m above MSL. The climate is cold arid with mean annual air temperature varies from -15° to 17°C and

mean annual rainfall ranges between 5.7 to 75 mm. The estimated MAST is 6.71°C, MSST 9.6°C and MWST -2.92°C. The difference between MSST and MWST is 12.49°C.

Drainage and permeability: Well drained soils with rapid permeability.

Land use and vegetation: Agriculture is extremely limited. Natural vegetation is sparse. The tree species like willows *(Salix sp.)* and *Populus species* are found along the Indus basin.
Distribution and extent: In Ladakh district covering 163 ha.

Series proposed: All India Soil and Land Use Survey, New Delhi, 1979

Interpretation: Ladakh (II) is characterized by high pH (usually >8.5), gravelly sandy loam followed by sandy texture. The effective depth of the soil is about 90 cm. Absence of vegetation is reflected in very low organic matter content (<0.13%). CEC of the soils is less than 2 m.e. /100 g and ESP is variable from 14 to 39. The horizon between 90 to 150 cm is embedded with boulders and cobbles, resulting in low water holding capacity.

Interpretative groupings:

Soil irrigability subclass	: C
Land irrigability subclass	: IVst (moderately suitable for irrigation with severe topographic restriction).

Soil datasets:

Horizon	Depth (cm)	pH	EC (dS m^{-1})	Total soluble salts (%)	CaCO$_3$ (%)	Gravels (%)	Sand (%)	Silt (%)	Clay (%)
A	0-10	8.5	0.21	0.03	2.6	13.0	78.2	11.0	10.8
IIC 1	10-28	8.6	0.29	0.04	1.0	21.0	85.2	4.0	10.8
IIIC 1	28-52	8.8	0.29	0.04	0.6	24.0	93.2	0.5	6.3
IIIC 2	52-75	8.9	0.21	0.03	0.6	14.0	95.2	0.5	4.3
IIIC 3	75-90	8.8	0.21	0.03	0.8	14.0	91.2	0.5	8.3
IIIC 4	90-150	8.8	0.29	0.04	0.4	25.0	93.2	0.5	6.3

Depth (cm)	Organic carbon (%)	CEC (cmol (p+) kg^{-1})	CEC/Clay (Clay CEC ratio) (cmol (p+) kg^{-1})
0-10	0.13	1.1	10.2
10-28	0.10	0.9	8.3
28-52	0.03	1.1	17.5
52-75	0.08	1.5	34.9
75-90	0.07	1.2	14.5
90-150	0.06	1.7	27.0

Source: Gawande, S. P., Sharma, S. P. and Chanan, R. K. (1979). Soils of the command area of Abichenmethong Canal in Ladakh and their management needs. Journal of the Indian Society of Soil Science, 27,427-433.

2.1.2 LADAKH (III) SERIES

Ladakh (III) series is a member of the coarse-loamy, (siliceous) mixed*, frigid family of Typic Cryorthents. Typically Ladakh (III) soils have dark brown to pale brown, moderately alkaline, gravelly sandy loam A horizons and dark brown to pale brown, moderately alkaline, gravelly sandy loam C horizons.

Water balance diagram Leh, J.&K.
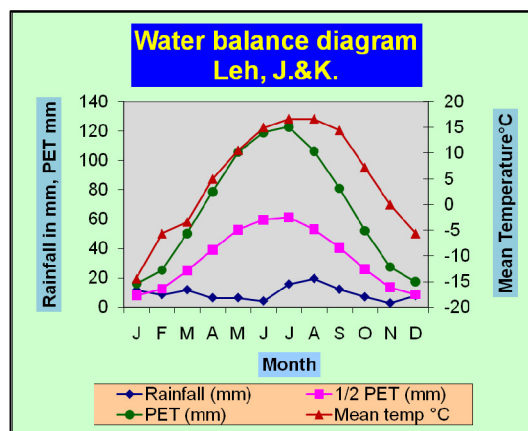
(*) This soil directly qualifies for "mixed" as the basic requirement for more than 90% siliceous material is not met. Moreover quartz may not be dominant in the clay fractions as the clay CEC is more than 22 cmol (p+) kg^{-1}

Typifying pedon: Ladakh III gravelly sandy loam - forest

A1   0-10 cm -- Dark brown (10 YR 4/3 M) and pale brown (10 YR 6/3D) gravelly sandy loam; weak inclined platy; soft, loose, slightly sticky and non-plastic; violent effervescence; strongly alkaline (pH 8.7); clear smooth boundary.

A2   10-30 cm -- Dark brown (10 YR 4/3 M) and pale brown (10 YR 6/3D) gravelly sandy loam; massive; hard, friable, slightly sticky and non-plastic; violent effervescence; strongly alkaline (pH 8.5); abrupt wavy boundary.

C1   30-40 cm -- Dark brown (10 YR 4/3 M) and pale brown (10 YR 6/3D) gravelly sandy loam; massive; slightly hard, friable, slightly sticky and non-plastic; violent effervescence; strongly alkaline (pH 8.9); abrupt wavy boundary.

C2   40-82 cm -- Dark brown (10 YR 4/3 M) and pale brown (10 YR 6/3D) gravelly sandy loam; massive; hard, friable, slightly sticky and non-plastic; violent effervescence; strongly alkaline (pH 8.6).

Geographic setting: Ladakh (III) soils are developed on granite-gneiss and Indus alluvium and occur on 1 to10 percent hilly slopes at an elevation ranging from 3500 to 6000 m above MSL. The climate is cold arid with mean annual air temperature varies from -15 to 17°C and mean annual rainfall ranges between 5.7 to 75 mm. The estimated MAST is 6.71^{o}C, MSST 9.6^{o}C and MWST -2.92^{o}C. The difference between MSST and MWST is 12.49^{o}C.

Drainage and permeability: Well drained soils with rapid permeability.

Land use and vegetation: Agriculture is extremely limited. Natural vegetation is sparse. The tree species like willows *(Salix sp.)* and *Populus species* are found along the Indus basin.

Distribution and extent: In Ladakh district covering nearly 164 ha.

Series proposed: All India Soil and Land Use Survey, New Delhi, 1979

Interpretation: These soils occupy the major portion in the command area and includes alkaline (pH 8.4 to 8.5), slightly gravelly sandy loam soils. The compacted horizon usually underlie below 20 cm depth. The organic matter content is very low (0.2%). Carbonate content is about 1.8 % and it decreases with depth. CEC is 3.7 m.e./100 g and ESP varies from 5 to 16. The soils are low in fertility.

Interpretative groupings:

Soil irrigability subclass	: C
Land irrigability subclass	: IIIs (moderately suitable for irrigation with Moderate soil restriction)

Soil datasets:

Hori-zon	Depth (cm)	pH	EC (dS m^{-1})	Total soluble salts (%)	CaCO$_3$ (%)	Gravels (%)	Sand (%)	Silt (%)	Clay (%)
A1	0-10	8.5	0.21	0.03	1.8	16.0	77.5	8.7	13.8
A2	10-30	8.5	0.43	0.06	0.3	15.0	77.4	8.8	13.8
C1	30-40	8.5	0.29	0.04	0.3	20.0	79.4	8.7	11.9
C2	40-82	8.5	0.21	0.03	0.6	20.0	70.4	8.7	11.9

Depth (cm)	Organic carbon (%)	CEC (cmol(p+)kg^{-1})	CEC/Clay (Clay CEC ratio) (cmol(p+)kg^{-1})
0-10	0.12	3.7	26.8
10-30	0.12	3.1	22.5
30-40	0.09	3.1	26.1
40-82	0.08	2.8	23.5

Source: Gawande, S. P., Sharma, S. P. and Chanan, R. K. (1979). Soils of the command area of Abichenmethong Canal in Ladakh and their management needs. Journal of the Indian Society of Soil Science, 27,427-433.

2.2 Soil Series: AESR 1.2

Western Aspect of Ladakh Plateau and north Kashmir Himalayas, cold to cool, typic-arid ESR with shallow, loamy- skeletal soils, low AWC and LGP 60-90 days (A13Et2)

2.2.1 KIBBER SERIES

Kibber series is a member of very deep, fine-loamy, mixed, calcareous, cryic (like) family of Humic Cryochrepts. Typically Kibber soils have very dark grayish brown, slightly alkaline, gravelly-loam A horizon, dark brown to very dark grayish brown, slightly alkaline, gravelly loam B horizons and dark brown to brown, slightly alkaline, gravelly loam to gravelly clay loam C horizon.

Water balance diagram Kibber, Himachal Pradesh
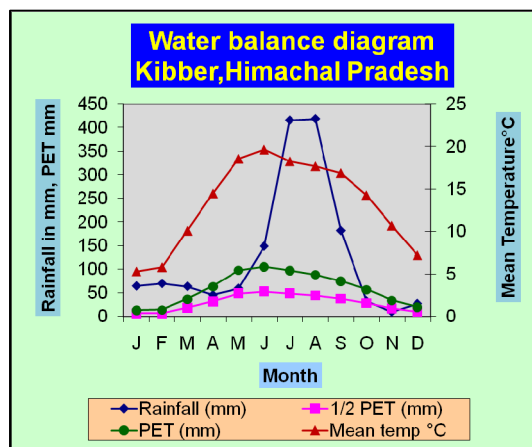
Typifying pedon: Kibber gravelly loam- cultivated

Ap   0-15 cm -- Very dark grayish brown (10 YR 3/2M) gravelly loam; massive; coarse gravels (20-30%); very friable, slightly sticky and slightly plastic; fine, many roots; slightly alkaline (pH 7.6); clear smooth boundary.

Bw1   15-32 cm -- Dark brown (10 YR 3/3M) gravelly loam; massive; coarse gravels (20-30%); fine, weak, subangular blocky structure; very friable, slightly sticky and slightly plastic; fine, common roots; slightly alkaline (pH 7.8); gradual smooth boundary.

Bw2   32-53 cm -- Very dark grayish brown (10 YR 3/2M) gravelly loam; massive; coarse gravels (30-40%); fine, weak, subangular blocky structure; friable, slightly sticky and slightly plastic; fine, common roots; slightly alkaline (pH 7.9); clear smooth boundary.

C1   53-72 cm -- Dark brown (10 YR 3/3M) gravelly loam; coarse gravels (40-60%); fine, weak, subangular blocky structure; very friable, sticky and plastic; fine, few roots; slightly alkaline (pH 7.9); clear smooth boundary.

C2   72-120 cm -- Brown (10 YR 5/3M) gravelly clay loam; massive; coarse gravels (80%); friable, sticky and plastic; slightly alkaline (pH 7.9).

Type location: 32°01′0″N; 78°00′04″E; village Kibber; tehsil Kaza; district Lahul and Spiti, Himachal Pradesh.

Range in characteristics: The thickness of solum is 53 cm. The estimated MAST is 5.1°C, MSST is 11°C and MWST is 3°C. The moisture regime is aridic (cold) and temperature regime is cryic (like). The A horizon is 15 cm thick. Its colour is in hue of 10 YR, value 3 and chroma 2. The texture is gravelly loam. The B horizon is 38 cm thick. Its colour is in hue of 10 YR, value 3 and chroma 3 to 2. The texture is gravelly loam. The structure is subangular blocky. The C horizon is 67 cm thick. Its colour is in hue of 10 YR, value 5 to 3 and chroma 3.

Competing soils and their taxonomy: Palchan soils which are deep, coarse-loamy, mixed, cryic (like), Typic Cryochrepts.

Geographic setting: Kibber soils are developed in colluvium and occur on moderately sloping (3-8%) terraces on steeply sloping hills (30-50%) at an elevation of 4000 m above MSL. The mean annual rainfall is 210 mm. The estimated MAST is 5.1°C. The MSST and MWST are 11°C and 3°C.

Geographically associated soils: These are Rangreek, Lari and Rangring soils alongwith rockout crops. Rangreek soils are fine-loamy, mixed, calcareous, cryic (like) Typic Cryorthents (Status report on Kinnaur and Spiti catchments, HPKVV, Palampur, 1991). Lari soils are deep, sandy-skeletal, mixed, cryic (like), Typic Cryorthents. Rangring soils are shallow, loamy-skeletal, calcareous, cryic (like), Lithic Cryorthents.

Drainage and permeability: Somewhat excessive with rapid permeability.

Land use and vegetation: Barley and pea.

Distribution and extent: Extensive in Lahaul and Spiti district of Himachal Pradesh (8,300 ha).

Series proposed: NBSS&LUP, Regional Centre, New Delhi.

Interpretation: These soils are deep and are the only soils in the region which have relatively high water holding capacity and cultivated to climatically adapted crops like barley, maize, peas and other vegetable crops.

Interpretative groupings:

i)	Land capability sub class	:	IVes
ii)	Land irrigability subclass	:	Not suitable (N2)
iii)	Productivity potential	:	Medium

Soil datasets:

Horizon	Depth (cm)	Particle size diameter (mm) (%)					Coarse fragments (>2mm) % of whole soil
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Silt		
					(0.002-0.02)	(0.02-0.05)	
Ap	0-15	47.5	34.5	18.0	20.0	14.5	20-30
Bw1	15-32	47.2	29.8	23.0	25.0	4.8	20-30
Bw2	32-53	42.7	34.3	23.0	25.5	8.8	20-30
C1	53-72	43.0	35.5	21.5	26.5	9.0	40-60
C2	72-120	42.6	22.4	35.0	15.0	7.4	>60

Depth (cm)	Organic carbon (%)	CaCO3 (%)	E.C. (1:2.5, soil:water) dSm-1	pH Soil: water (1:2.5)	C.E.C. (cmol(p+)/kg)	B.S. (%)
0-15	2.76	Nil	1.00	7.60	8.6	96
15-32	2.24	Nil	0.98	7.76	12.6	97
32-53	1.57	Nil	0.71	7.92	12.2	96
53-72	1.18	Nil	0.62	7.93	11.9	98
72-120	1.46	Nil	0.48	7.91	17.8	96

Source: Anonymous (2002), Soil series of Himachal Pradesh, NBSS Publ. No. 91, NBSS&LUP, Nagpur, 177 p.

2.3 Soil Series: AESR 2.1

Marusthali hot, hyper arid ESR with shallow and deep sandy desert soils very low AWC and LGP < 60 days (M9Eh1)

2.3.1 CHIRAI SERIES

The Chirai series is a member of the coarse-loamy, mixed, hyperthermic family of Typic Camborthids. Typically, Chirai soils have yellowish brown to pale brown, moderately alkaline, loamy fine sand to fine sandy loam A horizons; pale brown to brown or light yellowish brown, moderately alkaline, fine sandy loam, calcareous B horizons, and pale brown to yellowish brown, moderately alkaline, fine sandy loam, calcareous C horizons.
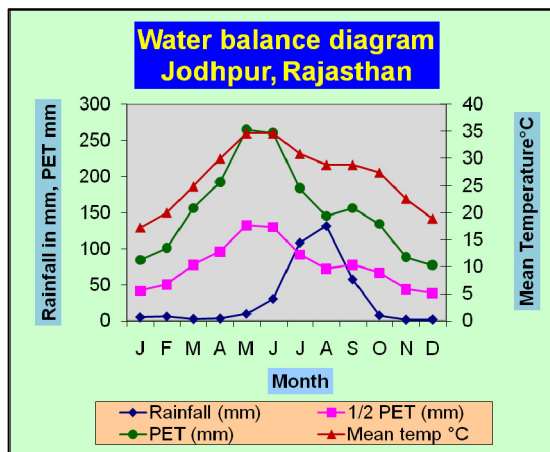
Typifying pedon: Chirai loamy fine sand - cultivated

Ap 	0-9 cm --- Yellowish brown (10YR 5/4 D) loamy fine sand; single grain; loose; many fine roots; slightly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

A 	9-36 cm --- Brown to pale brown (10YR 5.5/3 D) fine sandy loam; weak fine to medium subangular blocky structure; slightly hard, very friable, slightly sticky; many fine roots; many very fine to fine and common medium discontinuous vertical tubular pores; some pseudo-mycelial lime; strongly effervescent; moderately alkaline (pH 8.1); gradual smooth boundary.

BA 	36-76 cm --- Brown to pale brown (10YR 5.5/3 D) fine sandy loam; weak fine to medium subangular blocky structure; slightly hard, very friable, slightly sticky; common fine roots; many very fine to fine and common medium discontinuous vertical tubular pores; some pseudo-mycelial lime; strongly effervescent; moderately alkaline (pH 8.3); clear smooth boundary.

Bk 	76-90 cm --- Pale brown to light yellowish brown (10YR 6/3.5 D) fine sandy loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky; common fine roots; many very fine to fine and common medium discontinuous vertical tubular pores; lime concretions about 5 to 7 per cent by volume; violently effervescent; moderately alkaline (pH 8.3); clear smooth boundary.

Ck1 	90-140 cm --- Pale brown to light yellowish brown (10YR 6/3.5 D) fine sandy loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky; few fine roots; many very fine to fine discontinuous vertical tubular pores; lime concretions about 7 to 10 per cent by volume; violently effervescent; moderately alkaline (pH 8.4); clear smooth boundary.

Ck2   140-170 cm --- Yellowish brown (10YR 5/4 D) gravelly fine sandy loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky; few fine roots; many very fine to fine and common medium discontinuous vertical tubular pores; lime concretions about 20 to 25 per cent by volume; violently effervescent; moderately alkaline (pH 8.4).

Micromorphology: The sandy parent material is loosely packed. This packing gives the soil a high porosity and permeability but also induces instability. Due to the regular addition of aeolian sand on the surface and loose packing of the soil constituents, voids are commonly infilled with mineral grains. Carbonates have been accumulated and are accumulating. Carbonate particles form the major part of the fine material, and are present as coatings and bridges between coarse mineral grains.

Type location: $26^o05'$ N, $72^o50'$ E; about 4 km east of Bhandu village on Bhandu-Phinch road, tehsil Jodhpur, district Jodhpur, Rajasthan.

Range in characteristics: The thickness of the solum is 70 to 100 cm. The A horizon is 30 to 40 cm thick. Its colour is in hue of 10YR, value 5 or 5.5 and chroma 3 or 4. The texture is loamy fine sand to fine sandy loam. The thickness of the B horizon is 40 to 60 cm. Its colour is in hue 10YR, value 5 or 6 and chroma 3 or 4. The texture is dominantly fine sandy loam. The C horizon is 50 cm or more thick and strongly calcareous. Colour is in hue 10YR, value 5 of 6 and chroma 4. It has lime concretions 10 to 25 per cent by volume.

Geographic setting: Chirai soils are formed in old alluvium and are modified by aeolian action. They occur on hummocky plain at an elevation of 150 to 250 m above MSL. The climate is arid subtropical with mean annual air temperature of 26.7^oC and mean annual rainfall ranging from 250 to 350 mm. The estimated MAST is 28.2^oC, MSST 31.0^oC and MWST 21.3^oC. The difference between MSST and MWST is 9.7^oC. The soil moisture regime is aridic.

Drainage and permeability: Excessively drained with moderately rapid permeability.

Use and vegetation: Cultivated to pearl millet, cluster bean, *Dolichos spp.,* green gram and sesame; natural vegetation - *Prosopis spp.* (khejri), *Ziziphus spp.* (ber and jharberi) and local grasses.

Distribution and extent: Extensive in Jodhpur and Bikaner districts of Rajasthan

Series proposed: Central Arid Zone Research Institute, Jodhpur, 1978.

Interpretation: The soils are droughty due to low available moisture capacity. The surface sandy layer makes them susceptible to wind erosion. Aridity is the major limiting factor for crop production. Crops like millets and legumes can be raised 5 to 6 years in a cycle of 10 years.

a) Interpretative grouping:
  i)   Land capability subclass   VIc
  ii)   Irrigability subclass   3s
  iii)   Productivity potential   Low to medium

b) Yield: Based on data from farmers' fields (unirrigated)

Crop	Farmers' practices	Improved practices
	←----------------Yield, Mg ha⁻¹-------------→	
Pearl millet	0.30	0.75
Green Gram	0.15	0.45
Dolichos spp.	0.15	0.35
Sesame	0.15	0.45
Cluster bean	0.20	0.40

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)							Coarse fragments > 2 mm % of whole soil
		Total			Silt		Clay		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	(0.05-0.02)	(0.02-0.002)	(0.002-0.001)	(<0.001)	
		<--------------------------- % of < 2 mm --------------------------->							
Ap	0-9	82.8	8.0	9.2	4.9	3.1	5.2	4.0	1
A	9-36	80.0	8.8	11.2	5.2	3.6	6.7	4.5	NA
BA	36-76	76.2	11.4	12.4	5.9	5.5	7.7	4.7	NA
Bk	76-90	74.2	16.2	9.6	8.4	7.8	6.5	3.1	7
Ck1	90-140	71.8	15.5	12.7	7.5	8.0	8.4	4.3	11
Ck2	140-170	69.6	17.0	13.4	6.7	10.3	7.9	5.5	41

Depth (cm)	O.C. (%)	Carbon-ate as CaCO₃ < 2 mm (%)	Ext. iron as Fe (%)	pH (1:2.5) H₂O	E.C. (1:2.5) H₂O (dS m⁻¹)	Bulk density (Mg m⁻³)	Water retention		Micronutrients			
							33 kPa	1500 kPa	D T P A extractable			
									Zn	Cu	Mn	Fe
									<----------- ppm ----------->			
0-9	0.11	1	0.24	8.0	0.4	1.49	7.5	2.0	0.19	0.78	6	7
9-36	0.09	8	0.26	8.1	0.1	1.48	8.6	2.3	0.13	0.45	6	5
36-76	0.10	6	0.21	8.3	0.4	1.45	8.9	2.5	0.15	0.36	5	4
76-90	0.06	9	0.21	8.3	0.4	1.40	8.7	2.8	0.24	0.33	5	4
90-140	0.06	10	0.27	8.4	0.5	1.36	9.1	3.1	0.24	0.34	7	3
140-170	0.06	12	0.19	8.4	0.5	1.38	9.2	3.2	NA	NA	NA	NA

Depth (cm)	Extractable bases					CEC (NH₄OAc)	Base saturation (NH₄OAc)	Ratio to clay		
	Ca	Mg	Na	K	Sum			CEC (NH₄OAc)	Ext. iron	1500 kPa water
	<-------------- cmol (p+)kg-1 -------------->						%			
0-9	3.5	1.5	0.5	0.4	5.9	6.1	97	0.66	0.03	0.22
9-36	3.2	2.0	0.4	0.6	6.2	6.5	95	0.58	0.02	0.21
36-76	2.6	1.5	0.5	0.5	5.1	5.9	86	0.48	0.02	0.20
76-90	2.2	1.2	0.6	1.0	5.0	5.4	93	0.56	0.02	0.29
90-140	2.2	1.7	0.6	0.8	5.3	5.4	98	0.43	0.02	0.24
140-170	2.5	1.4	0.4	0.7	5.0	5.9	85	0.44	0.01	0.24

NA- Not available

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.3.2 PAL SERIES

The Pal series is a member of the coarse-loamy, mixed, hyperthermic family of Typic Camborthids. Typically, Pal soils have reddish brown to dark reddish brown, moderately alkaline, sandy loam A horizons; light reddish brown to dark reddish brown, moderately alkaline, gravelly sandy loam B horizons over C horizons characterised by the presence of lime coated and partly cemented gravels of igneous origin mixed with sandstone fragments.
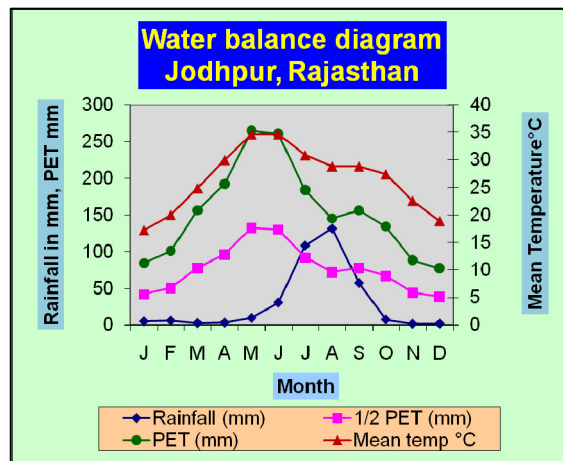
Typifying pedon: Pal sandy loam - cultivated

Ap 0-30 cm --- Reddish brown (5YR 5/4 D) and dark reddish brown (5YR 3/4 M) sandy loam; weak fine subangular blocky and fine granular structure; soft, friable, non- sticky and non-plastic; few fine roots; moderately alkaline (pH 8.4); clear smooth boundary .

B 30-75 cm --- Reddish brown (5YR 4/4 D) and dark reddish brown (5YR 3/4 M) sandy loam; moderate fine subangular blocky structure; slightly hard, friable, non-sticky and non-plastic; few fine roots; moderately alkaline (pH 8.4); gradual smooth boundary

BC 75-90 cm --- Light reddish brown (5YR 6/4 D) and reddish brown (5YR 5/4 M) gravelly sandy loam; few very fine roots, slightly effervescent; somewhat compact zone with lime coated gravels of igneous origin mixed with sandstone fragments; moderately alkaline (pH 8.3); abrupt smooth boundary.

Ck 90 cm + --- Lime coated partly cemented gravels of igneous origin mixed with sandstone fragments; strongly effervescent.

Type location: $26^o14'$ N, $72^o 58'$ E; village Panchayat Samiti, district Jodhpur, Rajasthan.

Range in characteristics: The thickness of the solum is 75 to 120 cm. The A horizon is about 15 to 30 cm thick. Its colour is in hue 10YR, 7.5YR and 5YR, value 3 to 5 and chroma 3or 4. The texture is loamy sand or sandy loam. The thickness of the B horizon is 60 to 100 cm. Its colour is in hue 5YR, value 3 to 6 and chroma 3 or 4. The texture is sandy loam or fine sandy loam and occasionally loam at places. The B horizon is gravelly below 45 to 60 cm depth and the gravel content varies from 18 to 34 per cent by volume. Structure is uniformly fine subangular blocky. The C horizon is light brown or brown, gravelly loamy sand or gravelly sandy loam in texture and calcareous.

Competing series and their differentiae: These are Chirai soils which are calcareous throughout and less gravelly in the control section. The Chirai series is a Typic Camborthid.

Geographic setting: Pal soils are formed in old alluvium that are modified by aeolian activity and occur on hummocky plain at an elevation of 250 to 300 m above MSL. The climate is arid subtropical with mean annual air temperature of 26.7^oC and mean annual rainfall ranging from 250 to 350 mm. The estimated MAST is 28.2^oC MSST 31.0^oC and MWST 21.3^oC. The difference

between MSST and MWST is 9.7°C. The moisture control section lies between 20 and 60 cm depth and is moist in some part for 20 to 30 consecutive days in July to September.

Geographically associated soils: These are soils of the Pipar series which are sandy loam to loam with underlying weathered granite and Pali series which have loam or clay loam texture and lime accumulation. Pipar and Pali series are Typic Calciorthid and Lithic Camborthid, respectively.

Drainage and permeability: Well to moderately well drained with rapid permeability.

Use and vegetation: Cultivated to pearl millet, green gram, kidney bean, sesame, cluster bean and castor in *kharif* and wheat and a variety of vegetable crops in *rabi* season under irrigation; natural vegetation - *Prosopis cineraria* (khejri), *Ziziphus nummularia* (Jharberi) and *Dichanthium annulatum* (jaunera).

Distribution and extent: Extensive (1,36,900 ha) in Jodhpur tehsil of Jodhpur district and Rohit tehsil of Pali district of Rajasthan.

Series proposed: Central Arid Zone Research Institute, Jodhpur, 1974,

Interpretation: The major limiting factor to produce biomass is the low and unpredictable rainfall. The soils are droughty as the available moisture capacity is low. Crops like pearl millet and kidney bean is grown in the area. Under irrigation water loss due to percolation will be significant. These soils will respond to management under irrigation. Measures to control wind erosion and to conserve moisture are essential. Furrow planting of crops will help better utilisation of moisture by crops.

a) Interpretative grouping:

i)	Land capability subclass	IVc
ii)	Irrigability subclass	3s
iii)	Productivity potential	Low

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
		<------------------------------------- % of < 2 mm ------------------------------------->									
Ap	0-30	75.0	17.0	8.0	8.5	9.0	9.0	26.0	22.5	11.0	6.0
B	30-75	65.0	24.0	11.0	7.0	8.5	8.0	16.5	25.0	11.0	13.0
BC	75-90	75.0	15.0	10.0	17.0	15.5	11.0	14.0	17.5	10.0	5.0

Depth (cm)	Organic carbon (%)	Carbonate as CaCO$_3$ < 2 mm (%)	pH (1:2.5) H$_2$O	E.C. (1:2.5) H$_2$O (dS m^{-1})	Moisture equivalent(%)	Water holding capacity(%)
0-30	0.22	-	8.4	<0.2	6.4	30.2
30-75	0.21	-	8.4	<0.2	8.8	33.6
75-90	-	0.7	8.3	0.2	9.8	35.8

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.4 Soil Series: AESR 2.2

Kachchh Peninsula (Great Rann of Kutch as inclusion), hot hyper-arid ESR with deep loamy saline and alkali soils, low AWC and LGP <60 days (L12Eh1)

2.4.1 AMLIARA SERIES

The Amliara series is a member of the fine-loamy, mixed, hyperthermic family of Fluventic Camborthids. Typically, Amliara soils have brown to dark brown, moderately alkaline, calcareous, loam, A horizons, and brownish yellow to dark yellowish brown, moderately alkaline, calcareous, sandy clay loam to gravelly sandy loam B horizons underlain by calcareous gravelly C horizons.
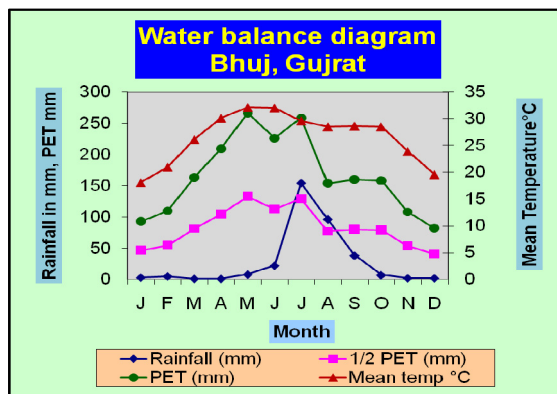
Typifying pedon: Amliara loam – cultivated

Ap   0-17 cm --- Brown (10YR 4/3 D) and dark brown (10YR 3/3 M) loam; weak fine subangular blocky structure; slightly hard, friable, non-sticky and non-plastic; few fine roots; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

BA   17-36 cm --- Yellowish brown (10YR 5/4 D) and dark yellowish brown (10YR 4/4 M) sandy clay loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and plastic; few fine roots; strongly effervescent; moderately alkaline (pH 8.2); diffuse wavy boundary.

Bw   36-55 cm --- Yellowish brown (10YR 5/4 D) and dark yellowish brown (10YR 4/4 M) sandy clay loam; moderate medium subangular blocky structure; hard, friable, sticky and plastic; few coarse roots; violently effervescent; moderately alkaline (pH 8.2); diffuse wavy boundary.

2BCk   55-94 cm --- Brownish yellow (10 YR 6/6 D, 6/8 M) gravelly sandy loam; weak fine subangular blocky structure; loose, non-sticky and non-plastic; violently effervescent; assorted gravels, pebbles and weathered sandstone; moderately alkaline (pH 8.4); gradual smooth boundary.

2Ck   94-105 cm --- Assorted quartz and sandstone pebbles mixed with sandy loam soil; violently effervescent; moderately alkaline (pH 8.3).

Type location: 23°13' N, 70°28' E; about 1.5 km south west of village Amliara, tehsil Bachau, district Kachchh, Gujarat.

Range in characteristics: The thickness of the solum ranges from 80 to 115 cm. The thickness of the A horizon is 15 to 20 cm. Its colour is in hue of 10YR, dry value 4 to 6 and moist value 3 to 4 and chroma 3 to 4. Its structure is weak fine subangular blocky. The thickness of the B horizon is 35 to 45 cm and structure moderate medium subangular blocky. Its colour is in hue of 10YR, dry value 5 to 6 and moist value 3 to 4 and chroma 4 both for dry and moist soils, but sometimes higher value and chroma are also observed. The 2BC and 2C horizons have very high content of carbonates and are gravelly sandy loams.

Competing series and their differentiae: The competing soils are Bhimdevka series. These are very deep soils with cambic horizon showing pressure faces on the peds. The texture of the Bhimdevka soils is finer than Amliara soils. The colour of the soil in Bhimdevka series is in hue of 10YR, value 3 and chroma 2 to 3 for moist soils. The Bhimdevka soils belong to Ustertic Camborthids.

Geographic setting: Amliara soils are formed in colluvial deposited hill and occur on nearly level to very gently sloping upper piedmont plain at an elevation of about 12 m above MSL. The climate is arid tropical with mean annual air temperature of 26.7°C and mean annual rainfall of 350 mm of which about 90 per cent is received during July to September in most of the years. The estimated MAST is 28.7°C, MSST 29.0°C, MWST 22.1°C and the difference between MSST and MWST is 6.9°C.

Geographically associated soils: The common associated soils are Jangi, a Haplic Natrargid, and Bhimdevka, an Ustertic Camborthid.

Drainage and permeability: Well drained with rapid to very rapid permeability.

Use and vegetation: Mostly uncultivated, covered mainly by *Prosopis juliflora* (mesquite); a small area is cultivated to cotton and pearl millet under rainfed conditions.

Distribution and extent: Extensive (about 90,000 ha) in Kachchh district of Gujarat.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur, 1967.

Interpretation: Amliara soils have good soil-air-water relationship. The major limitation is aridity and low uncertain rainfall. These soils are suited to all climatically adapted crops under irrigation. They can support a wide range of crops and they respond to management. The essential management practices include soils and water conservation measures and prevention of wind erosion.

   a) Interpretative grouping:

      i)   Land capability subclass   IIIc
      ii) Irrigability class   IIs
      iii) Productivity potential   Medium

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)					Coarse fragments > 2 mm % of whole soil
		Sand (2-0.2)	Silt (0.02-0.002)	Clay (<0.002)	Coarse Sand (2-0.2)	Fine Sand (0.2-0.02)	
		<------------ % of < 2 mm --------------->					
Ap	0-17	73.7	12.5	13.8	23.1	50.6	1
BA	17-36	70.7	5.8	23.5	19.1	51.6	1
Bw	36-55	73.6	4.8	21.6	32.9	40.7	2
2BCk	55-94	79.6	4.3	16.1	38.8	40.8	43
2Ck	94-105	84.9	3.5	11.6	42.0	42.9	61

Depth (cm)	Organic Carbon (%)	Carbonate as CaCO$_3$ < 2 mm (%)	pH (1:2.5) H$_2$O	E.C. (1:2.5) H$_2$O dS m^{-1}
0-17	0.61	Tr	8.0	<0.2
17-36	0.44	2.8	8.2	<0.2
36-55	0.35	3.6	8.2	<0.2
55-94	0.45	25.7	8.4	<0.2
94-105	0.24	28.7	8.3	5.0

Note: The soil texture is based on International particle size classification.

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.4.2 BALASAR SERIES

The Balasar series is a member of the mixed, hyperthermic family of Typic Torripsamments. Typically, Balasar soils have light yellowish brown to yellowish brown, strongly alkaline, loamy sand to sand A horizons, and very pale brown to yellowish brown, very strongly alkaline, sand C horizons.
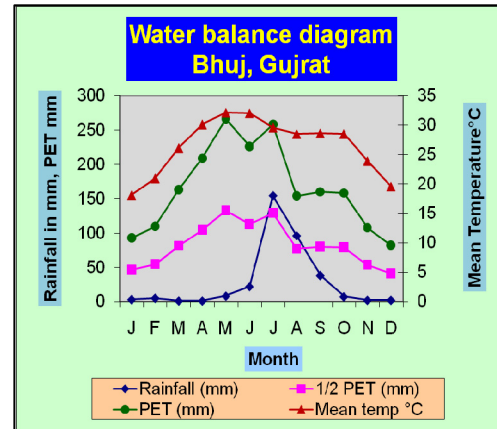
Typifying pedon: Balasar loamy sand – uncultivated

Ap1   0-10 cm --- Pale brown (10YR 6/3 D) and yellowish brown (10YR 5/4 M) loamy sand; weak fine subangular blocky structure; loose, non-sticky and non-plastic; few fine roots; many disseminated fine indurated lime nodules in the matrix; violently effervescent; few quartz gravels; strongly alkaline (pH 8.9); clear smooth boundary.

A2   10-32 cm --- Light yellowish brown (10YR 6/4 D) and yellowish brown (10YR 5/4 M) loamy sand; weak fine subangular blocky to single structure; loose non-sticky and non-plastic; few fine roots; powdery lime and fine indurated lime nodules; violently effervescent; few quartz gravels; very strongly alkaline (pH 9.3); clear smooth boundary.

Ck1   32-59 cm --- Very pale brown (10YR 7/4 D) and yellowish brown (10YR 5/4 M) gravelly sand; single grain structure; loose, non-sticky and non-plastic; few coarse roots; powdery lime and many indurated lime nodules; violently effervescent; few quartz gravels; very strongly alkaline (pH 9.3); abrupt smooth boundary.

Ck2   59-99 cm --- Very pale brown (10YR 7/4 D) and yellowish brown (10YR 5/4 M) sand; single grain structure; loose, non-sticky and non-plastic; few coarse roots; powdery lime and many indurated lime nodules; violently effervescent; few quartz gravels; strongly alkaline (pH 9.3); abrupt smooth boundary.

Ck3   99-137 cm --- Very pale brown (10YR 7/4 D) and brownish yellow (10YR 6/6 M) sand; single grain structure; loose, non-sticky and non-plastic; many powdery lime and nodules; violently effervescent; few quartz gravels; very strongly alkaline (pH 9.4).

Type location: 23°49' N, 70°40' E, about 5.5 km south of the village Balasar, tehsil Rapar, district Kachchh, Gujarat.

Range in characteristics: The A horizon is 10 to 20 cm thick. Its texture is loamy sand. The C horizon is more than 100 cm thick. Its texture varies from loamy sand to fine sand and the colour in hue of 10YR, value 5 to 7 and chroma 3 to 6.

Competing series and their differentiae: Soils of Kharirohar series are the competing soils which are very deep yellowish brown to dark yellowish brown, loamy sand and strongly alkaline. The Kharirohar soils belong to Typic Torripsamments.

Geographic setting: Balasar soils are formed in coarse sandy calcareous marine sediments on nearly level to very gently sloping beach ridge slough and marine salt waste at an elevation of about 12 m above MSL. The climate is arid subtropical with mean annual air temperature of 26.7^{o}C and mean annual rainfall of 350 mm. The estimated MAST is 28.7^{o}C, MSST 29.0^{o}C and MWST 22.1^{o}C and the difference between MSST and MWST is 6.9^{o}C

Geographically associated soils: These are Fatehgarh and Mayawandh soils, the Typic Salorthids, Jatawada, a Duric Chamborthid, and Lakhpat, a Typic Natrargid.

Drainage and permeability: Well drained with very rapid permeability.

Use and vegetation: Mostly uncultivated wasteland with halophyte and xerophyte species and at places occasionally cultivated for dry land crops like pearl millet and castor.

Distribution and extent: Extensive (about 30,000 ha) in Kachchh district of Gujarat.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur, 1977.

Interpretation: The soils are coarse textured and have severe moisture deficit. They have low available moisture capacity and rapid permeability and intake rate. They are susceptible to wind erosion and consequent over burdening by sandy material. Major problems are those of aridity and unpredictable rains. In years of good rainfall they can support crops like pearl millet and sorghum to some extent. They are saline and sodic and mostly wasteland.

Interpretative grouping:

    i)   Land capability subclass   IVc
   ii)   Irrigability subclass   4s
  iii) Productivity potential   Low

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)					Coarse frag-ments > 2 mm % of whole soil
		Sand (2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	Coarse Sand (2-0.2)	Fine Sand (0.2-0.02)	
		<----------------- % of < 2 mm ------------------>					
Ap1	0-10	85.5	4.6	9.9	54.4	31.1	16
A2	10-32	84.5	4.7	9.8	49.6	35.9	20
Ck1	32-59	91.1	3.8	5.1	52.4	38.7	22
Ck2	59-99	93.4	3.0	3.6	54.3	39.1	13
Ck3	99-137	94.0	2.9	3.1	53.3	40.7	17

Depth (cm)	Organic Carbon (%)	Carbonate as CaCO$_3$ <2 mm (%)	pH (1:2.5) H$_2$O	E.C. (1:2.5) H$_2$O dS m^{-1}	ESP (%)
0-10	0.21	16.5	8.9	<0.2	6
10-32	0.01	25.7	9.3	<0.2	6
32-59	0.01	22.9	9.3	<0.2	6
59-99	0.05	28.8	9.3	0.4	14
99-137	0.02	28.8	9.4	0.8	18

**Note:** The soil texture is based on International particle size classification.
Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.5 Soil Series: AESR 2.3

Rajasthan Bagar, North Gujarat Plain and South-Western Punjab Plain, hot typic- arid ESR with deep, loamy desert soils (inclusion of saline phase), low AWC and LGP 60-90 days (M9Et2)

2.5.1 HISAR SERIES

The Hisar series is a member of the fine-loamy, mixed, hyperthermic family of Typic Haplustepts. Typically, Hisar soils have pale brown to brown, moderately alkaline, sandy clay loam A horizons; yellowish brown to dark yellowish brown, moderately alkaline, clay loam to clay B horizons, and brown, moderately alkaline, clay C horizons.
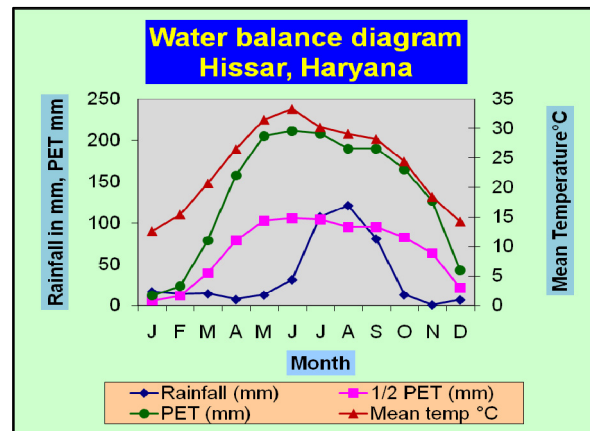
Typifying pedon: Hisar sandy clay loam - cultivated

Ap   0-16 cm --- Pale brown (10YR 6/3 D) and brown (10YR 5/3 M) sandy clay loam; fine to medium subangular blocky structure; hard, friable, slightly sticky and non-plastic; many very fine roots; moderately alkaline (pH 8.1); clear smooth boundary.

Bw1   16-37 cm --- Yellowish brown (10YR 5/4 M) clay loam; moderate medium subangular blocky structure; slightly firm, slightly sticky and non-plastic; many very fine roots; moderately alkaline (pH 7.9); diffuse smooth boundary.

Bw2   37-52 cm --- Dark yellowish brown (10YR 4/4 M) clay loam; moderate medium subangular blocky structure; firm, slightly sticky and slightly plastic; few fine roots; slightly effervescent; moderately alkaline (pH 7.9); clear smooth boundary.

Bt1   52-77 cm --- Dark yellowish brown (10YR 4/4 M) clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; few fine roots; slightly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

Bt2   77-105 cm --- Dark yellowish brown (10YR 4/4 M) clay; moderate medium angular blocky structure; firm, sticky and plastic; few fine roots; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

Bt3   105-128 cm --- Brown (10YR 5/3 M) clay; moderate medium angular blocky structure; firm, very sticky and plastic; few fine roots; strongly effervescent; moderately alkaline (pH 8.0); diffuse smooth boundary.

2Ck   128-168 cm --- Brown (10YR 5/3 M) clay; weak subangular blocky structure; firm sticky and plastic; 1 to 3 cm size lime concretions 30 to 40 per cent by volume; strongly effervescent; moderately alkaline (pH 8.2).

Type location: 29º40'19" N, 75º51'28" E; about 0.5 km from Amani on Amani to Jamalpur road, district Hisar, Haryana.

Range in characteristics: The thickness of the solum is more than 120 cm. The A horizon is 15 to 20 cm thick and its colour ranges from pale brown to dark yellowish brown in 10YR hue. Its texture ranges from sandy loam to clay loam. The structure of the A horizon varies from weak granular to moderate subangular blocky. The B horizon is more than 100 cm thick. The colour of the B horizon is in hue of 10YR and 7.5YR, value 4 to 5 and chroma 3 to 4. Its texture ranges from clay loam to clay and structure moderate medium subangular blocky to angular blocky. Lime concretions upto 20 to 40 per cent by volume are present in the C horizon. The thickness of the 2Ck horizon varies from 27 to 41 cm and is generally below 120 cm depth.

Competing series and their differentiae: Competing series are Tohana soils which are clayey and Juglaon soils which are fine-loamy in the control section. They belong to Typic Haplustepts.

Geographic setting: Hisar soils are formed in alluvium on nearly level land at an elevation of 225 m above MSL. The climate is semiarid subtropical with mean annual air temperature of 24.5ºC and mean annual rainfall of 440 mm. The estimated MAST is 26.0ºC. The difference between MSST and MWST is more than 5ºC.

Geogrphically associated soils: These are Tohana and Juglaon soils which are also Typic Ustochrepts.

Drainage and permeability: Well drained with moderate permeability.

Use and vegetation: Intensively cultivated under irrigation; important crops are paddy, cotton, sorghum, sugarcane, wheat, barley, gram and mustard; natural vegetation – *Acacia arabica* (babul), *Dalbergia sissoo* (shisham), *Prosopis spicigera* (jand) and *Cynodon dactylon* (dub).

Distribution and extent: Extensive in northern and central parts of tehsil and district of Hisar in Haryana and in Sangrur distict in Punjab. Hisar series is likely to occur in other adjoining areas of Punjab, Haryana and Delhi.

Series proposed: National Bureau of Soil Survey and Land Use Planning, (previously AIS&LUS), Regional Centre, Delhi, 1970.

Interpretation: Hisar soils are agriculturally important. They have good soil-air-water relationship. They are productive and respond to management.

Interpretative grouping
i)	Land capability subclass	IIe
ii)	Irrigability subclass	1
iii)	Productivity potential	High

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)
		<--------------- % of < 2 mm ------------------->		
Ap	0-16	68.8	8.0	23.2
Bw1	16-37	64.7	10.0	25.3
Bw2	37-52	58.5	12.0	29.5
Bt1	52-77	48.8	16.0	35.2
Bt2	77-105	42.6	18.0	39.4
Bt3	105-128	42.8	18.0	39.2
2Ck	128-168	40.9	20.0	39.1

Depth (cm)	Organic Carbon (%)	$CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})
0-16	0.14	0.2	8.1	0.3
16-37	0.16	0.2	7.9	0.3
37-52	0.14	0.6	7.9	0.3
52-77	0.14	0.6	8.0	0.3
77-105	0.14	1.3	8.0	0.3
105-128	0.11	1.7	8.0	0.3
128-168	0.11	8.5	8.2	0.3

Note: The soil texture is based on International particle size classification.

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.5.2 JAITARAN SERIES

The Jaitaran series is a member of the coarse-loamy, mixed, hyperthermic family of Typic Camborthids. Typically, Jaitaran soils have brown to dark brown, strongly alkaline, sandy loam A horizons; dark brown to dark reddish brown, moderately alkaline, sandy loam B horizons, and dark yellowish brown, strongly alkaline, loamy sand C horizons.

Water balance diagram Pali, Rajastan
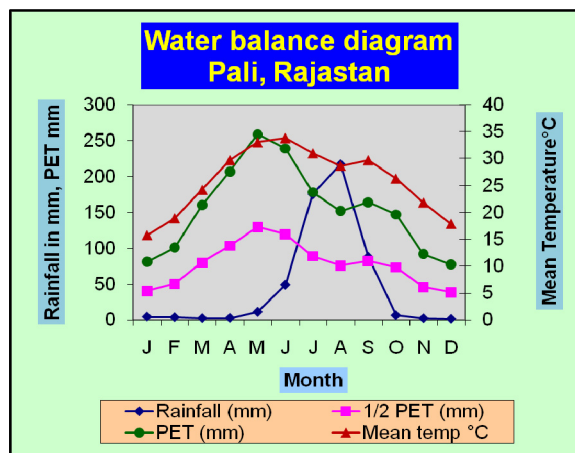
Typifying pedon: Jaitaran sandy loam - cultivated

Ap   0-20 cm --- Brown (7.5YR 5/4 D) and dark brown (7.5YR 4/4 M) sandy loam; moderate fine subangular blocky structure; slightly hard, friable, non-sticky and non-plastic; many fine roots; many fine and medium pores; strongly alkaline (pH 8.5); clear smooth boundary.

B1   20-45 cm --- Dark brown (7.5YR 4/4 D) and dark reddish brown (5YR 3/4 M) sandy loam; massive to very weak fine subangular blocky structure; very hard, friable, non-sticky and non-plastic; many fine roots; many fine and medium pores; moderately alkaline (pH 8.2); diffuse smooth boundary.

B2   45-80 cm --- Dark brown (7.5YR 4/4 D) and dark reddish brown (5YR 3/4 M) sandy loam; massive to very weak fine subangular blocky structure; very hard, friable, non-sticky and non-plastic; many fine roots; many fine and medium pores; few rounded quartz gravels; moderately alkaline (pH 8.1); diffuse smooth boundary.

B3   80-120 cm --- Dark brown (7.5YR 4/4 D) and reddish brown (5YR 4/4 M) sandy loam; massive; hard, friable, non-sticky and non-plastic; many fine and medium pores; moderately alkaline (pH 8.2); abrupt smooth boundary.

C   120-150 cm --- Dark yellowish brown (10YR 4/4 D) and dark yellowish brown (10YR 3/4 M) loamy sand; massive; slightly hard, friable, non-sticky and non-plastic; many fine and medium pores; slightly effervescent; strongly alkaline (pH 8.5).

Type location: 25°53' N, 73°19' E; 1 km south of village Neemtali Uda in Pali Panchayat Samiti on right bank of Phun Pheria nala, district Pali, Rajasthan.

Range in characteristics: The thickness of the solum ranges between 80 and 120 cm. The A horizon is about 20 cm thick. Its colour is in hue 7.5YR, value 4 or 5 and chroma 3 or 4. The texture is sandy loam. The structure is weak or moderate fine subangular blocky. The B horizon is 60 to 100 cm thick. Its colour is in hue 7.5YR or 5YR, value 3 or 4 and chroma 4. The texture is sandy loam and occasionally loamy sand. The structure is mostly very weak fine subangular blocky and occasionally massive. The C horizon occurs below the depth of 80 to 120 cm from the surface. Its colour is in hue mostly 10YR, value 3 or 4 and chroma 4 or 5. The texture is loamy sand. It has no structural development.

Geographic setting: Jaitaran soils are developed in mixed old alluvium and occur on nearly level and very gently sloping plain at an elevation of 200 to 300 m above MSL. The climate is semiarid

to arid subtropical with mean annual air temperature of 26.7°C and mean annual rainfall of 300 to 400 mm. The estimated MAST is 28.7°C, MSST 31.0°C and MWST 21.3°C. The difference between MSST and MWST is 9.7°C

Geographically associated soils: These are soils of Pali series, a Typic Camborthid, Sojat series, a Typic Camborthid, Chandawal series, a Typic Camborthid and Malkosoni series, a Typic Salorthid.

Drainage and permeability: Well drained or moderately well drained with moderate permeability.

Use and vegetation: Cultivated to pearl millet, sorghum, sesame, green gram, cluster bean, groundnut and castor in *kharif;* and wheat and mustard in *rabi* under irrigation; natural vegetation - *Acacia arabica* (babul), *Prosopis juliflora* (mesquite) and *Azadirachta indica* (neem).

Distribution and extent: Extensive in the Luni basin and in scattered patches of other parts of Pali district, Rajasthan.

Series proposed: Central Arid Zone Research Institute, Jodhpur, 1979

Interpretation: Aridity is the major limitation to grow crops. Jaitaran soils have good soil-water-air relationship. Available water capacity of the soils is moderate. Under years of normal rainfall, the soils can support climatically adapted crops producing moderate yields. They will respond to management. Main management practices required for these soils are measures to control wind erosion and conservation of soil moisture.

a) Interpretative grouping:

i)	Land capability subclass	IIIc
ii)	Irrigability subclass	2s
iii)	Productivity potential	Medium

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
		<-------------------------------------- % of < 2 mm -------------------------------------->									
Ap	0-20	73.5	15.5	11.0	21.5	16.0	9.5	14.0	12.5	9.0	6.5
B1	20-45	69.5	23.5	7.0	19.5	13.0	7.5	14.0	15.5	10.5	13.0
B2	45-80	57.5	24.5	18.0	14.0	10.0	8.0	13.0	12.5	7.5	17.0
B3	80-120	71.0	22.0	7.0	13.5	11.5	11.0	19.0	16.0	8.0	14.0
C	120-150	79.5	13.0	7.5	19.0	17.5	11.5	17.0	14.5	4.5	8.5

| Depth (cm)	Organic carbon (%)	pH (1:2.5) H₂O	E.C. (1:2.5) H₂O (dS m⁻¹)	Moisture equivalent (%)	Water holding capacity (%)
0-20	0.40	8.5	0.2	8.6	29.7
20-45	0.27	8.2	<0.2	12.4	30.9
45-80	0.22	8.1	<0.2	14.3	32.4
80-120	0.20	8.2	0.2	12.8	32.3
120-150	0.15	8.5	0.2	10.6	30.1

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.6 Soil Series: AESR 2.4

South Kachchh and North Kathiawar Peninsula, hot arid ESR with deep loamy saline and alkali soils, low AWC and LGP 60-90 days (L12Et2)

2.6.1 BHOLA SERIES

The Bhola series is a member of the fine, smectitic, hyperthermic family of Vertic Haplustepts. Typically, Bhola soils have brown to dark brown, moderately to strongly alkaline, sandy clay A horizons; very dark grayish brown to dark yellowish brown, strongly alkaline, clay B horizons, and yellowish brown, gravelly sandy loam Ck horizons.
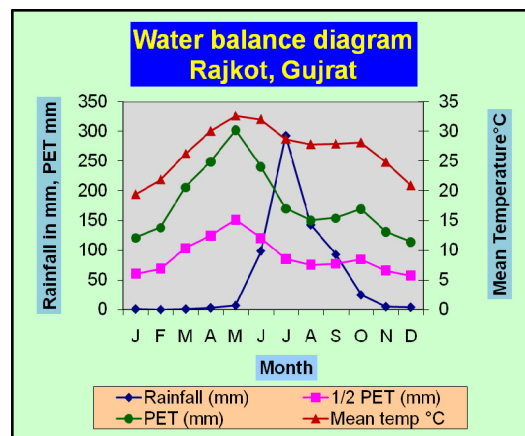
Typifying pedon: Bhola sandy clay – cultivated

Ap   0-16 cm --- Brown (10YR 5/3 D) and dark brown (10YR 3/3 M) sandy clay moderate medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many fine roots; 10 to 20 mm wide cracks; few fine lime nodules; violently effervescent; moderately alkaline (pH 8.1); clear smooth boundary.

A   16-33 cm --- Brown (10YR 5/3 D) and dark brown (10YR 3/3 M) sandy clay moderate medium subangular blocky structure; hard, friable, sticky and plastic; many fine roots; 10 to 20 mm wide cracks; few fine lime nodules; violently effervescent; strongly alkaline (pH 8.7); clear smooth boundary.

Bw1   33-56 cm --- Very dark grayish brown (10YR 3/2 D&M) clay; strong coarse subangular blocky structure; hard, firm, sticky and plastic; many very fine roots; 10 to 20 mm wide cracks; many fine lime nodules; violently effervescent; strongly alkaline (pH 8.6); gradual smooth boundary.

Bw2   56-73 cm --- Very dark grayish brown (10YR 3/2 D&M) clay; strong coarse subangular blocky structure; hard, firm, sticky and plastic; common very fine roots; many fine lime nodules; violently effervescent; strongly alkaline (pH 8.7); clear smooth boundary.

BC   73-96 cm --- Dark yellowish brown (10YR 4/4 M) gravelly clay; massive; friable, sticky and plastic; few very fine roots; many medium lime nodules; violently effervescent; strongly alkaline (pH 8.7); abrupt smooth boundary.

Ck   96-113 cm --- Yellowish brown (10YR 5/6 M) gravelly sandy loam with pebbles, cobbles and many lime nodules; violently effervescent.

Type location: 21°45' N, 70°25' E; village Bhola, tehsil Dhoraji, district Rajkot, Gujarat.

Range in characteristics: The solum is 87 to 122 cm thick below which gravelly weathered basalt with lime occurs. The A horizon is 20 to 35 cm thick. Its colour is in hue of 7.5YR and 10YR, value 3 and chroma 2 to 3. The texture ranges from clay loam to clay and structure is weak to strong and medium to coarse subangular blocky. There are 2 to 12 per cent coarse fragments. The B horizon is 50 to 100 cm thick. Its colour is in hue of 7.5 YR and 10YR, value 2 to 3 and chroma 2a to 4. The texture is clay loam to clay and gravelly clay. Its structure is moderate medium to strong coarse subangular blocky. 3 to 10 per cent concretionary lime lithorelicts of 5 to 20 cm size are present. 10 to 20 mm wide cracks extend upto 50 cm from the surface.

Geographic setting: Bhola soils are formed in alluvium and colluvium and occur on nearly level to very gently sloping old flood plain and upland at an elevation of 50 to 150 m above MSL. The climate is semiarid tropical with mean annual air temperature of 26.7°C and mean annual rainfall of 673 mm.The estimated MAST is 28.7°C, MSST 29.0°C and MWST 23.2°C. The difference between MSST and MWST is 5.8°C.

Geographically associated: Bhola soils are associated with Shivrajgadh and Semla soils. Shivrajgadh soils are calcareous and Semla soils have intersecting slikensides. Shivrajgadh and Semla soils belong to Vertic Haplustepts and Udic Haplusterts, respectively.

Drainage and permeability: Moderately well drained with slow permeability.

Use and vegetation: Mostly under wasteland but occasionally cultivated to cotton, wheat and sugarcane (fodder); natural vegetation – *Acacia spp.* (babul), *Calotropics spp.* (ak), *Cassia spp.* (siriss) and *Azadirachta indica* (neem).

Distriution and extent: Extensive (48,750 ha) in Rajkot district of Gujarat.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur, 1979.

Interpretation: Bhola soils are moderately deep to deep and strongly calcareous. They are subject to severe erosion and water stagnation during rainy season. Exchangeable sodium is somewhat high in the lower layers. Due to shrink-swell nature, these soils are less permeable to water. They may pose saline/sodic problems under irrigation. These soils if reclaimed are productive. They can be cultivated with proper management practices for both rainfed and irrigated crops. Under rainfed agriculture, proper water and soil conservation measures are necessary. They can support a variety of climatically adapted crops.

Interpretative grouping:

i)	Land capability subclass	IIc
ii)	Irrigability subclass	3s
iii)	Productivity potential	Medium

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								Coarse fragm-ents > 2 mm % of whole soil
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
		<--- % of < 2 mm --->								
Ap	0-16	45.4	12.6	42.0	2.5	4.3	8.4	15.2	15.0	1
A	16-33	45.5	13.5	41.0	3.0	3.5	13.0	11.0	15.0	-
Bw1	33-56	27.5	21.9	50.6	3.0	2.0	2.5	4.5	15.5	2
Bw2	56-73	25.5	26.0	48.5	3.0	2.0	3.0	7.0	10.5	6
BC	73-96	31.5	28.0	40.5	2.0	3.0	2.0	13.5	11.0	39

Depth (cm)	Organic Carbon (%)	Carbonate as CaCO₃ < 2 mm (%)	pH (1:2.5) H₂O	E.C. (1:2.5) H₂O (dS m⁻¹)	Bulk density (Mg m⁻³)	Water retention	
						33 kPa (%)	1500 kPa (%)
0-16	0.70	21.8	8.1	1.05	1.68	24.4	13.4
16-33	0.62	14.3	8.7	1.80	1.86	24.0	14.7
33-56	0.45	18.2	8.6	3.80	1.87	40.0	23.0
56-73	0.29	23.2	8.7	4.10	1.81	42.9	24.0
73-96	0.27	26.6	8.7	0.50	1.72	44.1	23.5

Depth (cm)	Extractable bases					CEC NH₄OAc	Base saturation NH₄OAc (%)	Ratio CEC/ Clay (%)	ESP (%)
	Ca	Mg	Na	K	Sum				
	<------------------------ cmol (p+)kg⁻¹ ------------------------>								
0-16	24.0	12.4	0.8	0.3	37.5	37.9	99	0.90	2.1
16-33	22.4	11.6	2.1	0.4	36.5	37.1	98	0.90	5.7
33-56	26.8	11.2	3.9	0.5	42.4	44.3	96	0.88	8.8
56-73	22.8	13.2	4.3	0.4	40.7	41.9	97	0.86	10.3
73-96	22.8	10.0	4.6	0.4	37.8	38.9	97	0.96	11.8

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.6.2 SEMLA SERIES

The Semla series is a member of the very fine, smectitic, hyperthermic family of Udic Haplusterts. Typically, Semla soils have very dark greyish brown, strongly alkaline, clay A horizons; very dark greyish brown, strongly alkaline, clay B horizons, and very pale brown Ck horizon.

Water balance diagram
Rajkot, Gujrat
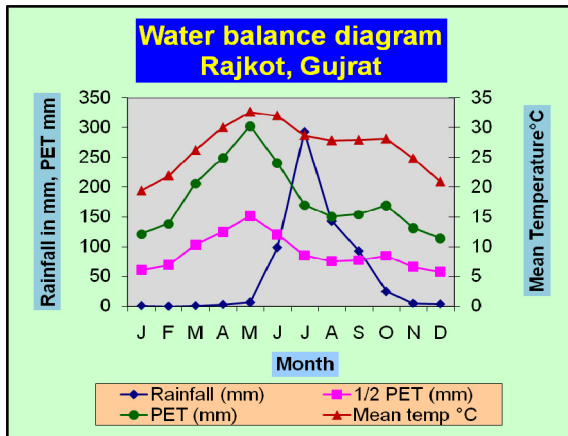
Typifying pedon: Semla clay -cultivated

Ap   0-10 cm --- Very dark greyish brown (10YR 3/2 D&M) clay; moderate medium subangular blocky structure; hard, firm, sticky and plastic; many fine roots, many fine oblique pores; few fine lime nodules; violently effervescent; strongly alkaline (pH 8.5); clear smooth boundary.

Bw   10-23 cm --- Very dark grayish brown (10YR 3/2 D&M) clay; strong coarse subandgular blocky structure with shiny pressure faces; hard, firm, sticky and plastic; few fine roots; many fine oblique tubular pores; few lime nodules; violently effervescent; strongly alkaline (pH 8.8); clear smooth boundary.

Bss1   23-45 cm --- Very dark grayish brown (10YR 3/2 M) clay; intersecting slickensides forming coarse parallelepipeds with long axes tilted 30º from the horizontal that break into strong coarse angular blocks with shiny pressure faces; firm, sticky and plastic; few fine roots; common fine oblique tubular pores; violently effervescent; strongly alkaline (pH 8.8); gradual smooth boundary.

Bss2   45-115 cm --- Very dark greyish brown (10YR 3/2 M) clay; intersecting slickensides forming coarse parallelepipeds with long axes tilted 45º from the horizontal that break into strong coarse angular blocks with shiny pressure faces; very firm, very sticky and very plastic; few very fine roots; few fine pores; violently effervescent; 3 to 4 per cent lime coated basalt fragments of 2 to 10 mm size strongly alkaline (pH 9.0); gradual smooth boundary.

BC   115-156 cm --- Very dark greyish brown (10YR 3/2 M) clay; intersecting slickensides forming coarse parallelepipeds with long axes tilted 30º to 45º from the horizontal that break into strong coarse angular blocks with shiny pressure faces; very firm, very sticky and very plastic; many fine lime nodules; violently effervescent; strongly alkaline (pH 8.9).

Ck   156-170 cm --- Very pale brown (10YR 7/3 M); fine calcareous basaltic material massive; violently effervescent.

Type location: 22º03' N, 70º48' E; about 500 m southwest of village Semla, tehsil Gondal, district Rajkot, Gujarat.

Range in characteristics: The A horizon is more than 20 to 25 cm thick. Its colour is in hue 10YR, value 3 and chroma 1 to 2. The texture is silty clay to clay. The structure of the surface

layer is moderate, medium to strong, coarse subangular blocky. The B horizon is 80 to 110 cm thick. Its colour is in hue 10YR, value 3 and chroma 1 to 2. Its texture is clay. The BC horizon is 40 to 45 cm thick. It has same colour and texture as of the B horizon. The B and BC horizons have intersecting slickensides forming parallelepipeds that break into angular blocks. The lime content is high throughout the profile depth. Cracks 20 to 40 mm wide taper and extend to 100 cm depth. Gilgai micro relief is common. Lower horizons remain moist for most part of the year.

Competing series and their differentiae: Sokhada soils are brown to dark brown with compact subsoil and belong to Chromic Haplusterts.

Geographic setting: Semla soils are formed in basaltic alluvium and occur on nearly level to very gently sloping lower piedmont at an elevation of 100 to 120 m above MSL. The climate is semiarid tropical with mean annual air temperature of 26.7ºC and mean annual rainfall of 673 mm. The estimated MAST is 28.7ºC, MSST 29.0ºC and MWST 23.2ºC. The difference between MSST and MWST is 5.8ºC.

Geographically associated soils: Semla soils are associated with Shivrajgadh and Bhola soils which are Vertic Haplustepts.

Drainage and permeability: Imperfectly drained with slow permeability.

Use and vegetation: Cultivated to rainfed cotton, sorghum, wheat, surgarcane and gram; natural vegetation *Acacia spp.* (babul), *Cassia spp.* (kasaunda), *Calotropis spp.* (ak) and *Azadirachta indica* (neem)

Distribution and extent: Extensive (62,700 ha) in Rajkot district of Gujarat.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur, 1978.

Interpretation: Semla soils are fine textured with high shrink-swell potential. They are prone to develop salinity and sodicity even when irrigated with water low in soluble salt. During monsoon, crops may be adversely affected due to stagnation of water. These soils are susceptible to erosion even on very gently sloping lands. They are highly productive with proper management and drainage under both rainfed and irrigated agriculture.

a) **Interpretative grouping:**
  i)   Land capability subclass   IIIs
  ii) Irrigability subclass   3d
  iii) Productivity potential   High

b) **Yield:** Based on data from farmers' fields

Crop	Farmers' practices	Improved practices
	<--------------------Yield, Mg ha^{-1}------------------------>	
Groundnut	0.5	1.3
Cotton	0.6	1.0
Pearl millet	0.5	1.8
Sorghum	0.3	1.6
Pigeonpea	0.6	1.0
Wheat	1.0	2.2

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								Coarse fragm-ents > 2 mm % of whole soil
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
		<--- % of < 2 mm --->								
Ap	0-10	22.6	20.5	56.9	6.4	4.4	2.5	2.3	7.0	-
Bw	10-23	20.5	19.5	60.0	5.0	3.5	2.5	3.5	6.0	-
Bss1	23-45	23.6	15.5	60.9	5.0	3.0	2.4	2.2	11.0	-
Bss2	45-115	19.4	18.7	61.9	5.6	2.5	2.0	2.0	7.3	3
BC	115-156	16.6	25.6	57.8	2.0	2.0	5.0	1.5	6.1	2

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})	Bulk density (Mg m^{-3})	Water retention	
						33 kPa	1500 kPa
0-10	0.72	21.8	8.5	0.50	1.80	31.6	16.1
10-23	0.67	21.1	8.8	0.70	1.80	32.9	15.7
23-45	0.62	24.7	8.8	0.80	1.82	35.9	16.5
45-115	0.59	21.7	9.0	1.10	1.89	42.2	20.4
115-156	0.43	22.1	8.9	0.90	1.82	40.6	20.8

Depth (cm)	Extractable bases					CEC NH$_4$OAc	Base saturation (%)	Ratio CEC/ Clay (%)	ESP (%)
	Ca	Mg	Na	K	Sum				
	<------------------------- cmol (p+)kg^{-1} ------------------------->								
0-10	32.3	12.0	1.4	1.0	46.7	47.8	98	0.84	2.9
10-23	37.6	16.8	2.7	0.9	58.0	58.9	98	0.98	4.6
23-45	34.8	16.4	2.9	0.6	54.7	55.7	98	0.91	5.2
45-115	30.8	20.0	3.8	0.8	55.4	56.1	99	0.91	6.8
115-156	27.6	19.6	3.1	0.4	50.7	51.7	98	0.89	6.0

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.7 Soil Series: AESR 3

Karnataka Plateau (Rayalseema as inclusion), hot arid ESR with deep loamy and clayey mixed Red and Black soils, low to medium AWC and LGP 60-90 days (K6Et2)

2.7.1 JAMAKHANDI SERIES

The Jamakhandi series is a member of the fine, mixed, isohyperthermic family of Typic Paleustalfs. Typically, Jamakhandi soils have dark brown to dark reddish brown, moderately alkaline, sandy clay loam A horizons, and dark reddish brown to dark red, moderately alkaline, sandy clay to clay B horizons underlain by calcareous BC horizons followed by lithologically discontinuous yellowish red, moderately alkaline, calcareous, sandy clay C horizons.

Water balance diagram Bijapur, Karnataka
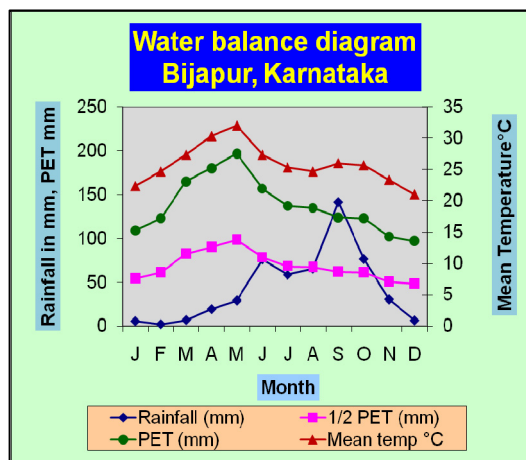
Typifying pedon: Jamakhandi sandy clay loam - cultivated

Ap   0-16 cm --- Dark reddish brown (5YR 3/4 D & M) sandy clay loam; weak fine subangular blocky structure breaking to fine to very fine granular; loose, friable, sticky and slightly plastic; few coarse to fine roots between peds; many very fine random open tubular imped pores; moderately alkaline (pH 8.2); clear smooth boundary.

BA   16-40 cm --- Dark reddish brown (5YR 2.5/2 D & M) sandy clay loam; moderate medium subangular blocky structure; friable, sticky and plastic; few fine roots inside peds; many very fine vertical open tubular imped pores; patchy thin cutans on ped faces; strongly alkaline (pH 8.5); clear smooth boundary.

Bt1   40-61 cm --- Dark reddish brown (5YR 2.5/2 D & M) sandy clay; moderate medium prismatic structure breaking to angular blocky; firm sticky and plastic; few fine roots inside peds; many very fine vertical open tubular imped pores; broken thin clay cutans on both horizontal and vertical ped faces; strongly effervescent at places; moderately alkaline (pH 8.2); clear smooth boundary.

Bt2   61-89 cm --- Dark reddish brown (5YR 2.5/2 M) clay; strong medium prismatic structure breaking to fine prismatic; firm, sticky and plastic; few very fine roots inside peds; may very fine vertical open tubular imped pores; continuous moderately thick clay cutans on both vertical and horizontal ped faces; strongly effervescent; moderately alkaline (pH 8.3); clear smooth boundary.

BC1   89-123 cm --- Reddish brown (5YR 4/4 M) clay; dark reddish brown (5YR 3/4 R); weak medium subangular blocky structure tending to prismatic; friable, slightly sticky and slightly plastic; vertical tubular imped pores; patchy thin clay cutans; few pseudomycelia of lime; strongly effervescent; strongly alkaline (pH 8.6); clear smooth boundary.

BC2   123-152 cm --- Reddish brown (5YR 5/3 M about 75 per cent) and dark reddish brown (2.5YR 3/4 M about 25 per cent) sandy clay; weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; many pseudomycelia of lime; violently effervescent; strongly alkaline (pH 8.5); abrupt smooth boundary.

2C   152-176 cm --- Yellowish red (5YR 4/6 M about 70 per cent) and dark reddish brown (2.5YR 3/4 M about 30 per cent) sandy clay loam; weak medium subangualr blocky structure, friable, slightly sticky and slightly plastic; few pseudomycelia of lime; strongly effervescent; quartz gravels about 25 to 30 per cent by volume of 5 to 10 mm size, moderately alkaline (pH 8.2).

Micromorphology: Three thin sections from the B horizon are studied. The B horizon has a subangular blocky structure in the upper and lower parts and a prismatic structure in the middle zone. The structure determined by physical processes of swelling and shrinking is strongest in the middle part. The fauna play an important role, most pronounced in the upper and lower part. The animals homogenize a large part of the groundmass and produce most of the common voids; Carbonates are present from a depth of 62 cm. Carbonates present in voids as cutans or complete infillings are needle-shaped as well as small, more equant, crystals. Carbonate precipitation is a current process. In the lower part of the horizon are embedded allochthonous fragments of clay illuviation incorporated by soil animals.

Type location: 16º31' N, 75º18' E; field No. 47, village Honnur, tehsil Jamakhandi, district Bijapur, Karnataka.

Range in characteristics: The depth of the solum is more than 150 cm. The A horizon is 15 to 20 cm thick. Its colour is in hue 5YR of 7.5YR, value 3 to 5 and chroma 4 to 6. The texture is loamy sand to sandy clay loam. The B horizon is 120 to 150 cm thick. Its colour is in hue 5YR of 2.5YR, value 2.5 to 5 and chroma 2 to 6. The structure is moderate subangular blocky to strong prismatic.

Geographic setting: Jamakhandi soils are formed in mixed alluvium derived from sandstone and quartzite and occur on very gently to gently sloping filled-in valleys at an elevation of 550 to 600 m above MSL. The climate is semiarid tropical with mean annual air temperature of 26.4ºC and mean annual rainfall of 575 mm. The estimated MAST is 28.4ºC. The difference between MSST and MWST is 2.3ºC.

Geographically associated soils: The associated soils are Marguppi and Arakeri series, which belong to Vertic Ustorthents and Udic Rhodustalfs, respectively.

Drainage and permeability: Moderately well drained with moderate permeability.

Use and vegetation: Cultivated to rainfed sorghum, pearl millet and Italian millet, and irrigated cotton, sugarcane and hybrid maize, natural vegetation – *Acacia spp.* (babul), *Prosopis spp.* and *Azadirachta indica* (neem).

Distribution and extent: Extensive in Bijapur and Belgaum districts of Karnataka.

Series proposed: State Soil Survey Organization, Department of Agriculture, Karnataka.

Interpretation: Jamakhandi soils have good air-water relationship. All climatically adapted crops respond to management. Rainfall variation appears to be the major limitation.

a) Interpretative grouping:
    i)   Land capability subclass   IIIc
    ii) Irrigability class   I
    iii) Productivity potential   High

b) Yield: Based on data from farmers' fields

Crop	Farmers' practices	Improved practices
	(Irrigated)	
	< --------------------Yield, Mg ha^{-1}------------------------ >	
Maize	2.4-2.7	3.0-3.2
Sorghum	1.0-1.2	2.5-2.7
Wheat	1.5-1.8	2.2-2.5

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								Coarse frag-ments > 2 mm % of whole soil
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
		<--------------------------------------- % of < 2 mm --------------------------------------->								
Ap	0-16	73.8	6.1	20.1	11.3	26.4	19.7	12.2	4.2	3
BA	16-40	65.1	5.8	29.1	8.9	24.7	17.1	10.5	3.9	1
Bt1	40-61	47.2	14.8	38.0	10.3	18.2	10.5	5.7	2.5	-
Bt2	61-89	44.0	10.5	45.5	5.4	18.4	11.4	6.4	2.4	-
BC1	89-123	42.8	16.3	40.9	8.5	17.0	9.9	5.2	2.2	1
BC2	123-152	51.9	8.9	39.2	8.6	22.2	12.7	6.1	2.3	5
2C	152-176	59.7	9.8	30.5	28.7	12.6	10.0	6.2	2.2	3

Depth (cm)	Organic Carbon (%)	Carbonate as CaCO$_3$ < 2 mm (%)	Ext. iron as Fe (%)	pH (1:2.5) H$_2$O	Bulk density (Mg m^{-3})	Water retention		Micronutrients			
						33 kPa	1500 kPa	D T P A extractable			
								Zn	Cu	Mn	Fe
								<------------- ppm --------------->			
0-16	1.03	1.2	0.75	8.2	-	14.5	5.7	0.43	2.23	13	14
16-40	1.17	0.8	1.71	8.5	1.58	21.7	9.8	0.14	3.08	16	11
40-61	1.46	1.6	2.00	8.2	1.68	-	-	0.14	4.52	21	11
61-89	1.15	2.9	1.96	8.3	1.66	-	-	0.13	4.35	21	11
89-123	0.77	8.4	1.69	8.6	1.37	-	-	0.17	5.16	14	9
123-152	0.51	9.2	1.68	8.5	-	-	-	-	-	-	-
152-176	0.22	3.9	1.89	8.2	-	-	-	-	-	-	-

Depth (cm)	Extractable bases					CEC NaOAc (pH 8.2)	Ratio to clay	
	Ca	Mg	Na	K	Sum		CEC NaOAc	Ext. iron
	<----------------------- cmol (p+)kg^{-1} ----------------------->							
0-16	11.3	1.8	0.3	0.9	14.3	16.6	0.83	0.04
16-40	16.9	2.3	0.3	0.4	19.9	23.8	0.82	0.06
40-61	27.3	4.8	0.4	0.5	33.0	35.8	0.94	0.05
61-89	28.8	6.4	0.5	0.6	36.3	38.4	0.84	0.04
89-123	24.8	6.7	0.6	0.5	32.6	35.3	0.86	0.04
123-152	20.4	8.3	0.6	0.5	29.8	29.8	0.76	0.04
152-176	15.8	8.3	0.4	0.4	24.9	23.9	0.78	0.06

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.7.2 SOLLAPURAM

The Sollapuram series is a member of the very fine, smectitic, isohyperthermic family of Sodic Haplusterts. Typically, Sollapuram soils have very dark grayish brown, moderately alkaline, clayey A horizons, and very dark gray to very dark grayish brown, moderately alkaline to strongly alkaline, clayey B horizons underlain by layers of soft powdery lime material of C horizons.

Water balance diagram Sollapuram, A. P.
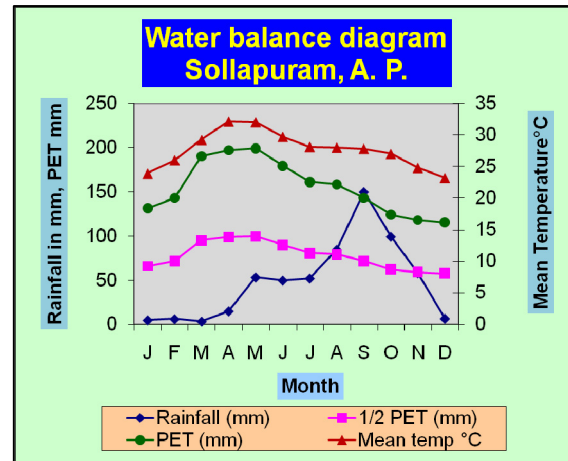
Typifying pedon: Sollapuram clay - cultivated.

Ap   0-14cm -- Very dark grayish brown (10YR3/2D&M) clay; moderate medium subangular blocky structure; very hard, friable, very sticky and very plastic; common very fine and fine roots; few medium roots; few very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.4); violently effervescent; clear smooth boundary.

Bw1   14-40cm -- Very dark gray (10YR3/1M) clay; strong medium subangular blocky structure with pressure faces on surface of peds; very hard, friable very sticky and very plastic; common very fine and fine roots, few very fine and fine lime nodules; moderately alkaline (pH 8.4); violently effervescence; gradual smooth boundary.

Bw2   40-63cm -- Very dark gray (10YR3/1M) clay; strong medium subangular blocky structure with well developed shiny pressure faces on surface of peds; friable, very sticky and very plastic, common very fine and fine roots; few very fine and fine lime nodules; strongly alkaline (pH 8.6); violently effervescence; gradual smooth boundary.

Bss1   63-102cm -- Very dark gray (10YR3/1M) clay; moderate medium angular blocky structure with weak development of slickensides and wedge shaped aggregates that break into weak angular peds; friable, very sticky and very plastic; common very fine and fine roots, few very fine, fine and medium lime nodules; strongly alkaline (pH 8.6); violently effervescence; clear smooth boundary.

Bss2   102-129cm -- Very dark gray to very dark grayish brown (10YR3/1.5M) clay; moderate medium angular blocky to subangular blocky structure with very weak development of slickensides and wedge shaped aggregates that break into very weak angular peds; very friable, very sticky and very plastic; few very fine roots; common very fine, fine and medium lime nodules; moderately alkaline (pH 8.2); violently effervescence; clear smooth boundary.

Bk1   129-150cm -- Dark grayish brown (10YR4/2 R) clay; weak medium subangular blocky structure; very friable, very sticky and very plastic; common very fine and fine, many medium lime nodules; moderately alkaline (pH 7.9); violently effervescent;abrupt smooth boundary.

Ck   150-180cm -- Layers of soft powdery lime material.

Type Location: 14°56'34" N, 77°09'37"E; 1.5 km from Sollapuram Village, Sollapuram, Oravukonda, Anantapur, Andhra Pradesh.

Range in characteristics: The solum is about 150cm thick and its colour is in hue 10YR, value 3 to 4 and chroma 1 to 2. The texture is clay and structure varies from moderate medium angular blocky to subangular blocky structure with very weak development of slickensides and wedge shaped aggregates.

Geographic setting: Sollapuram soils are formed in mixed alluvium (from granite-gneiss and basalt) and occur on level to very gentle sloping at an elevation of 150-300 m above MSL. The climate is semiarid (dry) tropical with mean annual air temperature of 27.65ºC and mean annual rainfall of 583 mm. The estimated MAST is 31.15ºC, MSST is 32.62ºC and MWST is 28.02ºC. The difference between MSST and MWST is 4.6ºC.

Drainage and permeability: Moderately well drained.

Vegetation: Neem, prosopis, acacia, grasses & shrubs, tamarind

Land use: Gram, sorghum, coriander

Soil datasets:

Lab. No	Hori-zon	Depth (cm)	Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Fine clay (%)	Fine clay/ total clay (%)	BD Mg/m³	COLE	HC* cm/hr	WDC (%)
			←------(% of <2 mm) -------→								
3191	Ap	0-14	12.3	23.0	64.7	41.5	64.1	-	0.22	0.5	8.9
3192	Bw1	14-40	12.2	24.4	63.4	47.7	75.2	1.4	0.21	0.2	14.2
3193	Bw2	40-63	11.8	24.3	63.9	55.1	86.2	1.3	0.19	0.1	16.0
3194	Bss1	63-102	9.2	23.9	66.9	57.2	85.5	1.2	0.14	0.1	14.0
3195	Bss2	102-129	6.0	22.3	71.7	63.0	87.8	1.4	0.14	0..2	11.0
3196	Bk1	129-150	6.2	21.9	71.9	61.2	85.1	-	0.13	0.3	11.6

* 2 mm hr⁻¹ is the HC (WM) in 0-100 cm depth of soil.

Horizon	Depth (cm)	33kPa	100kPa	300kPa	500kPa	800kPa	1000kPa	1500kPa	AWC
Ap	0-14	39.3	36.1	28.4	27.4	25.0	24.0	23.0	16.3
Bw1	14-40	50.2	37.5	29.9	29.1	27.1	24.2	22.3	28.0
Bw2	40-63	45.1	38.8	30.7	29.7	25.7	25.2	23.0	22.2
Bss	63-102	50.3	41.9	33.6	32.0	27.9	27.3	24.6	25.6
Bss/Bk	102-129	50.3	44.1	36.4	36.0	30.0	28.1	24.5	25.8
Bk2	129-150	53.5	47.5	36.3	35.3	34.2	30.9	29.3	24.2

Depth (cm)	pH water (1:2)	CaCO₃ (%)	OC (%)	Ca	Mg	Na	K	Sum	CEC	Clay CEC cmol(p+) kg⁻¹	B.S. (%)
0-14	8.4	18.0	0.6	36.0	11.1	4.9	1.0	53.0	58.7	91	90.3
14-40	8.4	16.0	0.5	31.4	12.0	7.7	0.8	52.0	58.7	92	88.6
40-63	8.6	16.4	0.5	31.8	12.2	9.0	0.7	53.7	65.2	102	82.4
63-102	8.6	19.1	0.5	28.6	17.7	11.2	0.7	58.2	63.0	94	92.3
102-129	8.2	18.1	0.4	28.7	14.9	14.1	0.8	58.5	65.2	91	89.7
129-150	7.9	23.1	0.3	38.0	14.6	14.9	0.8	68.3	69.0	96	99.0

Depth (cm)	Exch. Ca/Mg	ECP	EMP	ESP	CO₃ clay (%)	CO₃ clay (feb)* (%)
0-14	3.2	61.3	18.9	8.3	3.8	2.4
14-40	2.6	53.5	20.4	13.1	4.2	2.7
40-63	2.6	48.8	18.7	13.8	4.1	2.6
63-102	1.6	45.4	28.1	17.8	4.1	2.7
102-129	1.9	44.0	22.8	21.7	4.7	3.4
129-150	2.6	55.0	21.1	21.6	4.3	3.1

Depth (cm)	Sat %	ECe	Ca	Mg	Na	K	Sum	CO₃	HCO₃	Cl	SO₄	Sum	RSC	SAR
0-14	64.9	0.44	1.58	1.75	8.69	0.16	12.2	2.12	2.12	1.32	6.63	12.2	0.91	6.7
14-40	64.8	0.41	0.31	0.64	5.22	0.07	6.2	4.24	-	1.00	1.01	6.2	3.29	7.6
40-63	58.6	0.05	6.32	4.99	29.56	0.28	41.1	1.06	-	23.8	16.29	41.1	-10.25	12.4
63-102	74.8	0.20	1.76	1.24	19.57	0.11	22.7	1.06	-	12.40	9.22	22.7	-1.94	15.9
102-129	78.0	3.78	2.54	1.88	35.43	0.07	39.9	1.06	0.53	14.80	23.53	39.9	-2.83	23.8
129-150	82.3	6.70	12.73	11.1	78.26	0.07	102.2	1.06	1.59	3.40	96.11	102.2	-21.18	22.6

Source: Pal, D. K., Bhattacharyya, T., Ray, S. K. and Bhuse, S. R. 2003. "Developing a model on the formation and resllience of naturally degraded black soils of the Peninsular India as a decision support system for better land use planning" NRDMS, DST Project Report, NBSSLUP (ICAR), Nagpur, 144p.
* feb = fine earth (soil) basis

2.8 Soil Series: AESR 4.1

North Punjab Plain, Ganga-Yamuna Doab and Rajasthan Upland, hot semi-arid ESR with deep loamy alluvium-derived soils (occasional saline and sodic phases), medium AWC and LGP 90-120 days (N8Dd3)

2.8.1 ZARIFA VIRAN

The Zarifa Viran series is a member of the fine-silty, mixed, hyperthermic family of Typic Natrustalfs. Typically, Zarifa Viran soils have pale yellow to yellowish brown, very strongly alkaline, loam to clay loam A horizon; olive brown to light olive brown, very strongly alkaline, loam to clay loam B horizons, and light olive brown, very strongly alkaline, loam C horizons.
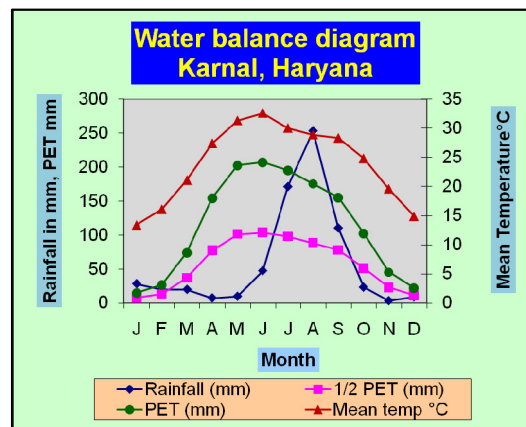
Typifying pedon: Zarifa Viran loam – wasteland

A1   0-5 cm --- Pale yellow (2.5Y 7/4 D) and brown to dark brown (10YR 4/3 M) loam; moderate fine to medium platy structure; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; many very fine discontinuous vertical and oblique tubular imped pores; strongly effervescent; very strongly alkaline (pH 10.3); abrupt smooth boundary.

A2   5-24 cm --- Yellowish brown (10YR 5/4 M) clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; few very fine roots; many very fine discontinuous vertical and oblique tubular imped pores; strongly effervescent; very strongly alkaline (pH 10.3); clear smooth boundary.

Btn1   24-56 cm --- Olive brown (2.5Y 4/4 M) clay loam; strong medium to coarse angular blocky structure; firm, very sticky and plastic; few very fine roots; many very fine discontinuous vertical and oblique tubular imped pores; patchy thin cutans; iron manganese concretions 3 per cent by volume of 2 to 3 mm; strongly effervescent; very strongly alkaline (pH 9.8); clear smooth boundary.

Btn2   56-85 cm --- Olive brown (2.5Y 4/4 M) clay loam; strong coarse angular blocky structure; very firm, very sticky and plastic; many very fine discontinuous vertical and oblique tubular imped pores; patchy thin cutans; iron-manganese concretions 4 to 7 per cent by volume of 2 to 3 mm; lime concretions of 5 to 15 mm; strongly effervescent; very strongly alkaline (pH 9.8); clear wavy boundary.

BCk   85-118 Light olive brown (2.5Y 5/4M) loam; many fine distinct yellowish brown (10YR 5/6) mottles; strong coarse angular blocky structure; very firm, very sticky and plastic; many very fine discontinuous vertical and oblique tubular imped pores; patchy thin cutans; 50 mm size lime concretions 30 per cent by volume; 50 mm size iron-manganese concretions; strongly effervescent; very strongly alkaline (pH 9.6); clear smooth boundary.

Ck   118-140 cm --- Light olive brown (2.5Y 5/4 M) loam; many medium distinct yellowish brown (10YR 5/6) mottles; moderate medium to coarse angular blocky structure; very firm, sticky and plastic; many very fine discontinuous vertical and oblique tubular imped pores; 1 to 3 mm size iron-manganese concretions 3 to 5 per cent by volume; violently effervescent; very strongly alkaline (pH 9.2).

Micromorphology: The high sodium saturation causes peptization of the soil material when wet. Clay is released and with drainage of the water, sorting of grain sizes occur, Over the depth of 85 cm few to common cutans and common complete infillings of voids composed of clay (e. g. argillans) and/or clay sized material and/or silt-sized material occur. Often, the cutans and complete infillings are laminated. Carbonates are accumulating over the studied depth. In the A horizon they occur to a minor extent, mainly as neocalcans or calcans. In the B horizon, the quantity increases rapidly and nodules of increasing diameters are found. Micas are under alteration in this soil. Some sesquioxides have been released and accumulate to a minor extent in the groundmass.

Type location: 29°25' N, 76°55' E; about 200 m southwest of tubewell No. 1 CSSRI farm, village Gudha, tehsil and district Karnal, Haryana.

Range in characteristics: The thickness of the solum is more than 100 cm. The A horizon is about 25 cm thick. Its colour is in hue 2.5Y and 10YR, value 5 to 7 and chroma 3 to 4. The texture is loam to clay loam. The Bt horizon is 50 to 60 cm thick. Its colour is in hue 2.5Y and 10YR, value 3 or 4 and chroma 4. The texture is clay loam. Iron-manganese concretions are present. The BCk horizon is about 30 cm thicky with the same colour and texture as in the Bt horizon. It has yellowish brown mottles. The Ck horizon has iron-manganese concretions and yellowish brown mottles. It has more lime than the overlying horizon.

Geographic setting: Zarifa Viran soils have developed in old alluvium in micro-depressions on nearly level to flat land at an elevation of 200 to 250 m above MSL. The climate is semiarid subtropical with mean annual air temperature of 25.0ºC and mean annual rainfall of 600 to 700 mm. The estimated MAST is 26.5ºC, MSST 30.7ºC and MWST 14.0ºC. The difference between MSST and MWST is 16.7°C.

Drainage and permeability: Imperfectly drained with moderately slow permeability.

Use and vegetation: Mostly barren with salt-loving grasses.

Distribution and extent: Extensive in alluvial plains in Karnal and adjoining districts of Haryana and parts of Uttar Pradesh.

Series proposed: Central Soil Salinity Research Institute, Karnal.

Interpretation: Zarifa Viran soils are saline and highly sodic with moderately slow permeability. Due to their location in depressions, water stagnates during rainy season. The soils need to be reclaimed before brought under cultivation.

Interpretative grouping:

      i)   Land capability subclass   IIIs
      ii) Irrigability class   3d
      iii) Productivity potential   Low

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)										Coarse fragm-ents > 2 mm % of whole soil
		Total			Sand					Clay		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.002-0.001)	(<0.001)	
		<-- % of < 2 mm -->										
A1	0-5	43.4	34.6	22.0	-	0.2	1.2	3.2	38.8	19.1	2.9	-
A2	5-24	33.4	37.6	29.0	-	0.3	0.3	1.9	30.9	24.6	4.4	-
Btn1	24-56	30.6	36.2	33.2	-	0.4	0.3	1.8	28.1	26.2	7.0	-
Btn2	56-85	26.0	42.6	31.4	-	0.2	0.4	1.6	23.8	24.2	7.2	4
BCk	85-118	33.2	40.0	26.8	-	0.6	0.8	1.6	30.2	23.0	3.8	10
Ck	118-140	45.0	32.0	23.0	-	-	0.1	0.4	44.5	19.6	3.4	-

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H2O	Bulk density (Mg m^{-3})	Micronutrients			
					D T P A extractable			
					Zn	Cu	Mn	Fe
					<------------------ ppm ------------------>			
0-5	0.30	0.5	10.3	1.42	0.36	2.01	12	9
5-24	0.30	0.9	10.3	1.48	0.36	2.32	9	16
24-56	0.20	1.4	9.8	1.48	0.34	1.38	11	6
56-85	0.20	3.3	9.8	1.63	0.21	0.80	8	5
85-118	0.10	12.4	9.6	1.47	0.21	0.50	6	4
118-140	0.10	20.5	9.2	1.50	-	-	-	-

Depth (cm)	Extractable bases			CEC NH_4OAc	Exchangeable sodium (%)	Ratio CEC/ clay
	Ca+Mg	Na	K			
	<-------------- cmol (p+)kg^{-1} --------------->					
0-5	0.2	9.9	0.1	10.2	97	0.46
5-24	0.3	12.1	0.4	12.8	95	0.44
24-56	0.8	13.4	0.6	14.8	91	0.45
56-85	1.8	12.4	0.4	14.6	85	0.46
85-118	3.1	7.6	0.5	11.2	68	0.42
118-140	5.6	3.8	0.4	9.8	39	0.43

Depth (cm)	Water saturation (%)	Soluble cations			Soluble anions				ECE dS m^{-1}	Clay fraction mineralogy
		Ca+Mg	Na	K	CO_3	HCO_3	Cl	SO_4		
		<--------- me/litre ------->			<--------- me/litre ------->					
0-5	33.0	0.4	85.3	0.2	30.0	36.5	12.5	5.5	8.2	
5-24	39.0	0.4	83.9	0.1	27.0	40.5	14.5	5.5	8.0	
24-56	32.0	0.6	18.0	0.1	2.5	8.5	5.5	3.0	1.9	
56-85	40.0	0.5	13.5	0.1	2.2	7.6	2.5	2.0	1.4	MI4 KK3 SM2
85-118	40.0	0.8	10.0	0.1	2.2	4.5	2.5	1.0	1.0	
118-140	44.0	1.0	9.2	0.1	1.5	5.0	2.5	1.0	0.9	

M1=Mica; KK=Kaolinitic; SM=Smectitic; 4=one half to ⅓; 3= ⅓ to 1/5; 2= 1/5 to 1/12

Source: Murthy, R. S., Hirekerur, L. R., Deshpande, S. B., VenKata Rao, B. V. and Shankaranarayana, H. S. (1982) Benchmark soils of India- morphology, characteristics and classification for resource management, National Bureau of soil survey and land use planning, Nagpur, India, p.374.

2.8.2 SHERGARH SERIES

The Shergarh series is a member of the mixed, calcareous, hyperthermic family of Typic Ustipsamments. Typically, Shorgarh soils have grayish brown to yellowish brown, moderate alkaline, sand to loamy sand, A horizons and gray, strongly alkaline sandy C horizons.
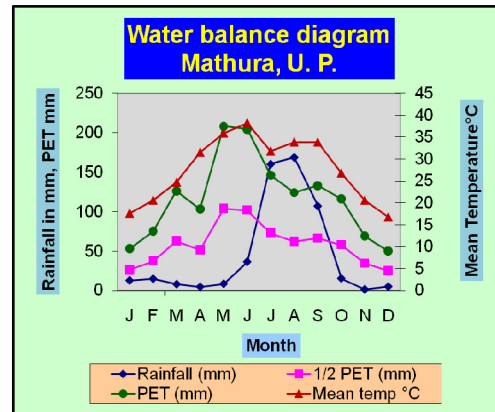
Typifying pedon: Shergarh loamy sand - cultivated

Ap   0-17 cm --- Yellowish brown (10YR 5/7) loamy sand; single grain; loose, very friable, non-sticky and non-plastic; common coarse pores; many fine roots; strongly effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

A2   17-40 cm --- Grayish brown (10YR 5/2) sand; single grain; loose, very friable, non-sticky and non-plastic; common, coarse pores; many fine root; strongly effervescent; moderately alkaline (pH 8.2); gradual smooth boundary.

A3   40-65 cm --- Grayish brown (10YR 5/2 M) sand; single grain; loose, very friable, non-sticky and non-plastic; common coarse pores; few fine roots; strongly effervescent; moderately alkaline (pH 8.4); gradual smooth boundary.

C1   65-95 cm --- Gray (10YR 6/1 M) sand; single grain; loose, very friable; non-sticky and non-plastic; common, coarse pores; strongly effervescent; strongly alkaline (pH 8.8); gradual smooth boundary.

C2   95-126 cm --- Gray (10YR 6/1 M) sand; single grain; loose, very friable, non-sticky; strongly alkaline (pH 8.7), gradual smooth boundary.

C3   125-150 cm --- Gray (10YR 6/1 M) sand; single grain; loose, very friable, non-sticky non-plastic, common coarse pores; slightly effervescent; strongly alkaline (pH 8.7).

Type location: 27°47'40" N, 77°37'30" E; village Shergarh, tehsil Chhata, district Mathura, Uttar Pradesh.

Range in characteristics: The thickness of the solum ranges from 145 to 165 cm. The A horizon is 45 to 65 cm thick. Its texture is loamy sand to sand. Its colour is in hue 10YR, value 5 to 6 and chroma 2 to 7. The C horizon is more than 75 cm thick. Its colour is in hue 10YR, value 5 to 6 and chroma 1 to 2. Its texture is dominantly sand.

Competing series and their differentiae: Competing soils are those Bechhawan Bihar series, a Typic Ustipsamment which is non-calcareous.

Geographic setting: Shergarh soils are developed in alluvium of Yamuna river and occur on gently sloping flood plain at an elevation of 168 m above MSL. The climate is semi-arid with mean annual air temperature 27.67°C and mean annual rainfall of 558 mm. The estimated MAST is 29.17ºC, MSST is 34.88ºC and MWST is 23.64ºC. The difference between MSST and MWST is 11.24ºC.

Geographically associated soils: Shergarh soils are associated with Bechhawan Bihar soils, a Typic Ustipsamment.

Drainage and permeability: Excessively drained with rapid permeability.

Use and vegetation: These soils are mostly cultivated to wheat, mustard, fodder crops and vegetables. Babool and shisham are the common vegetation.

Distribution and extent: Extensively (12,637 ha) occur in active flood plain of Yamuna river and distributed in Chhata, Mat, Mathura, Farah and Baldev blocks of Mathura district.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, New Delhi and Directorate of Agriculture, Uttar Pradesh, 2009.

Interpretative grouping:

i)	Land capability subclass:	IV sew
ii)	Land irrigability sub class:	3sd
iii)	Productivity potential:	low
iv)	Suitability for crop:	Summer vegetables and cucumbers

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)							
		Total			Sand				
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)
		<--- % of < 2 mm --->							
Ap	0-17	87.5	8.0	4.5	-	0.75	62.75	24.00	Nil
A2	17-40	89.5	7.0	3.5	-	0.80	64.00	24.70	-
A3	40-65	90.6	6.0	3.4	-	0.90	70.55	19.10	-
C1	65-95	96.4	1.0	2.6	-	12.50	80.50	3.40	-
C2	95-126	96.5	1.5	2.0	0.15	2.75	89.60	4.0	-
C3	126-150	98.6	0.9	0.5	-	4.60	88.05	6.00	-

Depth (cm)	Organic carbon (%)	CaCO$_3$ (%)	pH (1:2.5) H$_2$O	E.C. H$_2$O (dS m^{-1})	Available P	Available K
					----------(kg ha^{-1})------	
0-17	0.15	2.66	8.2	0.11	2.2	43
17-40	0.09	1.89	8.2	0.22	Nil	40
40-65	0.00	1.98	8.4	0.17	1.0	39
65-95	0.00	1.35	8.8	0.05	4.1	39
95-126	0.00	0.99	8.7	0.05	Nil	39
126-150	0.00	1.17	8.7	0.06	Nil	38

Depth (cm)	Extractable bases					C.E.C.	Base saturation (%)
	Ca	Mg	Na	K	Sum		
	<------------------------cmol(+)kg^{-1}---------------------------->						
0-17	1.3	1.0	0.04	0.12	2.46	3.1	79.0
17-40	1.5	1.1	0.17	0.10	2.87	3.5	82.0
40-65	1.2	1.0	0.13	0.07	2.40	2.6	92.0
65-95	1.0	0.6	0.13	0.06	1.79	2.1	85.0
95-126	1.0	0.4	0.10	0.05	1.55	1.8	86.0
126-150	0.9	0.4	0.10	0.03	1.43	1.7	84.0

Source: Mahapatra, S. K., Sharma, J. P. And Sarkar, Dipak, (2010). Soil resource mapping of Mathura district of Uttar Pradesh for perspective land use planning. NBSS Publ. NBSS&LUP, Nagpur, India, 156pp.

2.9 Soil Series: AESR 4.2

North Gujarat Plain (inclusion of Aravalli range and east Rajasthan Uplands), hot dry semiarid ESR with deep loamy Gray Brown and alluvium-derived soils, medium AWC and LGP 90-120 days (P14Dd3)

2.9.1 BALAND SERIES

The Baland series is the member of the fine-loamy, mixed (calcareous), hyperthermic family of Typic Haplustepts. Typically, Baland soils have dark yellowish brown, strongly alkaline sandy loam A horizons and brown to dark yellowish brown sandy clay loam to clay loam mildly to strongly alkaline B horizon underlain by Ck horizons.

Water balance diagram
Bhilwara, Rajasthan
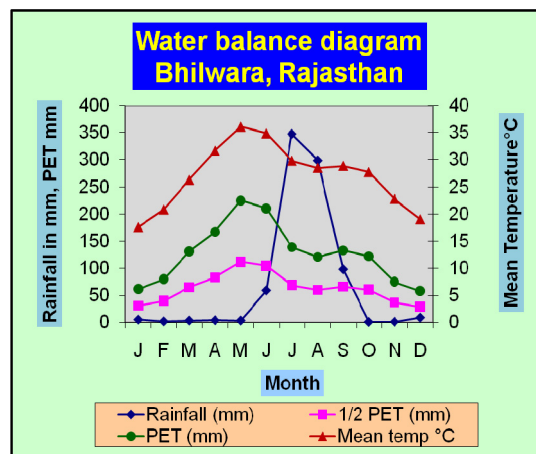
Typifying pedon: Baland, sandy loam- cultivated

Ap   0-11 cm --- Dark yellowish brown (10YR 4/4 M) sandy loam; weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many fine and very fine pores; many fine few and very fine roots; slightly effervescent; strongly alkaline (pH 8.6); clear smooth boundary.

Bw1   11-22 cm --- Dark yellowish brown (10YR 4/4 M) sandy clay loam; weak fine and medium subangular blocky structure; firm, sticky and plastic; many fine and very fine pores; very fine common roots; slightly effervescent; strongly alkaline (pH 8.5); clear smooth boundary.

Bw2   22-36 cm --- Dark yellowish brown (10YR 3/4 M) clay loam; moderate fine and medium subangular blocky structure; firm, sticky and plastic; many fine and very fine pores; very fine few roots; slightly effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bw3   36-69 cm --- Dark yellowish brown (10YR 3/4 M) clay loam; moderate, fine and medium, subangular blocky structure; firm, sticky and plastic; many fine and very fine pores; few very fine roots; strongly effervescent; mildly alkaline (pH 7.8); abrupt smooth boundary.

Bw4   69-83 cm --- Brown (10YR 4/3 M) clay loam; weak fine and medium subangular blocky structure; firm, sticky and plastic; many fine and very fine pores; violently effervescent; 10 to 20 per cent fine and medium $CaCO_3$ concretions; moderately alkaline (pH 7.9); abrupt irregular boundary.

Ck   83 + cm --- More than 90 per cent lime concretions of 2.5 to 7.5 and more than 7.5 cm size.

Type location: 25°38'47" N, 75°02'45" E; village Baland, tehsil Jahzpur, district Bhilwara, Rajasthan.

Range in characteristics: Soils of this series are olive brown to dark yellowish brown, moderately deep with solum depth varing from 75 to 98 cm and loamy sand to sandy clay loam/clay loam texture. These are mildly to very strongly alkaline. The A horizon is 9 to 22 cm

thick. Its colour is in hue of 7.5 YR to 10 YR, value 3 to 6 and chroma 2 to 4. Its texture ranges from loamy sand to clay loam. The B horizon is 53 to 85 cm thick. Colour in hue 10YR to 2.5Y, value 2 to 5 and chroma 2 to 4. Its texture ranges from sandy loam to sandy clay loam/clay loam. The C horizon is 15 to 44 cm thick. Its colour is in hue 10YR to 2.5Y, value 2 to 4 and chroma 2 to 4.

Geographic setting: Baland series are developed in the alluvium of the Aravalli systems of rocks formations and occur dominantly on nearly level (<1%) to very gently sloping (1-3%) valley and plains of the eastern Rajasthan upland at an elevation of 320 to 500 m above MSL. The climate is semi-arid (dry) and characterized by hot and dry summer and cool winters with mean annual air temperature of 27.0°C and mean annual rainfall of 500 to 900 mm. Estimated MAST is 29.0°C, MSST 30.1°C and MWST 20.1°C. The difference between MSST and MWST is 10.1°C. The length of growing period ranges between 120 and 150 days* with annual deficit of about 950 mm and seasonal surplus water of 250-300 mm.

Geographically associated soils: These are soils of Bawari (Lithic Ustorthents), Gandher and Ganeshpura (Vertic Haplustepts) and Atoli (Sodic Haplusterts) which are shallow to deep and occur in nearly level plains of various land forms in the Aravalli landscape.

Competing series and their differentiae: Rajyas series which are non-calcareous in reaction (Typic Haplustepts).

Drainage and permeability: Well drained and moderate permeability.

Land use and vegetation: Cultivated for maize, moong, guar, sesame and urd in kharif and wheat and mustard in rabi in patches. Area falls under the subsidiary type of tropical dry deciduous forest. The commonly occurring tree species are *Acacia leucophloea* (Aranja), *Acacia catechu* (Khair) (only in patches); *Holoptelia* (Churel/Papdi), *Butea monosperma* (Dhak or Palas) and *Zizyphus jujuba* (Ber) etc. In some valleys clumps of *Dendroealamus strictus* (Bamboo) occur whereas in nullahs *Terminalia arjuna* is common.

Distribution and extent: Occupy 70,872 ha area in Ajmer, Bhilwara and Bundi districts and distributed in Asind (3981 ha), Banera (198 ha), Bhilwara (4133 ha), Hurda (1871 ha), Jahazpur (13257 ha), Kotri (10015 ha), Mandal (2084 ha), Mandalgarh (9661 ha) and Shahpura (12792 ha) tehsil of Bhilwara and Hindoli (3975 ha), Indergarh (417 ha) and Nainwa (4606 ha) tehsils of Bundi district..

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Udaipur, 2003.

Interpretation: The soils of Baland series are moderately deep, calcareous, sandy loam to clay loam in texture and have moderate water holding capacity and nutrient retention capacity. These soils are moderate to marginally suitable for sorghum, maize, groundnut, sunflower, cotton, wheat, barley and mustard.

Interpretative groupings:
  i)   Land capability sub-class   IIIs
  ii) Land irrigability sub-class   3s
  iii) Productivity potential   Medium

  * *Although this AESR indicates the limit of LGP as 90-120 days this particular soil location shows higher LGP which demands refinement of AESR boundaries. NBSS&LUP is carrying out this research work.*

Soil datasets:

Horizon	Depth (cm)	Particle-size class and diameter in mm							
		Total			Sand				
		Sand	Silt	Clay	Very coarse	Coarse	Medium	Fine	Very Fine
		(2.0-0.05)	(0.05-0.002)	(<0.002)	(2.0- 1.0)	(1.0- 0.5)	(0.5 - 0.25)	(0.25-0.10)	(0.1-0.05)
		<------------------------------------- % of <2 mm ------------------------------------>							
Ap	0-11	59.6	24.3	16.1	1.19	4.75	18.46	21.80	13.35
Bw1	11-22	47.5	24.8	27.7	1.54	6.98	15.11	15.10	8.76
Bw2	22-36	42.1	25.6	32.3	2.49	5.30	12.02	13.98	8.35
Bw3	36-69	43.6	23.4	33.0	2.55	5.21	12.13	12.76	9.91
Bw4	69-83	42.6	24.3	33.1	3.30	4.76	11.24	13.53	9.76

Depth (cm)	Org.C	CaCO$_3$ equiv.	pH	EC dS m^{-1}	Extractable bases				CEC	ESP
					Ca	Mg	Na	K		
	---------%----------		-------1:2.5-------		<-------------------cmol (p+) kg^{-1} ------------------>					
0-11	0.58	3.5	8.6	0.15	10.0	5.25	0.28	0.43	16.13	1.7
11-22	0.48	4.5	8.5	0.15	17.0	7.5	0.41	0.26	25.87	1.6
22-36	0.35	5.5	8.2	0.34	19.5	4.0	0.45	0.30	24.65	1.8
36-69	0.29	10.5	7.8	1.07	24.0	2.5	0.41	0.32	27.93	1.5
69-83	0.12	18.5	7.9	1.57	21.0	6.0	0.37	0.27	28.22	1.3

Depth (cm)	Moisture retention (m^3 m^{-3})		Available Nutrients						
			N	P$_2$O$_5$	K	Fe	Mn	Zn	Cu
	33 kPa	1500 kPa	<--------kg ha^{-1}---------->			<----------------------mg kg^{-1}---------------->			
0-11	0.26	0.08	142	17	294	4.10	4.36	4.44	0.81
11-22	0.31	0.12	121	13	187	4.90	10.90	0.70	1.16
22-36	0.33	0.14	98	9	267	4.58	20.64	0.58	1.10
36-69	0.33	0.14	98	9	294	3.88	15.60	0.31	1.30
69-83	0.34	0.15	67	7	272	3.42	8.00	0.50	0.91

Sources: 1) Singh, R.S., Jain, B. L., Giri, J. D. and Shyampura, R. L. (2006). Soils of Bhilwara district for land use planning. NBSS Publ. No.135, NBSS&LUP, Nagpur, pp.239.
2) Giri, J. D., Singh, R. S., Singh, S. K., Jain, B. L. Shyampura, R. L. and Gajbhiye, K. S. (2003). Soils of Ajmer district for optimizing land use NBSS Publ. No.99, NBSS&LUP, Nagpur, pp.188.

2.9.2 KAJLODIYA SERIES

The Kajlodiya series is the member of the fine-loamy, mixed, hyperthermic family of Typic Haplustepts. Typically, Kajlodiya soils have dark yellowish brown, strongly alkaline sandy loam A horizons and dark yellowish brown, moderately alkaline, sandy loam to sandy clay loam B horizons underlain by Cr horizons of weathered rock fragments.
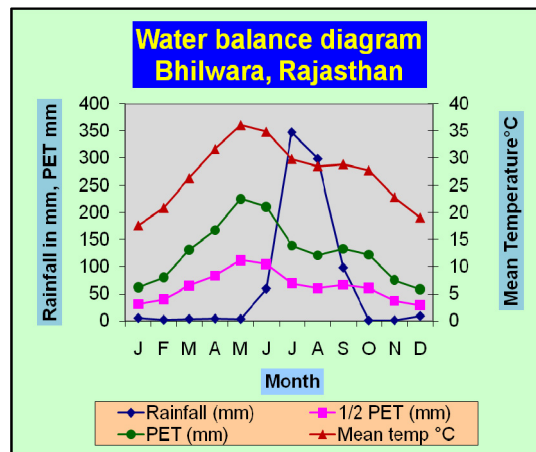
Typifying pedon: Kajlodiya, sandy loam- cultivated

Ap   0-28 cm --- Dark yellowish brown (10YR 3/4) sandy loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few medium and many very fine pores; few medium, common fine, many very fine roots; strongly alkaline (pH 8.6); clear smooth boundary.

Bw1   28-55 cm --- Dark yellowish brown (10YR 3/4) sandy clay loam; moderate medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common fine and many very fine pores; few fine, common very fine roots; moderately alkaline (pH 8.3); clear smooth boundary.

Bw2   55-85 cm --- Dark yellowish brown (10YR 3/4) sandy clay loam; moderate medium subangular blocky structure; firm, slightly sticky and slightly plastic; common fine, many very fine pores; few fine and very fine roots; moderately alkaline (pH 8.3); clear smooth boundary.

Bw3   85-115 cm --- Dark yellowish brown (10YR 3/4) sandy clay loam; moderate medium subangular blocky structure; firm, slightly sticky and slightly plastic; common fine, many very fine pores; few very fine roots; moderately alkaline (pH 8.2); clear smooth boundary.

Bw4   115-135 cm --- Dark yellowish brown (10YR 3/4) sandy loam; moderate fine and medium subangular blocky structure; firm, slightly sticky and slightly plastic; few fine and many very fine pores; few very fine roots; moderately alkaline (pH 8.4); abrupt smooth boundary.

Cr   135 + cm --- Weathered rock fragments.

Type location: $25^o25'53''$ N, $74^o38'50''$ E; village Mahuwa Khurd, tehsil Banera, district Bhilwara, Rajasthan.

Range in characteristics: Soils of this series are very dark grayish brown to dark yellowish brown, deep with average solum depth of 120 cm and loamy sand to clay loam texture. These are moderately to strongly alkaline and sodic in nature. The A horizon is 9 to 30 cm thick. Its colour is in hue of 7.5 YR to 10 YR, value 3 to 4 and chroma 2 to 4. Its texture ranges from loamy sand to clay loam. The B horizon is 50 to 130 cm thick. 7.5 YR to 10YR, value 2 to 4 and chroma 2 to 6. Its texture ranges from sandy loam to clay loam. The C horizon is 23 to 30 cm thick.

Geographic setting: Kajlodiya series are developed in the alluvium of the Aravalli systems of rocks formations and occur dominantly on nearly level (<1%) to gently sloping (3-8%) plains of the eastern Rajasthan upland at an elevation of 280 to 380 m above MSL. The climate is semi-arid (dry) and characterized by hot and dry summer and cool winters with mean annual air temperature of 24.7°C and mean annual rainfall of 600 to 800 mm. Estimated MAST is 26.7°C, MSST 28.0°C and MWST 17.1°C. The difference between MSST and MWST is 10.9^{o}C. The length of growing period ranges between 120 and 135 days* with annual deficit of about 950 mm and seasonal surplus water of 200 mm.

Geographically associated soils: These are soils of Kalanada (Typic Calciustepts), Gudha Gokulpura (Lithic Haplustepts) and Sukhpura (Lithic Ustorthents) along with rock outcrops at places.

Competing series and their differentiae: Motipura (Typic Haplustepts) which are calcareous in reaction.

Drainage and permeability: Well drained and moderate permeability.

Land use and vegetation: Cultivated for maize, moong, groundnut, sugarcane, sesame and urd in kharif and wheat, barley, gram, mustard in rabi. Area falls under the subsidiary type of tropical dry deciduous forest. The commonly occurring tree species are *Acacia leucophloea* (Aranja), *Acacia catechu* (Khair) (only in patches); *Holoptelia* (Churel/Papdi), *Butea monosperma* (Dhak or Palas), *Zizyphus jujuba* (Ber) etc. In some valleys clumps of *Dendroealamus strictus* (Bamboo) occur whereas in nullahs *Terminalia arjuna* is common.

Distribution and extent: Occupy 94,430 ha area distributed in Bhilwara, Ajmer and Bundi districts.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Udaipur, 2003.

Interpretation: The soils of Kajlodiya series are deep, sandy loam to clay loam texture and marginal in water holding capacity and nutrient retention capacity. These soils are suitable for all climatically adopted with amendments and with proper soil and water conservation.

Interpretative groupings:
   i)   Land capability subclass   IIIs
   ii) Land irrigability subclass   2s
   iii) Productivity potential   Medium to high

  * *Although this AESR indicates the limit of LGP as 90-120 days this particular soil location shows higher LGP which demands refinement of AESR boundaries. NBSS&LUP is carrying out this research work.*

Soil datasets:

Hori zon	Depth (cm)	Particle-size class and diameter in mm							
		Total			Sand				
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0- 1.0)	Coarse (1.0- 0.5)	Medium (0.5 - 0.25)	Fine (0.25-0.10)	Very Fine (0.1-0.05)
		<----------------------------------- % of <2 mm ----------------------------------->							
Ap	0-28	69.0	13.4	17.6	0	3.97	26.28	27.16	11.59
Bw1	28-55	67.7	11.5	20.8	0	3.83	23.83	29.27	11.17
Bw2	55-85	67.6	10.0	22.4	0	3.10	24.39	28.55	11.55
Bw3	85-115	66.7	11.1	22.2	0.59	3.03	21.37	29.54	12.19
Bw4	115-135	70.0	10.7	19.3	0.28	2.50	22.73	32.19	12.27

Depth (cm)	Org.C	CaCO$_3$ equiv.	pH	EC (dS m^{-1})	Extractable bases				CEC	ESP
	---------%----------		-------1:2.5 ----		Ca	Mg	Na	K		
					<----------------cmol (p$^+$) kg^{-1} ---------------->					
0-28	0.35	nil	8.6	0.31	9.0	3.5	2.39	0.33	16.65	15
28-55	0.24	nil	8.3	0.31	11.0	2.5	2.60	0.25	16.90	15
55-85	0.21	nil	8.3	0.45	9.0	6.0	2.69	0.28	18.17	15
85-115	0.21	nil	8.2	0.40	11.5	3.0	2.65	0.25	18.45	14
115-135	0.14	nil	8.4	0.34	6.5	7.5	2.78	0.25	17.87	16

Depth (cm)	Moisture retention (m^3 m^{-3})		Available Nutrients						
	33 kPa	1500 kPa	N	P$_2$O$_5$	K	Fe	Mn	Zn	Cu
			<--------kg ha^{-1}---------->			<-------------------mg kg^{-1}------------->			
0-28	0.19	0.09	119	13	214	9.80	18.54	0.80	3.42
28-55	0.24	0.11	107	11	219	11.18	25.26	0.38	1.28
55-85	0.24	0.17	107	9	193	9.46	26.26	0.34	1.26
85-115	0.23	0.11	107	9	193	7.40	13.66	0.92	1.04
115-135	0.16	0.11	69	6	161	6.38	19.84	031	0.76

Sources: 1) Singh, R.S., Jain, B. L., Giri, J. D. and Shyampura, R. L. (2006). Soils of Bhilwara district for land use planning. NBSS Publ. No.135, NBSS&LUP, Nagpur, pp.239.
2) Giri, J. D., Singh, R. S., Singh, S. K., Jain, B. L. Shyampura, R. L. and Gajbhiye, K. S. (2003). Soils of Ajmer district for optimizing land use NBSS Publ. No.99, NBSS&LUP, Nagpur, pp.188.

2.10 Soil Series: AESR 4.3

Ganga Yamuna Doab, Rohilkhand and Avadah Plain, hot moist semi-arid ESR with deep, loamy alluvium-derived soils (sodic phase inclusion), medium to high AWC and LGP 120-150 days (N8Dm4)

2.10.1 NAGARIYA SERIES

The Nagariya series is a member of the coarse-loamy, mixed, hyperthermic family of Typic Haplustepts. Typically, Nagariya soils have brown to yellowish brown, strongly to very strongly alkaline, sandy loam to loamy sand, A horizons and dark yellowish brown to olive brown, strongly alkaline, sandy loam B horizons over olive brown, moderately alkaline, sandy loam BC horizons.

Water balance diagram Shahajahanpur, U. P.
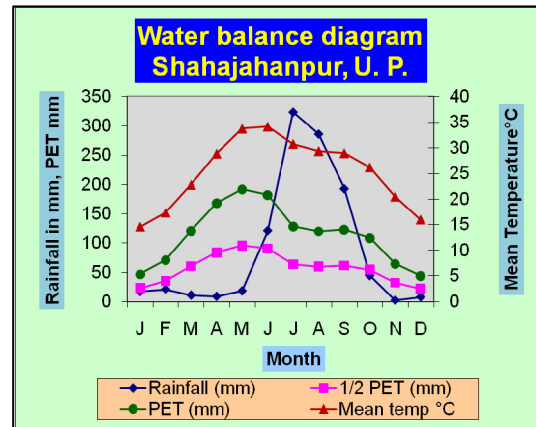
Typifying pedon: Nagariya sandy loam - cultivated

Ap   0-18 cm --- Yellowish brown (10YR 5/4 M) sandy loam; weak medium sub angular blocky structure; firm, non-sticky and non-plastic; many fine fibrous roots; common very fine pores; strongly alkaline (pH 8.9); clear smooth boundary.

Bw1   18-40 cm --- Brown (10YR 4/3 M) loamy sand; weak fine subangular blocky structure; firm, slightly sticky and non-plastic; common fine fibrous roots; common fine pores; very strongly alkaline (pH 9.1); clear smooth boundary.

Bw2   40-66 cm --- Dark yellowish brown (10YR 4/4 M) sandy loam; moderate medium subangular blocky structure; firm, slightly sticky and slightly plastic; common fine roots; common fine pores; strongly alkaline (pH 8.6); clear smooth boundary.

Bw3   66-96 cm --- Dark yellowish brown (10YR 4/4 M) sandy loam; weak medium subangular blocky structure; firm, slightly sticky and slightly plastic; few fine roots; common fine pores; 15 to 20 per cent lime nodules fine in size; common fine soft iron-manganese nodules; strongly alkaline (pH 8.5); clear smooth boundary.

Bw4   96-125 cm --- Olive brown (2.5Y 4/4 M) sandy loam; weak medium subangular blocky structure; firm, slightly sticky and slightly plastic; few fine roots; 25 to 30 per cent lime nodules fine in size; common fine soft iron-manganese nodules; strongly alkaline (pH 8.6); clear smooth boundary.

BC1   125-145 cm --- Olive brown (2.5Y 4/4 M) sandy loam; weak coarse subangular blocky structure; friable, slightly sticky and non-plastic; few fine roots; few very fine pores; 40 to 45 per cent lime nodules coarse in size; many fine soft iron- manganese nodules; strongly alkaline (pH 8.6); clear smooth boundary.

BC2   145-170 cm --- Olive brown (2.5Y 4/4 M) sandy loam; weak coarse subangular blocky structure; friable, slightly sticky and non plastic; few very fine pores; 40 to 45 per cent lime nodules coarse in size; many medium soft iron-manganese nodules; moderately alkaline (pH 8.0).

Type location: 27°58'03" N, 79°41'54" E; about 100 m South of village Nagariya, tehsil Tilhar, district Shahjahanpur, Uttar Pradesh.

Range in characteristics: The thickness of solum is more than 150 cm. The A horizon is 25 to 40 cm thick. Its colour is in hue 10YR, value 4 to 5 and chroma 3 or 4. Its texture is sandy loam or loamy sand. The B horizon is more than 100 cm thick. Its colour is in hue 2.5Y, value 4 to 5 and chroma 4. Its texture is dominantly sandy loam. Fine to coarse lime nodules (30-50 %) are present. Few fine Fe-Mn nodules are found below 70 cm from the surface. The BC horizon is 20 to 25 cm thick. Its colour is in hue 2.5Y, value and chroma 4. Its texture is dominantly sandy loam. Coarse nodules (40-59 %) and many fine to medium Fe-Mn nodules are present.

Competing series and their differentiae: The competing soil is Saunda series, a Typic Haplustept which is neutral in pH.

Geographic setting: The Nagariya soils are developed in recent alluvim of Ramganga and Bhagul rivers and their tributaries and occur on gently sloping plain at an elevation of 120 m above MSL. The climate is hot dry subhumid* with mean annual temperature of 27.0^{o}C and mean annual rainfall of 1047 mm. The estimated MAST is 28.5^{o}C and the difference between MSST and MAST is 2.9^{o}C.

Geographically associated soils: The associated soils are Charpur series, a Typic Haplustept.

Drainage and permeability: Moderately well drained with high permeability.

Use and vegetation: These soils are mostly cultivated to rice and wheat and rarely under sugarcane. Sometimes they are left fallow in kharif season due to moderate flooding during rainy season. Natural vegetation comprises *Eugenia Jambolana* (Jamun), *Azardichta indica* (Neem), *Zizyphus Jujuba* (Jharberi) and other grasses

Distribution and extent: Extensive (about 10,807 ha) in Tilhar, Sadar, Powayan and Jalalabad tehsils of Shahjahanpur district.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Delhi and Directorate of Agriculture, Uttar Pradesh, 2009.

Interpretative groupings:
i)	Land capability sub class	:	IIs
ii)	Land Irrigability sub class	:	2s
iii)	Productivity potential	:	Medium
iv)	Suitability for crops	:	Wheat, mustard and vegetable

Although, the description of the AESR indicates SAm bioclimatic system however this particular benchmark site represents SHd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)							
		Total			Sand				
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)
		<----------------------------------- % of < 2 mm ----------------------------------->							
Ap	0-18	70.0	23.8	6.2	-	-	0.53	42.10	27.37
Bw1	18-40	72.8	23.8	3.4	-	-	0.85	43.66	28.24
Bw2	40-66	54.0	30.3	15.7	-	-	0.20	23.12	30.68
Bw3	66-96	54.8	30.0	15.2	-	0.22	0.59	23.00	30.94
Bw4	96-125	63.8	24.0	12.2	-	0.35	1.35	30.08	31.97
BC1	125-145	70.0	22.5	7.5	-	-	0.49	29.10	40.41
BC2	145-170	71.3	22.5	6.2	-	-	0.45	26.36	44.44

Depth (cm)	Organic carbon (%)	$CaCO_3$ (%)	pH (1:2.5) H_2O	E.C. H_2O (dS m^{-1})
0-18	0.39	1.23	8.9	0.21
18-40	0.25	1.52	9.1	0.20
40-66	0.15	1.61	8.6	0.12
66-96	0.11	1.33	8.5	0.10
96-125	0.08	1.23	8.1	0.08
125-145	0.08	1.42	8.6	0.11
145-170	0.08	1.33	8.0	0.11

Depth (cm)	Extractable bases					C.E.C.	Base saturation (%)
	Ca	Mg	Na	K	Sum		
	<----------------cmol(+)kg^{-1}---------------->						
0-18	1.5	1.3	1.0	0.16	3.96	4.1	97
18-40	1.0	0.9	0.7	0.13	2.73	3.0	91
40-66	3.5	4.1	0.7	0.14	8.44	9.1	93
66-96	3.3	3.4	0.7	0.11	7.51	7.8	96
96-125	0.9	3.5	0.6	0.06	5.06	7.3	69
125-145	0.5	1.1	0.6	0.02	2.22	4.8	46
145-170	1.8	1.0	0.6	0.02	3.42	3.9	88

Source: Mahapatra, S. K., Sharma, J. P. And Sarkar, Dipak, (2010). Soil resource mapping of Mathura district of Uttar Pradesh for perspective land use planning. NBSS Publ. NBSS&LUP, Nagpur, India, 156pp.

2.10.2 BIJAIPUR SERIES

The Bijaipur series is a member of the fine-silty, mixed, hyperthermic family of Udic Haplustalfs. Bijaipur soils have pale brown to dark brown neutral silt loam A horizons, brown to dark brown neutral silt loam to silty clay loam B horizons and a lithologically discontinuous dark yellowish brown neutral silt loam C horizon.
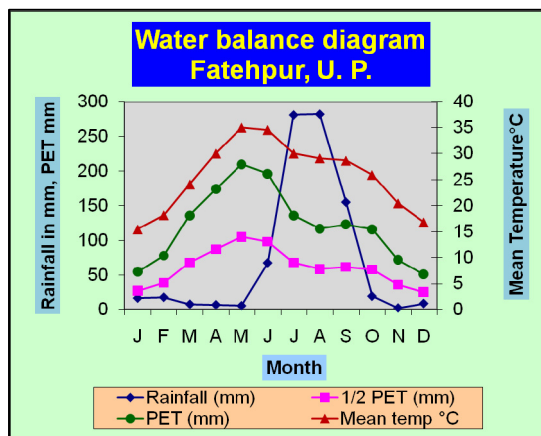
Typifying pedon: Bijaipur silt loam – cultivated

Ap	0-17 cm	Very pale brown (10 YR 7/3 D) silt loam, brown (10YR 5/3M); moderate very fine granular structure; slightly hard, friable and slightly sticky; many fine and very fine fibrous roots; neutral (pH 6.8); clear smooth boundary.
Bt1	17-32 cm	Brown to dark brown (10 YR 4/3 M) silt loam; weak medium subangular blocky structure; firm, sticky and plastic; few very fine roots ; many very fine to fine continuous random tubular imped pores; few sand and silt streaks; neutral (pH 6.9); clear smooth boundary.
Bt2	32-61 cm	Dark brown (10 YR 3.5/3 M) silt loam; moderate medium subangular blocky structure; firm, sticky and plastic; few very fine roots; many very fine to fine random tubular pores; few sand and silt streaks; neutral (pH 6.8); gradual smooth boundary.
Bt3	61-84 cm	Dark brown (10 YR 3.5/3 M) silty clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; few very fine roots; many very fine to fine random tubular pores; neutral (pH 6.7); diffuse smooth boundary.
Bt4	84-119 cm	Brown to dark brown (10 YR 4/3 M) silty clay loam; moderate medium prismatic structure; breaking to moderate medium angular blocky peds; firm, sticky and plastic; many very fine vertical tubular pores; few cutans in pores; neutral (pH 6.7); clear smooth boundary.
Bt5	119-139 cm	Brown to dark brown (10 YR 4/3, 3/3 M) silty clay loam; moderate medium angular blocky structure; firm, sticky and plastic; many very fine vertical tubular pores; neutral (pH 6.8); clear smooth boundary.
BC	139-172 cm	Dark yellowish brown (10 YR 4/5, 3/4 M) silt loam; massive tending to be blocky; firm, slightly sticky and plastic; many very fine vertical tubular pores; neutral (pH 6.9).

Type location: 25°42'00" N, 81°04'00" E; village Bijaipur, tehsil Khage, district Fatehpur, Uttar Pradesh.

Micromorphology: In the B horizon fine grained infillings mainly composed of clay sized material occur as dark brown cutans. Some of the infilled voids show deformation due to pressure. Faunal activity is distinctly evident and has contributed to the formation of moderate subangular blocky structure and enlarged voids. Micas are altered and are still altering forming clay and few ferri-argillans in the process. Accumulation of sesquioxides is common.

Range in characteristics: The thickness of the solum is 130 to 150 cm. The A horizon is 25 to 45 cm thick. Its colour is in hue 10YR, value 4 to 7 and chroma 3. The texture is loam to silt loam. The B horizon is 100 to 125 cm thick. Its colour is in hue 10YR, value 4 to 5 and chroma 3 to 4. The texture is clay loam to silty clay loam. Sand and silt streaks are present. The lithologically discontinuous C horizon is more than 40 to 50 cm thick. It is massive and variable in texture.

Geographic setting: The Bijaipur soils have developed in mixed alluvium in Fatehpur district of U.P. They occur on gental slopes of Ganga upland plains/ alluvial terraces at an elevation of about 150 m above MSL. The climate is semiarid subtropical with mean annual air temperature of 25.9°C and mean annual rainfall is 885 mm. The estimated MAST is 27.9ºC, MSST is 32.95ºC and MWST is 22.04ºC. The difference between MSST and MWST is 10.9ºC.

Drainage and permeability: Well drained with moderate permeability.

Land use and vegetation: Mostly cultivated to wheat and occasionally to rice under irrigation; natural vegetation – *Acacia spp.* and *Zizyphus spp.*

Distribution and extent: Extensive in Fatehpur district, U.P.

Series proposed: C. S. Azad University of Agriculture & technology Kanpur, U.P. 1978.

Interpretation: Bijaipur soils are agriculturally important. They have good air-water relationship and are productive. Crops respond to management practices. These soils have good available moisture capacity.

a) Interpretative groupings:
  i)   Land capability sub-class   IIe
  ii) Land irrigability sub-class   1
  iii) Productivity potential   High

b) Yield:

Management level	Yield q/ha	
	Wheat irrigated	Rice irrigated
Low	26	32
Medium	31	36
High	42	44

Soil datasets:

Hori-zon	Depth (cm)	Total			Sand					Silt		Coarse fragments >2mm % of whole soil
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)	
		---% of · 2 mm--										
Ap	0-17	31.2	58.7	10.1	0.1	0.2	0.2	0.4	30.3	27.3	31.4	-
Bt1	17-32	17.8	60.1	22.1	-	0.2	0.2	0.4	17.0	28.2	31.9	-
Bt2	32-61	15.1	59.9	25.0	-	0.1	0.7	0.4	13.9	28.3	31.6	-
Bt3	61-84	15.0	55.2	29.8	-	0.2	0.2	0.5	14.1	24.4	30.8	-
Bt4	84-119	13.8	54.0	32.2	-	0.2	0.2	0.5	12.9	22.8	31.2	-
Bt5	119-139	12.3	54.4	33.3	-	0.1	0.1	0.5	11.6	18.9	35.5	-
BC	139-172	19.2	57.4	23.4	-	0.1	0.1	0.4	18.6	29.7	27.7	-

Depth (cm)	Organic carbon %	Ext. ions as Fe %	pH (1:2.5) H$_2$O	Micronutrients			
				DTPA extractble			
				Zn	Cu	Mn	Fe
				----------------------ppm----------------------			
0-17	0.18	0.66	6.8	0.60	1.66	55	33
17-32	0.11	1.15	6.9	0.46	1.02	36	18
32-61	0.15	1.25	6.8	0.31	1.04	39	18
61-84	0.15	1.18	6.7	0.22	0.93	38	17
84-119	0.15	1.36	6.7	0.18	0.78	35	14
119-139	0.12	1.34	6.8	-	-	-	-
139-172	0.06	1.34	6.9	-	-	-	-

Depth (cm)	Extractable bases					CEC NH$_4$OAc	Base saturation NH$_4$OAc %	Ratios to clay	
	Ca	Mg	Na	K	Sum			CEC NH$_4$OAc	Ext. ions
	---------------------------------me/100g-------------------------------								
0-17	3.0	2.0	0.3	0.2	5.5	5.4	100	0.53	0.06
17-32	4.5	3.0	0.4	0.2	8.1	8.6	94	0.39	0.05
32-61	4.5	3.5	0.5	0.8	9.3	10.3	90	0.41	0.05
61-84	7.5	3.0	0.6	0.9	12.0	12.7	95	0.43	0.04
84-119	7.0	4.0	0.6	1.0	12.6	13.6	93	0.42	0.04
119-139	7.0	4.5	0.7	0.8	13.0	13.5	97	0.40	0.04
139-172	6.5	4.0	0.8	0.7	12.0	12.6	95	0.54	0.06

Source: Murthy, R. S., Hirekerur, L. R., Deshpande, S. B., VenKata Rao, B. V. and Shankaranarayana, H. S. (1982) Benchmark soils of India- morphology, characteristics and classification for resource management, National Bureau of soil survey and land use planning, Nagpur, India, p.374.

2.11 Soil Series: AESR 4.4

Madhya Bharat Plateau and Bundelkhand Uplands, hot, moist semi-arid ESR with deep loamy and clayey mixed Red and Black soils, medium to high AWC and LGP 90-120 days (N6Dm4)

2.11.1 HARIPUR SERIES

The Haripur series is a member of the fine, mixed, hyperthermic family of Vertic Haplustepts. Typically. Haripur soils have pale brown to brown mildly alkaline, clay loam A horizons and brown to dark brown moderately alkaline silty clay loam to clay B horizons.
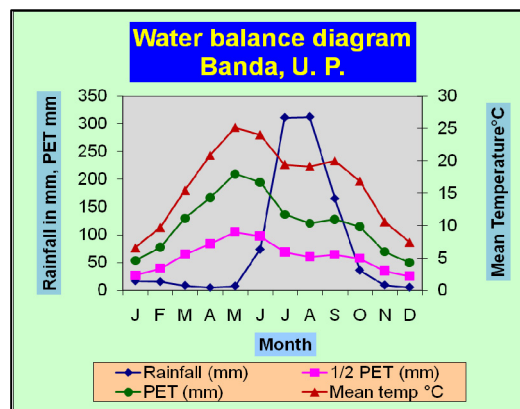
Typifying pedon: Haripur clay loam - cultivated

Ap   0-13 cm --- Pale brown (10YR 6/3 D) and brown (10YR 5/3 M) clay loam; strong very coarse angular blocky structure; very hard, very firm, very sticky and very plastic; many fine fibrous roots; many very fine horizontal pores; 5 per cent by volume basalt lithorelicts of 1 to 5 mm size; slightly effervescent; mildly alkaline (pH 7.7); clear smooth boundary.

Bw1   13-35 crn --- Brown (10YR 5/3 D) and dark brown (10YR 3/3 M) silty clay loam; moderate medium subangular blocky structure; very hard, very firm, very sticky and very plastic; few fine fibrous roots; many very fine horizontal pores; 5 per cent by volume basalt lithorelicts of 2 to 5 mm size; slightly effervescent: moderately alkaline (pH 7.9); clear smooth boundary.

Bw2   35-62 cm --- Brown (10YR 5/3 D) and dark brown (10YR 3/3 M) clay loam; strong medium subangular blocky structure; very hard, very firm, very sticky and very plastic; few fine fibrous roots; many very fine horizontal pores; about 5 per cent by volume basalt lithorelicts of 2 to 5 mm size; slightly effervescent; moderately alkaline (pH 7.9); diffuse smooth boundary.

Bw3   62-92 cm --- Brown (10YR 5/3 D) and dark brown (10YR 3/3 M) clay; moderate medium angular blocky structure; very hard, very firm, very sticky and very plastic; few very fine fibrous roots; many very fine horizontal pores; about 5 per cent by volume basalt lithorelicts of 2 to 5 mm size; slightly effervescent; moderately alkaline (pH 8.0); diffuse smooth boundary.

Bw4   92-140 cm --- Brown (10YR 5/3 D) and dark brown (10YR 3/3 M) clay loam; moderate medium subangular blocky structure; very hard, very firm, very sticky and very plastic; many very fine horizontal pores; 3 bout 5 per cent by volume basalt lithorelicts of 2 to 5 mm size; strongly effervescent; moderately alkaline (pH 8.1).

Type location: 25°04' N, 80°28' E; village Haripur on right side of Naraini-Kalinjar road, tehsil Nairaini, district Banda, Uttar Pradesh.

Range in characteristics: The solum is more than 130 cm thick. The A horizon is 12 to 15 cm thick and its colour is in hue 10YR, value 5 or 6 and chroma 3. Its texture is clay loam to clay and its structure ranges moderate to strong, medium to very coarse angular blocky. Cracks are upto 1 metre depth. The B horizon is 120 to 130 cm thick. Its colour is in hue 10YR, value 3 to 5 and chroma 3. Its texture varies from silty clay loam to clay. Its structure is strong medium to coarse subangular blocky to angular blocky. Basalt lithorelicts are present throughout the solum.

Competing series and their differentiae: Competing series is Nahari, a Vertic Ustochrept, which is comparatively lighter in texture.

Geographic setting: Haripur soils are formed in basaltic alluvium on sloping upland at an elevation of 124 m above MSL. The climate is semiarid subtropical with mean annual air temperature of 26.4°C with mean annual rainfall of 800 mm. The estimated MAST is 28.4°C. The difference between MSST and MWST is more than 5°C.

Geographically associated soils: Haripur soils are associated with soils of Pongari, Nahari, Badausa and Nasaini series, all Vertic Haplustepts and Kindhauli and Jamwara series, both Typic Haplustepts.

Drainage and permeability: Moderately well drained with slow permeability.

Use and vegetation: Mostly cultivated under rainfed conditions for wheat, gram, barley pigeonpea and mustard; natural vegetation - *Madhuca indica* (mahua), *Azadirachta indica* (neem), *Ficus bengalensis* (banyan), *Ziziphus spp.* (ber) and *Acacia arabica* (babul).

Distribution and extent: Extensive in Naraini and Karwi tehsils of Banda district and also in Hamirpur and Jalaun districts of Uttar Pradesh.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Delhi, 1979.

Interpretation: Haripur soils have good water retention capacity. They are productive and respond to management.

a) Interpretative grouping:

i)	Land capability subclass	IIw
ii)	Irrigability subclass	2d
iii)	Productivity potential	Medium to high

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)
		<----------------- % of < 2 mm ---------------->		
Ap	0-13	24.0	48.5	27.5
Bw1	13-35	16.7	45.0	38.3
Bw2	35-62	21.4	39.2	39.4
Bw3	62-92	23.3	35.4	41.3
Bw4	92-140	26.2	40.0	33.8

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})	Moisture equivalent %	CEC NH_4OAc cmol(p$^+$)kg^{-1}	Ratio CEC/Clay
0-13	0.46	2.5	7.7	<0.2	24.1	13.1	0.48
13-35	0.39	0.6	7.9	0.3	24.7	14.7	0.38
35-62	0.31	0.8	7.9	0.3	24.9	14.4	0.37
62-92	0.31	2.6	8.0	0.2	25.8	14.4	0.35
92-140	0.25	5.5	8.1	0.2	25.8	13.9	0.41

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.11.2 SINGPURA SERIES

The Singpura series is a member of the fine-loamy, mixed, hyperthermic family of Typic Haplustalfs. Singpura soils have yellowish brown mildly alkaline sandy clay loam A horizons, dark yellowish brown to dark brown middly to moderately alkaline clay loam to sandy clay loam B horizons and dark yellowish alkaline sandy clay loam C horizons.
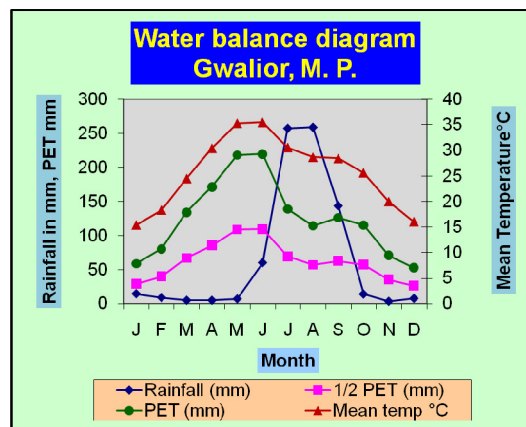
Typifying pedon: Singpura sandy clay loam – cultivated

Ap   0-20 cm --- Yellowish brown (10 YR 5/4 D) and dark yellowish brown (10 YR 4/4 M); sandy clay loam, weak fine subangular blocky structure; slightly hard, friable and slightly sticky; many fine roots; manyfine and medium vertical tubular pores; slightly alkaline (pH 7.7); clear smooth boundary.

Bw   20-32 cm --- Dark yellowish brown (10 YR 4/4 D & M) sandy clay loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and plastic; many fine roots; many fine discontinuous tubular imped and exped pores; slightly alkaline (pH 7.6); gradual smooth boundary.

Bt1   32-63 cm --- Dark yellowish brown (10 YR 4/4 D) and dark yellowish brown (10 YR 3.5/4 M); clay loam, moderate coarse prismatic structure breaking to moderate medium angular blocky peds; hard, slightly firm, slightly sticky and plastic; many fine roots; many fine discontinuous oblique tubular imped and exped pores; patchy thin clay cutans or ped exped pores; patchy thin clay cutans on ped faces; neutral (pH 7.5); gradual smooth boundary.

Bt2   63-96 cm --- Dark yellowish brown (10 YR 3/4 D) and dark brown (10 YR 3.5/3 M); clay loam, strong coarse prismatic structure breaking to moderate medium prismatic peds; hard, firm, sticky and plastic; few fine roots; few very fine and fine oblique tubular imped and exped pores; patchy thin clay cutans on ped faces; lime-coated rock fragments; slightly alkaline (pH 7.7); gradual smooth boundary.

Bt3   96-116 cm --- Dark brown (10 YR 3.5/3 D, 3/3 M) sandy clay; strong coarse prismatic structure breaking to moderate medium prismatic peds; hard, firm, sticky and plastic; few discontinuous oblique tubular imped and exped pores; patchy thin clay cutans; lime-coated rock fragments; slightly alkaline (pH 8.1); diffuse smooth boundry.

BC1   116-155 cm --- Dark yellowish brown (10 YR 4/4 D) sandy clay loam, dark brown (10 YR 3/3 M); strong coarse prismatic structure breaking to moderate medium prismatic peds; hard, firm, sticky and plastic; few fine pores; slightly alkaline (pH 8.1); diffuce smooth boundary.

BC2   155-190 cm --- Dark yellowish brown (10 YR 4/6 D & M) sandy clay loam; strong coarse prismatic structure; hard, firm, sticky and plastic; strongly effervescent;

slightly alkaline (pH 8.1).

Type location: 26°14′N 78°15′E, Plot No. C1, Agricultural College farm, JNKVV. Gwalior, Tehsil and district Gwalior, Madhya Pradesh.

Range in characteristics: The solum is 140 to 170 cm thick. The A horizon is about 25 cm thick. Its colour is in hue 10 YR, value 3 to and chroma 3 to 4. The texture is sandy clay loam. The thickness of the B horizon is about 10 cm. the colour is in hue 10 YR, value 3 to 4 and chroma 3 to 4. The texture ranges from clay loam to sandy clay. The structure grades from angular blocky in the upper part to prismatic in the lower part. The C horizon is sandy clay loam in texture and calcareous.

Geologic setting: They have developed in alluvium on gently sloping plains at an elevation of 180 to 220 m above MSL in Gwalior and Morena districts of Madhya Pradesh. The climate is subhumid subtropical* with mean annual air temperature of 25.7°C and mean annual rainfall of 900 mm. The estimated MAST is 27.2ºC, MSST is 33.37ºC and MWST is 21.91ºC. The difference between MSST and MWST is 11.5ºC. Moisture regime is ustic.

Drainage and permeability: Moderately well drained with moderate permeability.

Use and vegetation: Cultivated to pearl millet, pigeon-pea, gram, wheat and mustard; natural vegetation – *Zizuphus spp.*, and *Acacia spp.*

Distribution and extent: Extensive (60,000 ha) in Gwalior and Morena districts, Madhya Pradesh.

Series proposed: Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jablpur, December 1979.

Interpretation: Singpura soils have good soil moisture-air relationship, and the crops respond to management. A variety of crops can be grown under irrigated conditions.

a) **Interpretative grouping :**
    i)   Land capability sub-class :   IIe
    ii)   Irrigability class   :   1
    iii) Productivity potential   :   High

b)   Yield: Based on data from farmers′ fields

Crop	Yield Q/ha	
	Irrigated	Unirrigated
Wheat	20-30	10-12

Although, the description of the AESR indicates SA bioclimatic system however this particular benchmark site represents SH which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Soil datasets:

Hori-zon	Depth (cm)	Total			Sand					Clay		Coarse frag-ments. >2mm% of whole
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very Coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.002-0.001)	<0.001	
		-----------------------------of < 2 mm------------------------------------										
Ap	0-20	59.4	10.8	29.8	0.7	0.6	0.4	2.9	54.8	6.0	23.8	2
Bw1	20-32	47.0	17.6	35.4	0.3	0.4	1.1	2.0	43.2	7.7	27.7	-
Bt1	32-63	44.9	17.7	37.4	-	0.3	0.7	1.3	42.6	13.3	24.1	-
Bt2	63-96	42.9	17.6	39.5	-	0.2	0.7	1.3	40.7	15.5	24.0	2
Bt3	96-116	45.8	16.6	37.6	0.4	0.4	0.8	2.9	41.3	13.1	25.5	2
BC1	116-155	50.7	15.5	33.8	-	0.2	0.5	0.9	49.1	11.1	22.7	6
BC2	155-190	50.8	20.5	28.7	-	0.3	0.3	0.8	49.4	8.4	20.3	-

Depth (cm)	Organic carbon (%)	pH (1:2.5) H_2O	E. C. (1:2.5)H_2O (mmhos/ cm)	Micronutrients			
				D T P A extractable			
				Zn	Cu	Mn	Fe
				----------------ppm--------------			
0-20	0.34	7.7	0.2	0.56	1.29	14	8
20-32	0.21	7.6	0.2	0.34	1.14	23	10
32-63	0.21	7.5	0.3	0.34	1.13	32	10
63-96	0.21	7.7	0.2	0.36	1.05	23	10
96-116	0.20	8.1	0.1	0.25	0.84	18	8
116-155	0.10	8.1	0.1	-	-	-	-
155-190	0.05	8.1	0.2	-	-	-	-

Depth (cm)	Extractable bases			CEC (NaOAc) (pH8.2)	ESP (%)	Ratio CEC / Clay
	Ca + Mg	Na	K			
	----------------------me/100g -----------------------					
0-20	16.6	0.7	0.4	17.7	4	0.59
20-32	17.9	0.4	0.4	18.7	2	053
32-63	19.1	0.7	0.4	20.2	3	0.54
63-96	20.0	1.3	0.5	21.8	6	0.55
96-116	17.4	0.9	0.4	18.7	5	0.49
116-155	16.0	1.3	0.5	17.8	7	0.53
155-190	13.5	0.7	0.4	14.6	5	0.51

Analysed by: A. R. Kabhande, G. S. Sidhu and Raj Kumar
Micronutrients by: Staff AICSM (ICAR)
Source: Murthy, R. S., Hirekerur, L. R., Deshpande, S. B., VenKata Rao, B. V. and Shankaranarayana, H. S. (1982)
Benchmark soils of India- morphology, characteristics and classification for resource management, National Bureau of soil survey and land use planning, Nagpur, India, p.374.

2.12 Soil Series: AESR 5.1

Central Kathiawar Peninsula, hot, dry semiarid ESR with shallow and medium loamy to clayey black soils (deep black soils as inclusion) medium AWC and LGP 120-150 days (L4Dd3)

2.12.1 GONDAL SERIES

The Gondal series is a member clayey, smectitic, hyperthermic family of Lithic Ustorthents. Gondal soils have reddish brown, mildly alkaline, clay loam A horizon, reddish brown to yellowish red, mildly alkaline, clayey B horizons.
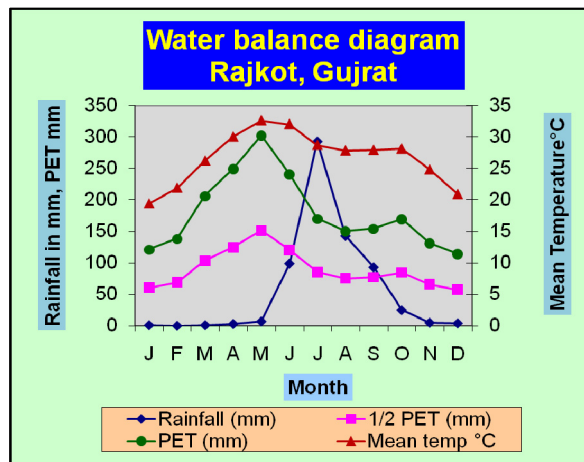
Typifying pedon: Gondal clay loam–cultivated

Ap   0-6 cm --- Reddish brown (5 YR 4/3M); clay loam; moderate, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many, fine roots; mildly alkaline (pH 7.4); clear and smooth boundary.

A2   6-27 cm --- Reddish brown (5 YR 4/3 M) clay; moderate, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic, many, fine roots; midly alkaline (pH 7.5); abrupt and smooth boundary.

C   27-30 cm --- Yellowish red (5 YR 4/6 D); weathered basalt.

Type location: 21°59′N and 70°49′E. Village: Gondal, tehsil: Gondal, district: Rajkot, Gujarat.

Range in characteristics: Thickness of the solum which has only the A-horizon, ranges from 25 to 35 cm. Its colour is in hue 7.5 and 5 YR, value 3 to 4 and chroma 2 to 4. Its texture is clay loam to gravelly clay. Its structure varies from fine to medium subangular blocky.

Competing series and their differentiae: Virpur series, a Lithic Haplustepts, is calcareous.

Geographical setting: Gondal soils are developed on weathered basalt with very gently sloping piedmont plain at an elevation of 200 to 250 M above MSL. The climate is semi arid with mean annual air temperature of 26.7°C and mean annual rainfall of 650 to 750 mm. The estimated MAST is 28.7ºC, MSST is 32.23ºC and MWST is 25.03ºC. The difference between MSST and MWST is 7.2ºC.

Geographically associated soils: Meghpur series and Kagwad series: Typic Haplustepts.

Drainage and permeability: Well drained with moderate permeability.

Land use and vegetation: Mainly cultivated to rainfed groundnut, pearl milet and fodder sorghum some patches of this landscape remains wasteland; natural vegetation consists of *Acacia spp.* (babul), *Ziziphus spp.* (ber), *Calotropsis spp.* (ak).

Distribution and extent: Extensive in Rajkot district, Gujarat state.

Interpretation: Gondal soils are shallow with limited available water and soil volume to hold and supply nutrient to plants. Choice of crops is therefore restricted. However, they are good for groundnut cultivation. Soil and water conservation measures are necessary to protect the soil from degradation due to erosion.

c)   Interpretative grouping :

i)	Land Capability sub-class	:	IIIs
ii)	Land Irrigability sub-class	:	3s
iii)	Productivity potential	:	low to medium

Soil datasets:

Hori-zon	Depth (cm)	Particocle size class (Diameter in mm)						Moisture retension (%)	
		Sand fraction (%)			Total (%)			33kPa	1500kPa
		Coarse (1.0-0.5)	Fine (0.25-0.1)	Very Fine (0.1-0.05)	Sand	Silt	Clay		
Ap	0-6	5	2.8	18.1	38.9	23.1	38.0	25.7	13.7
A2	6-27	7.5	4	14	37.0	17.5	45.5	26.2	13.1

Depth (cm)	pH	EC (dS^{-1})	CaCO$_3$ (%)	Organic Carbon (%)	Available		
					N	P$_2$O$_5$	K$_2$O
	--------(1:2.5)--------				--------------(kg/ha)--------------		
0-6	7.4	0.2	-	0.28	135.2	25.1	918.4
6-27	7.5	0.3	-	0.11	53.1	8.8	716.8

Depth (cm)	Exchangeable bases				Sum of cations	CEC	ESP
	Ca	Mg	Na	K			
	----------------------------[cmol(p+)kg^{-1}]----------------------------						
0-6	20.4	13.2	0.4	0.8	34.8	35.1	1.1
6-27	28.2	15.6	0.5	0.5	44.8	35.4	1.4

Source:1) Sharma, J. P. , Giri, J. D. , Shyampura, R. L. , and Gajbhiye, K. S. (2005). "Soil Series of Gujarat" NBSS&LUP Publ. no. 120, NBSS&LUP, Nagpur-440010

2) Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.12.2 KAGWAD SERIES

The Kagwad series is a member of clayey, smectitic (calcareous), hyperthermic family of Vertic Haplustepts. Kagwad soils have dark brown, moderately alkaline, clayey A horizons, dark brown, moderately alkaline, clayey B horizons, yellowish brown weathered calcareous basalt, C horizons.

Water balance diagram Rajkot, Gujrat
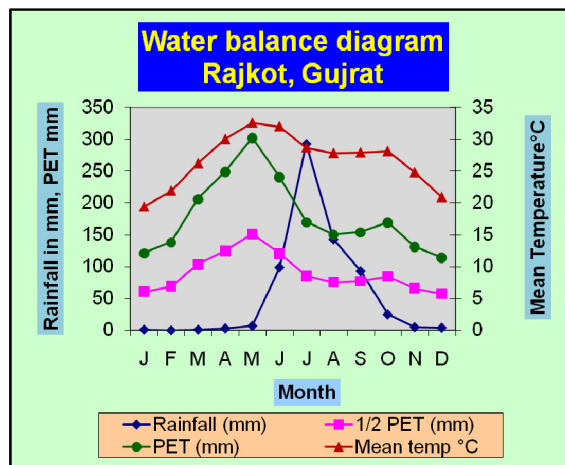
Typifying pedon: Kagwad clay–cultivated

Ap   0-17 cm --- Dark brown (7.5 YR 3/2 D&M); clay; moderate, medium, subangular blocky structure; slightly hard, friable, sticky and plastic; common, fine roots; slight effervescence; moderately alkaline (pH 8.2); clear and smooth boundary.

Bw1   17-35 cm --- Dark brown (7.5 YR 3/2 D&M) clay; moderate, medium, subangular blocky structure; friable, very sticky and very plastic slight effervescence; moderately alkaline (pH 8.1); clear and smooth boundary.

Bw2   35-46 cm --- Dark brown (7.5 YR 3/2 D&M) clay; strong, coarse, subangular blocky structure with shiny pressure faces; very firm, very sticky and very plastic; few, fine roots; strong effervescence; moderately alkaline (pH 8.1); abrupt and smooth boundary.

C   46-75 cm --- Yellowish brown (10 YR 5/4 M); weathered calcareous basalt.

Type location: $21^o48'30''$N and $70^o40'45''$E. Village Kagwad, tehsil: Jetpur, district: Rajkot, Gujarat.

Range in characteristics: The solum is 40 to 50 cm. The Ap horizon is 11 to 19 cm thick. Its colour is in hue 7.5 YR and 10 YR, value 3 and chroma 2. Its texture is clay, structure is moderate, medium, subangular to angular blocky. The B-horizon is 25 to 35 cm thick. Its colour is in hue 7.5 YR and 10 YR, value 3 and chroma 2. Its texture is clay. The structure ranges from moderate, medium to strong, coarse subangular to angular blocky. Shiny pressure faces are present in the lower part of the B horizon. Cracks of 10 to 15 mm width occur at 40 cm from the surface. The soils are calcareous throughout the depth.

Competing series and their differentiae: Meghpur soils, Typic Haplustepts, which are non-calcareous and clayey.

Geographic setting: Kagwad soils are developed on weathered basalt over nearly level to gently sloping piedmont plains at an elevation of 150 to 250 M above MSL. The climate is aridic with mean annual air temperature of 26.7°C and mean annual rainfall of 650 to 750 mm. The estimated MAST is 28.7ºC, MSST is 32.23ºC and MWST is 25.03ºC. The difference between MSST and MWST is 7.2ºC.

Geographically associated soils: Meghpur series: Typic Haplustepts; Virpur series: Lithic Haplustepts; Gondal series: Lithic Ustorthents.

Drainage and permeability: Well drained with slow permeability.

Land use and vegetation: Cultivated to groundnut, wheat, fodder sorghum and maize; natural vegetation consists of *Acacia spp.* (babul), *Calatropisis spp.* (ak), *Azadirachta indica* (neem).

Distribution and extent: Extensive in Rajkot district of Gujarat state.

Interpretation: Kagwad soils are agriculturally important. They are clayey and calcareous. They have good soil-air-water relationship. They are productive and respond well to management. They are good soils for groundnut in kharif, and wheat and gram in rabi under irrigation. They are susceptible to erosion and require soil and water conservation measures. The soils may pose the problem of phosphate fixation due to their calcareous nature.

a) Interpretative grouping:

Land Capability sub-class	:	IIIs
Land Irrigability sub-class	:	3s
Productivity potential	:	Medium

Soil datasets:

Hori-zon	Depth (cm)	Particle size class (Diameter in mm)						Moisture retension (%)	
		Sand fraction (%)			Total (%)			33kPa	1500kPa
		Coarse (1.0-0.5)	Fine (0.25-0.1)	Very Fine (0.1-0.05)	Sand	Silt	Clay		
Ap	0-17	3.0	3.5	10.0	22.0	16.4	61.6	30.9	15.7
Bw1	17-35	3.0	2.0	8.7	19.2	19.7	61.1	30.9	17.3
Bw2	35-46	3.0	3.0	14.0	25.0	12.4	62.6	32.0	17.3

Depth (cm)	pH	EC (dSm^{-1})	CaCO$_3$ (%)	Organic Carbon (%)	Available		
					N	P$_2$O$_5$	K$_2$O
	--------(1:2.5)--------				--------------(kg/ha)--------------		
0-17	8.2	0.3	1.6	0.39	188.3	34.9	515.2
17-35	8.1	0.2	1.6	0.35	169.0	39.2	515.2
35-46	8.1	0.3	5.5	0.29	140.0	30.9	313.6

Depth (cm)	Exchangeable bases				Sum of cations	CEC	Base Saturation (%)	ESP
	Ca	Mg	Na	K				
	----------------------------[cmol(p+)kg^{-1}]----------------------------							
0-17	46.0	7.8	0.4	0.8	55.0	55.1	99.8	0.7
17-35	44.5	8.8	0.4	0.5	54.2	55.2	98.2	0.7
35-46	44.3	9.2	0.4	0.5	54.4	55.2	98.6	0.7

Source: 1) Sharma, J. P., Giri, J. D., Shyampura, R. L. and Gajbhiye, K. S., (2005). "Soil Series of Gujarat" NBSS&LUP Publ. no. 120, NBSS&LUP, Nagpur-440010
2) Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.13 Soil Series: AESR 5.2

Madhya Bharat Plateau, Western Malwa Plateau, Eastern Gujarat Plain, Vindhyan and Satpura range and Narmada Valley, hot moist semi-arid ESR with medium and deep, clayey Black soils (shallow black soils as inclusions), medium to high AWC and LGP 120-150 days (I5Dm4)

2.13.1 HALDHAR SERIES

The Haldhar series is a member of the fine, smectite, hyperthermic family of Chromic Haplusterts. Typically, Haldhar soils have dark grayish brown to very dark grayish brown, mildly alkaline, clay A horizons; dark brown to very dark grayish brown, mildly to moderately alkaline, clay Bss horizons, and yellowish to dark yellowish brown, moderately alkaline, clay C horizons.
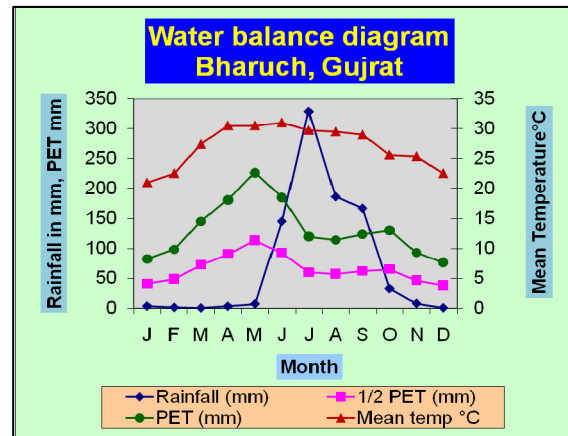
Typifying pedon: Haldhar clay - cultivated

Ap   0-17 cm --- Dark grayish brown (10YR 4/2 D) and dark brown (10YR 3/3 M) clay; coarse prismatic structure breaking into moderate medium subangular blocky; hard, friable, sticky and plastic; many fine roots inside peds; 50 to 70 mm wide crack; few basalt and quartz fragments of 2 to 5 mm size; mildly alkaline (pH 7.4); clear smooth boundary.

Bw   17-39 cm --- Dark grayish brown (10YR 4/2 D) and very dark grayish brown (10YR 3/2 M) clay; coarse prismatic structure breaking into moderate medium angular blocky peds with pressure faces; hard, firm, sticky and plastic; common fine roots; 50 to 60 mm wide cracks; few basalt and quartz fragments; mildly alkaline (pH 7.7); clear smooth boundary.

Bss1   39-56 cm --- Dark brown (10YR 3/3 D & M) clay; coarse prismatic structure with intersecting slickensides breaking into moderate medium angular blocky peds; hard, firm, sticky and plastic; few fine roots inside peds; 40 to 50 mm wide cracks; moderately alkaline (pH 8.0); diffuse wavy boundary.

Bss2   56-102 cm --- Dark brown (10YR 3/3 D) and very dark greyish brown (10YR 3/2 M) clay; coarse prismatic structure with intersecting slickensides breaking in to coarse medium angular blocky peds; hard, firm, sticky and plastic; few fine roots; mildly alkaline (pH 7.6); diffuse wavy boundary.

Bss3   102-130 cm --- Dark yellowish brown (10YR 3/4 D) and dark brown (10 YR 3/3 M) clay; coarse prismatic structure with intersecting slickensides breaking into coarse medium angular blocky peds; hard, firm, sticky and plastic; moderately alkaline (pH 7.9); diffuse smooth boundary.

BC   130-145 cm --- Yellowish brown (10YR 5/4 D) and dark yellowish brown (10YR 3/4 M) clay; weak medium subangular blocky structure; hard, firm, sticky and plastic; common lime nodules of 2 to 6 mm size; violently effervescent; moderately alkaline (pH 8.1).

Type location: 21° 43' N, 72°55' E; village Haldhar, tehsil and district Bharuch, Gujarat.

Range in characteristics: The solum is 90 to 140 cm thick and its colour is in hue 10YR, value 3 to 4 and chroma 2 to 3. The texture is clay and the structure varies from coarse prismatic to angular blocky with prominent slickensides. Quartz and basalt fragments are present throughout the profile.

Competing series and their differentiae: Haldhar soils are competing with Sisodra soils which are clayey, moderately well drained with moderately slow permeability and belong to Vertic Haplustepts.

Geographic setting: Haldhar soils are formed in alluvium of mixed origin and occur on nearly level to very gently sloping alluvial plain at an elevation of 20 m above MSL. The climate is subhumid tropical* with mean annual air temperature of 25.5^{o}C and mean annual rainfall of 1640 mm. The estimated MAST is 27.5^{o}C MSST, 31.7^{o}C and MWST 23.8^{o}C. The difference between MSST and MWST is 7.9 ^{o}C.

Geographically associated soils: Haldar soils are associated with Sisodra soils which are relatively less clayey and do not have slickensides. Sisodra soils belong to Vertic Ustochrepts.

Drainage and permeability: Imperfectly drained with slow to very slow permeability.

Use and vegetation: Intensively cultivated to cotton, rice, sugarcane, wheat, sorghum and banana; natural vegetation – *Acacia arabica* (babul), *Tamarindus indica* (tamarind) and *Cynodon dactylon* (dhub).

Distribution and extent: Extensive (2,70,000 ha) in Bharuch, Surat and Vadodara districts of Gujarat.

Series proposed: Soil Survey Organisation, Department of Agriculture, Navasari Unit Gujarat.

Interpretation: Haldhar soils are clayey. They develop cracks due to high swelling and shrinking potential. They are slowly permeable and due to their cracking nature the profile gets saturated during initial rainfall periods and the soil become susceptible to runoff, erosion and ponding. They are imperfectly drained and require measures for disposal of excess water to avoid adverse effects of crops. The available water and nutrient retention capacity is high. Under irrigation, these soils are likely to pose problems of drainage and rising ground water level. Hence, they need adequate surface drainage measures. All climatically adapted crops can be grown.

Interpretative grouping:
    i)   Land capability subclass   IIIs
    ii)   Irrigability subclass   2d
    iii) Productivity potential   Medium to high

  Although, the description of the AESR indicates SAm bioclimatic system however this particular benchmark site represents SHd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)				Coarse fragments > 2 mm % of whole soil
		Coarse Sand (2-0.2)	Fine Sand (0.2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	
		<----------------- % of < 2 mm --------------->				
Ap	0-17	0.1	20.1	25.3	54.5	7
Bw	17-39	0.1	19.6	20.4	59.9	3
Bss1	39-56	0.1	23.4	22.0	54.5	2
Bss2	56-102	0.3	28.1	15.1	56.5	2
Bss3	102-130	0.2	25.4	18.6	55.8	1
BC	130-145	0.8	26.6	22.5	50.1	6

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})	Water holding capacity (%)
0-17	0.27	0.7	7.4	0.15	63.3
17-39	0.20	1.3	7.7	0.12	63.2
39-56	0.20	1.3	8.0	0.15	65.3
56-102	0.20	1.3	7.6	0.08	62.4
102-130	0.27	1.7	7.9	0.16	64.2
130-145	0.17	10.9	8.1	0.17	60.2

Depth (cm)	Extractable bases				CEC	Base Saturation (%)
	Ca	Mg	Na	Sum		
	<--------------------------- cmol (p+)kg^{-1} --------------------------->					
0-17	32.0	10.0	0.7	42.7	44.0	97.0
17-39	30.0	10.0	0.4	40.4	44.7	90.4
39-56	30.4	11.0	Tr	41.4	44.8	92.4
56-102	32.0	12.4	0.4	44.8	46.4	96.5
102-130	31.0	11.4	0.3	42.7	44.0	97.0
130-145	29.4	9.6	Tr	39	38.6	100

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.13.2 JALALPUR SERIES

The Jalalpur series is a member of the very fine, smectitic, hyperthermic family of Typic Haplusterts. Typically, Jalapur soils have dark greyish brown to very dark greyish brown, moderately to strongly alkaline, clay A horizons; dark brown, strongly alkaline, clay Bss horizons and dark brown, very strongly alkaline, clay BC horizons.
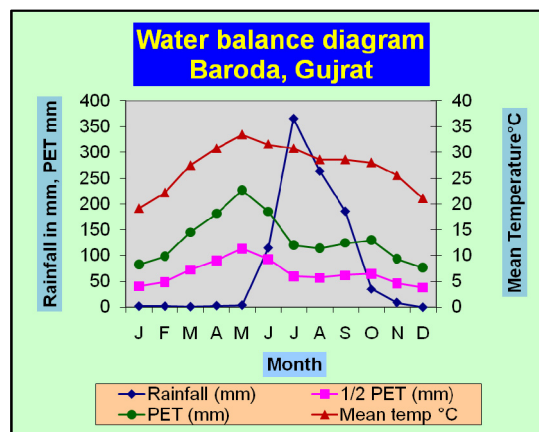
Typifying pedon: Jalalpur clay - cultivated

Ap   0-22 cm --- Dark greyish brown (10YR 4/2 D) and very dark greyish brown (10YR 3/2 M) clay; coarse columnar structure breaking into moderate medium subangular blocks; hard, firm, sticky and plastic; few fine roots; few lime nodules of 2 to 5 mm size; slightly effervescent; moderately alkaline (pH 8.3); clear smooth boundary.

Bw   22-65 cm --- Very dark greyish brown (10YR 3/2 M) clay; coarse columnar structure breaking into moderate medium subangular blocky peds with shiny pressure faces; firm, sticky and plastic; few coarse roots; many lime nodules of 2 to 5 mm size; slightly effervescent; few basaltic lithorelicts and mica flakes; strongly alkaline, (pH 8.5); clear smooth boundary.

Bss   65-110 cm --- Dark brown (10YR 3/3 M) clay; moderate medium angular blocky structure with intersecting slickensides; firm, very sticky and very plastic; few coarse roots; many lime nodules of 2 to 5 mm size; strongly effervescent; few basalt fragments; strongly alkaline (pH 8.7); clear wavy boundary.

BC   110-150 cm --- Dark brown (10YR 4/3 M) clay; weak medium subangular blocky structure; friable, sticky and plastic; many lime nodules of 2 to 3 mm size; violently effervescent; many basalt fragments; very strongly alkaline (pH 9.4).

Type location: 22°04' N, 73°38' E; about 0.25 km east of village Katkui, tehsil Tilakvada, district Vadodara, Gujarat.

Range in characteristics: The thickness of the Ap horizon is 11 to 25 cm and its colour is in hue 10YR, value 3 and chroma 2 to 3. Its texture is sandy clay to clay. The subsurface A horizon is 40 to 60 cm thick. Its colour is in hue 10YR, value 3 to 4 and chroma 2 to 3. Its structure is coarse columnar breaking in to moderate medium subangular blocky. The Bss horizon is 40 to 70 cm thick. Its colour is in hue 10YR, value 3 to 4 and chroma 2 to 3. In this horizon, the slickensides are prominent. Calcium carbonate ranges upto 10 per cent. Colour of the BC horizon is in hue 10YR, value 4 to 6 and chroma 3 to 4. The texture varies from sandy clay loam to clay. The structure of the BC horizon is weak medium subangular blocky with many 2 to 5 mm size lime nodules and basalt fragemts. Lime nodules and basalt fragments increase with depth. The BC horizon is strongly alkaline.

Competing series and their differentiae: Jalalpur series competes with Haldar and Mulad soils. Both the series have less than 60 per cent clay. Haldhar series is calcareous while Mulad series is non-calcareous. Both the series have cracks, slickensides and spheroidal structural aggretates. The Haldar and Mulad soils belong to Chromic Haplusterts and Udic Haplusterts, respectively.

Geographic setting: Jalalpur soils are formed in alluvium of mixed origin and occur on nearly level to gently sloping old flood plain at an elevation of 120 to 150 m above MSL. The climate is subhumid tropical* with mean annual air temperature of 28.0^{o}C and mean annual rainfall of 967 mm. The estimated MAST is 30.0^{o}C and the difference between MSST and MWST is more than 5°C.

Geographically associated soils: Jalalpur soils are associated with Sisodra and Mulad soils. The Sisodra and Mulad soils belong to Vertic Ustochrepts and Udic Haplusterts, respectively.

Drainage and permeability: Moderately well drained with slow to very slow permeability.

Use and vegetation: Cultivated to cotton, sorghum, pulses and oilseeds during *karif* as rainfed crops and wheat, banana and sugarcane are grown under irrigation; natural vegetation comprises of *Acacia arabica* (babul), *Tamarindus indica* (tamarind) and *Cynodon dactylon* (dhub).

Distribution and extent: Extensive (1,20,000 ha) in Bharuch, Vadodara and Surat districts of Gujarat.

Series proposed: Soil Survey Organisation, Department of Agriculture, Navasari Gujarat.

Interpretation: Jalalpur soils are very deep and clayey. They have high water and nutrient retention capacity. Due to their cracking nature, they conserve most of the initial rainfall. Once saturated, they are susceptible to runoff and erosion even of gently sloping land. Soils occurring on nearly level slopes are susceptible to stagnation of water. Without proper drainage measures, they are likely to pose saline and sodic problems under irrigation. These soils will respond to the use of fertilizers and other inputs and can support all climatically adapted crops. During high intensity rainfall periods, crops will suffer due to drainage and water stagnation problems.

Interpretative grouping:

    i)   Land capability subclass   : IIIs
    ii) Irrigability subclass   : 3d
    iii) Productivity potential   : Medium to high

Although, the description of the AESR indicates SAm bioclimatic system however this particular benchmark site represents SHd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)				Coarse fragments > 2 mm % of whole soil
		Coarse Sand (2-0.2)	Fine Sand (0.2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	
		<---------------------------- % of < 2 mm ---------------------------->				
Ap	0-22	6.0	23.4	10.0	60.6	1
Bw	22-65	5.1	21.7	12.3	60.9	3
Bss	65-110	5.6	20.4	13.6	60.4	1
BC	110-150	2.7	33.9	9.8	53.6	2

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})	Bulk density (Mg m^{-3})	Water holding capacity (%)	CEC (cmol (p+)kg^{-1})
0-22	0.49	2.9	8.3	0.8	1.20	60.9	42.7
22-65	0.42	3.7	8.5	0.2	1.40	54.8	47.1
65-110	0.56	7.5	8.7	0.4	1.20	65.1	36.7
110-150	0.22	23.2	9.4	0.2	1.20	61.0	25.1

Note: The soil texture is based on International particle size classification.

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.14 Soil Series: AESR 5.3

Coastal Kathiawar Peninsula, hot moist semi-arid ESR with deep loamy coastal alluvium-derived soils (saline/phases inclusion), low to medium AWC and LGP 120-150 days (L7Dm4)

2.14.1 KHUNTWADA SERIES

The Khuntwada series is a member of fine, smectitic (calcareous), hyperthermic family of Typic Haplusterts. Khuntwada soils have very dark brown, strongly alkaline, silty clay loam A horizons, dark brown to very dark brown, strongly alkaline, silty clay loam to clay B horizons underlying by yellowish brown, weathered basaltic parent material (C horizon).
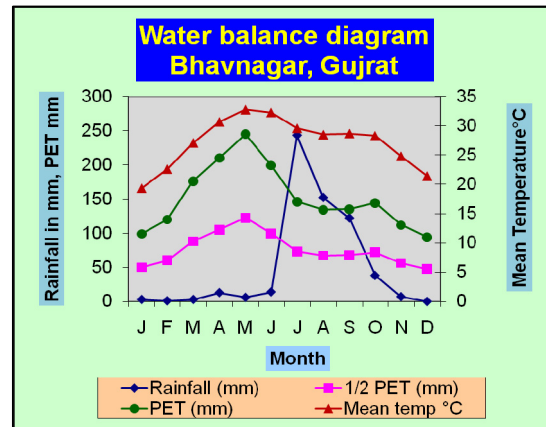
Typifying pedon: Khuntwada silty clay loam-cultivated.

Ap   0-12 cm --- Very dark brown (10 YR 2/2 M); silty clay loam; moderate, medium, subangular blocky structure; hard, firm, sticky and plastic; 2 to 5 mm, irregular lime nodules, gypsum and basaltic gravels; many, fine fibrous roots; violent effervescence; strongly alkaline (pH 9.0); clear smooth boundary.

Bw1   12-27 cm --- very dark brown (10 YR 2/2 M); silty clay loam; moderate, coarse, angular blocky structure peds with indistinct slickensides with shiny pressure faces; hard, friable, sticky and plastic; few 2 to 5 mm, gypsum, lime nodules and basaltic gravels; many, fine, fibrous roots; violent effervescence; strongly alkaline (pH 8.7); clear and smooth boundary.

Bss1   27-50 cm --- Very dark brown (10 YR 2/2 M); clay; coarse moderate angular blocky structure, peds with distinct slickensided shiny pressure faces about to intersect; hard, friable, sticky and plastic; few, 2 to 5 mm irregular lime nodules, gypsum and basaltic gravels; few, medium to coarse roots; violent effervescence; strongly alkaline (pH 8.7); gradual and wavy boundary.

Bss2   50-69 cm ---Very dark brown (10 YR 2/2 M); clay; coarse, prismatic peds breaking into moderate, strong, angular blocky structure, closely intersecting slickensides with shiny pressure faces; hard, firm, sticky and plastic; few, 2 to 5 mm irregular quartz and basaltic gravels; few, medium to coarse fibrous roots; violent effervescence; strongly alkaline (pH 8.7); gradual and wavy boundary.

Bss3   69-85 cm --- Dark brown (10 YR 3/3 M); clay; moderate, strong angular blocky structure, slickensides with shiny pressure faces about to intersect; hard, firm, sticky and plastic; violent effervescence; strongly alkaline (pH 8.7); clear and wavy boundary.

76

C   85-90 cm --- Yellowish brown (10 YR 5/3 M); weathered basaltic parent material giving violent effervescence to dilute HCl.

Type location: 21°11′30″N and 71°38′50″E. Village Mota Khuntwada, tehsil: Mahuva, district: Bhavnagar, Gujarat state.

Range in characteristics: The thickness of the solum ranges from 50 to 113 cm thick. The soils in the A horizon are dominantly of silty clay loam texture and are very dark grayish brown to dark brown in colour. Th B-horizon is 70 to 80 cm thick. The colour of the soils is in hue 10 YR hue, value 2 to 3 and chroma 2. The texture is clay to gravelly clay. The structure in the A-horizon is medium, moderate, subangular blocky and in the B-horizon it is coarse, prismatic breaking into coarse to medium, strong angular blocky peds with indistinct to prominent intersecting slickensides. The C-horizon has weathered basaltic parent material. Irregular lime nodules and gravels of gypsum and basalt are found throughout the soil depth.

Geographic setting: Khuntwada soils are formed on weathered basaltic material with nearly level to very gently sloping piedmont plain at an elevation of 60 to 80 M above MSL. The climate is semi-arid with mean annual air temperature of 27.2°C and mean annual rainfall of 600 to 650 mm. The estimated MAST is 29.2°C, MSST is 32.6°C and MWST is 25.4°C. The difference between MSST and MWST is 7.2°C.

Geographically associated soils: None

Drainage and permeability: Moderately well drained with moderately rapid permeability.

Land use and vegetation: These soils are mostly cultivated. Important crops are cotton, groundnut and pearl millets in kharif and wheat and cumin are the main rabi season crops.

Distribution and extent: Distributed in villages viz. Mota Khutwada, Kinkaria, Dudhala, Mota Asharana, Chaddika, Cerus, Shadra and Sangania in Mahuva Taluka of Bhavnagar district.

Interpretation: The soils are deep and have fine texture. These soils have good water and nutrient holding capacity. However the soils have alkaline soil reaction and therefore these soils should be managed properly if irrigated. Deep tillage, addition of adequate quantities of organic matter and balanced fertilizer application is essential to keep the soil productive for an extended period of time.

a) Interpretative grouping:

        Land capability sub-class   :   IIIsd
        Land Irrigability sub-class   :   3sd
        Productivity potential   :   Medium

Soil datasets:

Hori-zon	Depth (cm)	Particocle size class (Diameter in mm)						Moisture retension (%)	
		Sand fraction (%)			Total (%)			33kPa	1500kPa
		Coarse (1.0-0.5)	Fine (0.25-0.1)	Very Fine (0.1-0.05)	Sand	Silt	Clay		
Ap	0-12	7.20	8.06	-	15.3	51.0	33.7	33.6	12.9
Bw1	12-27	3.65	16.46	-	20.1	40.5	39.4	32.4	13.6
Bss1	27-50	12.14	17.17	-	29.3	19.2	51.5	40.2	15.3
Bss2	50-69	2.62	13.38	-	16.0	10.6	73.4	45.5	20.6
Bss3	69-85	13.34	23.77	-	37.1	13.4	49.5	37.7	14.4
C	85-90	---------------------------Weathered basaltic parent material---------------------------							

Depth (cm)	pH	EC (dS^{-1})	CaCO$_3$ (%)	Organic Carbon (%)	Available		
					N	P$_2$O$_5$	K$_2$O
	--------(1:2.5)--------				---------------(kg/ha)--------------		
0-12	9.0	0.1	11.9	0.3	39.7	13.4	380.8
12-27	8.7	0.2	8.7	0.9	100.2	11.2	470.4
27-50	8.7	0.03	10.0	0.7	70.7	6.7	268.8
50-69	8.7	0.02	9.8	0.4	50.2	9.0	224.0
69-85	8.7	0.02	18.3	0.6	57.1	9.0	246.4
85-90	---------------------------Weathered basaltic parent material---------------------------						

Depth (cm)	Exchangeable bases				Sum of cations*	CEC	Base Saturation (%)	ESP*
	Ca	Mg	Na*	K				
	------------------------------[cmol(p+)kg^{-1}]------------------------------							
0-12	64.0	1.0	10.3	0.2	76.0	87.3	87.1	11.8
12-27	64.0	8.0	7.3	0.1	80.1	85.9	93.2	8.5
27-50	68.0	8.2	7.3	0.5	85.0	79.0	107.6	8.5
50-69	64.4	9.4	7.3	0.5	87.3	74.9	109.9	8.5
69-85	60.0	8.0	7.3	0.2	76.6	69.4	110.4	8.5
85-90	---------------------------Weathered basaltic parent material---------------------------							

*Derived parameters from pedo-transfer functions.

Source: Sharma, J. P., Giri, J. D., Shyampura, R. L. and Gajbhiye, K. S., (2005). "Soil Series of Gujarat" NBSS&LUP Publ. no. 120, NBSS&LUP, Nagpur-440010

2.14.2 LILVAN SERIES

The Lilvan series is a member of very fine, smectitic (calcareous), hyperthermic family of Vertic Haplustepts. Lilvan soils have dark brown, mildly alkaline, clayey A horizons, dark brown, neutral to mildly alkaline, clayey B horizons, and dark yellowish brown C horizons.
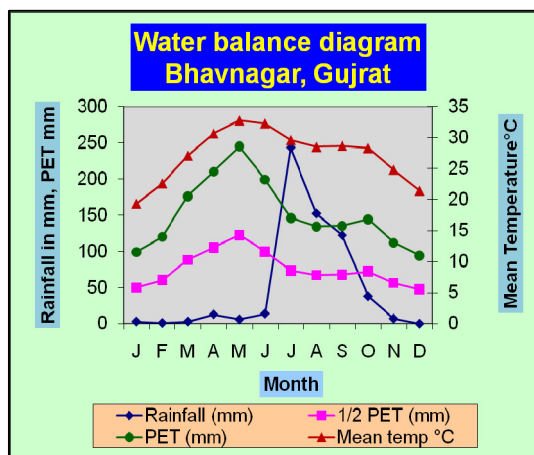
Typifying pedon: Lilvan clay–cultivated

Ap   0-15 cm --- Dark brown (10 YR 3/3 M); clay; moderate, medium, subangular blocky structure; slightly hard, friable, very sticky and plastic; irregular and round 1-3 mm basalt agate concretions; few, fine, roots; strong effervescence; mildly alkaline (pH 7.7); clear and smooth boundary.

Bw1   15-37 cm --- Dark brown (10 YR 3/3 M) clay; moderate, medium, subangular blocky structure; hard, moist firm, very sticky and plastic; round basalt agate concretions; gravels, 1-3 mm present; very few, very fine, roots; strong effervescence; neutral (pH 7.3); clear and smooth boundary.

Bw2   37-58 cm --- Dark brown (10 YR 3/3 M); clay; moderate, strong to medium, subangular blocky structure peds with shiny pressure faces; hard, firm, very sticky and plastic; round basalt agate concretions 1-3 mm size present; strong effervescence; neutral (pH 7.3); clear and smooth boundary.

Bw3   58-75 cm --- Dark brown (10 YR 4/3 M); clay; moderate, medium, subangular blocky structure; hard, firm, very slightly sticky and plastic; round basalt agate concretions 2-4 mm in size present; strong effervescence; mildly alkaline (pH 7.4); clear and wavy boundary.

C   75-80 cm --- Dark yellowish brown (10 YR 4/4 M) weathered calcareous parent material.

Type location: 21°12′N and 71°53′E. Lilvan Datha Road, Village Lilvan, tehsil: Mahuva, district Bhavnagar, Gujarat.

Range in characteristics: The solum depth varies from 50 to 95 cm. The colour of the surface soil varies from dark brown to very dark grayish brown in hue 10 YR , value 3 to 4 chroma 2 to 3.The soil texture of the surface is clay and at places gravelly sandy clay loam followed by gravelly clay to clay in lower horizon. The structure of the surface soil is medium moderate subangular blocky with shining pressure face. Soil cracks, 0-1 cm wide, extend up to a depth of 15 cm.

Competing series and their differentiae: None

Geographic setting: Lilvan soils are developed on weathered basalt with very gently sloping to gently sloping piedmont plain at an elevation of 60 to 80 M above MSL. The climate is semi arid

with mean annual air temperature of 27.2°C and mean annual rainfall of 650 to 750 mm. The estimated MAST is 29.2ºC, MSST is 32.6ºC and MWST is 25.4ºC. The difference between MSST and MWST is 7.2ºC.

Geographically associated soils: None

Drainage and permeability: Moderately well to well drained with slow permeability.

Land use and vegetation: These soils are cultivated for groundnut, sorghum, pearl millet, sesamum, maize, onion, coconut, wheat, cotton, etc.

Distribution and extent: This series extends in Ranivada, Kalsar, Katikada, Lilvan, Longadi Nani Jagdhur, Bhatikada, villages of the lilvan of Bhavnagar taluka.

Interpretation: These soils have very few soil constraints. Conservation of soil moisture, balanced application of nutrient, addition of adequate quantity of organic manure, and controlling surface erosion are some measures that can help sustain soil productivity.

Interpretative grouping:

Land capability sub-class	:	IIcs
Land irrigability sub-class	:	2s
Productivity potential	:	Medium

Soil datasets:

Hori-zon	Depth (cm)	Particle size class (Diameter in mm)					Moisture retension (%)	
		Sand fraction (%)		Total (%)			33kPa	1500kPa
		Coarse (1.0-0.5)	Fine (0.25-0.1)	Sand	Silt	Clay		
Ap	0-15	11.28	3.01	14.3	7.5	78.2	46.3	21.7
Bw1	15-37	10.15	4.7	14.9	7.2	77.9	46.1	21.6
Bw2	37-58	10.65	2.98	13.6	12.0	74.4	46.2	21.0
Bw3	58-75	30.86	1.76	32.6	4.0	63.4	39.8	17.4

Depth (cm)	pH	EC (dSm^{-1})	CaCO$_3$ (%)	Organic Carbon (%)	Available		
					N	P$_2$O$_5$	K$_2$O
	--------(1:2.5)--------				--------------(kg/ha)--------------		
0-15	7.7	0.21	1.67	0.51	80.2	31.1	500.7
15-37	7.3	0.23	5.17	0.48	70.1	20.2	403.3
37-58	7.3	0.16	8.77	0.48	71.2	11.3	226.7
58-75	7.4	0.18	8.92	0.31	50.2	11.2	225.1

Depth (cm)	Exchangeable bases				Sum of cations	CEC	Base Saturation (%)	ESP
	Ca	Mg	Na	K				
	----------------------------[cmol(p+)kg^{-1}]----------------------------							
0-15	27.4	10.6	0.063	0.2	38.3	52.8	72.5	0.1
15-37	25.2	16.4	0.062	0.4	42.1	52.6	80.0	0.1
37-58	28.4	13.2	0.087	0.6	42.3	50.4	83.9	0.2
58-75	21.4	19.6	0.1	0.5	41.6	43.4	95.9	0.2

Source: Sharma, J. P., Giri, J. D., Shyampura, R. L. and Gajbhiye, K. S., (2005). "Soil Series of Gujarat" NBSS&LUP Publ. no. 120, NBSS&LUP, Nagpur-440010

2.15 Soil Series: AESR 6.1

South Western Maharashtra and North Karnataka Plateau, hot dry semi-arid ESR with shallow and medium loamy Black soils (deep clayey Black soils as inclusion), medium to high AWC and LGP 90-120 days (K4Dd3)

2.15.1 TALEGAON SERIES

The Talegaon series is a member of the fine, smectitic, isohyperthermic family of Leptic Haplusterts. Typically, Talegaon soils have reddish brown to dark reddish brown, mildly alkaline, clay A horizons; dark reddish brown, mildly alkaline, clay Bss horizons, and pink to light reddish brown C horizons.
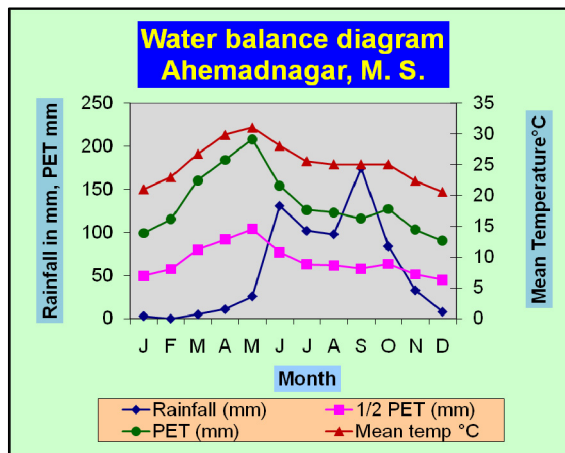
Typifying pedon: Talegaon clay - cultivated

Ap   0-20 cm --- Reddish brown (5YR 5/4 D) and dark reddish brown (5YR 3/2 M) clay; strong medium subangular blocky structure with shiny pressure faces; hard, firm, sticky and plastic; many coarse and fine roots; mildly alkaline (pH 7.6); gradual smooth boundary.

Bss   20-55 cm --- Dark reddish brown (5YR 3/2 D&M) clay; almost intersecting slickensides that break into coarse strong angular blocky peds with shiny pressure faces; very hard, firm, sticky and plastic; fine roots in the upper part and few medium and coarse roots between peds in the lower part; 5 to 15 mm wide cracks; mildly alkaline (pH 7.8); clear smooth boundary.

Cr   55-66 cm --- Pink (5YR 8/3 D) and light brown (7.5YR 6/4 D) weathered basalt with thin laminar materials; light reddish brown (5YR 6/4 D) loamy fills and white soft lime masses filling the interstices.

Type location: 19°17' N, 74°44' E; about 1.5 km northeast of Wambori railway station, tehsil Rahuri, district Ahmednagar, Maharashtra.

Range in characteristics: The thickness of the solum ranges from 40 to 60 cm. The texture of the A and the B horizons is silty clay to clay and peds are strongly developed. The colour of the A and the B horizons is in hue 5YR and 7.5YR, value 3 to 5 and chroma 2 to 4.

Competing series and their differentiae: Competing soils are those of Wadgaon and Sirasgaon which are Vertic Ustropepts and Typic Haplusterts, respectively.

Geographic setting: Talegaon soils are developed on calcareous weathered basalt on gently to very gently sloping lower pediment at an elevation of about 700 m above MSL. The climate is

semiarid tropical with mean annual air temperature of 25.0°C and mean annual rainfall of 510 mm. The estimated MAST is 27.0°C. The difference between MSST and MWST is less than 5°C.

Geographically associated soils: The associated soils are those of Pargaon and Torkewadi which are Lithic Ustorthents.

Drainage and permeability: Well drained with moderate to moderately slow permeability.

Use and vegetation: Mostly cultivated under rainfed pearl millet, sorghum and groundnut. At places, thin vegetal cover of .thorny bushes also met with.

Distribution and extent: Extensive soils (50,000 ha); found to occur mostly on higher contours along the leeward side of Sahyadris in Ahmednagar district of Maharashtra.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur, 1972.

Interpretation: The Talegaon soils are moderately deep with moderate permeability. These soils are cultivated with minor to moderate problems such as clay or moderate depth. Special attention may be given to erosion control and conservation of water.

Interpretative grouping:

i)	Land capability subclass	IIs
ii)	Irrigabi1ity subclass	2s
iii)	Productivity potential	Medium

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)			Coarse fragments > 2 mm % of whole soil
		Sand (2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	
		<----------------------- % of < 2 mm ----------------------->			
Ap	0-20	21.9	34.2	43.9	3
Bss	20-55	22.3	29.3	48.4	2

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})
0-20	0.45	Tr	7.6	0.2
20-55	0.26	1.0	7.8	0.2

| Depth (cm)	Extractable bases					CEC NH$_4$OAc	Ratio CEC/ Clay
	Ca	Mg	Na	K	Sum		
	<----------------------- cmol (p+)kg^{-1} ----------------------->						
0-20	28.7	10.3	-	-	-	41.9	0.95
20-55	30.5	14.7	-	-	-	48.2	1.00

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.15.2 SIRASGAON SERIES

The Sirasgaon series is a member of the fine, smectitic, isohyperthermic family of Typic Haplusterts. Typically, Sirasgaon soils have brown to dark brown, moderately alkaline, clay loam A horizons; dark brown, moderately alkaline, clay to gravelly clay B horizons, and light brown to reddish yellow, moderately alkaline, loamy materials with altered basalt and soft powdery lime C horizons.
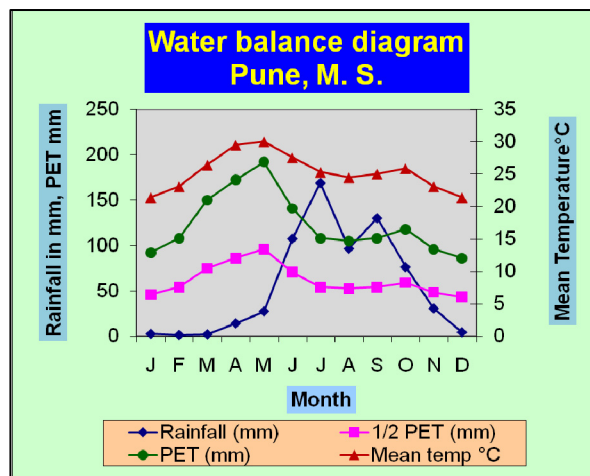
Typifying pedon: Sirasgaon clay loam - cultivated

Ap   0-14 cm --- Brown (7.5YR 5/2 D) and dark brown (7.5YR 3/2 M) clay loam; moderate medium subangular blocky structure; slightly hard, firm, sticky and plastic; many fine roots; few fine white indurated lime nodules; strongly effervescent; moderately alkaline (pH 7.9); clear smooth boundary.

Bw1   14-32 cm --- Dark brown (7.5YR 3/2 D&M) clay; moderate medium subangular blocky structure; hard, firm, sticky and plastic; few fine and medium roots; many fine to medium white lime nodules; strongly effervescent; moderately alkaline (pH 7.9); gradual smooth boundary.

Bss1 32-55 cm --- Dark brown (7.5YR 3/2 D&M) clay; strong medium angular blocky structure with shiny pressure faces; hard, firm, sticky and plastic; few fine and medium roots; many medium indurated lime nodules; violently effervescent; moderately alkaline (pH 7.9); clear smooth bou ndary.

Bss2 55-88 cm --- Dark brown (7.5YR 3/2 D&M) gravelly clay; coarse slickensides at an angle 60 degree from horizontal and about to intersect that break into coarse strong angular blocky structure with shiny pressure faces; hard, firm, sticky and plastic; many medium indurated lime nodules and some powdery lime in the lower part; violently effervescent; moderately, alkaline (pH 8.0); clear wavy boundary.

Ck   88-98 cm --- Light brown (7.5YR 6/4 D) and reddish yellow (7.5YR 7/8 M); fragments of altered basalt with soft powdery lime and medium indurated lime mixed with loamy materials filling the interstices; violently effervescent; moderately alkaline (pH 8.1).

Type location: 18°37'34" N, 74°28'15" E; village Sirasgaon, tehsil Sirur, district Pune, Maharashtra.

Range in characteristics: The thickness of the solum ranges from 75 to 100 cm. The colour of the A horizon varies from brown to dark brown in hue 7.5YR, dry value 5 and moist 3 and chroma 2 for both dry and moist soils. The common soil types are clay loam to silty, clay loam but at places silty clay is also met with. The thickness of the B horizon ranges from 65 to 85 cm and the content of $CaCO_3$ vary from 8 to 14 per cent through depth. The pedality in the B horizon varies from moderate medium subangular blocky to strong medium angular blocky peds showing

shiny pressure faces in the lower part of the horizon. The texture varies from clay to silty clay. The colour is in hue 7.5YR, value 3 and chroma 2 for both dry and moist soils. The Bss horizon may express slickensides peds inclining at 60° from the horizontal.

Competing series and their differentiae: The competing soils are those of Wadgaon and Talegaon series. The average thickness of the solum in Talegaon soils ranges from 40 to 60 cm and that in Wadgaon soils from 45 to 55 cm. There is no free lime accumulation in the solum of both Talegaon and Wadgaon series. The colour of the B horizon in Talegaon soils is in hue 5YR, value 3 and chroma 2 both for dry and moist soils and in Wadgaon soils it is in hue 7.5YR, value 3 and chroma 2 for dry and moist soils. Wadgaon and Talegaon soils belong to Vertic Ustropepts and Typic Haplusterts, respectively.

Geographic setting: Sirasgaon soils are developed over gently to very gently sloping plateau at an elevation of about 540 m above MSL in Pune district of Maharashtra. The climate is semiarid tropical with mean annual air temperature of 25.5^{o}C and mean annual rainfall of 650 mm. The estimated MAST is 27.5^{o}C, MSST 30.3^{o}C and MWST 25.6 ^{o}C. The difference between MSST and MWST is less than 5°C.

Geographically associated soils: Sirasgaon soils are associated with the soils of Wadgaon and Sibnery series. Wadgaon soils are moderately deep and Sibnery soils are very shallow. Wadgaon and Sibnery soils belong to Vertic Ustropepts and Lithic Ustorthents, respectively.

Drainage and permeability: Well drained with moderate to moderately slow permeability.

Use and vegetation: Mostly cultivated to rainfed sorghum and pearl millet, and at places to groundnut.

Distribution and extent: Extensive in Pune and Ahmednagar districts of Maharahstra.

Series proposed: National Bureau of Soil Survey and Land Use Planning (previously AIS&LUS), Regional Centre, Nagpur, 1965.

Interpretation: Sirasgaon soils are fine textured and they are productive and crops respond to management practices but stoniness is the limitation.

Interpretative grouping:
  i)   Land capability subclass   IIs
  ii) Irrigabillty subclass   3S
  iii) Productivity potential   Medium

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)					Coarse fragments > 2 mm % of whole soil
		Coarse sand (2-0.02)	Fine sand (2-0.02)	Total sand (2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	
		<----------------------- % of < 2 mm ----------------------->					
Ap	0-14	10.4	31.9	42.3	21.1	36.6	8
Bw1	14-32	8.3	31.5	39.8	19.0	41.2	4
Bss1	32-55	8.5	27.9	36.4	17.4	46.2	7
Bss2	55-88	11.8	29.4	41.2	14.0	44.8	31

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})	Bulk density (Mg m^{-3})	Moisture equivalent (%)
0-14	0.42	9.0	7.9	0.3	1.40	30
14-32	0.41	8.8	7.9	0.3	1.45	32
32-55	0.40	9.1	7.9	0.2	1.50	35
55-88	0.31	13.7	8.0	0.2	1.50	32

Depth (cm)	Extractable bases		CEC NH_4OAc
	Ca	Mg	
	<-------------------- cmol (p+)kg^{-1} ---------------->		
0-14	39.0	6.2	47.4
14-32	42.4	5.8	48.6
32-55	43.1	6.3	49.8
55-88	37.6	5.0	43.1

Note: The soil texture is based on International particle size classification.

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.16 Soil Series: AESR 6.2

Central and Western Maharashtra Plateau and North Karnataka Plateau and North Western Telangana Plateau, hot moist semi-arid ESR with shallow and medium loamy to clayey Black soils (medium land deep clayey Black soils as inclusion), medium to high AWC and LGP 120-150 days (K4Dm4)

2.16.1 ANNAPUR SERIES

The Annapur series is a member of the fine-loamy, smectitic, isohyperthermic family of Fluventic Haplustepts. Typically, Annapur soils have brown to dark yellowish brown, moderately alkaline, clay loam A horizons; dark brown, moderately alkaline, gravelly clay loam to gravelly sandy clay loam B horizons, and yellowish brown, moderately alkaline, gravelly loamy sand to sandy loam C horizons.

Water balance diagram Ahemadnagar, M. S.
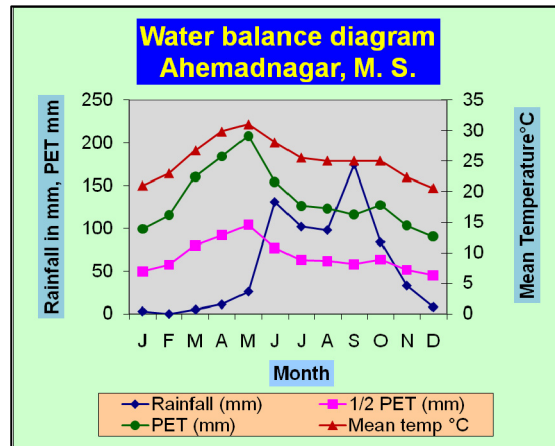
Typifying pedon: Annapur clay loam - cultivated

Ap   0-l8 cm --- Brown (l0YR 4/3 D) and dark yellowish brown (10YR 4/4 M) clay loam; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; many fine roots; few fine to medium disseminated lime nodules; strongly effervescent; moderately alkaline (pH 7.9); clear smooth boundary.

Bw1   18-43 cm --- Dark brown (10YR 3/3 D&M) gravelly clay loam; coarse prismatic structure breaking into moderate medium subangular blocky peds with shiny pressure faces; hard, firm, sticky and plastic; many fine roots; few sand lenses and assorted gravel pockets; few fine lime nodules; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

Bw2   43-65 cm --- Dark brown (10YR 3/3 D) and dark yellowish brown (10YR 3/4 M) gravelly sandy clay loam; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; few fine roots; many disseminated medium lime nodules; violently effervescent; many assorted gravel pockets; moderately alkaline (pH 8.1); clear irregular boundary.

BC   65-94 cm --- Dark yellowish brown (10YR 3/4, 4/4D&M) gravelly sandy loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky; many patches of pseudomycelium lime in the lower part; violently effervescent; many assorted gravel pockets; moderately alkaline (pH 8.2); gradual smooth boundary.

C2   94-120 cm --- Yellowish brown (10YR 5/4 D&M) gravelly loamy sand; weak fine subangular blocky structure; slightly hard, friable, non-sticky; many medium indurated lime nodules; violently effervescent; many lime coated basalt gravels and cobbles; moderately alkaline (pH8.2).

Type location: 19°50' N, 74°18' E; village Nimgaon (Jali), tehsil Sangamner, district Ahmednagar, Maharashtra.

Range in characteristics: The thickness of the solum ranges from 55 to 95 cm. The texture of the A and B horizons is clay loam and sandy clay to gravelly sandy clay loam. The peds are moderately developed. The colour of the A and B horizons is in hue 10YR. value 3 to 4 and chroma also 3 to 4.

Competing series and their differentiae: Annapur soils compete with Dholwad soils which have more carbonates in the B horizon and the soils crack upto 25 cm depth.

Geographic setting: Annapur soils are formed in alluvium and colluvium on nearly to very gently sloping piedmont plain at an elevation of 650 m above MSL. The climate is semiarid tropical* with mean annual air temperature of 25.0°C and mean annual rainfall of 510 mm. The estimated MAST is 27.0°C. The difference between MSST and MWST is less than 6°C.

Geographically associated soils: Annapur soils are associated with soils of Nimone, Umbraj and Otur series which belong to Typic Haplustert, Udic Haplustert, and Chromic Haplustert, respectively.

Drainage and permeability: Moderately well drained with moderate to moderately rapid permeability.

Use and vegetation: Usually cultivated during rainy season, common crops pearl millet and sorghum.

Distribution and extent: Extensive in Pune and Ahmednagar districts of Maharashtra.

Series proposed: National Bureau of Soil Survey and Land Use Planning (previously AIS & LUS) Regional Centre, Nagpur, 1965.

Interpretation: These soils are cultivated under minor to moderate problems. Special attention is needed to conserve soil and water.

Interpretative grouping:
i)	Land capability subclass	IIIs
ii)	Irrigability subclass	3s
iii)	Productivity potential	Medium

Although, the description of the AESR indicates SAm bioclimatic system however this particular benchmark site represents SAd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)			Coarse frag-ments > 2 mm % of whole soil
		Sand (2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	
		<--------- % of < 2 mm ------------>			
Ap	0-18	44.7	26.2	29.1	9
Bw1	18-43	44.5	20.1	35.4	22
Bw2	43-65	64.2	9.8	26.0	27
BC	65-94	76.6	6.5	16.9	28
C	94-120	81.3	6.6	12.1	43

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})	Extractable bases				CEC NH_4OAc
					Ca	Mg	Na	K	
					<---- cmol (p+)kg-1 ---->				
0-18	0.30	4.5	7.9	0.2	20.6	3.1	-	-	30.1
18-43	0.40	5.5	8.0	0.4	26.6	4.5	-	-	32.3
43-65	0.30	8.0	8.1	0.5	19.5	5.1	-	-	26.1
65-94	0.18	10.1	8.2	0.5	12.1	2.0	-	-	-
94-120	0.28	14.4	8.2	0.3	10.1	3.5	-	-	-

Note: The soil texture is based on International particle size classification.

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.16.2 TORKEWADI SERIES

The Torkewadi series is a member of the clayey-skeletal, mixed, isohyperthermic family of Lithic Ustorthents. Typically, Torkewadi soils have strong brown to dark brown, moderately alkaline, gravelly clay loam A horizons underlain by brown to grey, moderately alkaline, gravelly C horizons.
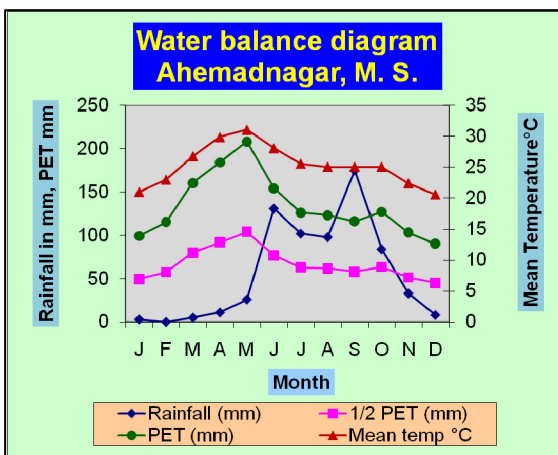
Typifying pedon: Torkewadi gravelly clay loam - grassland

A 0-15 cm --- Strong brown (7.5YR 5/6 D) and brown to dark brown (7.5YR 4/4 M) gravelly clay loam; moderate medium subangular blocky structure; slightly hard, friable, sticky and slightly plastic; many fine roots; many coarse fragments of basalt moderately alkaline (pH 7.9); clear smooth boundary.

C 15-23 cm --- Brown (7.5YR 5/4 D) and grey (10YR 5/1 D) partly altered coarse fragments of basalt mixed with brown (7.5YR 5/2 D&M) soil; massive; soft, friable, slightly sticky; few fine roots in the upper part and few coarse roots through depth; moderately alkaline (pH 7.9).

Type location: 19°22' N, 74°38' E; about 2 km south of village Digras. Tehsil Rahuri. District Ahmednagar, Maharashtra.

Range in characteristics: The thickness of the A horizon ranges from 10 to 22 cm. Its texture is gravelly clay loam to sandy clay loam. Its colour is in hue 7.5YR, value 4 to 5 and chroma 4 to 6.

Competing series and their differentiae: The competing soils are those of Khanapur and Pargon series which are Typic Ustorthent and Lithic Ustorthent, respectively.

Geographic setting: Torkewadi soils are developed on basaltic material and occur on gently to moderately sloping lower pediment at an elevation of 700 m above MSL. The climate is semiarid tropical* with mean annual air temperature of 25.0°C and mean annual rainfall of 510 mm. The estimated MAST is 27.0°C. The difference between MSST and MWST is less than 5°C.

Geographically associated soils: Torkewadi soils are associated with Pargaon soils which are Lithic Ustorthents.

Drainage and permeability: Well drained with somewhat excessive runoff and moderate permeability.

Use and vegetation: Mostly uncultivated soils and left as barren wasteland.

Although, the description of the AESR indicates SAm bioclimatic system however this particular benchmark site represents SAd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Distribution and extent: Extensive (about 1,10,000 ha) in the semi-arid agroclimatic zone along the leeward side of Sahyadri range in Pune and Ahmednagar districts of Maharashtra.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur.

Interpretation: The Torkewadi soils are occasionally cultivated in rotation with hay or pasture. Under cultivation, intensive erosion control measures are needed. They otherwise are not fit for cultivation.

Interpretative grouping:
i)	Land capability subclass	VIe
ii)	Irrigability subclass	6s
iii)	Productivity potential	Low

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)			Coarse fragments > 2 mm % of whole soil
		Sand (2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	
		<------------------ % of < 2 mm --------------------->			
A	0-15	36.3	26.5	37.2	42

Depth (cm)	Organic Carbon (%)	Carbonate as CaCO$_3$ < 2 mm (%)	pH (1:2.5) H$_2$O	E.C. (1:2.5) H$_2$O (dS m^{-1})
0-15	0.51	-	7.9	0.6

Depth (cm)	Extractable bases					CEC NH$_4$OAc
	Ca	Mg	Na	K	Sum	
	<----------------------------- cmol (p+)kg^{-1} ---------------------------->					
0-15	30.9	10.3	Tr	Tr	41.2	41.2

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.17 Soil Series: AESR 6.3

Eastern Maharashtra Plateau, hot moist semi-arid ESR with medium land deep clayey Black soils (shallow loamy to clayey Black soils as inclusion), medium to high AWC and LGP 120-150 days (K5Dm4)

2.17.1 JAMBHA SERIES

The Jambha series is a member of the very fine, smectitic, hyperthermic family of Typic Haplusterts. Typically, Jambha soils have dark greyish brown to very dark greyish brown, moderately to strongly alkaline, clay A horizons; dark greyish brown to dark brown, moderately to strongly alkaline, clay B horizons, and yellowish brown to dark yellowish brown, strongly alkaline, clay C horizons.

Water balance diagram Amravati, M. S.
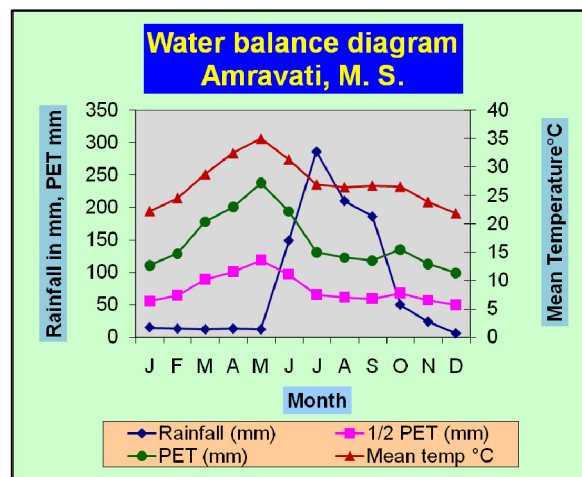
Typifying pedon: Jambha clay - cultivated

Ap   0-20 cm --- Dark greyish brown (10YR 4/2 D) clay, very dark greyish brown   (10YR 3/2 M); moderate medium subangular blocky structure; very hard, friable, very sticky and very plastic; few fine roots; few imped and exped pores; 20 mm wide cracks; slightly effervescent; strongly alkaline (pH 8.6); diffuse smooth boundary.

Bw1   20-45 cm --- Very dark greyish brown to dark greyish brown (10YR 3.5/2 D) clay, very dark greyish brown (10YR 3/2 M); strong coarse prismatic structure breaking into subangular blocks with shiny pressure faces; very hard, firm, sticky and very plastic; few fine roots; few irregular pores; 10 to 20 mm wide cracks; slightly effervescent; strongly alkaline (pH 8.5); diffuse smooth boundary.

Bw2   45-65 cm ---Very dark greyish brown (10YR 3/2 D&M) clay; strong coarse prismatic structure breaking into subangular blocks with shiny pressure faces; very hard, very firm, very sticky and very plastic; 10 mm wide cracks; slightly effervescent; moderately alkaline (pH 8.4); diffuse smooth boundary.

Bss1   65-105 cm --- Very dark greyish brown (10YR 312 D&M) clay; intersecting slickensides forming strong coarse parallelepipeds with long axes tilted 30 to 35° from the horizontal that break into strong coarse angular blocks with shiny pressure faces; very hard, very firm, very sticky and very plastic; slightly effervescent; moderately alkaline (pH 8.3); diffuse smooth boundary.

Bss2   105-145 cm --- Very dark greyish brown (10YR 3/2 D&M) clay; intersecting slickensides forming strong coarse parallelepipeds with long axes tilted 30 to 35° from the horizontal that break into strong coarse angular blocks with shiny pressure faces; very hard, very firm, very sticky and very plastic; slightly effervescent; strongly alkaline (pH 8.6); diffuse smooth boundary.

BC1   145-190 cm --- Dark greyish brown to brown (10YR 4/2, 5/3 D) and dark brown to brown (10YR 4/3, 5/3 M), clay; intersecting slickensides forming strong coarse

parallelepipeds with long axes tilted with 30 to 50° from the horizontal that break into strong medium angular blocks with shiny pressure faces; very hard, firm, very sticky and very plastic; strongly effervescent; strongly alkaline (pH 8.7); gradual smooth boundary.

BC2   190-240 cm --- Yellowish brown (10YR 5/4 D) clay, dark yellowish brown (10YR 4/4 M); strong coarse angular blocky structure with shiny pressure faces; very hard, firm, very sticky and very plastic; strongly effervescent; strongly alkaline (pH 8.6).

Micromorphology: The strong coarse angular blocky structure with an inclination of about 30° with the horizontal axis is due to strong swelling and shrinking of the montmo+rillonitic clays. The roundness of some of the large carbonate nodules and the orientation of clay domains resulting in a moderate ma-vosepic plasmic fabric strongly developed in the BC horizon are also consequences of the vertic properties of the soil. Carbonate nodules are common in the soil. In the B horizon the carbonate is predominantly present as small nodules of diameter < 2 mm, joined together forming larger irregular shaped nodules, indicating current accumulation of carbonates in this zone. Minerals and rock fragments are altering. Around these particles accumulations of sesquioxides commonly occur. In the B horizon pure sesquioxidic nodules up to 1 mm are also present indicating current accumulation. In many of the larger carbonate nodules accumulations of sesquioxides occur.

Type location: 20°56' N, 77°47' E; 2 km north-east of Chandur Railway Station, Survey No. 168 of village Palaskheda, tehsil Chandur, district Amravati, Maharashtra.

Range in characteristics: The thickness of the solum ranges from 130 to 170 cm. The colour of the A horizon is dark to very dark greyish brown in hue 10YR, value 3 to 4 and chroma 2. It is moderately to strongly alkaline. The structure is medium, subangular blocky to angular blocky. The colour of the B horizon is similar to that of the A horizon. Its texture is clayey and it has intersecting slickensides forming parallelepipeds that break into angular blocks with shiny pressure faces. The C horizon is yellowish brown and clayey. Gilgai micro-relief is common.

Competing series and their differentiae: Kalumna series, also a Typic Haplustert, is mottled in the subsoil.

Geographic setting: Jambha soils are formed in basaltic alluvium on very gently sloping to gently sloping Wardha flood plain at an elevation of 270 to 370 m above MSL. The climate is subhumid tropical* with mean annual air temperature of 27.2°C and mean annual rainfall of 975 mm. The estimated MAST is 29.2°C, MSST 30.4°C and MWST 25.4°C. The difference between MSST and MWST is 5°C.

Geographically associated soils: Jambha soils are associated with Kalumna soils which are mottled in the subsurface and belong to Typic Haplusterts.

Drainage and permeability: Somewhat poorly drained with slow to very slow permeability.

Use and vegetation: Mostly cultivated to rainfed cotton, sorghum, pigeonpea, gram, wheat and linseed; natural vegetation -*Acacia spp.* (babul) and thorny shrubs.

Distribution and extent: Extensive in Amravati, Wardha and Akola districts of Maharashtra.

Series proposed: Soil Survey Division, Directorate of Irrigation Research and Development, Pune, Maharashtra, 1971.

Although, the description of the AESR indicates SAm bioclimatic system however this particular benchmark site represents SHd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Interpretation: Jambha soils are deep and clayey. They have high water and nutrient retention capacity. These soils can conserve most of the initial rainfall received through the cracks. Once saturated, they are susceptible to erosion even on gentle slopes, and hence soil conservation measures are required. Under irrigation they may pose water logging and salinity problems unless adequate drainage is provided. They can support all climatically adapted crops.

a) Interpretative grouping:

i)	Land capability subclass	IIIs
ii)	Irrigabllity subclass	3d
iii)	Productivity potential	Medium

b) Yield: Based on data from farmers' fields

Crop	Farmers' practices	Improved practices
	←-------------Yield, Mg ha^{-1}-------------→	
Cotton	0.8	1.5
Sorghum	1.3	2.8
Groundnut	0.6	1.2
Pigeonpea	0.6	1.1
Safflower	0.7	1.5
Sunflower	0.3	0.7

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								Coarse frag-ments > 2 mm % of whole soil
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
		<------------------------------- % of < 2 mm ------------------------------->								
Ap	0-20	13.6	26.7	59.7	6.2	2.4	0.5	0.4	4.1	5
Bw1	20-45	15.2	13.3	71.5	6.8	3.4	0.8	0.5	3.7	3
Bw2	45-65	13.2	21.9	64.9	2.9	5.5	0.9	0.6	3.3	4
Bss1	65-105	8.5	25.7	65.8	3.6	1.2	0.8	0.4	2.5	3
Bss2	105-145	8.7	18.3	73.0	1.3	0.5	0.4	1.3	5.2	3
BC1	145-190	13.1	29.5	57.4	2.6	0.7	0.5	1.7	7.6	3
BC2	190-240	7.1	29.2	63.7	2.9	0.8	0.3	0.9	2.2	5

Depth (cm)	Organic Carbon (%)	Carbonate as CaCO$_3$ < 2 mm (%)	pH (1:2.5) H$_2$O	E.C. (1:2.5) H$_2$O (dS m^{-1})	Bulk density (Mg m^{-3})	Water retention		Micronutrients			
						33 kPa	1500 kPa	D T P A extractable			
								Zn	Cu	Mn	Fe
								<------------ ppm ---------------->			
0-20	0.46	1.9	8.6	0.17	1.71	38.4	22.5	0.66	0.51	10	9
20-45	0.46	2.3	8.5	0.15	1.88	34.5	21.5	0.46	1.54	10	8
45-65	0.44	2.5	8.4	0.13	2.04	36.5	22.6	0.34	1.52	9	9
65-105	0.37	2.6	8.3	0.17	1.99	36.4	20.9	0.31	1.59	11	10
105-145	0.36	1.4	8.6	0.20	1.97	NA	NA	NA	NA	NA	NA
145-190	0.31	3.0	8.7	0.23	1.90	NA	NA	NA	NA	NA	NA
190-240	0.17	5.3	8.6	0.23	1.93	NA	NA	NA	NA	NA	NA

| Depth (cm)	Extractable bases				CEC NH$_4$OAc	Base Saturation (%)	Exchangeable sodium (%)	Ratio CEC/ clay
	Ca+Mg	Na	K	Sum				
	<------------ cmol (p+)kg^{-1} ------------>							
0-20	54.0	0.2	1.0	55.2	55.2	100	0	0.92
20-45	48.3	0.4	0.9	49.6	49.6	100	1	0.69
45-65	45.8	0.4	0.8	47	47.0	100	1	0.72
65-105	41.5	1.3	0.9	43.7	43.7	100	3	0.66
105-145	46.0	2.8	0.9	49.7	49.7	100	6	0.68
145-190	39.0	5.0	1.0	45	45.0	100	11	0.78
190-240	38.3	6.0	1.0	45.3	45.3	100	13	0.71

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.17.2 LONI

The Loni series is a member of the very fine, smectitic, hyperthermic family of Typic Haplusterts. Typically, Loni soils have very dark gray to very dark greyish brown, mildly acidic, clay A horizons; very dark gray to dark brown, mildly acidic to neutral, clay B horizons.
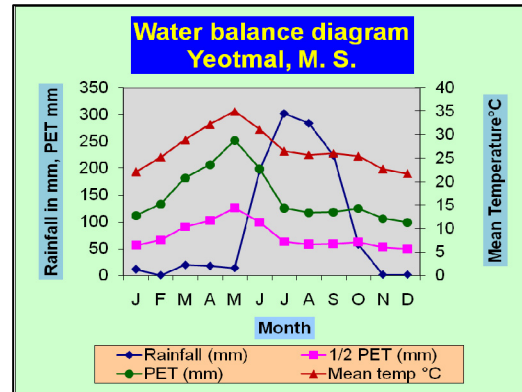
Typifying pedon: Loni clay – cultivated

Ap   0-14 cm -- Very dark gray (10YR 3/1D) and very dark grayish brown (10YR3/2M) clay; moderate medium subangular blocky structure; hard, friable, very sticky and very plastic, many very fine, common fine roots; many very fine and fine lime nodules; common fine pores; mildly acidic (pH 6.3); strongly effervescent; clear smooth boundary.

Bw1   14-36 cm -- Very dark gray (10YR3/1D) and very dark grayish brown (10YR3/2M) clay; moderate medium subangular blocky structure, hard, friable very sticky and very plastic; few very fine, common fine roots, many very fine and fine lime nodules; mildly acidic (pH 6.3); strongly effervescent; gradual wavy boundary.

Bw2   36-65 cm -- Very dark gray (10YR3/1D) and very dark grayish brown (10YR3/2M) clay; strong medium subangular blocky structure with pressure faces and wedge shaped aggregates on surface of peds; hard, friable, very sticky and very plastic; common fine roots; common fine and medium lime nodules; mildly acidic (pH 6.4); strongly effervescent; gradual smooth boundary.

Bss1   65-99 cm -- Very dark grayish brown (10YR3/2M) clay; strong coarse angular blocky structure with wedge shaped aggregates and slickensides that breaks into small angular peds; firm, very sticky and very plastic; fine common fine roots; few very fine lime nodules; mildly acidic (pH 6.4); slightly effervescent; gradual smooth boundary.

Bss2   99-144 cm -- Very dark grayish brown (10YR3/2M) clay; strong coarse angular blocky structure with well developed wedge shaped aggregates and slickensides that break into strong angular peds; firm, very sticky and very plastic; few fine roots; few very fine lime nodules; mildly acidic (pH 6.5); slightly effervescent; gradual smooth boundary.

Bss3   144-160 cm -- Very dark grayish brown to dark brown (10YR3/2.5M) clay; strong medium angular blocky structure with well developed wedge shaped aggregates and slickensides that break into strong angular peds; firm, very sticky and very plastic; few very fine lime nodules; neutral (pH 6.6); slightly effervescent.

Type location: $20^o14'19''$N, $78^o08'11''$E; about ½ km west of Loni village; Loni, Arni, Yeotmal, M.S.

Geographic setting: Loni soils are formed in basaltic alluvium on very gently sloping land (1-3%) of Lower Maharashtra Deccan Plateau at an elevation of 0 to 50 m above MSL. The climate is sub-humid* with mean annual air temperature of 26.9°C and mean annual rainfall of 1133.5 mm. The estimated MAST is 29.2°C, MSST 33.6°C and MWST 27.1°C. The difference between MSST and MWST is 6.5^{o}C.

Although, the description of the AESR indicates SAm bioclimatic system however this particular benchmark site represents SH which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Drainage and permeability: Moderately well drained.

Land use and vegetation: Cultivated under Cotton+pigeonpea, wheat (irrigated); natural vegetation- Palas, *Azadiracta indica* (Neem), *Acacia spp.* (Babul), soils receive quite a good amount of FYM for growing cotton.

Remarks: Slickensides below 40 cm. CaCO$_3$ as nodules only, no matrix effervercence. Parallel cracks from 65cm onwards.

Soil datasets:

Lab. No	Hori-zon	Depth (cm)	Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Fine clay (%)	Fine clay/ total clay (%)	BD Mg/m³	COLE	HC cm/hr	WDC (%)
			Size class and particle diameter (mm)								
			Total								
			←------(% of <2 mm) ------→								
3202	Ap	0-14	5.9	30.5	63.6	32.2	50.6	-	0.10	2.7	7.5
3203	Bw1	14-36	4.0	26.9	69.1	31.6	45.7	1.3	0.14	3.9	7.5
3204	Bw2	36-65	3.4	26.7	69.9	42.8	61.2	1.4	0.17	3.9	15.2
3205	Bss1	65-99	4.9	18.8	76.3	46.8	61.3	1.4	0.25	3.1	10.3
3206	Bss2	99-144	3.8	27.4	68.8	44.7	64.9	1.3	0.26	3.3	14.4
3207	Bss3	144-160	4.2	25.2	70.6	40.3	57.0	-	0.10	1.8	19.4

* 34 mm hr^{-1} is the HC (WM) in 0-100 cm depth of soil.

Horizon	Depth (cm)	33kPa	100kPa	300kPa	500kPa	800kPa	1000kPa	1500kPa	AWC
		Moisture retention%							
Ap	0-14	44.6	39.8	29.7	29.0	28.8	26.8	25	19.6
Bw1	14-36	45.4	39.5	31.1	30.3	27.8	26.6	24.8	20.7
Bw2	36-65	48.7	43.5	34.1	34.1	29.4	27.4	26.9	21.8
Bss1	65-99	38.3	35.9	29.2	29.1	27.5	25.4	21.9	16.5
Bss2	99-144	53.9	49.3	36.3	35.6	35.2	32.7	28.8	25.0
Bss3	144-160	52.3	45.2	35.8	35.1	33.2	31.0	28.5	23.8

Depth (cm)	pH water (1:2)	CaCO$_3$ (%)	OC (%)	Ca	Mg	Na	K	Sum	CEC	Clay CEC cmol(p+) kg^{-1}	B.S. (%)
				Extractable bases							
				←----------------cmol(p+)/kg^{-1}----------------→							
0-14	6.3	6.0	1.10	43.3	18.0	0.5	1.2	63.0	60.9	96	103
14-36	6.3	4.0	0.60	36.9	25.6	0.8	0.6	63.9	61.1	88	104
36-65	6.4	6.5	0.60	27.8	35.3	2.3	0.6	66.0	63.0	90	105
65-99	6.4	2.6	0.60	37.8	27.3	1.3	0.7	67.1	63.0	82	106
99-144	6.5	4.0	0.50	23.8	42.9	3.0	0.5	70.2	66.6	97	105
144-160	6.6	3.7	0.10	25.6	42.0	1.3	0.7	69.6	72.0	102	97

Depth (cm)	Exch. Ca/Mg	ECP*	EMP*	ESP*	CO$_3$ clay (%)	CO$_3$ clay (feb) (%)
0-14	2.4	71	29	0.80	3	1.9
14-36	1.4	60	42	1.30	3.2	2.2
36-65	0.8	44	56	3.60	3.4	2.4
65-99	1.4	60	43	2.10	3.5	2.7
99-144	0.6	36	64	4.50	3.6	2.5
144-160	0.6	35	58	1.80	4.5	3.2

Depth (cm)	Sat %	ECe	Ca	Mg	Na	K	Sum	CO$_3$	HCO$_3$	Cl	SO$_4$	Sum	RSC	SAR
		Soluble cations (meq/l)						Soluble anions (meq/l)						
0-14	77.5	0.94	5.15	5.04	1.52	0.02	11.7	2.12	3.18	0.34	6.09	11.7	-4.89	0.7
14-36	74.8	0.31	1.60	1.70	1.96	0.01	5.3	2.12	1.06	0.66	1.43	5.3	-0.12	1.5
36-65	85.2	0.41	1.06	2.00	4.10	0.03	7.2	2.12	1.59	0.80	2.68	7.2	0.65	3.3
65-99	75.5	0.38	2.02	1.71	5.22	0.02	8.9	2.12	0.53	0.60	5.72	8.9	-1.08	3.8
99-144	92.3	0.63	1.40	3.26	6.09	0.03	10.8	1.06	2.12	1.00	6.60	10.0	-1.48	4.0
144-160	89.2	0.54	1.20	2.43	4.78	.0.01	8.4	1.06	2.12	1.10	4.14	8.4	-0.45	3.5

* ECP = Exchangeable calcium percentage; EMP = Exchangeable Magnesium percentage; ESP = Exchangeable sodium percentage

Source: Pal, D. K., Bhattacharyya, T., Ray, S. K. and Bhuse, S. R. 2003. "Developing a model on the formation and resllience of naturally degraded black soils of the Peninsular India as a decision support system for better land use planning" NRDMS, DST Project Report, NBSSLUP (ICAR), Nagpur, 144p.

2.18 Soil Series: AESR 6.4

North Sahyadris and Western Karnataka Plateau, hot dry subhumid ESR (K4Cd5)

2.18.1 ACHMATTI SERIES

The Achmatti series is a member of the very fine, smectite, isohyperthermic family of Sodic Haplusterts. Typically, Achmatti soils have very dark grey to dark grey, moderately to strongly alkaline, clay A horizons and very dark grey to dark greyish brown, moderately to strongly alkaline, clay B horizons.
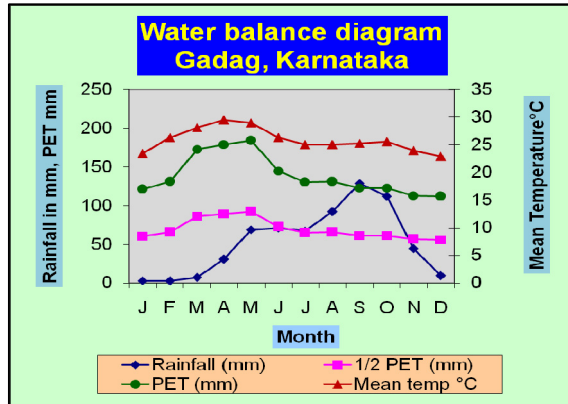
Typifying pedon: Achmatti clay - cultivated

Ap1   0-4 cm --- Dark grey to very dark grey (10YR 3.5/1 D) and very dark grey (10YR 3/1 M) clay; weak fine granular structure; slightly hard, friable, sticky and plastic; common very fine and medium roots; 2 per cent irregularly rounded lime nodules of 2 to 10 mm size; strongly effervescent; moderately alkaline (pH 8.3); clear smooth boundary.

Ap2   4-22 cm --- Very dark grey (10YR 3/1 M) clay; moderate medium subangular blocky and granular structure; firm, sticky and plastic; few medium roots inside peds; few very fine discontinuous vertical simple tubular imped pores; cracks 30 mm wide; 5 per cent irregularly rounded lime nodules of 2 to 10 mm size; strongly effervescent; strongly alkaline (pH 8.6); clear smooth boundary.

Bss1   22-54 cm --- Very dark grey (10YR 3/1 M) clay; intersecting slickensiedes breaking into strong coarse angular blocky structure; firm, sticky and plastic; few very fine roots inside peds; common very fine discontinuous vertical simple tubular impeded pores; cracks 10 to 15 mm wide; few 1 to 3 mm rounded manganese nodules and few lime nodules of 2 to 5 mm size; strongly effervescent; strongly alkaline (pH 8.7); gradual smooth boundary.

Bss2   54-87 cm --- Very dark grey (10YR 3/1 M about 60 per cent) and dark grayish brown (10YR 4/2 M about 40 per cent) clay; strong coarse angular blocky structure with prominent intersecting slickensides forming sphenoids; very firm, very sticky and very plastic; few very fine roots inside peds; few very fine discontinuous vertical simple tubular imped pores; cracks 10 mm wide; few lime nodules of 2 mm size; strongly effervescent; strongly alkaline (pH 8.8); gradual irregular boundary.

Bss3   87-152 cm --- Dark greyish brown (10YR 4/2 M about 70 per cent) and dark grey (10YR 4/1 M about 30 per cent) clay; strong coarse angular blocky structure with prominent intersecting slickensides forming sphenoids; firm, sticky and plastic; few very fine roots; few very fine discontinuous vertical simple open tubular pores; cracks less than 10 mm wide; 7 per cent lime nodules of 10 to 20 mm size; violently effervescent; strongly alkaline(pH 8.9); gradual irregular boundary.

Bss4   152-170 cm --- Very dark grey (10YR 3/1 m) clay; weak coarse angular blocky structure with few slickensides forming sphenoids; firm, sticky and plastic; cracks less than 10 mm wide; 10 per cent lime and manganese nodules of 1 to 5 mm size; violently effervescent; moderately alkaline (pH 8.4)

Micromorphology: The strong coarse angular blocky structure is due to high swelling and shrinking of the smectitic clays. The orientation of clay domains is due to vertic properties of the soil. In the zone studied (100 to 115 cm) sesquioxides are accumulating or have been accumulated, mainly manganese as neomangans, mangans and small irregular manganese accumulations in the groundmass. Many of the large carbonate nodules have an accumulation of manganese in the outer layer.

Type location: 15º39' N, 75º20' E; village Gobbargumpi, tehsil Navalgund, district Dharwad Karnataka.

Range in characteristics: The A horixon is 20 to 25 cm thick, Its colour is in hue 10YR, value 3 to 4 and chroma 1 to 1.5. Its texture is clay. The B horizon is 60 to 80 cm thick. Its colour is similar to that of the A horizon. It has prominent intersecting slickensides and well developed sphenoids. The BC horizon is 80 to 100 cm thick. Its colour is in hue 10YR, value 3 to 4 and chroma 1 to 2. It is clayey in texture and has 7 to 10 per cent lime nodules. 20 to 50 mm wide cracks extend deep into the profile.

Competing series and their differentiae: The competing series is Hirekumbi series, a Typic Haplustert, which has distinct pale yellowish brown mottles below 60 cm depth.

Geographic setting: Achmatti soils are formed in mixed alluvium on very gently sloping basin at an elevation of about 600 m above MSL. The climate is semiarid tropical* with mean annual air temperature of 25.7ºC and mean annual rainfall of 660 mm. The estimated MAST is 29.2ºC. The difference between MSST and MWST is 0.8ºC.

Geographically associated soils: Achmatti soils are associated with Hirekumbi and Hanchinal series which are Typic Haplusterts.

Drainage and permeability: Imperfectly drained with slow permeability.

Use and vegetation: Cultivated to cotton, sorghum, safflower and wheat under rainfed conditions; natural vegetation – *Acacia spp.* (babul), *Azadirachta indica* (neem) and *Prosopis spp.* (mesquite).

Distribution and extent: Extensive in Dharwad district of Karnataka.

Series proposed: State Soil Survey Organization, Department of Agriculture, Karnataka.

Interpretation: Soil of Achmatti series are highly clayey and pose problems due to cracking, slow permeability and sodic subsoil. The soils are susceptible to erosion. They are suitable for crops like sorghum, cotton, safflower and wheat. They are not suited for paddy. The soils are not recommended for perennial irrigation due to sodic condition in the subsoil.

a) Interpretative grouping:
    i)   Land capability subclass   IIIs
    ii) Irrigability subclass   4d
    iii) Productivity potential   Medium to high

Although, the description of the AESR indicates SHd bioclimatic system however this particular benchmark site represents SAd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

b) Yield: Based on data from demonstrations conducted on farmers' fields

Crop	Farmers' practices		Improved practices
	Rainfed	Irrigated	Irrigated
	<----------------------Yield, Mg ha^{-1}------------------------>		
Hybrid sorghum	2.0	3.0	5.0
Bengal gram	0.7	1.0	2.5
Safflower	0.7	1.2	2.3
Maize	1.2	2.6	4.0
Cotton	-	1.5	2.7
Wheat	0.7	1.5	2.2

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								Coarse frag-ments > 2 mm % of whole soil
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
		<--- % of < 2 mm --->								
Ap1	0-4	23.5	21.9	54.6	3.5	3.8	4.8	7.0	4.4	12
Ap2	4-22	22.3	19.1	58.6	2.8	3.4	5.0	7.6	3.5	12
Bss1	22-54	13.2	18.8	68.0	2.5	2.3	2.4	3.5	2.5	5
Bss2	54-87	9.8	20.7	69.5	1.4	1.7	1.8	2.6	2.3	8
Bss3	87-152	9.8	20.1	70.1	1.7	1.6	1.7	2.6	2.2	13
Bss4	152-170	10.0	19.7	70.3	1.5	2.0	1.7	2.6	2.2	9

Depth (cm)	Organic Carbon (%)	Carbonate as CaCO$_3$ < 2 mm (%)	pH (1:2.5) H$_2$O	E.C. (1:2.5) H$_2$O (dS m^{-1})	Water retention		Micronutrients			
					33 kPa	1500 kPa	D T P A extractable			
							Zn	Cu	Mn	Fe
							<--------------- ppm ------------>			
0-4	1.25	16.2	8.3	0.2	33.8	13.6	0.21	1.08	13	8
4-22	1.21	13.6	8.6	0.2	35.1	14.6	0.16	1.02	6	6
22-54	1.27	12.8	8.7	1.1	35.7	17.2	0.15	1.77	6	5
54-87	0.78	15.2	8.8	0.4	35.9	17.3	0.24	2.22	6	4
87-152	0.71	15.0	8.9	0.5	36.0	17.5	0.27	2.08	4	3
152-170	0.48	13.7	8.4	3.3	36.1	17.4				

Depth (cm)	Extractable bases					CEC (NaOAc pH 8.2)	Exchan-geable sodium (%)	Base saturation (NaOAc) (%)	Ratio to clay		ESP
	Ca	Mg	Na	K	Sum				CEC (NaOAc)	1500 kPa water	
	<------------------------ cmol (p+)kg^{-1} ---------------------->										
0-4	48.5	12.6	2.4	1.1	64.6	59.4	4	109	1.09	0.25	4.0
4-22	47.7	14.3	4.2	0.7	66.9	60.5	7	111	1.03	0.25	6.9
22-54	46.3	22.1	10.0	0.7	79.1	71.5	14	111	1.05	0.25	14.0
54-87	37.7	24.5	11.3	0.7	74.2	67.4	17	110	0.97	0.25	16.9
87-152	36.3	25.2	13.1	0.7	75.3	66.1	20	114	0.94	0.25	19.8
152-170	37.6	27.9	18.3	0.9	84.7	66.7	27	127	0.95	0.25	27.4

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.18.2 NIMONE SERIES

The Nimone series is a member of the fine, smectitic, isohyperthermic family of Typic Haplusterts. Typically, Nimone soils have dark greyish brown to very dark greyish brown, moderately alkaline, clay A horizons; dark greyish brown to very dark brown, moderately to strongly alkaline, clay B horizons, and dark yellowish brown, strongly alkaline, gravelly clay C horizons.

Water balance diagram Pune, M. S.
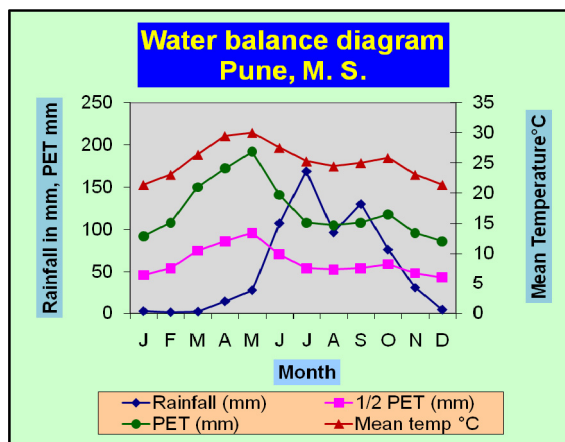
Typifying pedon: Nimone clay - cultivated

Ap	0-18 cm --- Dark greyish brown (10YR 4/2 D) and very dark greyish brown (10YR 3/2 M) clay; moderate medium subangular blocky structure; hard, friable, sticky and plastic; many fine roots; few fine to medium irregularly rounded lime nodules; strongly effervescent; moderately alkaline (pH 8.1); diffuse smooth boundary.
Bss1	18-46 cm --- Dark greyish brown (10YR 4/2 D) and very dark brown (10YR 2/2 M) clay; coarse closely intersecting slickensides breaking into strong medium subangular blocky peds with shiny pressure faces; hard, firm, sticky and plastic; many fine and medium roots; few medium irregularly rounded lime nodules; strongly effervescent; moderately alkaline (pH 8.2); diffuse smooth boundary .
Bss2	46- 76 cm --- Dark greyish brown (10YR 4/2 D) and very dark brown (10YR 2/2 M) clay; few medium dark grey (10YR 4/1) and black (10YR 2/1) mottles; coarse intersecting slickensides forming parallelepipeds with 20 to 25 cm long axes tilted at about 45° from horizontal breaking into strong coarse angular blocky peds with shiny pressure faces; very hard, firm, sticky and plastic; few medium roots; strongly effervescent; moderately alkaline (pH 8.4); diffuse smooth boundary.
Bss3	76-125 cm --- Dark greyish brown (10YR 4/2 D) and very dark brown (10YR 2/2 M) gravelly clay; few coarse grey (10YR 5/1) and very dark grey (10YR 3/1) disseminated mottles; coarse intersecting slickensides forming parallelepipeds with 40 to 45 cm long axes tilted at about 45° from horizontal breaking into strong coarse angular blocky peds with shiny pressure faces; very hard, firm, sticky and plastic; many medium to coarse irregularly rounded lime nodules; violently effervescent; strongly alkaline (pH 8.5); clear wavy boundary.
Ck	125-139 cm --- Dark yellowish brown (10YR 3/4 M) gravelly clay; massive; firm, sticky and plastic; many medium and coarse lime nodules; violently effervescent; many gravels and pebbles; strongly alkaline (pH 8.6).

Type location: 18°42' N, 74°24' E; village Nimone, tehsil Sirur, district Pune, Maharashtra.

Range in characteristics: The thickness of the solum ranges from 100 to 140 cm. The content of coarse fragments ranges from 5 to 25 per cent and CaCO$_3$ ranges from 3 to 10 per cent. The contents of clay in the series control section ranges from 50 to 60 per cent. Due to differential impedence to internal drainage there are coarse to medium, disseminated mottles of dark grey (10YR 4/1), very dark grey (10YR 3/1) and black (N 2/0) colours in Bss2 and Bss3 horizons.

The colour of the A horizon ranges from dark greyish brown (10YR 4/2) to very dark greyish brown (10YR 3/2) for dry and moist soils, and the colour in the B horizon ranges from

dark greyish brown (10YR 4/2) to very dark brown (10YR 2/2) for dry and moist soils. The colour of the C horizon ranges from brownish yellow (10YR 6/6) to yellowish brown (10YR 5/4) for dry soils and dark yellowish brown (10YR 3/4, 4/4) for moist soils. The surface cracks appear in the later part of the winter season and remain open till the onset of monsoon. Cracks 60 cm deep and 20 to 30 mm wide remain open for approximately 150 days in most of the years. Gilgai relief appears during dry period usually with the frequencies of linear distances measuring 0.50 to 0.75 metre between micro high and micro low.

Competing series and their differentiae: The competing soils are those of Umbraj series which are very deep and poorly drained soils. The content of clay within the series control section of Umbraj soils is relatively less than Nimone soils. The Umbraj soils belong to Udic Haplusterts.

Geographic setting: Nimone soils are formed in alluvium and colluvium and occur on level to gently sloping piedmont plain at an elevation of 550 m above MSL. The climate is semiarid tropical* with mean annual air temperature of 25.5°C and mean annual rainfall of 650 mm. The estimated MAST is 27.5°C. The difference between MSST and MWST is less than 5°C.

Geographically associated soils: Nimone soils are associated with Umbraj, Dholwad, and Annapur soils. The Umbraj soils belong to Udic Haplusterts, Dholwad to Vertic Ustropepts and Annapur to Fluventic Ustropepts.

Drainage and permeability: Imperfectly drained with slow to very slow permeability.

Use and vegetation: These soils are mostly cultivated. At places there may be patches of culturable wasteland with isolated stand of *Acacia arabica* (babul) and needle grasses.

Distribution and Extent: Extensive in lower piedmont slope merging with flood plain along the leeward side of Sahyadri in Maharashtra.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur.

Interpretation: The Nimone soils are fine textured with high shrink-swell potential. They are prone to develop salinity and sodicity even when irrigated with water low in soluble salts. During monsoon, crops may be adversely affected due to stagnation of water. These soils are also susceptible to erosion, even on gently sloping land. They are productive with proper management and drainage under both rainfed and irrigated agriculture.

a) Interpretative grouping:
i)	Land capability subclass	IIs
ii)	Irrigability subclass	3d
iii)	Productivity potential	Medium to high

b) Yield: Based on data from farmers' fields

Crop	Farmers' practices	Improved practices
	←----------------Yield, Mg ha^{-1}--------------→	
Cotton	0.6	1.2
Chickpea	0.7	1.3
Safflower	0.6	1.1
Sorghum	0.5	1.5
Groundnut	0.5	1.0
Pigeonpea	0.5	0.8

Although, the description of the AESR indicates SHd bioclimatic system however this particular benchmark site represents SAd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)				Coarse fragments > 2 mm % of whole soil
		Coarse sand (2-0.02)	Fine sand (2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	
		<------------------------- % of < 2 mm ----------------------->				
Ap	0-18	10.3	21.2	14.3	54.2	9
Bss1	18-46	10.0	22.0	13.0	55.0	6
Bss2	46-76	10.4	21.5	12.3	55.8	9
Bss3	76-125	10.1	18.1	12.7	59.1	20
Ck	125-139	22.4	21.7	10.6	45.3	30

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})	Bulk density (Mg m^{-3})	COLE
0-18	0.6	3.0	8.1	0.3	1.6	0.10
18-46	0.3	8.1	8.2	0.3	1.6	0.11
46-76	0.5	9.5	8.4	0.4	1.6	0.11
76-125	0.4	10.2	8.5	0.5	1.6	0.11
125-139	0.4	13.1	8.6	0.6	1.6	0.12

Depth (cm)	Extractable bases		CEC NH$_4$OAc
	Ca	Mg	
	<---------------- cmol (p+)kg^{-1} ---------------->		
0-18	42.5	7.4	56.9
18-46	38.0	8.2	56.4
46-76	38.0	7.5	59.8
76-125	33.0	8.1	56.1
125-139	21.3	8.9	35.0

Note: The soil texture is based on International particle size classification.

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.19 Soil Series: AESR 7.1

South Telangana Plateau (Rayalseema) and Eastern Ghat, hot dry semi-arid ESR with deep loamy to clayey mixed Red and Black soils, medium AWC and LGP 90-120 days (K6Dd3)

2.19.1 RAYADURG SERIES

The Rayadurg series is a member of the loamy-skeletal, mixed (calcareous), isohyperthermic family of Ustic Haplargids. Typically, Rayadurg soils have weak red, moderately alkaline, gravelly loam A horizons; dark reddish brown, moderately alkaline, gravelly loam to gravelly clay loam B horizons underlained by weathered slate, Cr horizon.
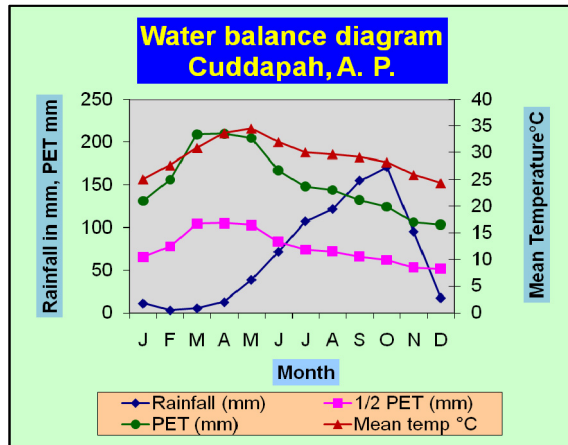
Typifying pedon: Rayadurg gravelly loam-cultivated.

Ap   0 – 12 cm -- Weak red (5YR 3/4 D) gravelly loam; weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; 25 per cent fine quartz gravel; many very fine roots; strong effervescence with dilute HCl; moderately alkaline (pH 8.7); abrupt smooth boundary.

Bt   12 – 35 cm -- Dark reddish brown (2.5YR 2.5/4 M) gravelly clay loam; weak medium subangular blocky structure; friable, sticky and plastic; patchy thin clay cutans; 35 per cent fine quartz gravel; common very fine roots; strong effervescence with dilute HCl.; moderately alkaline (pH 8.8); clear smooth boundary.

BC   35 – 64 cm -- Dark reddish brown (2.5YR 3/4 M) gravelly loam; weak medium subangular blocky structure; slightly sticky and slightly plastic; 50 per cent fine and coarse quartz gravel; common very fine roots; violent effervescence with dilute HCl; moderately alkaline (pH 8.6); clear smooth boundary.

Cr   64 cm -- Weathered slate.

Type location: 15°7' N, 78°57' E; Village P. Reddypalle, Tehsil Badvel, District Cuddapah, Andhra Pradesh.

Geographic setting: Rayadurg soils are formed in Pre-Cambrian slate and colluvium,   occur on 3 to 8 percent slope at an elevation of 200 m above MSL. The climate is semi-arid with mean annual air temperature of 29.2°C and mean annual rainfall of 740 mm. The estimated MAST is 32.7°C, MSST 34.6°C and MWST 29.4°C. The difference between MSST and MWST is 5.1°C.

Geographically associated soils: Clayey skeletal, mixed, Ustic Paleargids; Fine, mixed, Ustic Haplargids; Loamy-skeletal, mixed, Lithic Ustic,Torriorthents; Clayey-skeletal, mixed, Haplocambids.

Drainage and permeability: Somewhat excessively drained with moderate permeability.

Land use and vegetation: Bajra, tur and other millets.

Distribution and Extent: Extensive (135342 ha) in Anantpur (98697 ha), Cuddapah (32192 ha) and Kurnool (4453 ha) districts.

Interpretation: These are medium deep and loamy in texture. High subsoil gravelliness, moderate slopes, moderate erosion, low nutrient status and aridity are the major constraints for crop husbandry.

a) **Interpretative groupings:**

Land capability sub-class	: IVes
Land irrigability sub-class	: 3st
Length of growing period	: < 90 days
Productivity potential	: Low to medium

b) **Yield**: Based on data from farmers' fields:

Crops	Yield (q/ha)	
	Farmers' practices	Improved practices
Bajra	5.75	25
Cotton	1.89	11
Groundnut	3.72	18
Jowar	6.80	35
Red gram	4.20	18
Rice	21.27	60
Tobacco	5.69	14

c) **Land suitability for crops:**

Crops	Bajra	Sorghum	Rice	Red gram	Cotton	Tobacco
Suitability class	S3cz	S3cz	N	S3cz	N	N

Soil datasets:

Depth (cm)	Horizon	Particle-size distribution (%)			pH		OC (%)
		Sand (2-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)	Water (1:2.5)	KCl (1:2.5)	
		<--------------------(USDA)---------------------->					
0-12	Ap	39.2	39.6	21.2	8.7	7.7	0.49
12-35	Bt	29.9	38.3	31.8	8.8	7.7	0.55
35-64	BC	34.2	43.9	21.9	8.6	7.8	0.34

Source: Reddy, R. S., Budihal, S. L., Ramesh Kumar, S. C. and Naidu, L. G. K. (2005). Benchmark Soils of Andhra Pradesh. NBSS Publ. No.128, NBSS&LUP, Nagpur, 143p.

2.19.2 KURNOOL SERIES

The Kurnool series is a member of the fine, smectitic (calcareous), isohyperthermic, family of Vertic Haplustepts. Typically, Kurnool soils have very dark greyish brown, very strongly alkaline, clayey A horizons; dark brown to dark yellowish brown, very strongly alkaline, clayey B horizons.

Water balance diagram Kurnool, A. P.
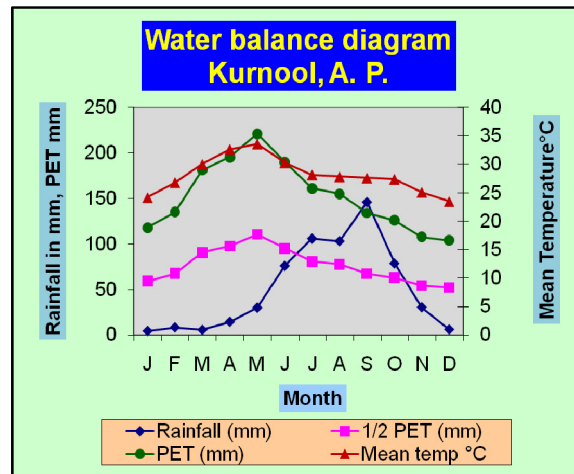
Typifying pedon: Kurnool clay-cultivated.

Ap   0–18 cm -- Very dark grayish brown (10YR 3/2 M) clay; strong medium subangular blocky structure; friable, very sticky and plastic; many very fine roots; violent effervescence with dilute HCl; very strongly alkaline (pH 9.1); clear smooth boundary.

Bw1 18–50 cm -- Dark brown (10YR 3/3 M) clay; moderate medium subangular blocky structure; firm, very sticky and very plastic; few very fine roots; violent effervescence with dilute HCl.; pressure faces; very strongly alkaline (pH 9.8); abrupt smooth boundary.

Bw2 50–79 cm -- Dark brown (10YR 3/3 M) clay; moderate medium subangular blocky structure; very firm, sticky and very plastic; non-intersecting slickensides; few very fine roots; violent effervescence with dilute HCl; very strongly alkaline (pH 9.6); gradual wavy boundary.

Bw3 79–109 cm -- Dark brown (10YR 3/3 M) clay; moderate medium subangular blocky structure; very firm, very sticky and very plastic; few very fine roots; violent effervescence with dilute HCl.; very strongly alkaline (pH 9.6); gradual wavy boundary.

Bw4 109–151 cm -- Dark yellowish brown (10YR 3/4 M) clay; strong medium subangular blocky structure; very firm, very sticky and very plastic; non-intersecting slickensides; violent effervescence with dilute HCl; very strongly alkaline (pH 9.5).

Type location: 15°19' N 78°9' E; Village Patapadu; Tehsil Banaganapalli; District Kurnool, Andhra Pradesh.

Geographic setting: Kurnool soils are formed in the Precambrian alluvio-colluvium of limestone;   occur on 0-1 per cent slope; at an elevation of 254 m above MSL. The climate is semi-arid with mean annual air temperature of 28.1°C and mean annual rainfall of 740 mm. The estimated MAST is 31.6°C, MSST 33.5°C and MWST 28.5°C. The difference between MSST and MWST is 5.0°C.

Geographically associated soils: These are fine, smectitic, (calc.) Typic Haplusterts, very fine, smectitic, (calc.) Leptic Haplusterts, fine, smectitic, (calc.) Chromic Haplusterts, fine, mixed, (calc.) Typic Haplustepts, fine, mixed, Typic Haplustepts, fine, smectitic, Vertic Haplustepts, very fine, smectitic, (calc.) Chromic Haplusterts, very fine, smectitic, (calc.) Typic Haplusterts, very fine, smectitic, Typic Haplusterts, very fine, smectitic, (calc.) Vertic Haplustepts.

Drainage and permeability: Moderately well drained with moderate permeability.

Land use and vegetation: Paddy, Acacia, neem, *Thangadi*.

Distribution and Extent: Extensive (2034944 ha) in the district of Kurnool (351264 ha), Cuddapah (167554 ha), Mahbubnagar (150465 ha), Krishna (140354 ha), Guntur (136937 ha), Medak (129352 ha), Warangal (114838 ha), Nellore (101840 ha), Karimnagar (97980 ha), Prakasam (96336 ha), West Godavari (85020 ha), Adilabad (81513 ha), Nalgonda (66647 ha) East Godavari (66253 ha), Nizamabad (57805 ha), Khammam (39578 ha), Chittoor (36372 ha), Rangareddi (35380 ha), Anantapur (33697 ha), Vizianagaram (24085 ha), Srikakulam (16412 ha), Visakhapatnam (4918 ha) and Yanam (344 ha).

Interpretation: These are very deep cracking clay soils. Low permeability, high shrink-swell potential, poor workability, high lime content, suboptimum oxygen availability, salinity and sodicity are the major constraints for crop production.

a) **Interpretative groupings:**
        Land capability sub-class : IIIws
        Land irrigability sub-class : 3ds
        Length of growing period : 150 – 210 days
        Productivity potential   : High to medium

b) **Yield:** Based on data from farmers' fields:

Crops	Yield (q/ha)	
	Farmers' practices	Improved practices
Bajra	18.43	25
Cotton	2.93	11
Groundnut	22.35	18
Jowar	10.29	35
Red gram	4.35	18
Rice	30.69	60

c) **Land suitability for crops:**

Crops	Rice	Sorghum	Cotton	Red gram	Groundnut
Suitability class	S2z	S3z	S3z	S3tz	S3tz

Soil datasets:

Horizon	Depth (cm)	Particle-size distribution (%)			Tex-ture	pH Water (1:2.5)	OC (%)	CaCO$_3$ (%)	ECe (1:2.5) dSm^{-1}
		Sand (2-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)					
		<---------------------------(USDA)--------------------------->							
Ap	0-18	32.1	26.2	41.7	c	9.1	0.78	16	0.0
Bw1	18-50	17.3	28.0	54.7	c	9.8	0.37	20	0.0
Bss1	50-79	14.1	27.0	58.9	c	9.6	0.32	18	0.0
Bss2	79-109	12.2	28.2	59.6	c	9.6	0.16	17	1.9
Bss3	109-151	11.6	26.3	62.1	c	9.5	0.23	16	2.2

Depth (cm)	Na	ESP*
0-18	11.3	23
18-50	18.4	37
50-79	16.4	33
79-109	16.4	33
109-151	15.4	31

*Assuming soil CEC ~50

Source: Reddy, R. S., Budihal, S. L., Ramesh Kumar, S. C. and Naidu, L. G. K. (2005). Benchmark Soils of Andhra Pradesh. NBSS Publ. No.128, NBSS&LUP, Nagpur, 143p.

2.20 Soil Series: AESR 7.2

North Telangana Plateau, hot moist semi-arid ESR with deep loamy and clayey mixed Red and Black soils, medium to very high AWC and LGP 120-150 days (K6Dm4)

2.20.1 KASIREDDIPALLI SERIES

The Kasireddipalli series is a member of the fine, smectitic, isohyperthermic family of Sodic Haplusterts. Typically, Kasireddipalli soils have dark grayish brown to very dark grayish brown, mildly alkaline, clay A horizons; very dark gray to very dark grayish brown, mildly to moderately alkaline, clay B horizons.
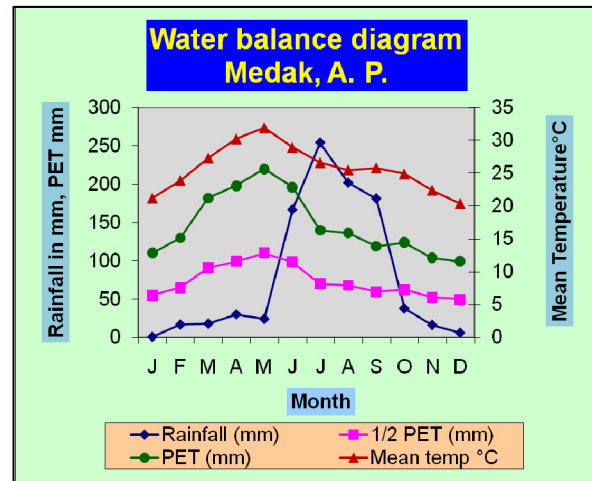
Typifying pedon: Kasireddipalli clay – cultivated

Ap   0-12 cm -- Dark grayish brown (10YR 4/2D) and dark grayish brown to very dark grayish brown (10YR 3.5/2M) clay; moderate medium subangular blocky structure; very hard, friable, sticky and plastic; many very fine and fine, few medium roots; many very fine, few fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); slightly effervescent; clear smooth boundary.

Bw   12-30 cm -- Very dark grayish brown (10YR 3/2M) clay; strong medium subangular blocky structure with shiny pressure faces on surface of peds; friable, sticky and plastic; many very fine and few fine roots; many very fine, few fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); slightly effervescent; clear wavy boundary.

Bss1 30-59 cm -- Very dark grayish brown (10YR 3/2M) clay; strong medium angular blocky structure with wedge shaped aggregates and slickensides that break into small angular peds; slightly firm, sticky and plastic; many very fine and few fine roots; very fine many, fine and medium common lime nodules; many very fine and fine pores; moderately alkaline (pH 8.1); slightly to strongly effervescent; gradual smooth boundary.

Bss2 59-101 cm -- Very dark gray to very dark grayish brown (10YR 3/1.5M) clay; strong coarse angular blocky structure with well developed wedge shaped aggregates and slickensides that break into well developed angular peds; firm, sticky and plastic; many very fine roots; many very fine, few fine and medium lime nodules; many very fine and fine pores; moderately alkaline (pH 8.5); strongly effervescent; gradual smooth boundary.

Bss3 101-130 cm -- Very dark gray and very dark grayish brown (2.5Y 3/1.5M), olive brown (2.5Y 4/3M) dark grayish brown to olive brown (2.5Y 4/2.5R) clay; strong coarse angular

blocky structure with well developed wedge shaped aggregates and slickensides that break into well developed angular peds; firm, sticky and plastic; common very fine roots; common very fine, medium and coarse lime nodules; few fine iron and manganese concretions; moderately alkaline (pH 8.5); strongly effervescent; clear smooth boundary.

BCk   130-160+ cm -- Light olive brown (2.5Y 5/4M&R) clay; moderate medium subangular blocky structure; slightly firm, sticky and plastic; very fine few roots; few very fine and fine, many medium and coarse lime nodules; 20-25% fine and coarse gravels; moderately alkaline (pH 8.2); strongly to violently effervescent.

Type location: $17^o30'28"$N Longitude $78^o15'49"$E; ICRISAT Farm BW4C, Patancheru, Ramchandrapuram, Medak, Andhra Pradesh.

Geographic setting: Kasireddipalli soils are formed in alluvium of Deccan plateau – boarder of granite and granite-gneiss and basalt on very gently sloping and undulating land, 1-3% (50-150 m). The climate is semiarid tropical* with mean annual air temperature of 25.8^oC and mean annual rainfall of 760 mm. The estimated MAST is 27.8^oC. The difference between MSST and MWST is 3.3^oC.

Drainage and permeability: Moderately well drained

Use and vegetation: Cultivated to chickpea; natural vegetation – *Prosopis juliflora*

Distribution and extent: Extensive (86,306 ha) in Medak district, Andhra Pradesh.

Series Proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore.

Interpretation: The soils occupy lower position and hence pose problems of drainage. The subsoils have tendency to become sodic. Crops like sorghum, chickpea, pigeonpea and safflower can be raised under rainfed conditions.

Interpretative grouping:
    i)   Land capability subclass   IIIs
    ii) Irrigability subclass   3s
    iii) Productivity potential   Medium

Although, the description of the AESR indicates SAm bioclimatic system however this particular benchmark site represents SAd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Soil datasets:

Hori-zon	Depth (cm)	Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Fine clay (%)	Fine clay/ total clay (%)	BD Mg/m^3	COLE	HC* cm/hr	WDC (%)
		Size class and particle diameter (mm)								
		Total								
		←----------(% of <2 mm) ----------→								
Ap	0-12	22.5	29.6	47.9	26.4	55.1	–	0.26	0.7	6.3
Bw1	12--30	18.7	29.8	51.5	29.7	57.7	1.6	0.24	0.6	10.0
Bss1	30-59	17.9	29.6	52.5	32.5	61.9	1.6	0.20	0.6	11.6
Bss2	59-101	16.6	27.8	55.6	36.4	65.5	1.6	0.24	0.2	12.0
Bss3	101-130	7.2	33.4	59.4	30.8	51.8	–	0.25	0.2	15.0
BCK	130-160	13.0	29.1	57.9	38.7	66.8	1.7	0.23	0.1	11.3

* 4 mm hr^{-1} is the HC (WM) in 0-100 cm depth of soil.

Depth (cm)	Moisture retention%							AWC
	33kPa	100kPa	300kPa	500kPa	800kPa	1000kPa	1500kPa	
0-12	36.3	27.4	22.6	20.2	19.9	19.7	18.2	18.2
12--30	36.4	29.1	23.4	23.3	23.1	20.5	17.0	19.4
30-59	38.5	32.3	25.1	25.0	24.9	21.2	20.1	18.4
59-101	47.4	36.4	27.3	26.1	24.9	22.8	22.8	24.6
101-130	49.3	39.2	29.6	28.6	27.2	26.0	21.9	27.4
130-160	47.7	36.2	29.6	28.6	25.2	24.4	24.4	23.3

Depth (cm)	pH water (1:2)	CaCO$_3$ (%)	OC (%)	Ca	Mg	Na	K	Sum	CEC	Clay CEC cmol(p+)kg^{-1}	B.S. (%)
				Extractable bases							
				←--------------------cmol(p+)/kg^{-1}--------------------→							
0-12	7.8	5.9	0.63	34.2	10.7	0.9	0.4	46.2	48.7	99	95
12--30	7.8	6.2	0.40	34.9	12.7	1.9	0.3	49.8	52.1	101	95
30-59	8.1	6.0	0.36	29.3	14.0	3.7	0.3	47.3	52.2	99	90
59-101	8.5	6.4	0.36	26.2	14.4	6.8	0.3	47.7	53.5	96	89
101-130	8.5	6.5	0.36	35.8	11.5	8.6	0.5	56.4	57.8	97	90
130-160	8.2	9.1	0.13	25.1	16.2	11.1	0.5	48.9	49.5	85	98

Depth (cm)	Exch. Ca/Mg	ECP	EMP	ESP	CO$_3$ clay (%)	CO$_3$ clay (feb) (%)
0-12	3.2	70	22	2.0	3.4	1.6
12--30	2.8	67	24	4.0	3.1	1.6
30-59	2.1	56	27	7.1	2.9	1.5
59-101	1.8	49	27	13.0	3.3	1.8
101-130	3.1	62	20	14.8	3.2	1.9
130-160	1.5	51	33	22.4	3.4	1.9

Depth (cm)	Sat %	ECe	Ca	Mg	Na	K	Sum	CO$_3$	HCO$_3$	Cl	SO$_4$	Sum	RSC	SAR
	Soluble cations (meq/l)							Soluble anions (meq/l)						
0-12	56.0	0.3	1.23	0.9	1.8	0.03	3.9	-	1.3	2.0	-	3.3	-0.83	1.1
12--30	57.6	0.3	0.87	0.7	2.7	0.07	4.3	-	2.2	2.2	-	4.4	-0.63	3.0
30-59	60.2	0.4	0.21	0.3	4.8	0.05	5.3	-	2.4	2.8	-	5.2	1.89	9.5
59-101	69.2	0.4	0.54	0.2	8.1	0.04	8.9	0.4	6.7	1.3	-	8.4	6.36	13.4
101-130	79.6	0.8	0.24	0.3	13.4	0.11	14.0	2.7	8.0	4.0	-	14.7	10.16	14.2
130-160	84.2	2.7	0.99	0.7	20.2	0.11	22.0	1.1	4.2	1.5	15.2	22.0	3.61	22.0

Source: Pal, D.K., Bhattacharyya, T., Ray, S.K. and Bhuse, S.R. 2003. "Developing a model on the formation and resilience of naturally degraded black soils of the Peninsular India as a decision support system for better land use planning" NRDMS, DST Project Report, NBSSLUP (ICAR), Nagpur, 144p.

2.20.2 CHITKUL SERIES

The Chitkul series is a member of the fine, smectitic, isohyperthermic family of Vertic Haplustepts. Typically, the Chitkul soils have dark gray, slightly alkaline, calcareous, clay loam A horizons, and dark brown to very dark grayish brown; slightly to moderately alkaline, clay loam to clay, calcareous B horizons.

Water balance diagram Medak, A. P.
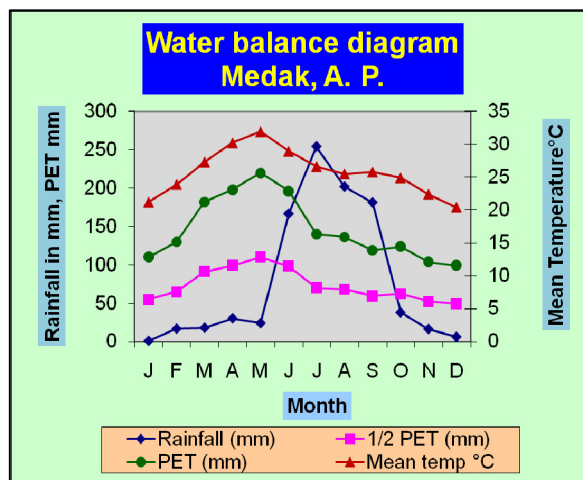
Typifying pedon: Chitkul clay loam – cultivated

Ap   0-20 cm --- Dark gray (10YR 4/1 M) clay loam; moderate coarse subangular blocky structure; friable, sticky and plastic; fine common roots; few fine calcium carbonate and iron nodules; slightly effervescent; slightly alkaline (pH 7.7); gradual smooth boundary.

Bw1   20-40 cm --- Dark brown (10YR 3/3 M) clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; few fine roots; few fine calcium carbonate and iron nodules; slightly effervescent; slightly alkaline (pH 7.7); gradual smooth boundary.

Bw2   40-60 cm --- Dark brown (10YR 3/3 M) clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; few fine roots; few fine calcium carbonate and iron nodules; slightly effervescent; slightly alkaline (pH 7.6); gradual smooth boundary.

Bw3   60-81 cm --- Dark brown (10YR 3/3 M) clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; few very fine roots; pressure faces; few fine calcium carbonate and iron nodules; slightly effervescent; slightly alkaline (pH 7.6); gradual smooth boundary.

Bw4   81-113 cm --- Dark brown (10YR 3/3 M) clay; moderate medium subangular blocky structure; firm, sticky and plastic; few very fine roots; pressure faces; few fine calcium carbonate and iron nodules; slightly effervescent; slightly alkaline (pH 7.8); gradual smooth boundary.

Bw5   113-150 cm --- Very dark grayish brown (10YR 3/2 M) clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; few very fine roots; pressure faces; few fine calcium carbonate and iron nodules; slightly effervescent; moderately alkaline (pH 8.1).

Type location: 18°02′45″ N and 78°08′40″ E; village Chitkul, tehsil Narsapur, district Medak, Andhra Pradesh.

Range in characteristics: The thickness of the solum ranges from 103 to 155 cm. The A horizon is 7 to 24 cm thick. Its colour is in hue of 10YR, value 4 to 3 and chroma 4 to 2. Its texture ranges from clay loam to clay and structure is medium, coarse subangular blocky. The B horizon is 80 to

120 cm thick. Its colour is in hue of 10YR, value 5 to 3, and chroma 3 to 1, slight to violent effervescence with dilute HCl. Its texture is clay loam to clay.

Geographic setting: Chitkul soils are developed over granite-gneiss and occur on nearly level to very gently sloping valleys at an elevation of 440 to 580 m above MSL. The climate is semi arid tropical* with mean annual air temperature of 28.0°C and mean annual rainfall of 890 mm. Estimated MAST is 30.0°C, MSST 28.4°C and MWST 24.1°C. The difference between MSST and MWST is 4.3°C.

Geographically associated soils: These are soils of Chandur (Typic Ustifluvents), Kasireddipalli (Typic Pellusterts), Shakapuram (Typic Ustifluvents) and Tadamanur (Typic Haplusterts). Tadamanur soils have weathered rock (granite-gneiss) within 100 cm depth and are calcareous both in solum and parent material. Chandur and Shankapuram soils are stratified soils. Kasireddipalli soils are calcareous shrink-swell soils.

Drainage and permeability: Moderately well drained with slow permeability.

Land use and vegetation: Mainly cultivated to crops like paddy, sugarcane, sorghum; natural vegetation: *Azadirachta indica* (neem), *Acacia spp.(babul), Butea frondosa* (palas) and *Eucalyptus spp*. (nilgiri).

Distribution and extent: Extensive (86,304 ha) in Dubbak, Narsapur, Ramayampet, Siddipet, Gajwel, Medak and all other divisions except Zaheerabad in Medak district of Andhra Pradesh.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore, 2002.

Interpretation: Imperfectly drained, slow permeability, sub-optimum oxygen availability, high shrink-swell potential, poor workability are the major constraints for normal crop husbandry.

Interpretative grouping

i)	Land capability subclass	IIIws
ii)	Land irrigability subclass	3ds
iii)	Productivity potential	Medium
iv)	Fertility capability class	CCv (Clay surface soil, clay subsoil, Vertic Properties

Although, the description of the AESR indicates SAm bioclimatic system however this particular benchmark site represents SAd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
		<--- % of < 2 mm --->									
Ap	0-20	40.4	21.9	37.7	3.0	10.4	8.5	11.4	6.9	7.4	14.5
Bw1	20-40	41.8	19.2	39.0	3.6	9.9	11.1	10.6	6.6	5.9	13.3
Bw2	40-60	42.1	21.9	36.0	3.7	11.4	9.0	10.7	7.3	8.5	13.4
Bw3	60-81	41.8	18.3	39.9	3.1	10.0	9.3	12.9	6.5	4.3	14.0
Bw4	81-113	39.0	17.9	43.1	2.9	9.9	11.0	9.2	6.0	10.3	7.6
Bw5	113-150	41.4	19.5	39.1	3.5	10.5	8.8	11.0	7.6	5.4	14.1

Depth (cm)	Organic carbon (%)	pH			E.C. Saturation Extract (dS m^{-1})	CaCO$_3$ (%)	Moisture Retention (Sat. %, w/w)
		(1:2.5) Water	(1:5) 0.01 M CaCl$_2$	(1:2.5) 1.0 M KCl			
0-20	1.05	7.7	7.4	7.3	0	2	52.6
20-40	0.31	7.7	7.3	7.0	0	0	43.3
40-60	0.30	7.6	7.3	7.0	0	0	41.9
60-81	0.26	7.6	7.5	7.2	0	0	42.7
81-113	0.24	7.8	7.4	7.1	0	0	43.1
113-150	0.24	8.1	7.5	6.9	0	0	41.1

Depth (cm)	Exchangeable bases					Acidity			CEC			CEC/Clay ratio	Base Saturation (%)	
	Ca	Mg	Na	K	Total	BaCl$_2$-TEA Extract	1.0 N KCl exch. H$^+$	Al^{3+}	NH$_4$OAc (pH 7.0)	Sum of cations[1]	ECEC[2]		CEC 7.0[3]	CEC 8.2[4]
							------------------------ cmol (+) kg^{-1} soil ------------------------							---- (%) -----	
0-20	---	---	0.9	0.4	---	4.8	0.0	0.0	---	---	---	0.67	--	--
20-40	16.2	6.7	0.5	0.2	23.6	5.8	0.0	0.0	23.1	29.4	23.6	0.59	102	80
40-60	15.5	6.6	0.4	0.2	22.7	6.3	0.1	0.0	22.6	29	22.8	0.59	100	78
60-81	17.0	6.2	0.4	0.2	23.8	6.7	0.0	0.0	23.3	30.5	23.8	0.58	102	78
81-113	17.5	5.5	0.5	0.2	23.7	5.7	0.1	0.0	22.6	29.4	23.8	0.52	105	81
113-150	17.2	5.9	0.5	0.2	23.8	5.5	0.0	0.0	21.7	29.3	23.8	0.55	110	81

[1]Summation of total of exchangeable bases plus BaCl$_2$ – TEA extractable acidity
[2]Summation of total exchangeable bases plus 1.0 N KCl exchangeable Al^{3+}
[3][Total exchangeable bases/CEC by NH$_4$OAc] x 100
[4][Total exchangeable bases/CEC by cations] x 100

Sources: 1. Reddy, R.S., Budihal, S.L., Ramesh Kumar, S.C., Naidu, L.G.K. and Krishnan, P. (2005a). Soil Series of Medak District, Andra Pradesh. NBSS Publ. No.127, NBSS&LUP, Nagpur, 102 pp.
2. Reddy, R.S., Naidu, L.G.K., Ramesh Kumar, S.C., Budihal, S.L. and Krishnan, P. (2005b). Land Resources of Medak District, Andra Pradesh for Land Use Planning. NBSS Publ. No.791, NBSS&LUP, Nagpur 401 pp.

2.21 Soil Series: AESR 7.3

Eastern Ghat (South), hot moist semi-arid/dry subhumid ESR with medium to deep, loamy to clayey mixed Red and Black soils, medium AWC and LGP 150-180 days (H6Dm/Cd5)

2.21.1. PEDDAPURAM SERIES

The Peddapuram series is a member of the fine, mixed, subactive, isohyperthermic family of Rhodic Paleustalfs. Typically, the Peddapuram soils have reddish brown to yellowish red, slightly acidic to moderately acidic, loamy sand to sandy loam A horizons, and dark red; slightly to moderately acidic, clayey, B horizons.
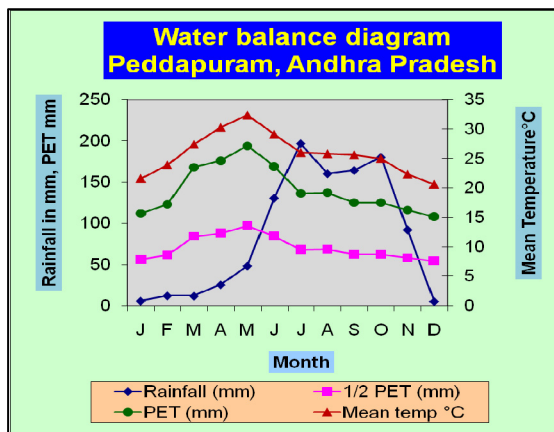
Typifying pedon: Virapelam loamy sand – cultivated.

Ap   0–10 cm -- Reddish brown (5YR 4/3 D) and dark reddish brown (5YR 3/3 M) loamy sand; weak fine granular structure; loose, friable, non sticky and non plastic; many fine roots; slightly acid (pH 6.3); abrupt smooth boundary.

Bw   10–21 cm -- Yellowish red (5YR 4/6 M) sandy loam; weak medium subangular blocky structure; firm, slightly sticky and slightly plastic; few fine roots; moderately acid (pH 5.2); clear smooth boundary.

Bt1   21–49 cm -- Dark red (2.5YR 3/6 M) sandy clay; moderate medium subangular blocky structure; very firm, sticky and plastic; continuous thin clay cutans; very fine common roots; moderately acid (pH 5.3); clear smooth boundary.

Bt2   49– 88 cm -- Dark red (2.5YR 3/6 M) sandy clay; moderate medium subangular blocky structure; very firm, sticky and plastic; continuous thin clay cutans; slightly acid (pH 5.6); clear smooth boundary.

Bt3   88–112cm -- Dark red (2.5YR 3/6 M) clay; moderate medium subangular blocky structure; very firm, very sticky and very plastic; continuous thin clay cutans; slightly acid (pH 5.6); clear smooth boundary.

Bt4   112–150 cm -- Dark red (2.5YR 3/6 M) clay; moderate medium subangular blocky structure; very firm, very sticky and very plastic; continuous thin clay cutans; slightly acid (pH 5.9).

Type location: 16°56' N 81°8' E; Village: Virapelam; Tehsil: Chintalapalli, District: West Godavari; Andhra Pradesh.

Geographical setting: Peddapuram soils are formed over sandstone on gently sloping land (1-3 per cent slopes) at an elevation of 100 m above MSL The climate is humid* with mean annual air temperature of 25.8°C and mean annual rainfall of 1300 mm. Estimated MAST is 27.8°C, MSST 31.6°C and MWST 26.0°C. The difference between MSST and MWST is 5.6°C.

Geographically associated soils: These are clayey-skeletal, mixed, Typic Rhodustalfs, fine, mixed, Typic Ustorthents, fine-loamy, mixed, Typic Haplustepts, fine, mixed, Typic Haplustepts, fine, mixed, Typic Rhodustalfs, fine-loamy, mixed, Typic Haplustalfs, clayey-skeletal, mixed, Typic Paleustalfs.

Drainage and permeability: Well drained with moderate permeability.

Land use and vegetation: Cashew plantation

Distribution and extent: Extensive (512579 ha) in West Godavari (78467 ha), East Godavari (74536 ha), Vizianagaram (62975 ha), Visakapatnam (53165 ha), Khammam (45912 ha), Guntur (33189 ha), Krishna (28763 ha), Adilabad (27003 ha), Chittoor (25365 ha), Nellore (23610 ha), Srikakulam (18089 ha), Nalgonda (15445 ha), Anantapur (10581 ha), Warangal (8088 ha), Karimnangar (5182 ha), Prakasam (1509 ha) and Mahbubnagar (700 ha)

Interpretation: These are very deep and clayey in texture; have high potential for growing mango, cashew and other horticultural crops.

a) **Interpretative groupings:**

Land capability sub-class	: IIIes
Length of growing period	: 120 – 150 days
Land irrigability sub-class	: 2st
Productivity potential	: Medium

b) **Yield: Based on data from Farmers' fields:**

Crops	Yield (q/ha)	
	Farmers' practices	Improved practices
Black gram	5.76	13
Green gram	3.93	12
Rice	35.15	60
Sugarcane	879.91	1250
Tobacco	14.74	14

c) **Land suitability for crops:**

Crops	Sugarcane	Tobacco	Rice	Green gram	Black gram
Suitability class	S2tn	S2tn	S3tw	S3tn	S2tn

*Although, the description of the AESR indicates Sam/SHd bioclimatic system however this particular benchmark site represents humid climate which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Soil datasets:

Horizon	Depth (cm)	Particle-size distribution (%)			pH		OC (%)	ECe (1:2.5) dSm^{-1}
		Sand (2-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)	Water (1:2.5)	KCl (1:2.5)		
		<----------------------(USDA)---------------------->						
Ap	0-10	85.0	4.8	10.2	6.3	4.9	0.28	0.0
Bw	10-21	76.8	6.7	16.5	5.2	4.2	0.24	0.1
Bt1	21-49	57.7	2.9	39.4	5.3	4.2	0.26	0.1
Bt2	49-88	48.5	1.9	49.6	5.6	4.5	0.26	0.0
Bt3	88-112	41.2	1.4	57.4	5.6	4.5	0.25	0.0
Bt4	112-150	44.8	2.2	53.0	5.9	4.5	0.26	0.0

Depth (cm)	ESP	Exchangeable bases cmol(+) kg^{-1}					Extractable acidity cmol(+) kg^{-1}		
		Ca	Mg	Na	K	Total	BaCl$_2$-TEA	1.0 N KCl	
								H+Al	Al^{3+}
0-10	0.0	0.6	0.3	0.0	0.2	1.1	1.4	0.0	0.0
10-21	3.7	0.5	0.2	0.1	0.2	1.0	2.6	0.2	0.1
21-49	0.0	1.1	0.8	0.0	0.3	2.2	0.0	0.0	0.0
49-88	1.4	1.9	1.0	0.1	0.3	3.3	5.8	0.2	0.1
88-112	1.1	2.3	1.4	0.1	0.3	4.1	5.6	0.1	0.0
112-150	1.3	2.3	1.2	0.1	0.2	3.8	4.7	0.0	0.0

Depth (cm)	Cation exchange capacity cmol(+) kg^{-1}			CEC/Clay ratio	Per cent Base Saturation	
	ECEC	NH$_4$OAc (pH 7.0)	Sum of Cations		CEC (pH 7.0)	CEC (pH 8.2)
0-10	1.1	1.9	2.5	0.18	58	44
10-21	1.2	2.7	3.6	0.16	37	28
21-49	0.0	6.6	0.0	0.17	33	00
49-88	3.5	7.4	9.1	0.15	45	36
88-112	4.2	8.8	9.7	0.15	47	42
112-150	3.8	7.6	8.5	0.16	50	45

Source: Reddy, R. S., Budihal, S. L., Ramesh Kumar, S. C. and Naidu, L. G. K. (2005). Benchmark Soils of Andhra Pradesh. NBSS Publ. No.128, NBSS&LUP, Nagpur, 143p.

2.21.2 NUZVID SERIES

The Nuzvid series is a member of the fine, mixed, semiactive, isohyperthermic Typic Paleustalfs. Nuzvid soils have yellowish red, neutral, loamy sand A horizons, red to dark red, slightly acid, sandy clay loam to sandy clay B horizons.
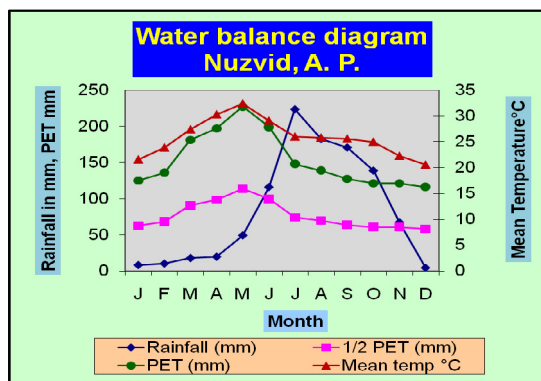
Typifying pedon: Nuzvid loamy sand– cultivated

Ap   0-8 cm --- Yellowish red (5 YR 5/6 M) loamy sand; weak fine granular structure; friable non-sticky and non-plastic; many fine to medium roots; neutral (pH 6.9); abrupt smooth boundary.

Bt1   8-30 cm --- Red (2.5 YR 4/6 M) sandy clay loam; moderate medium subangular blocky structure; friable, slightly sticky and slightly plastic; patchy thin clay cutans; few medium fine roots; slightly acid (pH 6.1); gradual smooth boundary.

Bt2   32-63 cm --- Dark red (2.5 YR 3/6 M) sandy clay; moderate coarse subangular blocky structure; friable, slightly sticky and slightly plastic; patchy clay cutans; few fine to medium roots; slightly acid (pH6.0); gradual smooth boundary.

Bt3   63-150 cm --- Dark red (2.5 YR 3/6 D) sandy clay; moderate medium subangular blocky structure; friable, sticky and plastic; patchy moderately thick clay cutans; slightly acid (pH 5.9).

Type location: $16^o52'7''$N; $80^o50'5''$E. Village: Digavalli; tehsil: Nuzvid; district: Krishna; State: Andhra Pradesh.

Geographical setting: Nuzvid soils are formed on very gently sloping lands (1-3 per cent slopes) at an elevation of 160 to 170 m above MSL. The climate is sub humid with mean annual air temperature of 25.8°C and mean annual rainfall of 1006 mm. Estimated MAST is 27.8°C, MSST 31.6°C and MWST 26.0°C. The difference between MSST and MWST is 5.6^oC.

Geographically associated soils: These are fine, mixed, Typic Ustorthents, fine, mixed, Typic Haplustalfs, fine, mixed, Typic Haplustepts, clayey-skeletal, mixed, Typic Rhodustalfs, clayey-skeletal, mixed, Typic Haplustepts.

Drainage and permeability: Well drained with moderate permeability.

Land use and vegetation: Mango and other horticultural crops

Distribution and extent: Extensive (250161 ha) in the districts of Khammam (54408 ha), srikakulam (41759 ha), Adilabad (36248 ha), Vizianagaram (31797 ha), Warangal (27190), Visakhapatnam (16655 ha), Krishna (15975 ha), Nellore (6764 ha), Kurnool (5883 ha), Guntar (4791 ha), Mahbubnagar (3506 ha), Karimnagar (2475 ha), West Godavari (2277 ha) and Prakasam (433 ha).

Interpretation: These are very deep and clayey in texture and are suitable for growing mango, cashew and other horticultural crops and medicinal and aromatic plants.

a) Interpretative grouping:

Land capability sub-class	:	IIes
Land irrigability sub-class	:	2s
Length of growing period	:	150-180 days
Productivity potential	:	Medium to high

b) Yield: Based on data from farmers′ fields

Crops	Yield (q/ha)	
	Farmers' practices	Improved practices
Green gram	3.93	12
Groundnut	8.96	18
Horse gram	2.43	12
Rice	34.62	60
Sesamum	2.61	6

c) Land suitability for crops:

Crops	Groundnut	Sesamum	Green gram	Rice
Suitablity class	S1/S2n	S2n	S2t	S3tn

Soil datasets:

Depth (cm)	Horizon	Particle size distribution			pH		OC (%)
		Sand (2-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002mm)	Water (1:2.5)	KCl (1:2.5)	
0-8	Ap	85.9	6.8	7.3	6.9	6.2	0.31
8-30	Bt1	63.7	5.7	30.6	6.1	4.9	0.39
30-63	Bt2	58.7	6.0	35.3	6.0	5.0	0.25
63-150	Bt3	49.9	7.5	42.6	5.9	5.0	0.26

Depth (cm)	ESP	Exchangeable bases {cmol(+)kg^{-1}}					Extractable acidity {cmol(+)kg^{-1}}		
		Ca	Mg	Na	K	Total	BaCl$_2$-TEA	1.0 N KCl	
								H+Al	Al^{3+}
0-8	0.0	1.0	1.0	0.0	0.2	2.2	1.4	0.0	0.0
8-30	0.0	2.5	2.7	0.0	0.3	5.5	3.7	0.1	0.0
30-63	0.0	3.5	3.1	0.0	0.3	6.9	4.2	0.0	0.0
63-150	1.0	4.2	3.4	1.0	0.3	8.0	4.5	0.0	0.0

Depth (cm)	Cation Exchange capacity {cmol(+)kg^{-1}}			CEC/clay ratio	Per cent Base Saturation	
	ECEC	NH$_4$OAc (pH 7.0)	Sum of cations		CEC (pH 7.0)	CEC (pH 8.2)
0-8	2.2	02.4	03.6	0.33	92	61
8-30	5.6	07.1	09.2	0.23	77	60
30-63	6.9	08.1	11.1	0.23	85	62
63-150	8.0	10.5	12.5	0.25	76	64

Source: Reddy, R. S., Budihal, S. L., Ramesh Kumar, S. C. and Naidu, L. G. K. (2005) "Benchmark soils of Andhra Pradesh"NBSS Publ. No. 128, NBSS&LUP, Nagpur, pp 143

2.22 Soil Series: AESR 8.1

Tamil Nadu Uplands and Leeward Flanks of South Sahyadris, hot dry semi-arid ESR with moderately deep to deep, loamy to clayey, mixed Red and Black soils, medium AWC and LGP 90-120 days (H6Dd3)

2.22.1 COIMBATORE SERIES

The Coimbatore series is a member of the fine, smectitic, isohyperthermic family of Vertic Haplustepts. Typically, Coimbatore soils have greyish brown to dark greyish brown, strongly alkaline, clay A horizons, and very dark greyish brown, strongly alkaline, clay B horizons over variegated colour calcareous, strongly alkaline, clay C horizons.
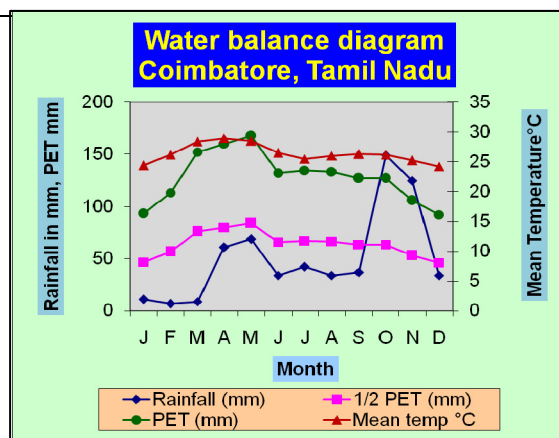
Typifying pedon: Coimbatore clay - cultivated

Ap   0-15 cm --- Dark greyish brown (10YR 4/2 D) and greyish brown (10YR 5/2 M) clay; moderate fine to coarse granular structure; loose, friable, sticky and plastic; few fine roots inside peds; few irregular lime nodules of 2 to 5 mm size; slightly effervescent; strongly alkaline (pH 8.7); clear smooth boundary.

Bw   15-42 cm --- Very dark greyish brown (10YR 3/2 D & M) clay; strong coarse prismatic structure breaking to angular blocky with prominent pressure faces; very hard, firm, very sticky and plastic; few fine roots inside peds; many very fine discontinuous exped pores; few subrounded lime nodules of 2 to 10 mm size; strongly effervescent; few coarse rock fragments; strongly alkaline (pH 8.8); clear smooth boundary.

Bw2   42- 75 cm --- Dark yellowish brown and very dark greyish brown (10YR 4/4,3/2 M) clay; moderate coarse prismatic and subangular blocky structure; friable, sticky and plastic; common medium and coarse roots; many very fine discontinuous pores; subrounded lime nodules of 2 to 10 mm size; violently effervescent; few rock fragments of 1 to 2 mm size; strongly alkaline (pH 8.5); clear wavy boundary.

Bwk1 75-124 cm -- Variegated light yellowish brown, dark yellowish brown, brown, very dark greyish brown and white (10YR 6/4, 4/4, 5/3, 3/2, 8/1 M) clay; moderate coarse prismatic and subangular blocky structure; friable, sticky and plastic; many fine roots inside peds; 10 per cent subrounded lime nodules of 2 to 10 mm size; violently effervescent; strongly alkaline (pH 8.5).

Micromorphology: In this soil the influence of the fauna has resulted in homogenization. In the whole profile voids and irregular zones, often interconnected, are partly or completely filled with soil aggregates, mainly excrements but also soil fragments and often some mineral grains. In the BC and Ck horizons these features are abundant and have changed the type of structure. The quantity of soil fragments mainly formed by swelling and shrinking of the soil material decreases with depth. Sesquioxides, mainly manganese, are accumulating to a slight extent. Deeper in the

pedon a few thin cutans and/or neocutans of manganese occur. The whole profile is rich in carbonate. Carbonate nodules, common in the Ap horizon, increase with depth. In the Ck horizon some voids are filled with gypsum crystals of different sizes.

Type location: $11^o00'$ N, $76^o52'$ E; plot No.7, Tamil Nadu Agricultural University farm, Coimbatore, Tamil Nadu.

Range in characteristics: The thickness of the solum is 70 to 90 cm. The thickness of the A horizon is 10 to 20 cm. Its colour is in hue 10YR, value3 to 5 and chroma 2 to 3. Its texture is clay loam to clay. Lime nodules are present. The cambic B horizon is 20 to 30 cm thick. It is darker in colour than the A horizon and has hue 10YR, value 3 to 4 and chroma 2. Its texture is clay. Peds show prominent pressure faces. Lime nodules are present. The B horizon is about 25 to 35 cm thick. Its colour is in hue 10YR, value 4 to 5 and chroma 2 to 4. It is also clayey and has lime nodules. The underlying Ck horizon is variegated in colour and is clayey. The soils crack during dry season.

Geographic setting: Coimbatore soils are formed in alluvium of calcic gneiss on level to very gently sloping interfluve plain at an elevation of 375 to 400 m above MSL. The climate is semiarid tropical with mean annual air temperature of 26.5^oC and mean annual rainfall of 570 mm. The estimated MAST is 30.0^oC. The difference between MSST and MWST is 0.5^oC.

Geographically associated soils: The associated soils are Palathurai and Salem series, which are Typic Haplustalf and Udic Haplustalf, respectively.

Drainage and permeability: Imperfectly drained with moderately slow permeability.

Use and vegetation: Cultivated to sorghum, cotton, pigeonpea under rainfed conditions, and rice and sugarcane under irrigation; natural vegetation - *Acacia spp.* (babul) and *Prosopis spp.* (mesquite).

Distribution and extent: Extensive in Coimbatore, Salem and Dharampuri districts of Tamil Nadu.

Series proposed: All India Soil and Land Use Survey, Regional Centre, Bangalore

Interpretation: Fine texture and imperfect drainage pose problems. The soils can be used for all adapted crops. Provision of drainage is necessary to raise irrigated crops.

a) Interpretative grouping:
    i)   Land capability subclass   IIIs
    ii)   Irrigability subclass   2d
    iii)   Productivity potential   Medium

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								Coarse frag-ments > 2 mm % of whole soil
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
		<---------------------------------- % of < 2 mm ---------------------------------->								
Ap	0-15	40.7	16.3	43.0	1.8	4.4	10.9	17.0	6.6	2
Bw1	15-42	32.7	16.2	51.1	1.0	3.0	8.3	14.1	6.3	1
Bw2	42-75	23.6	21.7	54.7	0.8	2.2	5.7	9.6	5.3	1
Bwk1	75-124	23.1	21.9	55.0	1.1	1.7	5.3	9.3	5.7	5

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	Micronutrients			
				D T P A extractable			
				Zn	Cu	Mn	Fe
				<----------- ppm ----------->			
0-15	0.35	6.9	8.7	0.19	0.88	7	3
15-42	0.40	9.1	8.8	0.20	1.14	7	2
42-75	0.41	11.7	8.5	0.28	1.50	8	2
75-124	0.31	13.8	8.5	0.27	1.60	6	1

Depth (cm)	Extractable bases					CEC NH_4OAc	Base saturation NH_4OAc (%)	Ratio CEC/ Clay (%)
	Ca	Mg	Na	K	Sum			
	<-------------- cmol $(p^+)kg^{-1}$ -------------->							
0-15	30.8	6.1	1.3	0.9	39.1	39.7	98	0.92
15-42	34.0	7.0	3.7	0.5	45.2	50.0	90	0.98
42-75	36.8	6.7	4.4	0.6	48.5	51.6	94	0.94
75-124	30.5	9.0	4.5	0.6	44.6	46.1	97	0.84

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.22.2 KOVILPATTI SERIES

The Kovilpatti series is a member of the very fine, smectitic, isohyperthermic family of Gypsic Haplusterts. Typically, Kovilpatti soils have very dark grayish brown, moderately alkaline, clayey A horizons, very dark gray to dark grayish brown, mildly alkaline to moderately alkaline, clayey B horizons, and light brownish gray, mildly alkaline silt loam.

Water balance diagram Kovilpatti, Tamil Nadu
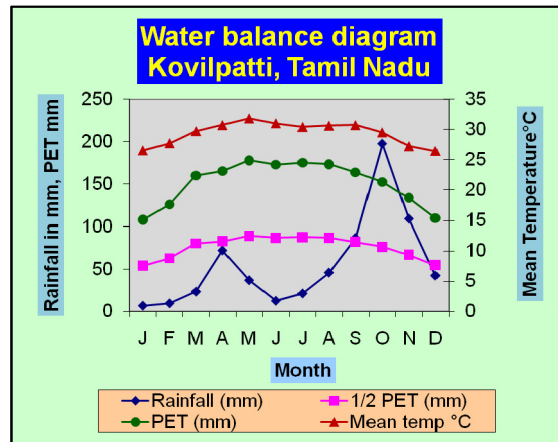
Typifying pedon: Kovilpatti clay - cultivated

Ap1   0-6 cm -- Very dark grayish brown (10YR 3/2R) clay; fine granular structure; very friable sticky and plastic; many very fine and fine, few medium roots; common very fine, few fine lime nodules; many very fine and fine, common medium pores; moderately alkaline (pH 8.0); slightly effervescent; clear smooth boundary.

Ap2   6-20 cm -- Very dark grayish brown (10YR 3/2M) clay; moderate fine subangular blocky structure; very friable, sticky and plastic, many very fine and fine, few medium roots; common very fine, few fine lime nodules; moderately alkaline (pH 8.0); slightly effervescent; clear smooth boundary.

Bw1   20-41 cm -- Very dark gray to very dark grayish brown (10YR 3/1.5M) clay; weak medium subangular blocky structure with pressure faces on surface of peds; friable, very sticky and very plastic; common very fine and fine, few medium roots; common very fine, few fine lime nodules; moderately alkaline (pH 8.0); slightly effervescent; clear smooth boundary.

Bw2   41-74 cm -- Very dark gray to very dark grayish brown (10YR 3/1.5M) clay; weak medium subangular blocky to angular blocky structure with well developed pressure faces and weakly developed wedge shaped aggregates and slickensides that break into small weak angular blocky peds; slightly friable; very moist; sticky and very plastic; common very fine and fine, common very fine and fine lime nodules; moderately alkaline (pH 8.0); slightly effervescent; gradual smooth boundary.

Bss1   74-104 cm -- Very dark gray (10Y/R 3/1M) clay; strong, medium angular blocky (weak) structure with weak development of wedge shaped aggregates and slickensides that break into small weak angular peds; slightly friable, very sticky and very plastic; few very fine, fine and medium roots; common very fine and fine, few medium roots; moderately alkaline (pH 8.0); strongly effervescent; clear smooth boundary.

Bss2   104-118 cm -- Very dark gray to very dark grayish brown (10YR 3/1.5M) clay; strong moderate angular blocky structure with wedge shaped aggregates and slickensides that break into small angular peds; slightly friable, very sticky and very plastic; few very fine roots; common very fine, fine and medium lime nodules; moderately alkaline (pH 7.9); violently effervescent; clear smooth boundary.

BC   118-140 cm -- Grayish brown to dark grayish brown (10YR 4.5/2R) clay; weak medium subangular blocky structure; friable, very sticky and very plastic; few very fine roots; mildly alkaline (pH 7.9); violently effervescent; abrupt smooth boundary.

2Cky   140+ cm -- Light brownish gray (10YR 6/2R) silt loam; layer of gypsum and lime with very little soil; massive structure; mildly alkaline (pH 7.4); violently effervescent.

Type location: 09°12'18"N, 77°52'40"E; TNAU farm area, Kovilpatti, District: Toothokudi, Tamil Nadu.

Geographic setting: Kovilpatti soils have developed on granite-gneiss and mixed alluvium; occur on very gently sloping (1-3%) riverine landform at an elevation of 50 to 150 m above MSL. The climate is semiarid dry with mean annual air temperature of 29.35°C and mean annual rainfall of 660 mm. The estimated MAST is 32.85ºC, MSST 32.95°C and MWST 30.08°C. The difference between MSST and MWST is 2.9ºC.

Drainage and permeability: Moderately well drained.

Land use and vegetation: Sorghum/cotton (2 yr rotation), sunflower, soybean, blackgram; neem, prosopis, tamarind, parthenium grasses and shrubs.

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%)	Fine clay/ total clay (%)	BD Mg/m³	COLE	HC* cm/hr	WDC (%)
		Total								
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)						
		←----------(% of <2 mm) ----------→								
Ap1	0-6	22.8	21.0	56.2	31.9	56.8	-	0.21	1.9	11.5
Ap2	6-20	17.6	20.8	61.6	44.3	72.0	1.1	0.22	2.2	12.0
Bw1	20-41	15.5	19.3	65.2	46.3	71.0	1.4	0.22	4.4	16.5
Bw2	41-74	15.0	19.3	65.7	50.3	76.5	1.4	0.20	3.0	12.3
Bss1	74-104	13.0	20.1	66.9	50.8	76.0	1.4	0.24	3.7	20.7
Bss2	104-118	10.2	17.7	72.1	60.0	83.2	1.4	0.25	3.4	20.1
BC	118-140	9.8	19.9	70.3	54.8	78.0	-	0.17	3.2	12.8
2Cky	140-+	22.9	52.4	24.7	10.2	41.3	-	0.10	4.8	7.1

* 33 mm hr⁻¹ is the HC (WM) in 0-100 cm depth of soil.

Horizon	Depth (cm)	Moisture retention (%)							AWC
		33kPa	100kPa	300kPa	500kPa	800kPa	1000kPa	1500kPa	
Ap1	0-6	37.1	29.9	25.0	22.5	22.1	21.1	21.0	16.0
Ap2	6-20	36.7	31.3	25.5	24.3	23.5	22.1	21.1	15.5
Bw1	20-41	40.2	34.8	30.3	27.8	24.6	24.4	23.3	16.9
Bw2	41-74	43.6	36.5	31.9	30.6	27.1	26.8	24.8	18.8
Bss1	74-104	45.5	36.8	33.0	32.4	28.8	27.6	26.3	19.2
Bss2	104-118	48.9	39.8	33.4	32.8	30.6	27.1	27.1	21.9
BC	118-140	48.3	39.7	35.4	30.2	29.9	29.3	29.0	19.3
2Cky	140-+	35.6	25.0	23.4	23.2	20.5	20.2	19.6	16

Depth (cm)	pH water (1:2)	CaCO₃ (%)	OC (%)	Extractable bases					CEC	Clay CEC cmol(p+)kg⁻¹	B.S. (%)
				Ca	Mg	Na	K	Sum			
				←---------------------cmol(p+)/kg⁻¹---------------------→							
0-6	8.0	5.4	0.34	47.3	11.3	0.3	0.7	59.6	60.9	108	98
6-20	8.0	4.3	0.37	48.2	13.1	0.3	0.6	62.2	56.7	92	110
20-41	8.0	5.3	0.35	50.8	14.2	0.4	0.4	65.8	65.2	100	101
41-74	8.0	7.9	0.35	50.6	18.0	0.6	0.4	69.6	63.0	96	110
74-104	7.9	12.5	0.30	53.7	15.3	0.8	0.4	70.2	71.7	107	98
104-118	7.9	12.8	0.28	55.5	14.0	0.9	0.5	70.9	65.2	90	109
118-140	7.4	15.6	0.28	57.2	12.3	1.0	0.5	71.0	54.4	77	130
140-+	7.5	17.4	0.12	47.9	8.1	0.1	0.2	56.3	32.6	132	173

Depth (cm)	Exch. Ca/Mg	ECP	EMP	ESP	CO₃ clay (%)	CO₃ clay (feb) (%)
0-6	4.3	78	18	0.5	2.7	1.5
6-20	3.7	85	23	0.9	2.5	1.5
20-41	3.5	78	22	0.6	2.7	1.7
41-74	2.8	80	28	0.9	2.8	1.8
74-104	3.6	75	21	1.1	3.4	2.3
104-118	4.0	85	21	1.4	3.2	2.3
118-140	4.6	105	23	1.8	3.1	2.2
140-+	5.9	147	25	0.3	4.5	1.1

Depth (cm)	Soluble cations (meq/l)						Soluble anions (meq/l)					RSC	SAR
	Sat %	ECe	Ca	Mg	Na	K	Sum	CO₃	HCO₃	Cl	SO₄	Sum		
0-6	65.2	0.2	3.27	3.5	0.76	0.01	7.6	1.1	0.9	0.5	5.2	7.6	-4.77	0.5
6-20	65.6	0.3	1.43	0.5	0.87	0.07	2.9	1.5	0.6	0.5	0.3	2.9	0.17	0.9
20-41	72.6	0.5	2.39	1.6	1.96	0.07	6.1	3.8	0.5	0.5	1.2	6.1	0.31	1.4
41-74	76.5	0.4	1.48	0.7	1.09	0.02	3.3	1.6	0.5	0.7	0.5	3.3	-0.08	1.0
74-104	73.7	0.2	0.92	0.6	1.09	0.02	2.6	1.1	0.5	0.4	0.6	2.6	0.08	1.2
104-118	69.9	0.6	3.16	1.5	2.16	0.02	6.9	1.1	0.5	0.5	4.8	6.9	-3.06	1.4
118-140	83.8	2.7	3.22	3.8	4.10	0.07	11.2	1.1	0.5	0.5	9.1	11.2	-5.42	2.1
140+	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Source: Pal, D. K., Bhattacharyya, T., Ray, S. K. and Bhuse, S. R. 2003. "Developing a model on the formation and resllience of naturally degraded black soils of the Peninsular India as a decision support system for better land use planning" NRDMS, DST Project Report, NBSSLUP (ICAR), Nagpur, 144p.

2.23 Soil Series: AESR 8.2

Central Karnataka Plateau, hot moist semi-arid ESR with medium to deep Red loamy soils, low AWC and LGP 120-150 days (K1Dm4)

2.23.1 TYAMAGONDALU SERIES

The Tyamagondalu series is a member of the fine, mixed, isohyper-thermic family of Kandic Paleustalfs. Typically, Tyamagondalu soils have dark reddish brown to dark red, neutral, loamy sand to sandy loam A horizons, and dark reddish brown to dark red, slightly to moderately acid, sandy clay to clay Bt horizons with iron and manganese concretions.

Water balance diagram Bangalore, Karnataka

Typifying pedon: Tyamagondalu sandy loam - cultivated
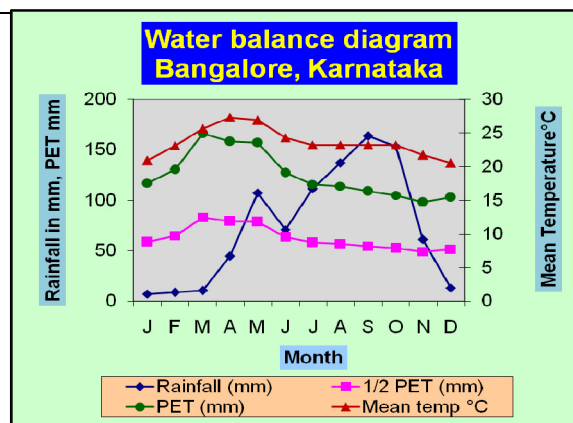
Ap   0-13 cm --- Dark reddish brown to dark red (2.5YR 3/4 M) sandy loam; weak medium subangular blocky structure breaking to weak fine and medium granules; friable, slightly sticky; many medium roots inside peds; neutral (pH 6.8); clear smooth boundary.

Bt1   13-34 cm --- Dark reddish brown (2.5YR 3/4 M) sandy clay; strong coarse subangular blocky structure; friable, slightly sticky and plastic; many fine roots inside peds; many very fine tubular imped pores; patchy thin clay cutans in pores and on ped faces; moderately acid (pH 5.9); clear smooth boundary.

Bt2   34-80 cm --- Dark reddish brown (2.5YR 3/4 M) sandy clay; strong coarse subangular blocky structure; firm, sticky and plastic; many fine roots inside peds; many fine tubular pores; patchy thin clay cutans in pores and on ped faces; few iron and manganese concretions of 1 mm size; slightly acid (pH 6.1); clear smooth boundary.

Bt3   80-110 cm --- Dark red (2.5YR 3/6 M) clay; strong coarse subangular blocky structure; firm, sticky and plastic; few coarse and fine roots inside peds; many fine tubular imped pores; broken thick clay cutans in pores and on ped faces; few soft iron and manganese concretions of 2 to 4 mm size; slightly acid (pH 6.5); gradual smooth boundary.

Bt4   110-160 cm --- Dark red (2.5YR 3/6 M) clay;strong coarse subangular blocky structure; firm, sticky and plastic; few coarse and fine roots inside peds; many fine tubular imped pores; broken thick clay cutans in pores and on ped faces; many soft iron and manganese concretions of 2 to 3 mm size; slightly acid (pH 6.5).

Type location: 13º13' N, 77º18' E; about 2 km from the village crossing of T. Begur-Niduvanda road, village Tyamagondalu, tehsil Nelamangala, district Bangalore, Karnataka.

Range in characteristics: The thickness of the solum ranges from 150 to 250 cm. The thickness of the A horizon is about 15 cm. Its colour is in hue 2.5YR or 5YR, value 3 and chroma 4 to 6.

Texture is loamy sand to sandy loam. The thickness of the B horizon ranges from 120 to 160 cm. Its colour is also in hue 2.5YR to 5YR, value 3 and chroma 4 to 6. Texture is sandy clay to clay. Thin to thick clay cutans are present in pores and on ped faces. Coarse fragments may appear as thin stone lines.

Geographic setting: Tyamagondalu soils are developed in weathered gneiss on nearly level to gently sloping land at an elevation of 900 to 1000 m above MSL. The climate is semiarid tropical with mean annual air temperature of 23.6ºC and mean annual rain fall of 750 to 850 mm. The estimated MAST is 27.1ºC. The difference between MSST and MWST is 1.5ºC.

Geographically associated soils: The associated soil is Channasandra series, which is also a Kandic Paleustalf.

Drainage and permeability: Well drained with moderate permeability.

Use and vegetation: Cultivated to minor millets, pigeonpea and groundnut; natural vegetation – *Ficus spp.* (banyan) and local grasses.

Distribution and extent: Extensive in Bangalore district of Karnataka.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore, 1972.

Interpretation: Tymagondalu soils are agriculturally important. They have good soil-air-water relationship. They can retain moisture under proper conservation measures. All climatically adapted crops respond to management both under rainfed and irrigated conditions.

a) Interpretative grouping:
    i)   Land capability subclass   IIe
    ii) Irrigability class   1
    iii) Productivity potential   Medium to high

b) Yield: Based on data from farmers' fields

Crop	Farmers' practices		Improved practices
	Unirrigated	Irrigated	Unirrigated
	< --------------------Yield, Mg ha^{-1}------------------------ >		
Finger millet	0.6	3.0	1.5
Groundnut	0.8	2.0	1.2
Pigeonpea	0.6	1.5	1.2

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								Coarse frag-ments > 2 mm % of whole soil
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
		<---------------------------------- % of < 2 mm ------------------------------------>								
Ap	0-13	79.3	7.9	12.8	5.4	10.5	19.8	30.8	12.8	2
Bt1	13-34	50.6	9.3	40.1	2.4	9.5	13.9	17.6	7.2	-
Bt2	34-80	46.2	10.5	43.3	3.1	8.0	12.2	16.0	6.9	1
Bt3	80-110	42.2	9.8	48.0	3.1	6.5	11.1	14.7	6.8	1
Bt4	110-160	38.5	11.8	49.7	3.8	5.9	9.2	13.2	6.4	1

Depth (cm)	Organic Carbon (%)	Ext. iron as Fe (%)	pH (1:2.5) KCl	pH (1:2.5) H_2O	Bulk density Mg m^{-3}	Water retention 1500 kPa	Micronutrients D T P A extractable			
							Zn	Cu	Mn	Fe
							<--------------- ppm ----------------->			
0-13	0.50	1.92	5.5	6.8	-	4.2	0.33	1.32	28	19
13-34	0.46	3.34	4.7	5.9	1.50	12.3	0.27	3.63	62	14
34-80	0.50	3.65	5.0	6.1	-	12.4	0.26	3.39	35	13
80-110	0.49	3.95	5.2	6.5	1.52	12.5	0.33	2.53	26	10
110-160	0.36	4.22	5.4	6.5	1.53	13.1				

Depth (cm)	Extractable bases					Ext. acidity	CEC NH$_4$OAc	Base saturation NH$_4$OAc	Ratio to clay		
	Ca	Mg	Na	K	Sum				CEC NH$_4$OAc	Ext. iron	1500 kPa water
	<--------------------- cmol (p+)kg^{-1} ------------------------>							%			
0-13	2.0	0.3	0.1	0.3	2.7	0.02	2.9	93	0.23	0.15	0.33
13-34	5.0	0.6	0.2	0.2	6.0	0.05	8.0	75	0.20	0.08	0.31
34-80	6.4	0.3	0.1	0.1	6.9	0.03	8.7	79	0.20	0.08	0.29
80-110	6.9	0.4	0.2	0.1	7.6	0.03	9.1	84	0.19	0.08	0.26
110-160	7.3	0.2	0.5	0.1	8.1	0.03	9.4	86	0.19	0.08	0.26

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.23.2 CHANNASANDRA SERIES

The Channasandra series is a member of the clayey-skeletal, mixed, isohyperthermic family of Kanhaplic Haplustalfs. Typically, Channasandra soils have dark reddish brown, neutral gravelly sandy loam, A horizons, and dark red, slightly acid to neutral, gravelly sandy clay to gravelly clay Bt horizons over weathered granite-gneiss.
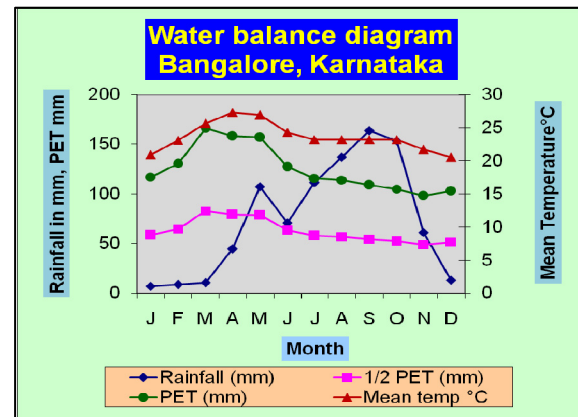
Typifying pedon: Channasandra gravelly sandy loam – cultivated

Ap   0-17 cm --- Dark reddish brown (5YR 3/3 M) gravelly sandy loam; weak fine granular structure; very friable; common fine roots inside peds; common very fine and fine tubular imped pores; angular cobbles and gravels 25 per cent by volume of 5 to 20 mm size; neutrall (pH 6.7); clear smooth boundary.

Bt1   17-52 cm --- Dark red (2.5YR 3/6 M) gravelly clay; moderate fine and medium subangular blocky structure; firm, sticky and plastic; many fine roots; common fine and very fine tubular pores; few thin clay cutans on vertical and horizontal ped faces and few thick clay cutans in pores; angular quartz gravels 40 per cent by volume of 10 to 40 mm size; slightly acid (pH 6.5); clear smooth boundary.

Bt2   52-87 cm --- Dark red (2.5YR 3/6 M) gravelly sandy clay; moderate medium and fine subangular blocky structure; firm, sticky and plastic; many fine roots; common fine tubular pores; few thick clay cutans on vertical and horizontal ped faces and few moderately thick clay cutans in pores; quartz gravels 30 to 35 per cent by volume of 5 to 10 mm size; neutral (pH 6.7); clear wavy boundary.

Bt3   87-106 cm --- Dark red (2.5YR 3/6 M) clay; moderate medium subangular blocky structure ; firm , very sticky and very plastic ; few very fine roots ; many very fine discontinuous tubular pores; common thin patchy cutans on ped faces; few fine quartz gravels; neutral (pH 6.7); clear smooth boundary.

BC   106-146 cm --- Dark red (2.5YR 3/6 M) and yellowish red (5YR 5/6 M) gravelly sandy clay loam; weak fine subangular blocky structure breaking into granules; friable; many discontinuous random tubular pores; few thin patchy cutans; on ped-faces; quartz gravels 80 to 90 per cent by volume (quartz vein); neutral (pH 6.7); abrupt smooth boundary.

Cr   146-163 cm --- Soft weathered granite-gneiss.

Micromorphology: In this pedon strong clay illuviation has occurred. Many ferri-argillans and complete infillings with red-coloured clay occur in the B horizon. In the C horizon few to common ferri-argillans and a few infillings of clay are observed. The moderate, mainly medium, subangular blocky structure is an old void system, largely determined by physical processes and influenced by former fauna. Some of the voids with clay illuviation features are old faunal voids. The present fauna play a minor role producing a small number of new voids, often partly or completely filled with mineral excrements. Papules, fragments of argillans, and clay infillings are

commonly present in excrements. In the C horizon, the influence of the present fauna is more pronounced. The quantity of more or less filled voids with excrements is higher than in the upper horizons. The C horizon consists of disintegrated granitic gneiss, the micas of which are altering. Slightly rounded quartz gravel and rounded sesquixidic nodules, both indications of a colluvium, are present.

Type location: 12º52' N,   77º20' E; about 150 m north of Government Silk farm, village Talaghattapura, tehsil Bangalore North, district Bangalore, Karnataka.

Range in characteristics: The thickness of the solum is 100 to 150 cm. The A horizon is 15 to 20 cm thick. Its colour is in hue 5YR, value 3 and chroma 3. The texture is gravelly loamy sand to gravelly sandy loam. The Bt horizon is 85 to 120 cm thick. Its colour is in hue 2.5YR, value 3 or 4 and chroma 4 to 6. Coarse fragments of quartz and gneiss are distributed in different proportions.

Geographic setting: The Channasandra soils are formed over weathered granite-gneiss and occur on undulating pediments at an elevation of about 850 to 900 m above MSL. The climate is semiarid tropical with mean annual air temperature of 23.6ºC and mean annual rainfall of 750 to 850 mm. The estimated MAST is 27.1ºC. The difference between MSST and MWST is 1.5ºC.

Geographically associated soils: The associated soil is Tyamagondalu series which is also a Kandic Paleustalf.

Drainage and permeability: Well drained with moderately rapid permeability.

Use and vegetation: Cultivated to rainfed finger millet and pulses; natural vegetation – *Pongamia spp.* (karanj) and *Ficus spp.* (banyan).

Distribution and extent: Extensive in parts of Bangalore district, Karnataka.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore.

Interpretation: The soils are gravelly and subject to drought. Crops respond well under irrigation.

a) Interpretative grouping:
  i)   Land capability subclass   IIIs
  ii) Irrigability subclass   3t
  iii) Productivity potential   Medium

b) Yield: Based on data from demonstrations conducted on farmers' fields

Crop	Farmers' practices		Improved practices	
	Unirrigated	Irrigated	Unirrigated	Irrigated
	<--------------------Yield, Mg ha^{-1}------------------------>			
Finger millet	0.7	-	2.5	-
Mulberry (Green leaves)	3.0	20.0	9.0	28.0

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								Coarse fragments > 2 mm % of whole soil
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
		<------------------------------------- % of < 2 mm ------------------------------------>								
Ap	0-17	78.1	13.4	8.5	9.1	9.5	14.6	28.2	16.7	38
Bt1	17-52	41.0	8.7	50.3	7.6	5.4	7.2	13.2	7.6	71
Bt2	52-87	50.8	10.1	39.1	12.8	10.1	9.1	11.7	7.1	38
Bt3	87-106	41.2	17.6	41.2	4.8	4.4	6.9	14.5	10.6	6
BC	106-146	57.9	21.9	20.2	12.4	12.7	10.5	12.6	9.7	78

Depth (cm)	Organic Carbon (%)	Ext. Iron as Fe (%)	pH (1:2.5) H_2O	Bulk density (Mg m^{-3})	Micronutrients			
					D T P A extractable			
					Zn	Cu	Mn	Fe
					<---------------- ppm --------------------->			
0-17	0.53	1.42	6.7	-	2.80	3.38	38	36
17-52	0.88	3.38	6.5	1.73	0.58	1.27	19	12
52-87	0.39	2.82	6.7	1.60	0.29	0.69	12	6
87-106	0.46	2.92	6.7	1.60	0.24	0.75	7	6
106-146	0.14	1.32	6.7					

Depth (cm)	Extractable bases					Ext. acidity	CEC NH$_4$OAc pH 8.2	Ratio to clay	
	Ca	Mg	Na	K	Sum			CEC NH$_4$OAc	Ext. iron
	<-------------------------- cmol (p+)kg^{-1} -------------------------->								
0-17	3.5	0.8	0.3	0.2	4.8	0.05	4.4	0.52	0.17
17-52	9.1	1.0	0.4	0.2	10.7	0.05	11.5	0.23	0.07
52-87	7.2	1.0	0.3	0.1	8.6	0.05	8.2	0.21	0.07
87-106	8.7	1.0	0.2	0.1	10.0	0.05	10.3	0.25	0.07
106-146	5.4	1.0	0.2	0.1	6.7	0.05	6.5	0.32	0.07

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.24 Soil Series: AESR 8.3

Tamil Nadu Uplands and Plains, hot moist semi-arid ESR with deep red loamy soils, low AWC and LGP 120-150 days (H1Dm4)

2.24.1 SIVAGANGAI SERIES

The Sivagangai series is a member of the clayey-skeletal, mixed, isohyperthermic family of Rhodic Paleustalfs. Typically, Sivagangai soils have yellowish red, moderately acid, sandy clay loam A horizons and dark reddish brown to dark red, moderately acid to neutral, sandy clay to gravelly clay B horizons.
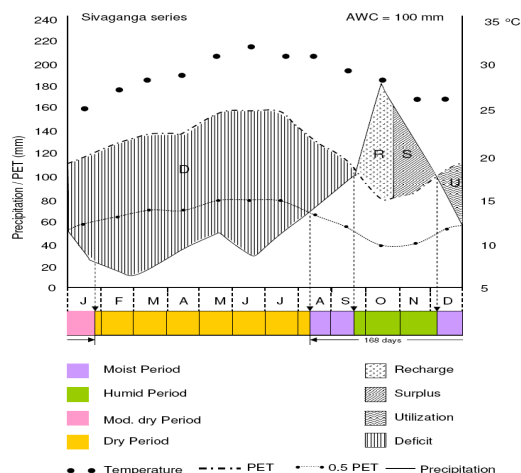
Typifying pedon: Sivagangai sandy clay loam - fallow lands

A   0-10 cm --- Yellowish red (5YR 4/6 M) sandy clay loam; moderate medium subangular blocky structure; very friable, slightly sticky and slightly plastic; common fine few medium roots; 5 per cent gravels mainly of quartz; moderately acid (pH 5.8); clear smooth boundary.

Bt1   10-24 cm --- Dark red (2.5YR 3/6 M) sandy clay; strong coarse subangular blocky structure; friable, sticky and plastic; common fine roots; thick continuous clay skins; 5 per cent gravels mainly of quartz; moderately acid (pH 5.9); clear wavy boundary.

Bt2   24-42 cm --- Dark reddish brown (2.5YR 3/4 M); sandy clay; strong coarse subangular blocky structure; friable, sticky and plastic; common fine roots; thick continuous clay skins; 10 per cent gravels mainly of quartz; slightly acid (pH 6.2); clear smooth boundary.

2Bt3   42-70 cm --- Dark red (2.5YR 3/6 M); gravelly clay; moderate medium subangular blocky structure; very friable, sticky and plastic; few fine roots; thin patchy clay skins; many fine iron concretions; 55 per cent gravels mainly of quartz and iron; slightly acid (pH 6.4); clear wavy boundary.

2Bt4   70-96 cm --- Dark red (10R 3/6 M); gravelly clay; strong coarse subangular blocky structure; friable, sticky and plastic; few fine roots; thin patchy clay skins; many fine iron concretions; 60 per cent gravels mainly of quartz and iron; slightly acid (pH 6.5); clear wavy boundary.

2Bt5   96-138 cm --- Dark reddish brown (2.5YR 3/4 M); gravelly clay; moderate medium subangular blocky structure; very friable, sticky and plastic; few fine roots; thin patchy clay skins; many fine iron concretions; 75 per cent gravels mainly of quartz and iron; neutral (pH 6.8); clear wavy boundary.

2Bt6   138-164 cm --- Dark red (2.5YR 3/6 M); gravelly clay; moderate medium subangular blocky structure; very friable, very sticky and very plastic; few fine roots; thin patchy clay skins; many fine iron concretions; 75 per cent gravels mainly of quartz and iron; neutral (pH 6.8).

Type location: 09°57'00" N, 78°25'00" E; village Malampatti, tehsil Sivagangai, district Sivagangai, Tamil Nadu.

Range in characteristics: The A horizon is 5 to 15 cm thick. Its texture is loamy sand to sandy clay loam. Its colour is in hue of 7.5YR, 5YR and 2.5YR, value 3 to 6 and chroma 4 to 8. The gravel content ranges from 5 to 10 per cent. The B horizon is more than 125 cm thick. Its texture is clay loam to gravelly clay. Its colour is in hue of 2.5YR and 10R, value 3 and chroma 4 to 6. The gravel content ranges from 35 to 75 per cent.

Geographic setting: Sivagangai soils are developed over weathered gneiss and occur on very gently sloping lower part of the sloping uplands at an elevation ranging from 90 to 100 m above MSL. The climate is semi-arid tropical with mean annual air temperature of 28.7°C and mean annual rainfall of 786 mm. The estimated MAST is 32.2°C, MSST 30.2°C and MWST 27.1°C. The difference between MSST and MWST is 3.1°C.

Geographically associated soils: These are soils of Malampatti series, a Typic Rhodustalf.

Drainage and permeability: Well drained with moderately rapid to rapid permeability.

Use and vegetation: Majority of the area is under fallow. In patches, sugarcane, cluster beans, chillies, yam, groundnut, vegetables, coconut etc. are cultivated; natural vegetations: Arali (*Neerium oleander*), Ilandai (*Zizyphus jujuba*), Karuvel (*Acacia arabica*), Kodukkapuli (*Pitchecolobium dulce*), Nuna (*Morinda tinctoria*), Odai (*Acacia planifrons*), Palmyrah (*Borassus flabellifer*), Tirugukalli (*Euphorbia tricalli*), Sappathikalli (*Opuntia dillenii*), Neem (*Azadirachta indica*), Velikaruvel (*Prosopis juliflora*), Avarai (*Cassia auriculata*), Erukku (*Calotropis gigantea*), Kandankathiri (*Solanum surattense*), Kathalai (*Agave americana*), Kolunji (*Theprosia purpurea*), Pirandai (*Cissus quadrangularis*), Purasal Chedi (*Ipomea cornea*), Hariyali (*Cyanodon dactylon*), Nutgrass (*Cyperus rotundus*), Keelanelli (*Phyllanthus niruri*), Thulasi (*Ocimum sanctum*), Thumbai (*Leucas aspera*).

Distribution and extent: Extensive (5064 ha) in Sivagangai block, Sivagangai district of Tamil Nadu.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore, 2006.

Interpretation:
a) Interpretative grouping
      i) Land capability sub-class   IIIse
      ii) Land irrigability sub-class   3st
      iii) Fertility capability classification   LCh (1-3%) (slightly acidic, loamy surface
                                                  and clayey sub-soil)

b) Crop yield (kg/ha):
- Groundnut (*Arachis hypogaea*) - rainfed   1200 to 1500 pods
- Red gram (*Cajanus cajan*) – rainfed   900 to 1000
- Gingelly (*Sesamum indicum*) – rainfed   450 to 650
- Cumbu (*Pennisetum glacum*) – rainfed   2000
- Minor millets – Tenai (*Setaria italica*) - rainfed – 600 to 1000
- Green gram (*Vigna radiata*) – rainfed   900
- Black gram (*Vigna mungo*) – rainfed   700

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)							
		Total			Sand				
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)
		<------------------------------------- % of <2 mm ------------------------------------->							
A	0-10	73.0	6.5	20.5	15.2	12.6	35.9	9.3	0.0
Bt1	10-24	58.4	6.6	35.0	12.0	7.9	30.5	8.0	0.0
Bt2	24-42	55.4	8.6	36.0	1.1	10.1	32.3	11.9	0.0
2Bt3	42-70	44.3	10.2	45.5	12.1	6.7	19.4	6.1	0.0
2Bt4	70-96	40.6	11.9	47.5	12.8	8.5	13.9	5.4	0.0
2Bt5	96-138	41.5	9.5	49.0	12.5	7.7	15.7	5.6	0.0
2Bt6	138-164	40.2	9.3	50.5	10.0	8.0	16.8	5.4	0.0

Depth (cm)	Organic carbon (%)	pH (1:2.5) Water	E.C. (dS m^{-1})
0-10	0.46	5.8	0.01
10-24	0.43	5.9	0.01
24-42	0.32	6.2	0.01
42-70	0.09	6.4	0.01
70-96	0.09	6.5	0.01
96-138	0.09	6.8	0.02
138-164	0.09	6.8	0.01

Depth (cm)	Exchangeable bases					CEC NH$_4$OAc (pH 7.0)	Ratio CEC/ Clay	Base saturation (NH$_4$OAc)[1] (%)	ESP
	Ca	Mg	Na	K	Total	cmol(+)kg^{-1} soil			
0-10	3.25	1.75	–	0.07	5.07	7.9	0.38	64.2	–
10-24	4.25	2.00	–	0.07	6.32	9.5	0.27	66.5	–
24-42	4.25	1.75	–	0.13	6.13	9.2	0.25	66.6	–
42-70	6.75	2.50	–	0.13	9.38	13.8	0.30	67.9	–
70-96	9.25	3.25	–	0.20	12.70	17.4	0.37	72.9	–
96-138	10.75	3.75	0.25	0.26	15.01	19.9	0.41	75.4	1.2
138-164	8.25	2.75	0.25	0.26	11.51	14.7	0.29	78.3	1.7

Available nutrients (0-10 cm)								
N	P$_2$O$_5$	K$_2$O	S	Fe	Mn	Cu	Zn	B
-----------kg ha^{-1} -------------			--------------------------- mg kg^{-1} soil -------------------------					
71	19	269	Nil	15	1.6	0.7	0.8	Nil

[1][Total exchangeable bases/CEC by NH$_4$OAc] x 100

Source: Natarajan, A., Janakiraman, M., Manoharan, S., Balasubramaniyan, V., Murugappan, K., Udayakumar, J., Ramesh, M., Chandramohan, D., Niranjana, K. V., Venkatesh, D. H., Krishnasamy, M., Sennimalai, P., Thanikody, M., Krishnan, P., Rajamannar, G., Natarajan, S., Jagadeesan, P., and Vadivelu, S., (2006). Land Resources of Sivagangai Block, Sivagangai District, Tamil Nadu (Executive Summary). NBSS Publ. No.1028, p. 261.

2.24.2 SALUR SERIES

The Salur series is a member of the fine, smectitic, isohyperthermic family of Vertic Haplustepts. Typically, Salur soils have brown, moderately alkaline, sandy clay A horizons and brown to dark yellowish brown, moderately alkaline, clay loam to sandy clay B horizons.
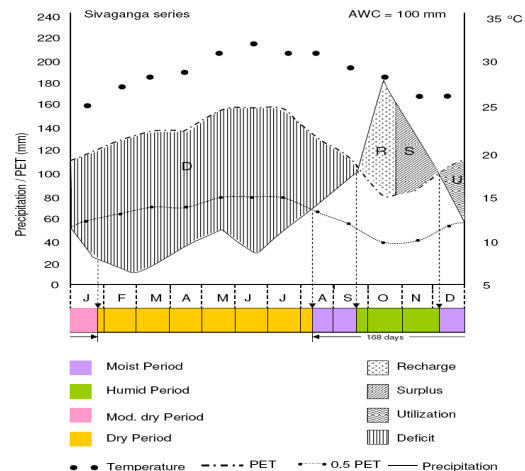
Typifying pedon: Salur sandy clay – cultivated

Ap   0-23 cm --- Brown (10YR 5/3 D; 4/3 M) sandy clay; moderate medium subangular blocky structure; hard firm, sticky and slightly plastic; many fine roots; many fine and few medium pores; moderately alkaline (pH 8.0); clear smooth boundary.

Bw1   23-59 cm --- Brown (10YR 4/3 M) clay loam; strong coarse subangular blocky structure; very firm, sticky and slightly plastic; few fine calcareous nodules; slightly effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bw2   59-85 cm --- Brown (10YR 4/3 M) sandy clay; strong coarse subangular blocky structure with pressure faces; very firm, sticky and slightly plastic; few fine pores; few fine calcareous nodules; strongly effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Bw3   85-109 cm --- Dark yellowish brown (10YR 4/4 M) sandy clay; few fine distinct black mottles (10 YR 2/1); strong coarse subangular blocky structure with pressure faces; very firm, sticky and slightly plastic; very few fine pores; many fine to medium calcareous nodules; strongly effervescent; moderately alkaline (pH 8.4); clear wavy boundary.

Bw4   109-155 cm --- Dark yellowish brown (10YR 4/4 M) sandy clay, common fine distinct black mottles (10 YR 2/1); strong coarse subangular blocky structure with pressure faces; very firm, moderately sticky and moderately plastic; many fine to medium calcareous nodules; strongly effervescent; moderately alkaline (pH 8.4).

Type location: 09°48'15" N, 78°22'00" E; village Kallurani, tehsil Sivagangai, district Sivagangai, Tamil Nadu.

Range in characteristics: The thickness of solum is more than 150 cm. The A horizon is 10 to 25 cm thick. Its colour is in hue 10YR and 7.5YR, value 4 or 5 and chroma 3. Its texture ranges from clay loam to clay. The B horizon is more than 100 cm thick. Its colour is in hue 10YR and 7.5YR, value and chroma 3 or 4.

Geographic setting: Salur soils are developed over gneiss - derived alluvium on nearly plain low land at an elevation ranging from 60 to 80 m above MSL. The climate is semi-arid tropical with mean annual air temperature of 28.7°C and mean annual rainfall of 786 mm. The estimated MAST is 32.2°C, MSST 30.2°C, MWST 27.1°C and difference between MSST and MWST is 3.1°C.

Geographically associated soils: Salur soils are associated with Tamarakki and Tamaraikulam soils which are Vertic Haplustepts and Aquertic Natrustalfs, respectively.

Drainage and permeability: Somewhat poorly drained with slow permeability.

Use and vegetation: These soils are mainly cultivated to paddy, sugarcane, coconut, banana and vegetables; natural vegetation: Karuvel (*Acacia arabica*), Kodukkapuli (*Pitchecolobium dulce*), Palmyrah (*Borassus flabellifer*), Neem (*Azadirachta indica*), Velikaruvel (*Prosopis juliflora*), Avarai (*Cassia auriculata*), Erukku (*Calotropis gigantea*), Kandankathiri (*Solanum surattense*), Kathalai (*Agave americana*), Kolunji (*Theprosia purpurea*), Pirandai (*Cissus quadrangularis*), Purasal Chedi (*Ipomea cornea*), Hariyali (*Cyanodon dactylon*), Nutgrass (*Cyperus rotundus*), Keelanelli (*Phyllanthus niruri*), Thulasi (*Ocimum sanctum*), Thumbai (*Leucas aspera*).

Distribution and extent: Nearly 3153 ha in lowlands of Sivagangai block of Sivangangai district.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Tamil Nadu State Soil Survey and Land Use Organisation and Tamil Nadu Agricultural University, 2006.

Interpretation:

a) Interpretative grouping
    i) Land capability sub-class   IIIsw
    ii) Land irrigability sub-class   3sd
    iii) Fertility capability classification   Cgb (<1%) (clayey and gleyed soil with effervescence).

b) Crop yield (kg/ha^{-1}):
- Paddy (*Oryza sativa*)   3000 to 4000
- Sugarcane (*Saccharum officinarum*)   100 to 120 tons
- Ragi (*Eleusine coracana*) - irrigated   3000 to 4000

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)							
		Total			Sand				
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)
		<------------------------------------ % of <2 mm ------------------------------------>							
Ap	0-23	58.2	6.5	35.3	8.5	11.2	17.6	11.0	9.9
Bw1	23-59	44.8	19.6	35.6	9.6	10.2	11.0	10.3	3.7
Bw2	59-85	54.1	7.7	38.2	8.5	11.2	18.2	11.5	4.7
Bw3	85-109	51.5	9.1	39.4	8.6	12.2	14.5	10.0	6.2
Bw4	109-155	51.7	7.8	40.5	4.7	10.9	17.4	14.5	4.2

Depth (cm)	Organic carbon (%)	pH (1:2.5) Water	E.C. (dS m^{-1})	CaCO$_3$ (%)
0-23	0.54	8.0	0.35	1.0
23-59	0.42	8.2	0.48	2.2
59-85	0.36	8.2	0.61	3.0
85-109	0.21	8.4	0.78	3.1
109-155	0.12	8.4	0.94	3.4

| Depth (cm) | Exchangeable bases | | | | | CEC NH$_4$OAc (pH 7.0) cmol(+)kg^{-1} soil | Ratio CEC/ Clay | Base saturation (NH$_4$OAc)[1] % | ESP |
	Ca	Mg	Na	K	Total				
0-23	14.75	3.25	0.85	0.3	19.2	19.4	0.55	99	4.3
23-59	15.00	3.25	0.90	0.4	19.6	19.8	0.56	99	4.5
59-85	16.00	3.50	1.10	0.4	21.0	21.3	0.56	99	5.1
85-109	17.25	3.25	1.25	0.6	22.4	22.6	0.57	99	5.5
109-155	18.25	3.75	1.50	0.5	24.0	24.1	0.59	99	6.2

Available nutrients (0-23 cm)								
N	P$_2$O$_5$	K$_2$O	S	Fe	Mn	Cu	Zn	B
----------- kg ha^{-1} -----------			---------------------- mg kg^{-1} soil ----------------------					
109	128	354	Nil	11.3	17.5	4.7	0.8	Nil

[1][Total exchangeable bases/CEC by NH$_4$OAc] x 100

Source: Natarajan, A., Janakiraman, M., Manoharan, S., Balasubramaniyan, V., Murugappan, K., Udayakumar, J., Ramesh, M., Chandramohan, D., Niranjana, K. V., Venkatesh, D. H., Krishnasamy, M., Sennimalai, P., Thanikody, M., Krishnan, P., Rajamannar, G., Natarajan, S., Jagadeesan, P., and Vadivelu, S., (2006). Land Resources of Sivagangai Block, Sivagangai District, Tamil Nadu (Executive Summary). NBSS Publ. No.1028, p. 261.

2.25 Soil Series: AESR 9.1

Punjab and Rohilkhand Plains, hot dry/moist subhumid transitional ESR with deep, loamy to clayey alluvium-derived (inclusion of saline and sodic phases) soils, medium AWC and LGP 120-150 days (N8Cm/Cd4)

2.25.1 BERPURA SERIES

The Berpura series is a member of the fine-loamy, mixed, hyperthermic family of Udic Haplustepts. Typically, Berpura soils have pale brown to dark yellowish brown, moderately alkaline, loam A horizons, and dark yellowish brown to brown, mildly to moderately alkaline, clay loam B horizons.

Water balance diagram Berpura, Haryana
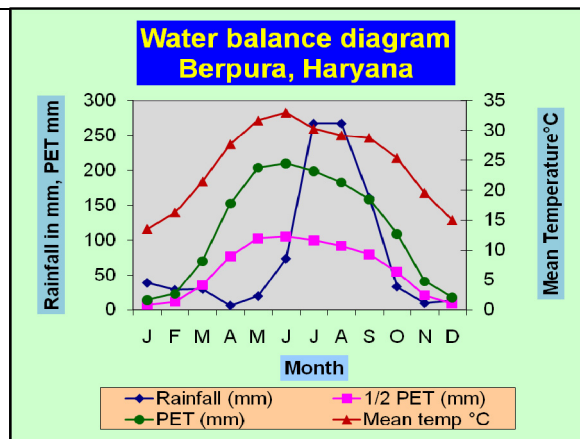
Typifying pedon: Berpura loam - cultivated

Ap1   0-12 cm -- Pale brown (10YR 6/3 D) and dark yellowish brown (10YR 4/4 M) loam; moderate medium subangular blocky structure; hard, firm, sticky and slightly plastic; many fine to medium fibrous roots; moderately alkaline (pH 8.4); clear smooth boundary.

Ap2   12-33 cm -- Brown (10YR 5/3 D) and dark yellowish brown (10YR 4/4 M) loam; moderate medium to coarse subangular blocky structure; hard, firm, sticky and slightly plastic; many fine fibrous roots; many fine to medium tubular pores; moderately alkaline (pH 8.2); clear smooth boundary.

Bw1   33-60 cm -- Dark yellowish brown (10YR 4/4 M) clay loam; strong medium to coarse angular blocky structure; very hard, firm, slightly sticky and slightly plastic; many very fine fibrous roots; many fine to medium tubular pores; moderately alkaline (pH 8.1); clear smooth boundary.

Bw2   60-92 cm -- Dark yellowish brown (10YR 4/4 M) clay loam; few faint mottles; strong angular blocky structure; very hard, firm, very sticky and plastic; few very fine fibrous roots; many very fine tubular pores; mildly alkaline (pH 7.8); clear smooth boundary.

Bw3   92-121 cm -- Dark yellowish brown (10YR 4/4 M) clay loam; few faint mottles; strong medium to coarse angular blocky structure; very hard, firm, very sticky and plastic; few very fine fibrous roots; many very fine tubular pores; mildly alkaline (pH 7.8); clear smooth boundary.

BC   121-150 cm -- Brown to dark brown (10YR 4/3 M) clay loam; few faint mottles; moderate medium to coarse subangular blocky structure; very hard, firm, sticky and plastic; mildly alkaline (pH 7.4).

Type location: 30°26'N, 76°58'E; village Berpura, block Naraingarh, district Ambala, Haryana.

Range in characteristics: The thickness of the solum ranges from 140 to 160 cm. The colour of the A horizon is in hue 10YR, value 4 to 5 and chroma 3 to 4. Its texture is loam to clay loam. Its structure is moderate medium subangular blocky. The colour of the B horizon is in hue 10YR, value 3 to 5 and chroma 3 to 4. Its texture is loam to silty clay loam but it is generally clay loam.

Its structure is strong medium to coarse angular blocky. Iron-manganese concretions and mottles are present in the lower layers.

Geographic setting: Berpura soils are formed in mixed alluvium on nearly level old flood plain at an elevation of 250 to 330 m above MSL. The climate is subhumid subtropical with mean annual temperature of 24.3°C and mean annual rainfall of 946 mm. The estimated MAST is 25.8°C, MSST 30.6°C, MWST 20.0°C and difference between MSST and MWST is 10.6 °C

Drainage and permeability: Moderately well drained with moderately slow permeability.

Use and vegetation: Cultivated to rainfed sorghum, black gram, maize and barley and paddy, wheat and sugarcane under irrigation; natural vegetation - mainly *Acacia arabica* (babul), *Saccharum munja* (munj) and *Lantana spp.* (lantana).

Distribution and extent: Extensive in northern parts of Haryana.

Series proposed: State Soil Survey Organisation, Department of Agriculture, Haryana.

Interpretation: Berpura soils are high in available moisture capacity. Soil productivity is good. In years of normal rainfall they can support a variety of climatically adapted crops. They can conserve enough moisture to support crops like gram and mustard during rabi season.

Interpretative grouping:

i)	Land capability subclass	IIc
ii)	Irrigability class	1
iii)	Productivity potential	High

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
		←---% of <2 mm---→									
Ap1	0-12	23.5	50.0	26.5	-	0.1	0.4	13.7	9.3	13.9	36.1
Ap2	12-33	28.0	45.7	26.3	-	-	-	19.6	8.4	10.0	35.7
Bw1	33-60	26.6	43.1	30.3	-	-	-	21.0	5.6	5.4	37.7
Bw2	60-92	20.0	44.7	35.3	-	-	-	12.0	8.0	6.0	38.7
Bw3	92-121	23.6	44.9	31.5	-	-	-	12.4	11.2	10.4	34.5
BC	121-150	33.7	36.0	30.3	-	-	0.2	28.0	6.2	6.3	29.7

| Depth (cm)	Organic carbon (%)	Carbonate as CaCO₃ <2 mm (%)	pH (1:2.5) H₂O	E.C. (1:2.5) H₂O (dS m⁻¹)	Water retention	
					33 kPa (%)	1500 kPa (%)
0-12	0.39	-	8.4	<0.2	23.6	10.4
12-33	0.19	-	8.2	<0.2	22.8	9.9
33-60	0.19	-	8.1	<0.2	24.7	11.6
60-92	0.23	-	7.8	<0.2	24.6	13.0
92-121	0.23	-	7.8	<0.2	23.8	12.7
121-150	0.27	-	7.4	<0.2	22.4	11.5

Source: Sohan Lal, Deshpande, S.B. and Sehgal, J.L. (Eds) (1994). Soil Series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India 684pp.

2.25.2 SHAHAZADPUR SERIES

The Shahazadpur series is a member of the fine-loamy, mixed, hyperthermic family of Typic Haplustalfs. Typically, Shahazadpur soils have yellowish brown to dark yellowish brown, neutral, loamy fine sand A horizons, and yellowish brown to dark brown, slightly acid to neutral, sandy loam to sandy clay loam B horizons underlain by brown to dark brown, slightly acid, sandy loam C horizons.

Water balance diagram Ambala, Haryana
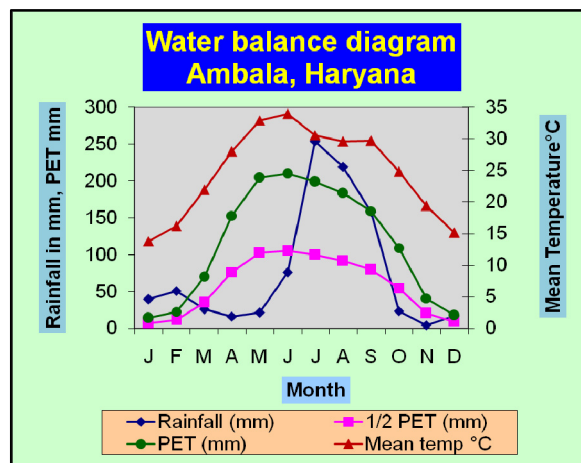
Typifying pedon: Shahazadpur loamy fine sand –cultivated

Ap   0-18 cm --- Yellowish brown (10YR 5/6 D) and dark yellowish brown (10YR 4/4 M) loamy fine sand; weak fine subangular blocky structure; soft, loose; fibrous roots; very fine to fine pores; neutral (pH 7.0); abrupt smooth boundary

Bt1   18-43 cm --- Yellowish brown (10YR 5/4 D) and dark yellowish brown (10YR 4/4 M) fine sandy loam; moderate to medium subangular blocky structure; hard, friable, slightly sticky; fibrous roots; many fine pores; slightly acid (pH 6.5) gradual smooth boundary.

Bt2   43-93 cm --- Dark yellowish brown (10YR 4/4 M) sandy clay loam; moderate medium subangular blocky structure; hard friable, slightly sticky fibrous roots; common very fine pores; neutral (pH 6.7); gradual smooth boundary.

Bt3   93-133 cm --- Brown to dark brown (7.5YR 4/4 M) sandy clay loam; weak fine to medium subangular blocky structure; slightly hard, friable; slightly sticky; common very fine roots; neutral (pH 6.6); clear smooth boundary.

BC   133-150 cm --- Brown to dark brown (7.5YR 4/4 M) fine sandy loam; weak fine subangular blocky structure; soft, very friable; few very fine roots; slightly acid (pH 6.5).

Type location: 30º29' N, 77º09' E; left side of the road from Naraingarh to Taka Gurudwara, village Kularpur, tehsil Naraingarh, district Ambala, Haryana.

Range in characteristics: The thickness of the solum ranges from 110 to 160 cm. The thickness of the A horizon is 14 to 20 cm and its colour is in hue 10YR, value 4 to 5 and chroma 4 to 6. Its texture ranges from loamy fine sand to fine sandy loam and its structure is weak granular to weak fine subangular blocky. The thickness of the B horizon is 100 to 140 cm. Its colour is in hue 10YR and 7.5 YR, value 4 to 5 and chroma 4 to 6. Its texture is sandy loam to sandy clay loam and its structure is moderate medium subangualr blocky.

Geographic setting: Shahazadpur soils are formed in alluvium on nearly level to gently sloping flood plain at an elevation of 250 to 325 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 21.0ºC and mean annual rainfall of 1125 mm. The estimated MAST is 22.5ºC, MSST 28.3ºC, MWST 15.8ºC, and difference between MSST and MWST is 12.5°C.

Drainage permeability: Well drained with moderate permeability.

Use and vegetation: Cultivated to groundnut, millets, pigeonpea, cluster bean, and maize in *kharif* and gram and lentil in *rabi* under rainfed agriculture and wheat and barley under irrigation; natural vegetation – *Ziziphus jujuba* (ber), *Acacia arabica* (babul) and *Dalbergia sissoo* (shisham).

Distribution and extent: Extensive in northern parts of Haryana.

Series proposed: State Soil Survey Organisation, Department of Agricultural, Haryana.

Interpretation: Shahazadpur soils have coarse texture upto about 40 cm depth from the surface. Their intake rate of water is high and these are moderately permeable. They have moderate available water capacity. Soil-water-air relationship is good. They can hold enough moisture to support crops like gram in *rabi* season. Under normal years of rainfall a variety of climatically adapted crops can be grown during *kharif*.

Interpretative grouping:
- i) Land capability subclass   IIc
- ii) Irrigability class   1
- iii) Productivity potential   Medium to high

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
		<------------------------------------- % of < 2 mm ------------------------------------->									
Ap	0-18	82.2	7.3	10.5	-	0.4	3.8	62.8	15.2	5.3	2.0
Bt1	18-43	67.5	14.7	17.8	-	0.3	2.6	46.5	18.1	8.0	6.7
Bt2	43-93	59.1	17.1	23.8	-	0.3	2.1	42.3	14.4	7.4	9.7
Bt3	93-133	65.0	10.5	24.5	-	0.3	2.0	52.2	10.5	5.0	5.5
BC	133-150	73.0	11.2	15.8	-	0.2	2.4	58.8	11.6	6.0	5.2

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H2O	E.C. (1:2.5) H2O (dS m⁻¹)	Water retention	
					33 kPa	1500 kPa
0-18	0.25	-	7.0	<0.2	7.8	2.4
18-43	0.17	-	6.5	<0.2	11.5	5.9
43-93	0.17	-	6.7	<0.2	11.7	6.8
93-133	0.14	-	6.6	<0.2	11.7	6.5
133-150	0.08	-	6.5	<0.2	10.3	4.7

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.26 Soil Series: AESR 9.2

Rohilkhand, Avadh and south Bihar Plains, hot dry subhumid ESR with deep loamy alluvium-derived soils, medium to high AWC and LGP 150-180 days (N8Cd5)

2.26.1 BASIARAM SERIES

The Basiaram series is a member of the fine-silty, mixed, hyperthermic family of Sodic Haplustalfs. Typically, Basiaram soils have light brownish gray to light yellowish brown, neutral to mildly alkaline, silt loam A horizons, and yellowish brown to brown, mildly alkaline to neutral, silt loam to silty clay loam B horizons.
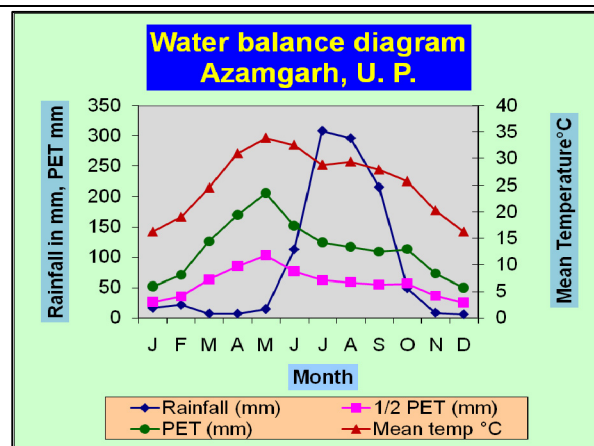
Typifying pedon: Basiaram silt loam - cultivated

Ap   0-13 cm --- Light brownish gray (10YR 6/2 D) and dark grayish brown (10YR 4/2 M) silt loam; moderate medium granular structure; soft, friable, slightly sticky; many very fine fibrous roots; very fine to fine interstitial pores; neutral (pH 7.2); abrupt wavy boundary.

Bt1   13-28 cm --- Light yellowish brown (10YR 6/4 D) and brown (10YR 5/3 M) silt loam; common fine faint yellowish brown (10YR 5/8) mottles; moderate coarse angular blocky structure; hard, firm, sticky and slightly plastic; many very fine fibrous roots; very fine to fine discontinuous interstitial pores; thin clay cutans on ped faces; many iron-manganese concretions of 1 to 2 mm size; mildly alkaline (pH 7.4); clear smooth boundary.

Bt2   28-44 cm --- Yellowish brown (10YR 5/4 D) and dark yellowish brown (10YR 4/4 M) silt loam; common fine faint yellowish brown (10YR 5/8) mottles; strong coarse angular blocky structure; very hard, very firm, sticky and plastic; common very fine fibrous roots; very fine to fine discontinuous interstitial pores; thin clay cutans on ped faces; few iron-manganese concretions about 7 to 10 per cent by volume of 2 mm size; mildly alkaline (pH 7.4); clear smooth boundary.

Bt3   44-82 cm --- Light yellowish brown (10YR 6/4 D) and yellowish brown (10YR 5/4 M) silt loam; common fine faint yellowish brown (10YR 5/8) mottles; strong coarse angular blocky structure; very hard, very firm, sticky and plastic; few very fine fibrous roots; very fine to fine discontinuous interstitial pores; thin clay cutans on ped faces; many iron-manganese concretions about 10 per cent by volume of 2 to 5 mm size; neutral (pH 7.3); clear smooth boundary.

Bt4   82-110 cm --- Yellowish brown (10YR 5/4 M) silt loam; common fine faint brownish yellow (10YR 6/6 M); moderate fine to medium subangular blocky structure; firm, sticky and plastic; few very fine fibrous roots; very fine to fine discontinuous interstitial

Bt5   110-136 cm --- Brown (10YR 5/3 M) silt loam; common fine faint brownish yellow (10YR 6/6) mottles; moderate fine to medium subangular blocky structure; firm, sticky and plastic; very fine to fine interstitial pores; few iron-manganese concretions about 10 per cent by volume of 2 to 5 mm size; neutral (pH 7.2); gradual wavy boundary.

Bt6   136-170 cm --- Brown (10YR 5/3 M) silty clay loam; common fine faint yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; firm, sticky and plastic; very fine to fine interstitial pores; neutral (pH 7.1).

Micromorphology: In the AB horizon, common well developed cutans mainly consisting of clay-sized material occur. These are impure clay pedofeatures confirming clay illuviation process (Pal et al., 1994). Sometimes, cutans consist of alternating clay-sized and silt-sized laminae. In this zone, some voids are also partly filled with mineral grains derived from the topsoil. In the Bw2 horizon, few to common often discontinuous thin cutans mainly consisting of clay-sized material are present. This illuviation is identical to that which leads to the development of an argillic horizon. The higher clay content in the B horizon is partly due to varying sedimentations. In wet periods, shifting of soil material also occurs on the surface resulting in the formation of slaking crusts composed of laminae of graded clay and silt- sized soil material. Mica is under alteration in the AB horizon to the Bw2 horizon. Sesquioxidic nodules also occur.

Type location: $26^{o}15'$ N, $83^{o}13'$ E; field No.1399, Kulawa No.4 along Dhorighat canal, village Gotha, tehsil Goshi, district Azamgarh, Uttar Pradesh.

Range in characteristics: The thickness of the solum is more than 150 cm. The A horizon is 25 to 40 cm thick. Its colour is in hue 10YR, value 4 to 6 and chroma 2 to 4. The texture is sandy loam to silt loam. The cambic B horizon is more than 100 cm thick. Its colour is in hue 10YR, value 4 to 6 and chroma 3 to 4. The texture is dominantly silt loam. Thin clay cutans, mottles and iron-manganese concretions are present.

Competing series and their differentiae: Panail series is a coarse-loamy, Typic Haplustalf.

Geographic setting: Basiaram soils are formed in silty alluvium on nearly level river terraces and levees at an elevation of 75 to 100 m MSL. The climate is subhumid subtropical with mean annual air temperature of 26.0°C and mean annual rainfall of 1140 to 1300 mm. The estimated MAST is 27.5^{o}C, MSST 30.2^{o}C, MWST 17.5^{o}C, and difference between MSST and MWST is 12.7^{o}C.

Geographically associated soils: Basiaram soils are associated with Dhorighat and Panail soil series which are Aeric Endoaqualf and Typic Haplustalf, respectively.

Drainage and permeability: Somewhat poorly drained with slow permeability.

Use and vegetation: Extensively cultivated to wheat, rice, sugarcane, pigeonpea, gram and pulses: natural vegetation - *Acacia spp.* (babul) and *Mangifera indica* (mango).

Distribution and extent: Extensive along the terraces of the Ghaghara river in Azamgarh district, Uttar Pradesh.

 a) Interpretative grouping:
      i)   Land capability subclass   IIIw

ii)   Irrigability subclass   2d
iii)   Productivity potential   Medium to high

b) **Yield:** Based on information collected from CADP, Varanasi, U.P.

Crop	Farmers' practices	Improved practices
	←---------------Yield, Mg ha^{-1}--------------→	
Rice	3.5	5.0
Wheat	2.0	5.0
Potato	15.0	30.0
Gram	1.0	1.5
Barley	1.6	3.5

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
		<------------------------------------- % of < 2 mm ------------------------------------->									
Ap	0-13	24.2	65.5	20.3	-	0.1	0.7	3.4	20.0	37.3	28.2
Bt1	13-28	24.5	60.5	20.0	0.2	0.3	0.2	3.5	20.3	33.0	27.5
Bt2	28-44	20.5	58.0	21.5	0.1	0.3	0.3	2.6	17.2	26.7	31.3
Bt3	44-82	16.2	58.5	21.5	0.1	0.5	0.3	1.6	13.7	26.9	31.6
Bt4	82-110	21.7	57.0	21.3	0.6	0.5	2.0	1.5	17.1	27.2	29.8
Bt5	110-136	11.6	65.8	22.6	0.1	0.2	0.2	1.3	9.8	18.8	47.0
Bt6	136-170	8.3	62.7	29.0	0.1	0.1	0.1	1.4	6.6	13.3	49.4

Depth (cm)	Organic Carbon (%)	Carbon-ate as CaCO3 < 2 mm (%)	Ext. iron as Fe (%)	pH (1:2.5) H2O	E.C. (1:2.5) H2O (dS m^{-1})	Bulk density (Mg m^{-3})	Water retention		Micronutrients			
							33 kPa	1500 kPa	D T P A extractable			
									Zn	Cu	Mn	Fe
									<---------- ppm ---------->			
0-13	0.48	Tr	0.29	7.2	0.34	1.19	19.3	4.7	0.73	2.90	41	38
13-28	0.25	Tr	0.44	7.4	0.45	1.23	21.3	5.7	0.30	2.06	23	12
28-44	0.15	Tr	0.79	7.4	0.40	1.30	23.1	8.7	0.60	1.02	40	11
44-82	0.15	-	1.09	7.3	0.42	1.35	24.1	10.8	0.25	0.85	20	8
82-110	0.12	-	1.02	7.3	0.32	1.30	24.0	6.8	0.25	0.42	19	6
110-136	0.07	-	1.24	7.2	0.46	1.32	27.5	12.1				
136-170	0.07	Tr	1.44	7.1	0.31	1.34	29.2	13.6				

Depth (cm)	Extractable bases					CEC NH4OAc	Ratios to Clay			Clay fraction mineralogy*	ESP
	Ca	Mg	Na	K	Sum		CEC NH4OAc	Ext. iron	1500 kPa water		
	<------------------ cmol (p[+])kg^{-1} ------------------>										
0-13	2.3	2.3	0.6	0.3	5.5	6.3	0.61	0.03	0.46	IL 5 CH 1 VM 2	9.5
13-28	3.0	2.5	0.6	0.9	7.0	7.5	0.50	0.03	0.38	IL 5 CH 1 VM 1	8.0
28-44	3.3	2.5	0.8	0.9	7.5	8.5	0.40	0.04	0.40	IL 5 CH 1 VM 1	9.4
44-82	3.0	2.5	1.3	1.8	8.6	10.6	0.42	0.04	0.43	IL 5 CH 1 VM 1	12.2
82-110	4.0	2.5	1.5	0.9	8.9	9.8	0.46	0.05	0.32	IL 5 CH 1 VM 2	15.3
110-136	4.3	3.0	1.5	0.8	9.6	10.1	0.45	0.05	0.54	IL 5 CH 2 VM 2	14.8
136-170	5.0	2.3	1.0	0.9	9.2	10.2	0.35	0.05	0.47		9.8

IL = Illite   5 = (>50%)
CH = Chloriite   2 = (5-20%)
VM = Vermiculite   1 = (· 5%)
It = Interlayered

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.26.2 SARTHUA SERIES

The Sarthua series is a member of the fine, mixed, hyperthermic family of Vertic Endoaqualfs. Typically, Sarthua soils have light yellowish brown to brown, neutral, silty clay loam A horizons, and dark brown to light olive brown, moderately to very strongly alkaline, silt clay to silty clay loam Bt horizons.
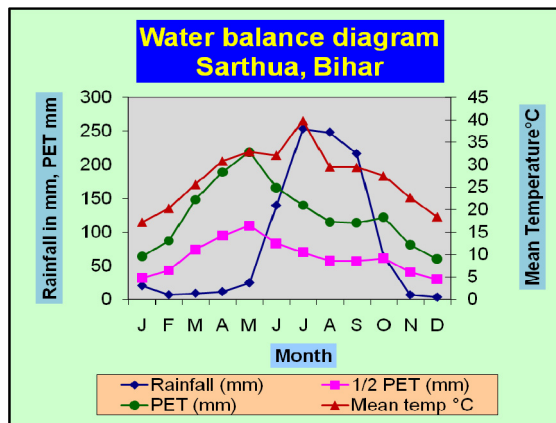
Typifying pedon: Sarthua – silty clay loam - cultivated

Ap   0-13 cm -- Light yellowish brown to very pale brown (10YR 6.5/4 D) and brown (10YR 4/3 M) silty clay loam; common fine distinct strong brown (7.5YR 5/8) mottles; moderate medium subangular blocky structure; hard, friable, sticky and slightly plastic; many very fine and common fine roots; 5-10 mm wide cracks; few fine and medium pores; few fine and very fine iron nodules; neutral (pH 6.8); clear smooth boundary.

Bt1   13-28 cm -- Dark brown to brown (10YR 4/3 M 4/3.5 R) silty clay loam; many fine to medium prominent strong brown (7.5YR 5/8) mottles; strong medium subangular blocky structure; 1-2 per cent by volume fine gravels; friable, sticky and plastic; common very fine and few fine roots; few fine and medium pores; patchy broken thin clay cutans; few very fine and fine iron nodules; slightly effervescent; moderately alkaline (pH 8.0); gradual smooth boundary.

Bt2   28-52 cm -- Very dark grayish brown to dark grayish brown (10YR 3.5/2 M) silty clay loam; common fine faint prominent dark yellowish brown (10YR 4/6) mottles; strong medium to coarse subangular tending to angular blocky structure with pressure faces; 1-2 per cent fine gravels; firm, sticky and plastic; few very fine roots; common very fine and fine pores; patchy broken thin clay cutans; few fine and very fine iron nodules; slightly effervescent; moderately alkaline (pH 8.2); gradual smooth boundary.

Bt3   52-84 cm -- Olive brown (2.5Y 4/3 M) and light olive brown (2.5Y 5/3 R) silt clay; many fine faint dark yellowish brown (10YR 4/6) mottles; strong medium to coarse subangular and angular (weak) blocky structure with pressure faces; 1-2 per cent fine gravels; firm, sticky and plastic; few very fine roots; common very fine and fine pores; patchy broken thin clay skins; few very fine and fine iron nodules; slightly effervescent; strongly alkaline (pH 8.5); gradual smooth boundary.

Bt4   84-117 cm -- Dark grayish brown to olive brown (2.5Y 4/2.5 M) silty clay; many fine distinct yellowish brown (10YR 5/6) mottles; strong medium subangular blocky structure with pressure faces; 1-2 per cent fine gravels; firm, sticky and plastic; few very fine roots; few very fine and fine pores; patchy broken thin clay cutans; common very fine and fine iron nodules; slightly effervescent; very strongly alkaline (pH 9.2); gradual smooth boundary.

Bt5   117-150+ cm -- Dark grayish brown to brown (10YR 4/2.5 M) and dark yellowish brown to yellowish brown (10YR 4.5/4 R) silt clay; many fine to medium distinct

strong brown (7.5YR 5/6) mottles; strong medium subangular tending to angular blocky structure with pressure faces; 1-3 per cent fine gravels; firm, sticky and plastic; few very fine and fine pores; patchy broken thin clay cutans; common very fine and fine iron nodules; slightly effervescent; very strongly alkaline (pH 9.4).

Type location: 25°28'52" N, 84°39'37" E; about 1 km north of village Sarthua, village Sarthua, block Buhia, district Bhojpur, Bihar.

Range in characteristics: These soils are very deep. The thickness of the A horizon varies from 12 to 15 cm. It has variegated colour in hue 10YR, value 4 to 7 and chroma 3 to 4. The texture is dominantly silty clay loam and structure is moderate medium suganbular blocky. The thickness of Bt horizon is more than 140 cm. Its colour is in hue of 10YR and 2.5Y, value 3 to 4 and chroma 2 to 3. Its texture varies from silty clay to silty clay loam and structure is strongly developed medium suganbular blocky and also tending to angular blocky with pressure faces. It has 1-3 per cent by volume fine gravels and thin patchy broken clay skins. Common to many, fine to medium, distinct mottles of variegated colours – strong brong (7.5 YR 5/8) and dark yellowish brown 10YR 4/6) are present throughout the profile. These soils also have very fine to fine sized iron nodules. These soils develops 5-10 mm wide cracks in summer season.

Geographic setting: Sarthua soils are formed in level to nearly level (0-1%), Indo-gangetic alluvial plain : recent alluvial plain at an elevation of 40-50 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 27.2°C and mean annual rainfall of 1003 mm. The estimated MAST is 29.2°C, MSST 32.2°C and MWST 23.3°C.

Geographically associated soils: Principal associated soil is Barew series which is very fine Vertic Haplustepts.

Drainage and permeability: Poorly drained with slow permeability.

Use and vegetation: Paddy is commonly grown in kharif season. Wheat, gram, vegetables are also suitable under irrigation during rabi season. Natural vegetatrion includes *Ficus spp*. (pipal), *Azadirachta indica* (neem), *Madhuca indica* (mahua) and grasses.

Distribution and extent: It is distributed in East Champaran, Rohtas, Bhojpur, Jahanabad and Patna districts (Area : 169841 ha).

Interpretation: The soils of Sarthua series are fine textured with slow permeability. They have moderate to high available moisture holding capacity.

a)   **Interpretative grouping:**
    i)   Land capability subclass   IIws
    ii)   Irrigability class   3d
    iii)   Productivity potential   Medium to high

b)   **Yield: Based on data from farmers' fields**

Crop	Farmers' practices	Improved practices
	← --------------Yield, Mg ha^{-1}----------------→	
Rice (winter)	18 – 23	25 – 35

Soil datasets:

Hori zon	Depth (cm)	Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Fine clay (%)	FC/TC ratio	Moi sture %	Ove n dry	Roo m temp.	40°C	Oven dry	Weight ed mean (WM) 0-100 cm	HC* mm/hr	WDC (%)	Textu ral class
		←---(% of <2 mm)--→					BD Mg/m³		COLE						
Ap	0-13	6.9	65.5	27.7	20.4	0.7		1.5	0.06	0.07	0.07		0.57	2.42	sicl
Bt1	13-28	5.0	61.2	33.9	25.4	0.7		1.7	0.08	0.10	0.10		0.37	2.65	sicl
Bt2	28-52	4.2	52.0	43.9	35.1	0.7		1.7	0.08	0.12	0.12	0.132	0.13	2.80	sic
Bt3	52-84	4.3	50.4	45.4	32.8	0.7		1.7	0.07	0.15	0.15		nil	2.88	sic
Bt4	84-117	4.9	55.6	39.5	29.5	0.5		1.6	0.07	0.18	0.20		nil	2.80	sicl
Bt5	117-150+	3.4	46.4	50.2	34.4	0.7		1.6	0.08	0.10	0.20		nil	1.83	

Depth (cm)	pH water (1:2)	CaCO₃ (%)	OC (%)	Ca	Mg	Na	K	Sum	CEC	Clay CEC cmol(p+)kg -1	B.S. (%)
				Extractable bases ←--------------------cmol(p+)/kg⁻¹--------------------→							
0-13	6.8	1.3	0.83	6.1	3.7	0.5	0.2	10.5	15.8	57	66
13-28	8.0	1.6	0.36	9.5	3.6	1.1	0.4	14.6	18.8	55	77
28-52	8.2	1.7	0.36	10.0	5.5	2.0	0.5	18.0	18.7	43	96
52-84	8.5	1.9	0.32	3.2	2.5	4.6	0.5	10.8	11.0	24	98
84-117	9.2	2.0	0.26	4.4	5.6	8.4	0.6	19.0	19.9	50	95
117-150+	9.4	2.7	0.25	3.0	9.9	6.0	0.6	19.5	21.6	43	90

Depth (cm)	Exch. Ca/Mg	ECP	EMP	ESP	CO₃ clay (%)	Org.C arbon% on WDClay basis
0-13	1.6	39	23	3	1.28	0.026
13-28	2.6	50	19	6	1.15	Nil
28-52	1.8	53	29	11	0.12	Nil
52-84	1.3	29	23	42	1.29	Nil
84-117	0.8	22	28	42	1.29	Nil
117-150+	0.3	14	46	28	1.27	Nil

Depth (cm)	Sat %	ECe	Ca	Mg	Na	K	Sum	CO₃	HCO₃	Cl	SO₄	Sum	SAR
	Soluble cations (meq/l)							Soluble anions (meq/l)					
0-13	38.89	0.30	1.00	1.00	1.47	0.04	3.51	tr	2.50	1.50	tr	4.0	
13-28	38.97	0.31	1.00	0.50	1.55	0.03	3.08	tr	2.50	1.50	tr	4.0	1.47
28-52	39.03	0.29	2.00	2.00	1.88	0.04	5.92	tr	5.00	1.25	tr	6.25	1.79
52-84	44.41	0.46	2.00	tr	3.40	0.04	5.44	tr	4.00	1.50	tr	5.50	1.33
84-117	48.66	1.36	2.00	tr	9.29	0.04	11.33	tr	6.00	3.00	2.33	11.33	3.04
117-150+	44.60	0.93	2.00	tr	6.17	0.04	8.21	tr	5.00	3.00	0.21	8.21	9.29

Source: Pal, D.K., Sohan Lal, Bhattacharyya, T., Chandran, P., Ray, S.K., Satyavathi, P.L.A., Raja, P., Maurya, U.K., Durge, S.L. and Kamble, G.K. (2010). "Pedogenic thresholds in Benchmark soils under rice-wheat cropping system in a climosequence of the Indo-Gangetic Alluvial Plains" Final Project Report, Division of Soil Resource Studies, NBSS&LUP, Nagpur, p.193.

2.27 Soil Series: AESR 10.1

Malwa Plateau, Vindhyan Scarpland and Narmada Valley, hot dry subhumid ESR with medium and deep clayey Black soils (shallow loamy Black soils as inclusion), high AWC and LGP 150-180 days (15Cd5)

2.27.1 KHERI SERIES

The Kheri series is a member of the fine, smectitic, hyperthermic family of Typic Haplusterts. Typically, Kheri soils have dark grayish brown to very dark grayish brown, neutral, clay A horizons, and very dark grayish brown, neutral to moderately alkaline, clay B horizons.

Water balance diagram Kheri, Jabalpur, M. P.
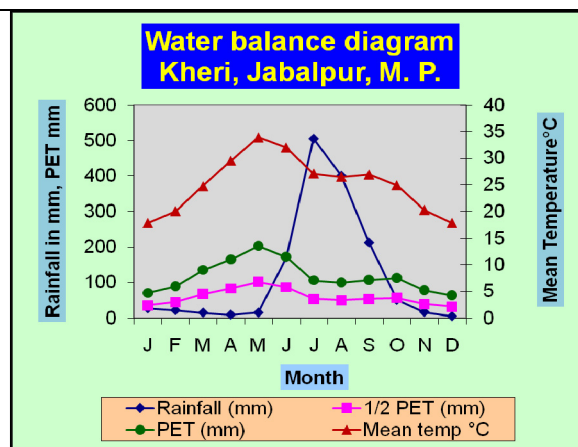
Typifying pedon: Kheri clay -cultivated

Ap   0-14 cm -- Grayish brown (2.5Y 5/2D) and light olive brown to olive brown (2.5Y 4.5/3M) clay; moderate medium subangular blocky structure; hard, firm, sticky and plastic; many fine and medium roots; common fine pores; many very fine and fine lime nodules; mildly alkaline (pH 7.5); strongly effervescent; clear smooth boundary.

Bw1   14-32 cm -- Very dark grayish brown (10YR 3/2M) clay; moderate medium subangular blocky structure with pressure faces on ped surfaces; firm, sticky and plastic; common fine roots; many very fine and fine lime nodules; mildly alkaline (pH 7.6); strongly effervescent; clear smooth boundary.

Bw2   32-61 cm -- Very dark grayish brown (10YR 3/2M) clay; moderate medium angular blocky structure with well developed pressure faces and small wedge shaped aggregates; friable, sticky and plastic; common fine roots; many very fine and fine lime nodules; mildly alkaline (pH 7.6); strongly effervescent; gradual smooth boundary.

Bss1   61-82 cm -- Very dark grayish brown (10YR 3/2M) clay; strong medium angular blocky structure with well developed wedge shaped aggregates and slickensides that breaks into small angular peds; friable, very sticky and plastic; common fine roots; many very fine and fine lime nodules; mildly alkaline (pH 7.6); strongly effervescent; clear smooth boundary.

Bss2   82-112 cm -- Very dark grayish brown (10YR 3/2) clay; strong medium angular blocky structure with well developed wedge shaped aggregates and slickensides that breaks into small angular peds; friable, very sticky and plastic; few fine roots; many very fine and fine lime nodules; mildly alkaline (pH 7.8); violently effervescent; gradual smooth boundary.

Bss3   112-133 cm -- Very dark grayish brown (10YR 3/2M) clay; strong medium angular blocky structure with weakly developed wedge shaped aggregates and slickensides

that breaks into small angular peds; friable, very sticky and plastic; few very fine roots; many very fine and fine lime nodules; mildly alkaline (pH 7.7); violently effervescent; gradual smooth boundary.

Bss4   133-156 cm -- Very dark grayish brown (10YR 3/2M) clay; strong medium angular blocky structure; with weakly developed wedge shaped aggregates and slickensides that breaks to weak angular peds; friable, very sticky and plastic; few very fine roots; many very fine and fine lime nodules; moderately alkaline (pH 8.0); violently effervescent.

Type location: $23^o14'00''N$, $79^o55'19''E$; Vill. Khajri Kheri, tehsil and district Jabalpur, Madhya Pradesh.

Range in characteristics: The A horizon is more than 35 to 50 cm thick. Its colour is in hue 2.5Y and 10YR, value 3 to 4 and chroma 2. The texture is clayey. The B horizon is 100 to 120 cm thick. Its colour is in hue 2.5Y and 10YR, value 3 to 4 and chroma 2. The texture is clayey with more than 60 per cent clay. It has intersecting slickensides forming strong coarse parallelepipeds that break into angular blocks. The soils crack during dry season.

Geographic setting: Kheri soils are formed in basaltic alluvium on very gently sloping (1-3%) in the Deccan plateau – Satpura ranges at an elevation of 50 to 150 m above MSL. The climate is subhumid moist with mean annual air temperature of 25.1^oC and mean annual rainfall of 1440 mm. The estimated MAST is 27.1^oC, MSST 32.1^oC and MWST 23.3^oC. The difference between MSST and MWST is $8.7\,^oC$.

Geographically associated soils: Kheri soils are associated with Adhartal soils which are cracking and clayey. They do not have gilgai relief, slickensides, and wedge shaped aggregates. The Adhartal soils belong to Vertic Haplustepts.

Drainage and permeability: Moderately well drained.

Use and vegetation: Cultivated to rice Soybean-Wheat/Paddy-Wheat/Fallow-Wheat; natural vegetation - Ber, Acacia, Mango, Neem.

Distribution and extent: Extensive in the upper catchment of Narmada covering Jabalpur and Narsinghpur districts of Madhya Pradesh.

Series proposed: Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh.

Interpretation: Kheri soils are moderately productive and crops respond to management. In some soils poor drainage may give rise to problems.

lnterpretative grouping:
      i)   Land capability subclass   IIIs
      ii)   Irrigabillty subclass   3d
      iii)   Productivity potential   Medium

b) **Yield**: Based on data from farmers' fields:

Crop	Farmers' practices	Improved practices
	←---------------Yield, Mg ha^{-1}-------------→	
Rice	1.6	3.0
Pigeonpea	0.7	2.0
Wheat	1.2	2.0
Chickpea	0.5	1.0
Pea	0.6	1.0

Soil datasets:

Hori-zon	Depth (cm)	Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Fine clay (%)	Fine clay/ total clay (%)	BD Mg/m³	COLE	HC* cm/hr	WDC (%)
		←----------(% of <2 mm) -----------→								
Ap	0-14	18.4	30.5	51.1	27.3	53.4	1.4	0.2	2.3	8.1
Bwl	14-32	16.6	29.7	53.7	32.2	60.0	1.4	0.2	3.2	8.0
Bw2	32-61	16.8	36.9	46.3	31.0	67.0	1.4	0.2	2.2	8.3
Bss1	61-82	6.0	40.4	53.6	28.7	53.4	1.4	0.3	2.1	9.8
Bss2	82-112	14.8	38.6	46.6	33.7	72.3	1.5	0.2	1.6	8.0
Bss3	112-133	16.4	39.0	44.6	27.0	60.5	1.5	0.2	1.0	6.5
Bss4	133-156	15.9	37.4	46.7	34.8	74.5	-	0.2	2.0	6.6

* 23 mm hr^{-1} is the weighted mean (WM) HC is 0-100 cm depth of soil.

Depth (cm)	Moisture retention%							AWC (%)
	33kPa	100kPa	300kPa	500kPa	800kPa	1000kPa	1500kPa	
0-14	25.9	23.1	19.6	19.1	17.0	15.8	12.6	13.3
14-32	24.4	22.8	19.7	19.0	17.7	16.9	15.6	8.8
32-61	25.1	24.8	20.7	20.0	17.8	17.6	16.0	9.1
61-82	38.7	33.3	26.7	26.3	23.5	23.2	20.6	18.1
82-112	30.3	25.0	21.1	21.0	18.4	16.6	16.2	14.1
112-133	28.3	25.2	20.1	20.0	17.2	16.4	13.3	15.0
133-156	28.0	26.0	21.2	20.9	20.0	18.0	16.7	11.4

Depth (cm)	pH water (1:2)	CaCO₃ (%)	OC (%)	Extractable bases					CEC	Clay CEC cmol(p+)kg⁻¹	B.S. (%)
				Ca	Mg	Na	K	Sum			
				←--------------------cmol(p+)/kg⁻¹--------------------→							
0-14	7.5	3.6	0.72	35.4	9.4	0.4	6.4	47.2	47.9	94	98
14-32	7.6	4.4	0.56	30.7	7.3	0.4	6.5	43.2	47.9	89	90
32-61	7.6	3.9	0.50	29.3	9.2	0.3	6.5	45.8	53.5	115	85
61-82	7.6	7.1	0.60	46.8	10.9	1.6	6.5	53.8	49.3	92	109
82-112	7.8	7.3	0.40	25.7	6.9	0.5	6.7	40.8	49.3	106	83
112-133	7.7	5.0	0.63	30.0	4.6	0.5	6.6	41.8	49.3	110	85
133-156	8.0	5.5	0.36	27.8	8.8	0.4	6.6	41.7	52.1	111	80

Depth (cm)	Exch. Ca/Mg	ECP	EMP	ESP	CO₃ clay (%)	CO₃ clay (feb) (%)
0-14	3.4	75	22	0.8	3.7	1.9
14-32	4.2	71	17	0.8	3.7	1.9
32-61	3.2	64	20	0.9	3.7	1.7
61-82	4.6	87	19	0.8	3.6	1.9
82-112	3.7	63	17	1.2	4.2	1.9
112-133	6.5	72	11	0.8	4.1	1.8
133-156	2.7	57	21	1.1	4.0	1.8

Depth (cm)	Soluble cations (meq/l)						Soluble anions (meq/l)					RSC	SAR
	Sat %	ECe	Ca	Mg	Na	K	Sum	CO₃	HCO₃	Cl	SO₄	Sum	
0-14	49.9	0.4	2.56	0.2	1.30	0.02	4.0	1.1	1.6	0.8	0.6	4.0	-0.06	1.1
14-32	51.6	0.3	0.89	0.4	1.99	0.03	3.3	1.1	1.5	0.7	-	3.3	1.31	2.5
32-61	49.7	0.2	0.75	0.4	1.30	0.02	2.5	-	2.7	0.8	-	3.5	1.55	1.7
61-82	68.6	0.3	0.41	1.1	1.09	0.04	2.6	-	2.7	0.8	-	3.5	1.19	1.2
82-112	57.6	0.2	0.97	0.6	1.30	0.01	2.9	-	2.9	1.1	-	4.0	1.33	1.5
112-133	51.7	0.3	1.48	0.7	0.98	0.03	3.2	-	2.4	0.8	-	3.2	0.22	0.9
133-156	45.5	0.2	1.15	0.9	0.97	0.01	3.1	-	2.7	0.7	-	3.4	0.65	0.9

Source: Pal, D. K., Bhattacharyya, T., Ray, S. K. and Bhuse, S. R. 2003. "Developing a model on the formation and resllience of naturally degraded black soils of the Peninsular India as a decision support system for better land use planning" NRDMS, DST Project Report, NBSSLUP (ICAR), Nagpur, 144p.

2.27.2 JAMRA SERIES

The Jamra series is a member of the fine, smectitic, hyperthermic family of Chromic Haplusterts. Typically, Jamra soils have light brownish gray to dark grayish brown, mildly to moderately alkaline, clay A horizons, and dark grayish brown, moderately alkaline, clay B and BC horizons.

Water balance diagram Sagar, M. P.
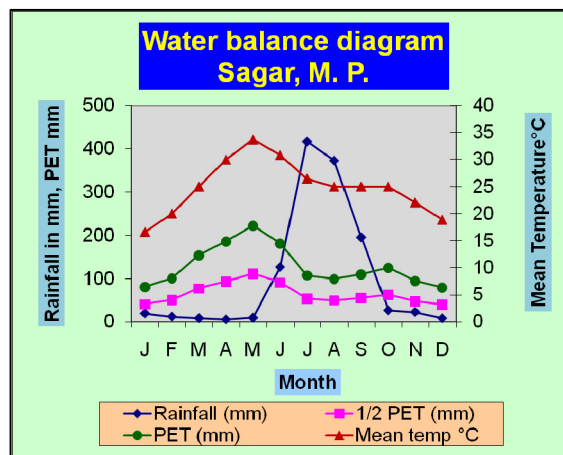
Typifying pedon: Jamra clay - cultivated

Ap 0-16 cm --- Light brownish gray (10YR 6/2 D) and dark grayish brown (10YR 4/2 M) clay; moderate medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common medium roots; 15 to 20 mm wide cracks; slightly effervescent; mildly alkaline (pH 7.8); clear smooth boundary.

Bw 16-45 cm --- Grayish brown (10YR 5/2 D) and dark grayish brown (10YR 4/2 M) clay; moderate medium subangular blocky structure with shiny pressure faces; hard, firm, slightly sticky and slightly plastic; common medium roots; 5 to 10 mm wide cracks; strongly effervescent; moderately alkaline (pH 8.1); clear smooth boundary.

Bss 45-102 cm --- Grayish brown (10YR 5/2 D) and dark grayish brown (10YR 4/2 M) clay; moderate medium angular blocky structure with shiny pressure faces and intersecting slickensides; hard, firm, sticky and plastic; few fine roots; 5 to 10 mm wide cracks; powdery lime pockets; strongly effervescent; moderately alkaline (pH 8.1); gradual smooth boundary.

BC 102-140 cm --- Dark grayish brown (10YR4/2 D&M) clay; strong medium angular blocky structure with shiny pressure faces; hard, firm, sticky and plastic; 5 mm wide cracks; lime accretions; violently effervescent; moderately alkaline (pH 8.4).

Type location: 24°12' N, 78°12' E; village Utawa, tehsil Khurai, district Sagar, Madhya Pradesh.

Range in characteristics: The A horizon is 40 to 50 cm thick. Its colour is in hue 10YR and 2.5Y, value 4 to 6 and chroma 2 to 3. Its texture is clay loam to silty clay and clay. The B horizon is more than 50 cm thick. Its colour is in hue 10YR and 2.5Y, value 3 to 5 and chroma 2 to 3. The texture is silty clay loam to clay. The structure varies from moderate to strong, medium to coarse and subangular to angular blocky. The BC horizon is 35 to 50 cm thick.

Competing series and their differentiae: Marha series is the competing series. These soils are very deep, moderately well drained and non-calcareous. The Marha soils also belong to Chromic Haplusterts.

Geographic setting: Jamra soils are formed in basaltic alluvium and occur on gently sloping flood plain at an elevation of 400 to 500 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 25.2°C and mean annual rainfall of 1394 mm. The estimated MAST is 27.2°C, MSST 30.3°C and MWST 21.8°C. The diference between MSST and MWST is 8.5 °C.

Geographically associated soils: Jamra soils are associated with Marha soils which are non-calcareous and dominantly silty clay in texture. The Marha soils are also Chromic Haplusterts.

Drainage and permeability: Moderately well drained with moderately slow permeability.

Use and vegetation: Mostly cultivated to rainfed crops like wheat, gram and mustard; natural vegetation -*Acacia spp.* (babul).

Distribution and extent: Extensive in Bundelkhand region of Madhya Pradesh and Uttar Pradesh.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur, 1979.

Interpretation: Jamra soils have shrink-swell characteristics and they crack during summer. The moisture retention capacity is high. The early rainfall enters into the soil through cracks and once the cracks are closed the water stagnation occurs due to slow permeability. As the rainfall is high during rainy season, runoff and erosion are the main problems.

These soils need proper surface drainage during rainy season. As the available moisture capacity of the profiles is high, the soils have potential for double cropping. They will respond to management. High lime may pose the problem of phosphate fixation.

Interpretative grouping:
i)	Land capability subclass	IIs
ii)	Irrigability subclass	2d
iii)	Productivity potential	High

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)			Coarse fragments > 2 mm % of whole soil
		Sand (2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	
		<--------------- % of < 2 mm --------->			
Ap	0-16	25.8	29.4	44.8	3
Bw	16-45	25.0	23.5	51.5	2
Bss	45-102	22.7	19.3	58.0	2
BC	102-140	21.6	25.4	53.0	1

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})	Bulk density (Mg m^{-3})
0-16	0.78	0.4	7.8	0.3	1.67
16-45	0.68	8.0	8.1	0.2	1.78
45-102	0.65	9.3	8.1	0.2	1.79
102-140	0.45	10.0	8.4	0.2	1.94

Depth (cm)	Extractable bases					CEC NH_4OAc	Ratio CEC/ Clay	ESP
	Ca	Mg	Na	K	Sum			
	<------------------- cmol (p+)kg^{-1} ----------------->							
0-16	25.4	10.5	1.0	0.5	37.4	40.2	0.90	2.5
16-45	25.2	15.0	2.1	0.5	42.8	44.2	0.86	4.7
45-102	24.2	15.4	2.0	0.6	42.2	43.9	0.76	4.5
102-140	23.4	15.0	3.4	0.7	42.5	43.5	0.82	7.8

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.28 Soil Series: AESR 10.2

Satpura and Eastern Maharashtra Plateau, hot dry subhumid ESR with shallow and medium loamy to clayey Black soils (deep clayey Black soils as inclusion), medium to high AWC and LGP 150-180 days (K4Cd5)

2.28.1 LINGA SERIES

The Linga series is a member of the very fine, smectitic, hyperthermic family of Typic Haplusterts. Typically, Linga soils have dark grayish brown to very dark grayish brown, moderately alkaline, clay A horizons, and very dark grayish brown to brown, mildly to moderately alkaline, clay B horizons.
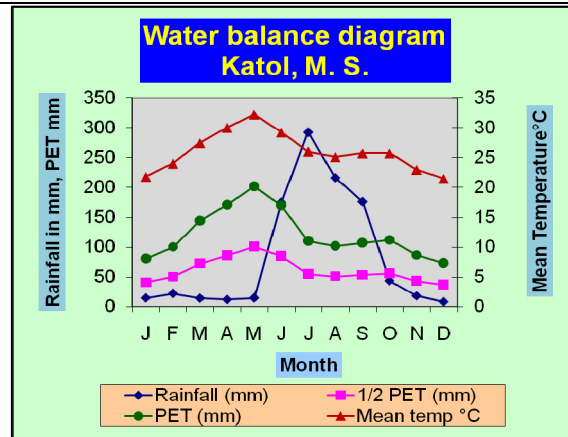
Typifying pedon: Linga clay – cultivated

Ap   0-16 cm -- Dark grayish brown to very dark grayish brown (10YR 3.5/2D) very dark grayish brown (10YR 3/2M) clay; medium, moderate subangular blocky structure; slightly hard, friable, sticky and plastic; many very fine and fine, few medium roots; many very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); slightly effervescent; clear smooth boundary.

Bw1   16-44 cm -- Very dark grayish brown (10YR 3/2M) clay; medium strong subangular blocky structure with pressure faces; friable, sticky and plastic; common very fine and fine, few medium roots; many very fine and fine, few medium lime nodules; many very fine, common few pores; moderately alkaline (pH 8.0); nil to slightly effervescent; gradual smooth boundary.

Bw2   44-69 cm -- Very dark grayish brown to very dark gray (10YR 3/1.5 M) clay; medium strong subangular to angular blocky structure with well developed pressure faces; friable, sticky and plastic; common very fine and fine roots; many very fine and fine, few medium lime nodules; mildly alkaline (pH 7.8); nil to slightly effervescent; gradual smooth boundary.

Bss1   69-102 cm -- Very dark grayish brown to very dark gray (10YR 3/1.5 M) clay; medium, strong, subangular blocky to medium strong angular blocky structure with weak development of slickensides; friable, very sticky and very plastic; few, very fine and fine roots; common very fine and fine few medium line nodules; moderately alkaline (pH 7.9); nil to slightly effervescent; gradual smooth boundary.

Bss2   102-128 cm -- Very dark grayish brown to dark brown (10YR 3/2.5M) clay; medium strong angular blocky structure with well developed slickensides and wedge shaped aggregates which break into small angular blocks; friable, very sticky and very plastic; few, very fine roots; common very fine and fine, few medium lime nodules; moderately alkaline (pH 8.0); gradual smooth boundary.

Bss3   128-150+ cm -- Brown (10YR 4/3M) clay; coarse, strong angular blocky structure with well developed slickensides and wedge shaped aggregate which break into small angular blocks; friable, very sticky and very plastic; common very fine and fine, few medium and coarse lime nodules moderately alkaline (pH 7.9); clear smooth boundary.

Type location: 21^0 15'18"N; 78^0 36'40"E; 1/2 km west of Res. Farm Bldg of Regional Fruit Research Station Farm, village Wandli, tehsil Katol, district Nagpur, Maharashtra.

Range in characteristics: The A horizon is 15 to 20 cm thick. Its colour is in hue 10YR and 2.5Y, value 3 to 4 and chroma 2. The texture is clayey. The structure is coarse subangular blocky. The B horizon is 80 to 120 cm thick. Its colour is in hue 10YR and 2.5Y, value 3 to 4 and chroma 2. The texture is clayey. It has intersecting slickensides forming parallelelpipeds that break into angular blocky peds. The lime content increases with depth. 30 to 50 mm wide cracks are observed. Gilgai microrelief is common.

Geographic setting: Linga soils are formed in basaltic alluvium on plain to very gently sloping land at an elevation of 50 to 150 m above MSL. The climate is suhhumid tropical with mean annual air temperature of 26.0°C and mean annual rainfall of 1010 mm. The estimated MAST is 28.0°C, MSST 31.6 and MWST 26.2. The difference between MSST and MWST is 5.4°C.

Geographically associated soils: Linga soils are associated with Karla and Wadhona soils which belong to Vertic Haplustepts and Fluventic Haplustepts, respectively.

Drainage and permeability': Moderately well drained.

Land use and vegetation: Cultivated to citrus (horticultural system); *Acacia*, neem, palas, ber, karanji, parthenium; Kans, dub

Distribution and extent: Extensive in Nagpur and adjoining districts of Maharashtra.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur, 1969.

Interpretation: Linga soils are fine textured with high shrink-swell potential. They are prone to develop salinity and alkalinity even when irrigated with water low in soluble salts. During monsoon, crops may be adversely affected due to stagnation of water. These soils are also susceptible to erosion even on gently sloping land. They are productive with proper management and drainage under both rainfed and irrigated agriculture.

Interpretative grouping:
i)	Land capability subclass	IIIs
ii)	Irrigability subclass	3d
iii)	Productivity potential	Medium

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm) Total			Fine clay (%)	Fine clay/ total clay (%)	BD Mg/m³	COLE	HC* cm/hr	WDC (%)
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)						
		←----------(% of <2 mm) ----------→								
Ap	0-16	1.2	33.3	65.5	42.3	64.6	-	0.24	2.3	6.9
Bw1	16-44	0.7	32.5	66.8	46.7	69.9	1.4	0.21	2.8	10.9
Bw2	44-69	0.7	32.3	67.0	51.9	77.6	1.4	0.22	2.5	9.2
Bss1	69-102	0.6	28.4	71.0	50.0	70.4	1.5	0.22	1.8	10.5
Bss2	102-128	0.4	28.4	71.2	48.9	68.8	1.5	0.25	0.8	17.9
Bss3	128-150+	0.5	29.2	70.3	51.2	72.8	1.4	0.26	0.6	12.9

* 23 mm hr^{-1} is the HC (WM) in 0-100 cm depth of soil.

Depth (cm)	Moisture retention%							AWC
	33kPa	100kPa	300kPa	500kPa	800kPa	1000kPa	1500kPa	
0-16	41.5	37.7	30.4	28.5	28.4	25.6	19.5	21.9
16-44	37.1	35.3	29.6	27.1	26.9	22.7	18.8	18.4
44-69	37.4	34.7	28.7	26.8	26.8	26.6	19.7	17.6
69-102	39.2	36.0	28.5	27.1	26.1	25.6	20.4	18.8
102-128	41.2	36.5	31.6	29.1	27.4	25.5	18.1	23.0
128-150+	42.0	40.6	33.5	31.8	29.9	25.2	20.5	21.4

Depth (cm)	pH water (1:2)	CaCO₃ (%)	OC (%)	Extractable bases					CEC	Clay CEC cmol(p+)kg⁻¹	B.S. (%)
				Ca	Mg	Na	K	Sum			
				←--------------------cmol(p+)/kg⁻¹--------------------→							
0-16	7.9	6.9	1.03	40.0	11.8	0.6	1.3	53.7	65.2	99	82
16-44	8.0	7.6	0.66	43.5	10.9	0.5	0.7	55.6	64.1	96	87
44-69	7.8	7.2	0.58	41.3	10.2	0.6	0.7	52.8	63.0	94	84
69-102	7.9	9.0	0.54	40.2	13.1	0.7	0.7	54.7	63.0	89	87
102-128	8.0	9.2	0.50	37.8	14.4	0.9	0.8	53.9	61.8	87	87
128-150+	7.9	9.4	0.37	40.4	19.1	0.8	0.8	61.1	63.0	90	97

Depth (cm)	Exch. Ca/Mg	ECP	EMP	ESP	CO₃ clay (%)	CO₃ clay (feb) (%)
0-16	3.4	61.3	18.1	0.9	2.8	1.8
16-44	4	67.8	17.0	0.8	3.1	2.1
44-69	4.0	65.5	16.2	0.9	2.5	1.7
69-102	3.1	63.8	20.8	1.1	3.0	2.1
102-128	2.6	61.2	23.3	1.4	2.9	2.1
128-150+	2.1	64.1	30.3	1.3	2.6	1.8

Depth (cm)	Soluble cations (meq/l)						Soluble anions (meq/l)					RSC	SAR
	Sat %	ECe	Ca	Mg	Na	K	Sum	CO₃	HCO₃	Cl	SO₄	Sum	
0-16	73.0	0.4	1.74	0.7	1.9	0.07	4.41	1.0	0.5	0.6	2.31	4.40	-0.94	1.7
16-44	67.6	0.3	1.55	0.8	2.2	0.03	4.58	1.0	1.6	0.8	1.18	4.58	0.25	2.0
44-69	68.8	0.2	1.57	1.2	2.5	0.03	5.30	1.0	-	0.6	3.70	5.30	-1.77	2.1
69-102	67.4	0.2	0.95	0.5	2.9	0.04	4.39	-	2.7	0.7	1.00	4.40	1.25	3.4
102-128	69.2	0.3	0.96	0.7	4.3	0.03	5.94	1.0	1.1	0.9	2.99	6.00	0.44	4.7
128-150+	74.3	0.3	0.94	0.6	3.8	0.04	5.38	-	2.1	1.1	2.18	5.38	0.56	4.3

Source: Pal, D.K., Bhattacharyya, T., Ray, S.K. and Bhuse, S.R. 2003. "Developing a model on the formation and resilience of naturally degraded black soils of the Peninsular India as a decision support system for better land use planning" NRDMS, DST Project Report, NBSSLUP (ICAR), Nagpur, 144p.

2.28.2 SUKALI SERIES

The Sukali series is a member of the fine Ioamy, mixed, hyperthermic family of Typic Haplustepts. Typically, Sukali soils have brown to dark brown, moderately alkaline, clay loam A horizons; and dark yellowish brown to dark brown, mildly to moderately alkaline, clay loan, B horizons.
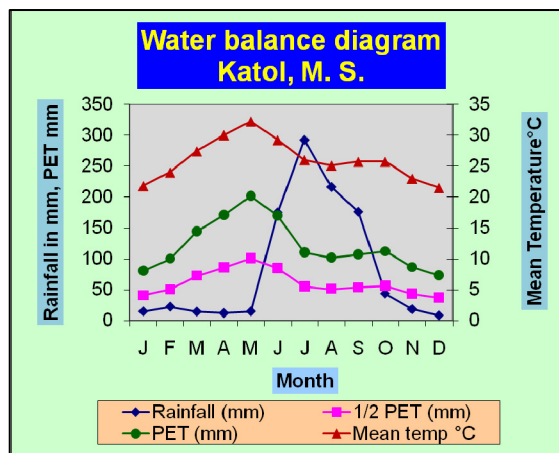
Typifying pedon: Sukali clay loam – cultivated

Ap   0-14 cm --- Brown (10YR 5/3 D) and brown to dark brown (10YR 4/3 M) clay loam; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and plastic; few to many medium roots inside peds; common medium pale brown lime concretions; strongly effervescent; moderately alkaline (pH 7.9); gradual smooth boundary.

Bw1   14-42 cm --- Brown (10YR 5/3 D) and brown to dark brown (10YR 4/3 M) clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; common to many medium lime nodules; strongly effervescent; moderately alkaline (pH 7.9); gradual smooth boundary.

Bw2   42-63 cm --- Brown (10YR 5/3 D) and brown to dark brown (10YR 4/3 M) clay loam; weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; many lime concretions; scattered pockets of gravels; strongly effervescent; mildly alkaline (pH 7.8); gradual smooth boundary.

Bw3   63-97 cm --- Light yellowish brown (10YR 6/4 D) and dark yellowish brown (10YR 4/4 M) clay loam; weak medium subangular blocky structure; friable, slightly sticky; many medium lime concretions; strongly effervescent; scattered lenses of coarse sand; mildly alkaline (pH 7.7); gradual smooth boundary.

Bw4   97-150 cm --- Brown to dark brown (10YR 4/3 M) clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; many lime concretions of 5 to 10 mm; violently effervescent; mildly alkaline (pH 7.8).

Type location: 21°19' N, 78°37' E; village Wadhona, tehsil Katol, district Nagpur, Maharashtra.

Range in characteristics: The thickness of the solum is 55 to 70 cm. The A horizon is 15 cm thick. Its colour is in hue 10YR, value 3 to 5 and chroma 3. The texture is clay loam to silt loam and the structure is weak to moderate, fine to medium subangular blocky .The texture in B horizon ranges from silty clay to clay loam and at places clay. The scattered pockets of gravel and many lenses of sand are present throughout the profile. Lime concretions of 1 to 5 rnm size are present throughout the soil.

Competing series and their differentiae: Sukali soils compete with Sur soils which are Typic Ustifluvents.

153

Geographic setting: Sukali soils are formed in alluvium on nearly level to gently sloping flood plain river terraces and levees at an elevation of 280 to 300 m above MSL. The climate is subhumid tropical with mean annual air temperature of 27.2^{o}C and mean annual rainfall of 1125 mm. The estimated MAST is 29.2^{o}C, MSST 30.9^{o}C, MWST 24.1^{o}C and difference between MSST and MWST is 6.8^{o}C.

Geographically associated soils: Sukali soils are associated with Linga soils which are Udic Haplusterts.

Drainage and permeability: Moderately well drained with moderate permeability.

Use and vegetation: Extensively cultivated to cotton, sorghum, wheat, pigeonpea; groundnut and gram; under irrigation used for double crops including vegetables and oranges.

Distribution and extent: Extensive along the terraces and banks of river Kanhan, Wunna, Jam and their major tributaries in the district of Nagpur and adjoining areas of Maharashtra.

Series proposed: Regional Soil Survey Office, Department of Agriculture, Government of Maharashtra, Nagpur.

Interpretation: Sukali soils are deep to very deep, fine textured, calcareous and moderately well drained. They are susceptible to erosion. They are suitable for all climatically adapted crops under proper management.

Interpretative grouping:

i)	Land capability subclass	IIe
ii)	Irrigabilliy subclass	2d
iii)	Productivity potential	High

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)			Coarse fragments > 2 mm % of whole soil
		Sand (2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	
		<---------------- % of < 2 mm ---------------->			
Ap	0-14	37.5	27.8	34.7	4
Bw1	14-42	36.0	28.5	35.5	4
Bw2	42-63	44.3	26.4	29.3	2
Bw3	63-97	41.8	26.3	31.9	4
Bw4	97-150	36.2	28.7	35.1	5

Depth (cm)	Organic Carbon (%)	Carbonate as CaCO3 < 2 mm (%)	pH (1:2.5) H$_2$O	E.C. (1:2.5) H$_2$O (dS m^{-1})	CEC NH$_4$OAc {cmol (p+)kg^{-1}}
0-14	0.38	4.4	7.9	0.7	31.8
14-42	0.21	6.6	7.9	0.3	32.2
42-63	0.17	5.4	7.8	0.5	32.2
63-97	0.17	4.7	7.7	0.3	30.4
97-150	0.10	5.2	7.8	0.5	31.5

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.29 Soil Series: AESR 10.3

Vindhyan Scarp land and Bundelkhand Plateau, hot dry subhumid ESR with deep loamy to clayey mixed Red and Black soils, medium to high AWC and LGP 150-180 days (I6Cd5)

2.29.1 SUNDRA SERIES

The Sundra series is a member of the very fine, smectitic, hyperthermic family of Chromic Haplusterts. Typically, Sundra soils have light olive brown to dark grayish brown, moderately to strongly alkaline, clay A horizons, and dark grayish brown, moderately to strongly alkaline, clay B horizons.

Water balance diagram Satna, M. P.
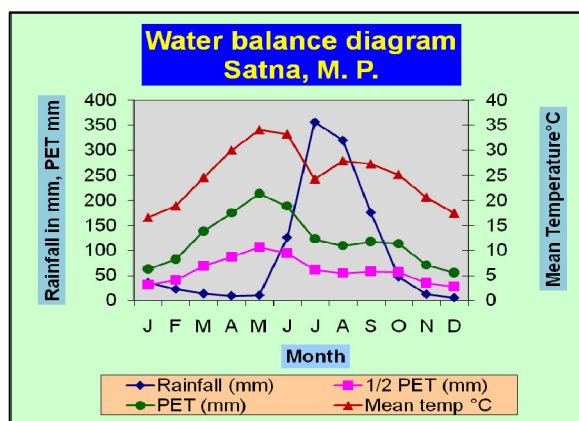
Typifying pedon: Sundra clay -cultivated

Ap   0-12 cm --- Light olive brown (2.5Y 5/3 D) and dark grayish brown (2.5Y 4/2 M) clay; moderate medium subangular blocky structure; hard, friable, sticky and plastic; common fine and medium roots; 10 mm wide cracks; strongly alkaline (pH 8.9); diffuse smooth boundary.

A   12-40 cm --- Light olive brown (2.5Y 5/3 D) and dark grayish brown (2.5Y 4/2 M) clay; moderate medium subangular blocky structure with pressure faces; hard, firm, sticky and plastic; common fine and medium roots; 5 mm wide cracks; moderately alkaline (pH 7.9); diffuse smooth boundary.

Bss   40- 70 cm --- Dark grayish brown (2.5Y 4/2 M) clay; intersecting slickensides forming parallelepiped structural aggregates breaking to moderate medium angular blocky structure; firm, very sticky and very plastic; few fine and medium roots; 5 mm wide cracks; moderately alkaline (pH 8.0); diffuse smooth boundary.

Bss2   70-140 cm --- Dark grayish brown (2.5Y 4/2 M) clay; intersecting slickensides forming parallelopiped structural aggregates breaking to moderate medium angular blocky structure; firm, very sticky and very plastic; few fine roots; strongly alkaline (pH 8.5).

Type location: 24°36' N, 80°27' E; village Sundra on Panna to Satna road, tehsil and district Panna, Madhya Pradesh.

Range in characteristics: The thickness of the A horizon ranges from 40 to 50 cm. Its colour is in hue 2.5Y, value 4 to 5 and chroma 2 to 3. Its texture is clay. Its structure is strong to moderate medium subangular blocky. The B horizon is more than 100 cm thick. Its colour is in hue 2.5Y, value 4 and chroma 2. The texture is clay. A few basaltic lithorelics and lime nodules are present throughout the profile. Clay percentage in the control section below 40 cm is more than 60.

Competing series and their differentiae: Sundra soils compete with Bira series. Bira soils are well drained and their colours are in 10YR hue.

Geographic setting: Sundra soils are formed in basaltic alluvium on nearly level to very gently sloping piedmont plain at an elevation of 300 to 350 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 25.0°C and mean annual rainfall of 1230 mm. The estimated MAST is 27.0°C, MSST 30.3°C and MWST 21.8°C. The difference between MSST and MWST is 8.5°C.

Geographically associated soils: Sundra soils are associated with Jamra soils which are very deep and moderately well drained. The Jamra soils belong to Chromic Haplusterts.

Drainage and permeability: Moderately well drained with slow permeability.

Use and vegetation: Cultivated to rainfed mixed crops like pigeonpea, sorghum and minor millets in *kharif* and wheat and gram in *rabi;* natural vegetation - *Acacia spp.* (babul).

Distribution and extent: Extensive in Bundelkhand region of Madhya Pradesh.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur, 1979.

Interpretation: Sundra soils are moderately well drained and slowly permeable. In periods of excessive rainfall crops may suffer due to water stagnation. Measures to conserve soils and water are necessary. Recycling the runoff water will be advantageous for *rabi* crops. During *kharif,* protection from stagnation effect through proper management of surface drainage is necessary. Moisture and nutrient retention capacity of the soils is good. The soils will respond well to fertilizer and other inputs. Mixed cropping of sorghum, pigeonpea and minor millets is an adapted system. Wheat and gram can be grown successfully on conserved moisture during *rabi* season as being the practice at present.

a) Interpretative grouping:
  i)   Land capability subclass   IIs
  ii)   Irrigability subclass   2d
  iii)   Productivity potential   High

b) **Yield**: Based on data from farmers' fields

Crop	Farmers' practices	Improved practices
	←----------------Yield, Mg ha^{-1}--------------→	
Sorghum	1.2-1.5	2.0-2.5
Pigeonpea	0.7-0.8	1.3-1.5
Wheat	1.0-1.2	3.0-3.5
Gram	0.7-0.8	1.2-1.5

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)			Coarse fragments > 2 mm % of whole soil
		Sand (2-0.02)	Silt (0.02-0.002)	Clay (<0.002)	
		<-------------- % of < 2 mm ------->			
Ap	0-12	18.6	22.4	59.0	6
A	12-40	17.1	28.7	54.2	4
Bss	40-70	10.5	26.0	63.5	3
Bss2	70-140	14.8	20.8	64.4	2

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	Bulk density (Mg m^{-3})
0-12	0.7	0.5	8.9	1.61
12-40	0.6	0.6	7.9	1.88
40-70	0.5	0.7	8.0	1.74
70-140	0.2	0.8	8.5	1.79

Depth (cm)	Extractable bases				CEC NH_4OAc	Ratio CEC/ Clay %	ESP
	Ca	Mg	Na	K			
	<---------------- cmol (p+)kg-1 -------------------->						
0-12	24.0	6.5	1.9	0.6	34.4	0.58	5.5
12-40	26.3	5.0	2.0	0.5	37.5	0.69	5.3
40-70	21.7	9.0	2.1	0.5	31.2	0.49	6.7
70-140	24.0	9.0	2.7	0.5	33.2	0.52	8.1

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.29.2 MARHA SERIES

The Marha series is a member of the fine, smectitic, hyperthermic family of Chromic Haplusterts. Typically, Marha soils have very dark grayish brown to dark grayish brown, moderately alkaline, silty clay A horizons, and dark grayish brown to grayish brown, moderately alkaline, silty clay B horizons.
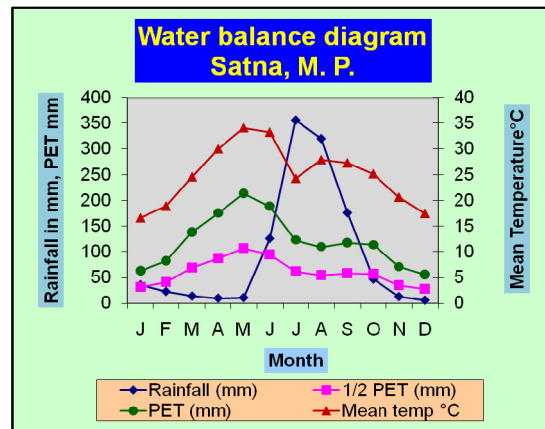
Typifying pedon: Marha silty clay -cultivated

Ap   0-12 cm --- Dark grayish brown to grayish brown (2.5Y 4.5/2 D) and dark grayish brown (2.5Y 4/2 M) silty clay; moderate medium subangular blocky structure; soft, friable, sticky and plastic; common fine roots inside peds; fine interstitial pores; moderately alkaline (pH 8.0); clear wavy boundary.

Bw1   12-44 cm --- Very dark grayish brown to dark grayish brown (2.5Y 3.5/2 D) and very dark grayish brown (2.5Y 3/2 M) silty clay; strong coarse angular blocky structure; slightly hard, friable, sticky and plastic; many fine roots inside peds; fine interstitial pores; moderately alkaline (pH 8.0); gradual wavy boundary.

Bw2   44- 70 cm --- Very dark grayish brown to dark grayish brown (2.5Y 3.5/2 D&M) silty clay; coarse prismatic structure breaking to strong coarse angular blocky peds with prominent pressure faces; hard, firm, sticky and plastic; few fine roots inside peds; fine interstitial pores; moderately alkaline (pH 8.0); gradual smooth boundary.

Bss1   70-105 cm --- Dark grayish brown (2.5Y 4/2 D & M) silty clay; coarse prismatic structure breaking to strong coarse angular blocky peds with prominent slicken- sides close enough to intersect; hard, firm, sticky and plastic; few fine roots inside peds; fine interstitial pores: moderately alkaline (pH 8.0); diffuse smooth boundary.

Bss2   105-137 cm --- Dark grayish brown to grayish brown (2.5Y 4.5/2 D) and grayish brown (2.5Y 5/2 M) silty clay; coarse prismatic structure breaking to strong coarse angular blocky peds with slickensides close enough to intersect; very hard, very firm, very sticky and plastic; few fine roots inside peds; fine interstitial pores; moderately alkaline (pH 8.0); diffuse smooth boundary.

Bss3   137-180 cm --- Dark grayish brown (2.5Y 4/2 D & M) silty clay; coarse prismatic structure breaking to strong coarse angular blocky peds with slickensides close enough to intersect, very hard, very firm, very sticky and plastic; slightly effervescent; moderately alkaline (pH 8.1).

Micromorphology: Two thin sections from the A2 and the Bss1 horizons were studied. The fine material is largely clay-sized, includes a few particles upto 10 mm and has a moderate vomasepic plasmic fabric. The coarse material consists of a variety of minerals and rock fragments which

show varying stages of alteration but are mainly rather fresh, and a few coarse organic fragments. Carbonate nodules are common. They usually have clear external boundaries and are randomly distributed. The majority of the carbonate nodules have accumulation of sesquioxides often predominantly manganese, in the outer zones of the nodules.

Type location: 24°34' N, 80°15' E; village Marha, tehsil Lauri, district Chhatarpur, Madhya Pradesh.

Range in characteristics: The A horizon is more than 70 cm thick. Its colour is in hue 2.5Y and 10YR, value 3 to 5 and chroma 2 to 3. Texture is silty clay loam to silty clay. The B horizon is more than 80 cm thick. Its colour is in hue 2.5Y and 10YR, value 3 to 5 and chroma 2. Texture is dominantly silty clay. Cracks 20 to 40 mm wide at the surface that taper and extend into the BC horizon.

Competing series and their differentiae: Marha soils compete with Jamra series which is in hue 10YR and calcareous. It belongs to Chromic Haplustert.

Geographic setting: Marha soils are formed in basaltic alluvium on nearly level to gently sloping old plain at an elevation of 300 to 330 m above MSL in Bundelkhand region of Madhya Pradesh. The climate is subhumid subtropical with mean annual air temperature of 25.2°C and mean annual rainfall of 1330 mm. The estimated MAST is 27.2°C, MSST 30.2°C, MWST 20.2°C and difference between MSST and MWST is 10.0°C.

Geographically associated soils: Marha soils are associated with Jamra soils which are calcareous clayey and belong to Chromic Haplusterts.

Drainage and permeability: Moderately well drained with moderate permeability.

Use and vegetation: Cultivated to mixed rainfed crops like sorghum, pigeonpea, wheat and gram; natural vegetation - *Madhuca spp.* (mahua), *Butea spp.* (palas) and *Acacia spp.* (babul).

Distribution and extent: Extensive in Bundelkhand region of Madhya Pradesh.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur.

Interpretation: Marha soils have good water retention capacity. They are productive and crops respond to management practices. They are susceptible to erosion.

a) Interpretative grouping:
  i)   Land capability subclass   IIs
  ii) Irrigabiiity subclass   2d
  iii) Productivity potential   High

b) Yield: Based on data from farmers' fields:

Crop	Farmers' practices	Improved practices
	←----------------Yield, Mg ha⁻¹--------------→	
Sorghum	1.5-1.8	2.8-3.0
Pigeonpea	0.7-0.8	1.2-1.5
Wheat	1.0-1.2	3.0-3.5
Gram	0.8-1.0	1.5.2.0

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)										Coarse frag-ments > 2 mm % of whole soil
		Total			Sand					Clay		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.002-0.001)	(<0.001)	
		<------------------------------------- % of < 2 mm ------------------------------------->										
Ap	0-12	11.7	44.1	44.2	0.8	1.1	1.0	0.7	8.1	28.0	16.2	4
Bw1	12-44	9.2	43.6	47.2	1.1	1.0	0.8	0.7	5.6	31.8	15.4	6
Bw2	44-70	5.5	43.4	51.1	1.0	0.7	0.6	1.0	2.2	34.0	17.1	0
Bss1	70-105	7.0	45.1	47.9	1.0	1.0	0.9	0.9	3.2	31.2	16.7	0
Bss2	105-137	5.3	49.4	45.3	1.4	1.0	0.7	1.0	1.2	36.8	8.5	3
Bss3	137-180	10.6	49.0	40.4	2.3	1.1	0.8	0.5	5.9	23.3	17.1	6

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})	Bulk density (Mg m^{-3})	Micronutrients			
						D T P A extractable			
						Zn	Cu	Mn	Fe
						<-------------- ppm -------------->			
0-12	0.48	-	8.0	<0.2	1.60	0.22	0.24	5	5
12-44	0.36	-	8.0	<0.2	1.90	0.77	0.65	5	6
44-70	0.30	-	8.0	<0.2	1.92	0.21	0.68	5	6
70-105	0.24	-	8.0	<0.2	1.97	0.25	0.71	6	6
105-137	0.24	-	8.0	<0.2	1.97	ND*	ND	ND	ND
137-180	0.21	2.0	8.1	<0.2	2.01	ND	ND	ND	ND

Depth (cm)	Extractable bases			CEC NH$_4$OAc	ESP	Ratio CEC/ clay
	Ca+Mg	Na	K			
	<---------- cmol (p+)kg^{-1} --------->					
0-12	45.8	1.6	0.6	48.0	3	1.09
12-44	50.5	1.1	0.6	52.2	2	1.11
44-70	48.7	5.4	0.3	54.4	10	1.06
70-105	41.2	5.4	0.8	47.4	11	0.99
105-137	44.7	1.1	0.6	46.4	2	1.02
137-180	45.4	1.6	0.5	47.5	3	1.18

* ND =Not done

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.30 Soil Series: AESR 10.4

Satpura range and Wainganga Valley, hot moist subhumid ESR with shallow to deep loamy to clayey mixed Red and Black soils, low to medium AWC and LGP 180-210 days (K6Cm6)

2.30.1 SAGAR SERIES

The Sagar series is a member of fine, mixed, hyperthermic family of Vertic Haplustepts. Typically, the Sagar soils have very dark grayish brown, slightly acid, clayey A horizons and very dark grayish brown to very dark gray, slightly acid to mildly alkaline, clay to sandy clay loam B horizons over weathered basaltic material.
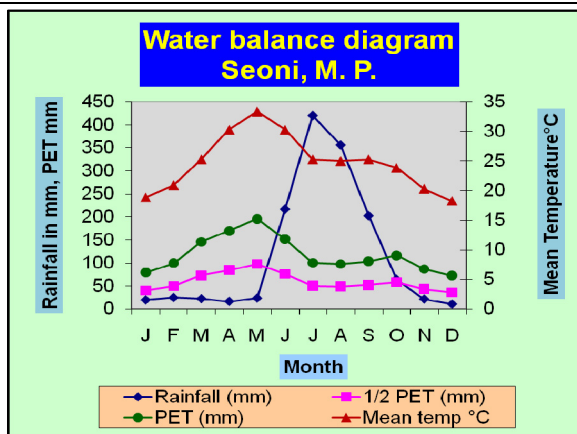
Typifying pedon: Sagar clay - cultivated

Ap   0-12 cm --- Very dark grayish brown (10YR 3/2 M) clay; medium moderate subangular blocky; hard firm very sticky and very plastic; fine few roots; slightly acid (pH 6.4); clear smooth boundary.

Bw1   12-32 cm --- Very dark grayish brown (10YR 3/2 M) clay; moderate subangular blocky; hard firm very sticky and very plastic; fine few roots; slightly acid (pH 6.7); gradual smooth boundary.

Bw2   32-46 cm --- Very dark gray (10YR 3/1 M) clay; moderate subangular blocky; hard firm very sticky and very plastic; neutral pH (7.0); gradual smooth boundary.

BC   46-60 cm --- Very dark gray (10YR 3/1 M) sandy clay; moderate subangular blocky; slightly hard firm, sticky and plastic; mildly alkaline (pH 7.4); gradual smooth boundary.

Cr   60+ --- Weathered basalt.

Type location: 22°17'18" N, 79°26'05" E; village Sagar, tehsil Seoni, district Seoni, Madhya Pradesh.

Range in characteristics: The thickness of the solum ranges from 50 to 60 cm. The A horizon is very dark grayish brown to very dark gray with 10YR hue, value 3 and chroma 2. Its texture is clay more than 56 per cent The B horizons are very dark grayish to very dark gray 10YR hue, value 3 and chroma 1 to 2 with sandy clay to clay texture. The clay content ranges from 28 to 63 per cent. This horizon is slightly alkaline below 50 cm with CEC of 44 to 46 cmol (p+) kg^{-1}.

Competing series and their differentiae: Not identified.

Geographic setting: Sagar soils are developed in the weathered basaltic material and occur on gently sloping broad interhill basins and valley bottoms at an elevation of 580 m above MSL. The climate is subhumid to semiarid with mean annual air temperature of 25.97°C and mean annual rainfall is 1200 mm. The estimated MAST is 27.97°C, MSST 28.5°C and MWST 24.9°C. The difference between MSST and MWST is 3.6°C.

Geographically associated soils: These soils are Atari, Paddikona, Parasia, Nadora, Dhenka, Lakhanadon, Lungsa, Pipriya, Jamunpani, Gondaola and Bhimgarh.

Drainage and permeability: Moderately well drained with slow permeability.

Use and vegetation: Mainly under the cultivation of rice, wheat. Natural vegetation includes Acacia spp., Jamun and Mahua.

Distribution and extent: Extensive in Sagar, Chargaon and Bakhari area of tehsil Seoni, district Seoni, Madhya Pradesh

Series proposed: National Bureau of Soil Survey and Land Use Planning, Nagpur, 2008.

Interpretation: This soil is moderately shallow, moderately well drained and moderately eroded. This soil is slightly acid to slightly alkaline, low in N, P and medium in K and Zn. This soil is under moderately good cultivable land that needs careful management of excess water and selection of crops adapted to wet conditions.

Interpretative grouping:
  i) Land capability subclass   :   IIIw
  ii) Irrigability subclass   :   2st
  iii) Productivity potential   :   Low to medium

Soil datasets:

Horizon	Depth (cm)	Particle size diameter (mm)			Coarse fragments >2mm % of whole soil
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	
		<----------------------(%)---------------------->			
Ap	0-12	18.6	25.4	56.0	1
Bw1	12-32	16.9	19.9	63.2	6
Bw2	32-46	19.7	22.1	58.2	4
BC	46-60	58.8	13.0	28.2	2

Depth (cm)	Organic carbon (%)	E.C. (1:2.5) (soil:water dS m^{-1})	pH soil: water (1:2.5)	Water retention (%)	
				33 kPa	1500 kPa
0-12	1.07	0.09	6.4	23.8	12.3
12-32	0.68	0.06	6.7	29.4	11.1
32-46	0.54	0.06	7.0	32.8	16.6
46-60	0.20	0.07	7.4	24.2	11.2

Depth (cm)	Exchangeable cations					C.E.C.	Base Saturation (%)
	Ca	Mg	Na	K	Sum		
	<-----------------------cmol(+)kg^{-1}---------------------------->						
0-12	22.4	17.4	0.5	0.3	40.6	40.0	101.5
12-32	25.0	17.5	0.5	0.4	43.4	46.8	92.7
32-46	25.0	16.3	0.5	0.3	42.1	45.2	93.1
46-60	34.7	20.4	0.6	0.2	55.9	44.2	103

Depth (cm)	DTPA Extractable (mg kg^{-1})				Available(mg kg^{-1})		
	Cu	Fe	Mn	Zn	N	P	K
0-12	6.3	14.0	87.0	0.9	93.8	1.9	370.0
12-32	5.5	10.2	47.7	0.7	86.8	2.4	350.0
32-46	5.0	8.4	31.3	0.8	78.4	1.3	345.0
46-60	1.6	5.1	5.8	0.1	77.0	1.3	195.0

Source: Tamgadge, D.B., Bhaskar, B.P., Singh, S.R., Bobade, S.V., Gaikwad, M.S. and Gaikwad S.S. (2008). Soil Resource Inventory for Land Use planning of Seoni District, Madhya Pradesh. NBSS Publ., Technical Report No. 1020, NBSS&LUP, Nagpur, pp.154.

2.30.2 GONDATOLA SERIES

The Gondatola series is a member of the fine, mixed, hyperthermic family of Typic Rhodustalfs. Typically, Gondatola soils have dark reddish brown, very strongly acid, clay A horizons and dark red, strongly to moderately acid, clay to sandy clay loam Bt horizons over hard and compact lateritic material.

Water balance diagram Seoni, M. P.

Rainfall in mm, PET mm / Mean Temperature°C

Legend: Rainfall (mm); 1/2 PET (mm); PET (mm); Mean temp °C

Month: J F M A M J J A S O N D
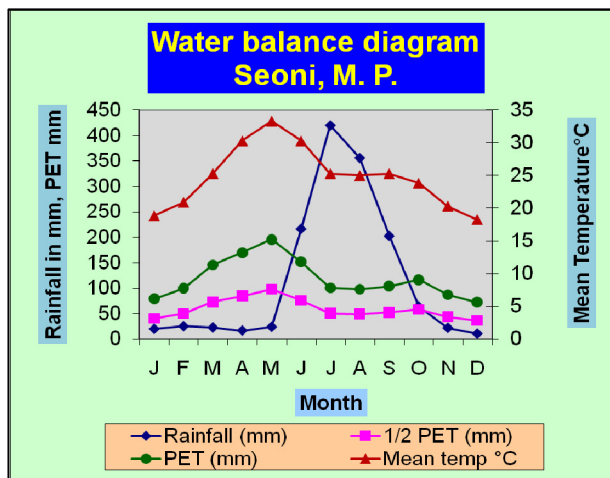
Typifying pedon: Gondatola clay - cultivated

Ap   0-14 cm --- Dark reddish brown (2.5YR 3/4 M) clay; medium weak subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; fine few roots; strongly acid (pH 4.9); clear smooth boundary.

Bt1   14-43 cm --- Dark red (2.5YR 3/4 M) clay; medium weak subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy clay cutans; strongly acid (pH 5.1); clear smooth boundary.

Bt2   43-78 cm --- Dark red (2.5YR 3/6 M) clay; medium moderate subangular blocky structure; slightly hard, friable, sticky and plastic; thin patchy clay cutans; strongly acid (pH 5.5); clear smooth boundary.

Bt3   78-122 cm --- Dark red (2.5YR 3/6 M) sandy clay loam; medium weak subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; thin patchy clay cutans; medium acid pH 5.7; clear smooth boundary.

Cr   122+ cm --- Lateritic material.

Type location: 21°56'24" N, 79°35'36" E; village Gondatola, tehsil Kurai, district Seoni, Madhya Pradesh.

Range in characteristics: The thickness of the solum is 66 to 122 cm. The thickness of A horizon is 14 cm. Its colour is in hue of 2.5YR, value 3 and chroma 6. The texture is clay loam and the structure is medium, weak subangular blocky. The thickness of B horizon is 108 cm. Its colour is in hue of 2.5YR, value 3 and chroma 6. The texture is sandy clay loam to clay and the structure is medium, weak subangular blocky. The soil has very strongly acid A horizons and strongly to moderately acid, dark red B horizons.

Geographic setting: Gondatola soils rest on lateritic material and occur on moderately sloping rolling land (8-15% slope) at an elevation of 620 m above MSL. The climate is semi arid with mean annual air temperature of 26.0°C and mean annual rainfall of 1170 mm. The estimated MAST is 28.0°C, MSST 28.5°C and MWST 24.9°C. The difference between MSST and MWST is 3.6°C.

Geographically associated soils: Atari

Drainage and permeability: Well drained with moderate permeability.

Use and vegetation: Mainly under teak forest. Natural vegetation includes Acacia spp., grasses, bamboo and palas.

Distribution and extent: Extensive in lateritic terrain of Mohgaon, Gopalganj and adjoining areas of Kurai tehsil of Seoni district, Madhya Pradesh

Series proposed: National Bureau of Soil Survey and Land Use Planning, Nagpur, 2008.

Interpretation: This soil is deep, moderately eroded on moderately sloping lands, well drained and moderate permeability. This soil series have clayey top and subsoil types with ustic moisture and have gravels more than 30 per cent by volume in sub soils. These soils are moderately good cultivable lands, very strongly to moderately acid, low in NPK and Zn status.

Interpretative grouping:
i) Land capability subclass	:	IIIe
ii) Irrigability subclass	:	4t
iii) Productivity potential	:	Low to medium

Soil datasets:

Horizon	Depth (cm)	Particle size diameter (mm)			Coarse fragments (>2mm) % of whole soil
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	
		<--------------------(%)--------------------->			
Ap	0-14	25.2	33.8	41.0	2
Bt1	14-43	15.7	25.9	58.4	2
Bt2	43-78	25.8	16.0	58.2	2
Bt3	78-122	41.1	10.8	48.1	2

Depth (cm)	O.C. (%)	E.C.(1:2.5) (soil:water dS m^{-1})	pH soil: water (1:2.5)	Water retention (%)	
				33 kPa	1500 kPa
0-14	1.11	0.01	4.9	21.4	11.0
14-43	0.91	0.01	5.1	25.6	11.8
43-78	0.62	0.02	5.5	18.6	11.5
78-122	0.49	0.01	5.7	17.9	10.8

Depth (cm)	Exchangeable cations					C.E.C.	Base Saturation (%)
	Ca	Mg	Na	K	Sum		
	<-----------------------cmol(+)kg^{-1}---------------------------->						
0-14	5.0	2.0	Tr.	0.1	7.1	13.6	52
14-43	7.8	2.9	Tr.	0.1	10.9	18.0	60
43-78	7.9	2.9	0.1	0.2	10.9	16.7	67
78-122	6.8	2.3	0.1	0.1	9.3	13.8	67

Depth (cm)	DTPA Extractable (mg kg^{-1})				Available (mg kg^{-1})		
	Cu	Fe	Mn	Zn	N	P	K
0-14	5.5	58.3	153.0	0.7	120	3.7	155.0
14-43	5.5	23.7	82.6	0.3	110	0.8	140.0
43-78	3.3	14.8	47.4	0.3	100	1.4	145.0
78-122	2.1	13.8	29.4	0.2	95	1.7	115.0

Source: Tamgadge, D.B., Bhaskar, B.P., Singh, S.R., Bobade, S.V., Gaikwad, M.S. and Gaikwad S.S. (2008). Soil Resource Inventory for Land Use planning of Seoni District, Madhya Pradesh. NBSS Publ., Technical Report No. 1020, NBSS&LUP, Nagpur, pp.154.

2.31 Soil Series: AESR 11

Moderately to gently sloping Chattisgarh/Mahanadi Basin, hot moist/dry subhumid transitional ESR with deep loamy to clayey Red and Yellow soils, medium AWC and LGP 150-180 days (J3Cd/Cm5)

2.31.1 BICHANPUR SERIES

The Bichanpur series is a member of the fine, smectitic (cal.), hyperthermic family of Chromic Haplusterts. Typically, Bichanpur soils have brown, neutral, clayey A horizon, brown to dark brown, neutral, clayey B horizons.
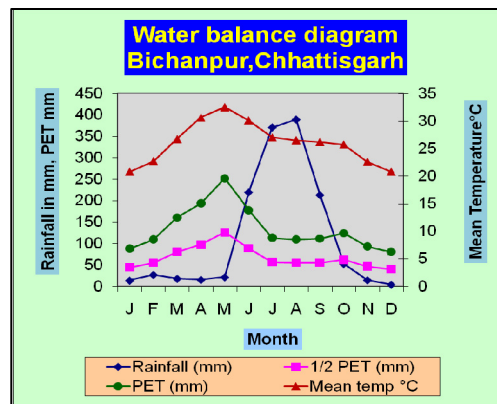
Typifying pedon: Bichanpur – clay, cultivated

Ap   0-14 cm -- Brown (10YR 5/3), clay; dark brown (10YR 4/3); weak, medium, subangular blocky; slightly hard, friable, sticky and plastic; slight effervescence; common very fine roots, pH 7.0; clear smooth boundary.

Bw   14-45 cm -- Brown to dark brown (10YR 4/3 M), clay; moderate, medium, subangular blocky peds with pressure face; hard, firm, very sticky and very plastic; slight effervescence; few very fine roots, pH 7.3; gradual smooth boundary.

Bss1   45-75 cm -- Dark brown (10YR 3/3 M), clay; strong, coarse, angular blocky peds with slickenside tilted at an angle of 20° to the horizontal axis; hard, firm, very sticky and very plastic; slight effervescence; few very fine roots, pH 7.4; gradual smooth boundary.

Bss2   75-109 cm -- Dark brown (10YR 3/3 M), clay; strong, coarse, angular blocky peds with slickenside tilted at an angle of 30° to the horizontal axis; hard, firm, very sticky and very plastic; slight effervescence; few very fine roots, pH 7.5; gradual smooth boundary.

Bss3   109-150 cm+ -- Dark brown (10YR 3/3 M), clay; strong, coarse, angular blocky; slickenside tilted at an angle of 40° to the horizontal axis; hard, firm, very sticky and very plastic; slight effervescence; pH 7.6.

Type location: 22°10'25" N, 81°38'58" E; village Bichanpur, tehsil Lormi, District Bilaspur, Chhattisgarh.

Range in characteristics: The thickness of the control section is 120 to 150 cms. The A horizon is 120 to 150 cm thick. Its colour is in hue 10YR, value 3 to 4 and chroma 3. The texture is clay slickenside tilted with 10° to 60°. Deep wide cracks upto 100 cms.

Competing soils and their taxonomy: Fine, smectitic, hyperthermic (cal.), Typic Haplusterts/ Vertic Haplustepts. Fine-loamy, mixed, hyperthermic, Typic Haplustepts.

Geographic setting: Bichanpur soils have developed in limestone alluvium and occur on very gently sloping 1-3 per cent slope at an elevation of 300m above MSL. The climate is humid with mean annual air temperature of 26.02°C and mean annual rainfall of 1359 mm. The estimated

MAST is 28.01°C, MSST 32.0°C and MWST 25.5°C. The difference between MSST and MWST is 6.5°C.

Geographically associated soils: Vertic Haplustepts (53,911 ha); Typic Haplusterts (22,666 ha); Typic Haplustepts (88,476 ha); Typic Haplustalfs (2,883 ha)

Land use and vegetation: Paddy, wheat, gram; babul, neem, ber.

Drainage and permeability: Moderately well drained, slow permeability.

Distribution and extent: Extensive in tahsil Lormi, district Bilaspur (C.S.706-710; 86,583 ha)

Interpretation: Bichanpur soils have high available water holding and retentive capacity and fertility status.

a) Interpretative grouping:

i)	Land capability subclass	IIes
ii)	Irrigability subclass	2s
iii)	Productivity potential	High

b) Yield: Based on data from farmers' fields

Crops	Farmers' practices	Improved practices
	---------------(yield q/ha^{-1})--------------------	
Paddy	10-12	10-15
Wheat	15-20	20-30
Gram	5-7	7-10

Suggested land use: Bichanpur soils are suitable for paddy, gram, linseed, mustard and vegetables.

Soil datasets:

Horizon	Depth (cm)	Particle size diameter (mm)		
		Sand	Silt	Clay
		--------------------- (%)--------------------------		
Ap	0-14	18.2	31.0	50.8
Bw	14-45	18.2	30.8	51.0
Bss1	45-75	17.2	28.8	54.0
Bss2	75-109	17.2	28.0	54.6
Bss3	109-150+	17.0	27.0	56.0

Depth (cm)	Organic Carbon (%)	CaCO$_3$ (%)	E.C. (1:2.5) (soil:water dSm^{-1})	pH soil:water (1:2.5)	Bulk density (Mg m^{-3})	Water retension (%)	
						33 kPa	1500 kPa
0-14	0.82	1.3	<0.2	7.0	1.70	20.8	9.8
14-45	0.66	1.6	<0.2	7.3	1.71	21.6	11.5
45-75	0.70	1.9	<0.2	7.4	1.73	24.6	12.6
75-109	0.51	2.2	<0.2	7.5	1.75	24.9	13.9
109-150+	0.47	2.0	<0.2	7.6	1.80	26.5	14.6

Depth (cm)	Extractable bases					C.E.C.	Base saturation (%)
	Ca	Mg	Na	K	Sum		
	<------------------------------- cmol (p+)kg^{-1} ---------------------->						
0-14	30.0	10.0	0.5	0.4	40.9	41.2	99.0
14-45	31.0	10.0	0.5	0.5	42.0	42.4	99.0
45-75	32.0	10.0	0.5	0.4	42.0	43.6	98.3
75-109	32.0	11.0	0.63	0.5	44.1	44.8	98.0
109-150+	28.0	12.0	0.7	0.5	41.2	44.0	93.6

Source: Tamgadge, D.B., Gajbhiye, K. S. and Pande, G. P. (2002). Soil series of Chattisgarh Sate, NBSS Publ. No. 85, NBSS&LUP, Nagpur, 183p.

2.31.2 HITEKUSA SERIES

The Hitekusa series is a member of the fine-loamy, mixed, isohyperthermic family of Typic Haplustalfs. Typically, Hitekusa soils have dark yellowish brown, strongly acid, sandy clay loam A horizons, brown to yellowish red, slightly acid, sandy clay loam B horizons followed by C horizon of hard murrum.
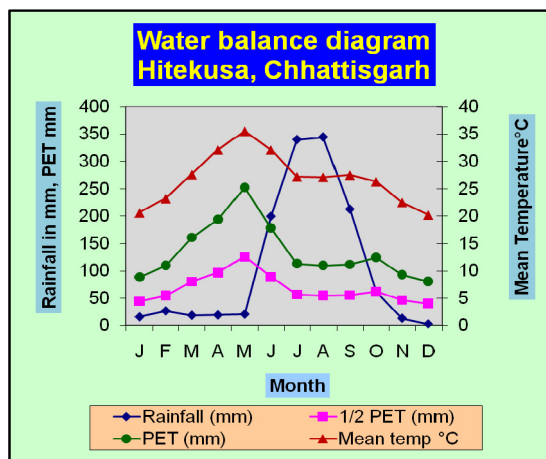
Typifying pedon: Hitekusa sandy clay loam – forest.

A   0-18 cm -- Dark yellowish brown (10YR 4/4), sandy clay loam; dark yellowish brown (10YR 3/4); weak, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many fine and common medium roots, strongly acid (pH 5.4); clear smooth boundary.

Bw   18-40 cm -- Brown (7.5YR 5/4), sandy clay loam; dark brown (7.5YR 3/4); moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common fine roots, medium acid (pH 5.6); gradual smooth boundary.

Bt1   40-75 cm -- Yellowish red (5YR 5/6), sandy clay loam; yellowish red (5YR 4/6); moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; many fine roots, thick patchy clay cutans on ped faces; medium acid (pH 5.7); gradual smooth boundary.

Bt2   75-104 cm -- Yellowish red (5YR 5/6), sandy clay loam; yellowish red (5YR 4/6); moderate, medium, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few fine roots, thick patchy clay cutans on ped faces; medium acid (pH 5.6); gradual smooth boundary.

Cr   104-120 cm+ -- Weathered parent material

Type location: 20°37'00" N, 81°20'05" E; Village Hitekusa, Tehsil Balod, District Durg, Chhattisgarh.

Range in characteristics: The thickness of the control section is 100 to 110 cms. The A horizon is 30 to 40 cm thick. Its colour is in hue 10YR and 7.5YR, value 3 and chroma 4. The texture is sandy clay loam. The thickness of B horizon is 60 to 70 cm. Its colour is in hue 5YR, value 4 and chroma 6. The texture is sandy clay followed by C horizon (hard murrum).

Competing soils and their taxonomy: Fine-loamy, kaolinitic, isohyperthermic, Typic Rhodustalfs/Typic Haplustepts.

Geographic setting: Hitekusa soils are developed on sedimentary rock and occur on gently sloping 3-8 per cent slope at an elevation of 400m above MSL. The climate is humid with mean

annual air temperature of 26.8°C and mean annual rainfall of 1276 mm. The estimated MAST is 28.8°C, MSST 33.8°C and MWST 25.8°C. The difference between MSST and MWST is 8.0°C.

Geographically associated soils: Lithic Haplustepts, Typic Haplustepts, Lithic Ustorthents, Typic Rhodustalfs, Plinthustalfs, Chromic Haplusterts, Vertic Haplustepts, Udic Haplustepts.

Land use and vegetation: Forest, Tendu, Mahua, Harra, Karra.

Drainage and permeability: Well drained, moderately rapid permeability.

Distribution and extent: Extensive in tehsil Balod, district Durg (C.S. 790-795; 95,780ha).

Interpretation: Hitekusa soils have medium available water holding and retentive capacity and low fertility status.

Interpretative grouping:
    i)   Land capability subclass   IVes
    ii) Irrigability subclass   4st
    iii) Productivity potential   Low

Suggested land use: Suitable for plantation of sal, sarai, eucalyptus, teak, bamboo andcoarse grasses.

Soil datasets:

Horizon	Depth (cm)	Particle size diameter (mm)		
		Sand	Silt	Clay
		<----------------------(%)------------------------>		
A	0-18	59.2	16.3	24.5
Bw	18-40	59.2	14.5	26.3
Bt1	40-75	57.5	14.0	28.5
Bt2	75-104	54.3	13.0	32.7

Depth (cm)	Organic Carbon (%)	CaCO₃ (%)	E.C. (1 :2.5) (Soil : water dS m⁻¹)	pH (1:2.5) Soil:Water	Bulk density Mg m⁻³	Water retention (%)	
						33 kPa	1500 kPa
0-18	0.91	-	<0.2	5.4	1.62	18.7	6.6
18-40	0.91	-	<0.2	5.6	1.63	19.9	8.6
40-75	0.87	-	<0.2	5.7	1.65	18.5	8.2
75-104	0.83	-	<0.2	5.6	1.66	19.7	8.6

Depth (cm)	Extractable cations					CEC	Base saturation (%)
	Ca	Mg	Na	K	Sum		
	<-------------------------------- cmol (p+)kg⁻¹ ---------------------------->						
0-18	5.0	1.0	0.30	0.19	8.49	10.0	84
18-40	6.0	2.0	0.21	0.12	8.33	10.1	82
40-75	6.0	2.0	0.23	0.14	8.30	10.4	80
75-104	7.0	2.0	0.28	0.14	8.42	11.5	73

Source: Tamgadge, D.B., Gajbhiye, K. S. and Pande, G. P. (2002). Soil series of Chattisgarh Sate, NBSS Publ. No. 85, NBSS&LUP, Nagpur, 183p.

2.32 Soil Series: AESR 12.1

Garjat Hills, Dandakaranya and Eastern Ghats, hot moist subhumid ESR with deep loamy Red and Lateritic soils, low to medium AWC and LGP 180-210 days (J2Cm6)

2.32.1 GADCHIROLI SERIES

The Gadchiroli series is a member of the fine-loamy, mixed, hyperthermic family of Typic Haplustoll. Typically, Gadchiroli soils have dark reddish gray to dark reddish brown, slightly acid, loamy A horizons and dark reddish gray to dark reddish brown, slightly acid, loamy B horizons.
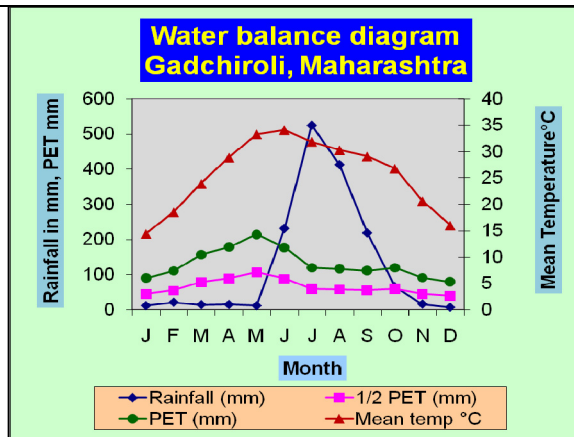
Typifying pedon: Gadchiroli loam – Reserved forest

A   0-18 cm -- Dark reddish gray (5YR 4/2 D) dark reddish brown (5 YR 3/2 M) loam; medium weak subangular blocky; slightly hard, friable slightly sticky and slightly plastic; fine many roots; pH 5.9; gradual smooth boundary.

B1   18-44 cm -- Dark reddish gray (5YR 4/2 D) dark reddish brown (5 YR 3/2 M) loam; medium weak subangular blocky; slightly hard, friable slightly sticky and slightly plastic; fine many roots; pH 5.8; diffuse smooth boundary.

B2   44-75 cm -- Reddish brown (5YR 4/3 D) light reddish brown (5 YR 6/3 M) loam; medium moderate subangular blocky; hard, friable; sticky and plastic; fine many roots; pH 6.1; diffuse smooth boundary.

B3   75-105 cm -- Reddish brown (5YR 4/3 D) dark reddish brown (5 YR 3/3 M) loam; medium moderate subangular blocky; hard, friable; sticky and plastic; very fine very few roots; pH 6.4; diffuse smooth boundary.

B4   105-125 cm+ -- Reddish brown (5YR 4/3 D) dark reddish brown (5 YR 3/3 M) loam; medium moderate subangular blocky; hard, friable; sticky and plastic; very fine very few roots; pH 6.4.

Type location: 19º28'30" N, 80º09'00" E; Village: Pediguradom RF; Tahsil: Ahiri; Distt: Gadchiroli; Maharashtra.

Range in characteristics: The thickness of solum is 125 cm. The A horizon is 14-18 cm thick. Its colour is in hue 10YR to 5YR value 3 to 4 and chroma 2. The texture is loam to sandy loam. The structure is subangular blocky. The B horizon is more than 100 cm thick. Its colour is in hue 7.5YR to 5YR, value 3 and chroma 2 to 4. The texture is loam to sandy loam. The structure is subangular blocky.

Competing soils and their taxonomy: Nil

Geographic setting: Gadchiroli soils have developed in granite and weathered granite and occur on gently sloping (3-8%) of North Deccan Maharashtra lower plateau (Metamorphic): Hill lands and ridges with pediments at an elevation of 200 m above MSL. The climate is humid with mean annual air temperature of 25.7^{o}C and mean annual rainfall of 1552 mm. The estimated MAST is 27.7^{o}C, MSST 32.0^{o}C and MWST 21.4^{o}C. The difference between MSST and MWST is 10.6^{o}C.

Geographically associated soils: Ahiri series

Land use and vegetation: Reserve forest- Bamboo, Tendu, Teak

Drainage and permeability: Well drained with moderate permeability.

Distribution and extent: Extensive in Ahiri and Gadchiroli district (Mapping units 345, 347).

Interpretation: These soils are very deep, rich in organic matter and could be kept under both rainfed and irrigated crops.

a) Interpretative grouping:
i)   Land capability subclass   : IIe
ii) Irrigability subclass   : Moderately sutaible (S2)
iii) Productivity potential   : Good

Soil datasets:

Horizon	Depth (cm)	Particle size diameter (mm)			Coarse fragments (2mm) (% of whole soil)
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay ($\cdot$ 0.002)	
		--------------------(%)--------------------			
A	0-18	58.3	10.7	30.0	5.0
B1	18-44	56.4	10.2	33.4	5.0
B2	44-75	60.4	9.1	30.5	3.0
B3	75-105	54.2	11.0	34.8	3.0
B4	105-125+	54.0	10.5	35.5	3.0

Depth (cm)	Organic carbon (%)	CaCO$_3$ (%)	E.C. (1:2.5, soil:water) (dS m^{-1})	pH soil:water (1:2.5)		Bulk density (Mg m^{-1})	Water retention (%)	
				H$_2$O	KCl		33 kPa	1500 kPa
0-18	1.42	Nil	0.08	5.9	4.6	1.78	16.8	8.7
18-44	1.37	Nil	0.06	5.8	4.4	1.71	17.9	8.9
44-75	0.84	Nil	0.08	6.1	4.6	1.67	15.9	7.2
75-105	0.81	Nil	0.13	6.4	4.7	1.76	17.1	9.1
105-125+	0.72	Nil	0.10	6.4	4.7	1.67	17.8	9.3

Depth (cm)	Exchangeable cations					C.E.C.	Base saturation (%)
	Ca	Mg	Na	K	Sum		
	-------------------------------- c mol(+)kg-^{1}--------------------------------						
0-18	7.5	3.3	0.02	0.2	11.0	13.2	83
18-44	6.5	4.2	0.04	0.2	10.8	12.3	88
44-75	7.5	4.3	0.05	0.2	12.0	13.4	89
75-105	10.8	4.8	0.06	0.2	15.8	17.4	91
105-125+	11.1	4.7	0.05	0.2	16.9	18.0	94

Source: Challa, O., Gajbhiye, K. S. And Velayutham, M. (1999). "Soil series of Maharashtra" NBSS Publ. No. 79, NBSS&LUP, Nagpur, 428p.

2.32.2 BAWANPURI SERIES

The Bawanpuri series is a member of the fine, mixed, isohyperthermic family of Chromic Haplusterts. Typically, Bawanpuri soils have light yellowish brown to yellowish brown, moderately acid, clayey A horizons and yellowish brown to dark grayish brown, medium acid to neutral, clayey B horizons.
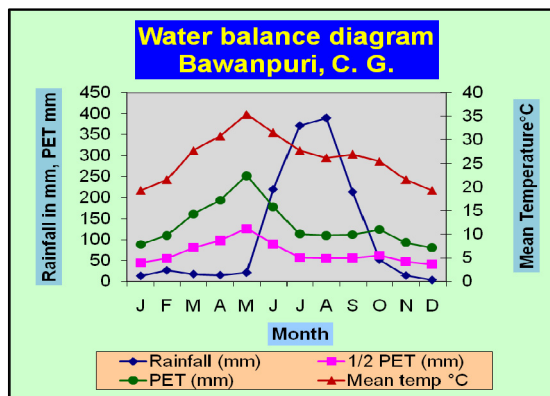
Typifying pedon: Bawanpuri clay – cultivated.

Ap   0-12 cm --- Light yellowish brown (10YR 6/4 D) and yellowish brown (10YR 5/4 M); clay, moderate, medium, subangular blocky; slightly hard, friable, sticky and plastic; many fine roots; strongly acid (pH 5.4); clear smooth boundary.

Bw   12-42 cm --- Yellowish brown (10YR5/4 D) and dark yellowish brown (10YR 4/4 M); clay, strong coarse, angular blocky; hard, firm, sticky and plastic; common fine roots; medium acid (pH 6.0); gradual smooth boundary.

Bss1   42-79 cm --- Grayish brown (2.5Y 5/2 D) and dark grayish brown (2.5Y 4/2 M); clay, strong, coarse, angular blocky peds with shiny pressure face slickenside tilted at an angle of 20° to the horizontal axis; hard, firm, very sticky and very plastic; few fine roots; slightly acid (pH 6.2); gradual smooth boundary.

Bss2   79-111 cm --- Grayish brown (2.5Y 5/2 D) and dark grayish brown (2.5Y 4/2 M); clay, strong, coarse, angular blocky peds with intersecting slickenside tilted at an angle of 30-40° to the horizontal axis; hard, firm, very sticky and very plastic; few medium roots; slightly acid (pH 6.4); gradual smooth boundary.

Bss3   111-150+ cm --- Grayish brown (2.5Y 5/2); clay, moderate, medium, subangular blocky peds with intersecting slickenside tilted at an angle of 30° to the horizontal axis; very hard, firm, very sticky and very plastic; slightly acid (pH 6.6).

Type location: 20°05' N, 81°45' E; Village: Bawanpuri, Tehsil: Kondagaon, District: Bastar, Chhattisgarh.

Range in characteristics: The thickness of the control section is 100 to 115 cms. The A horizon is 10-15 cm thick. Its colour is in hue 10YR and 2.5Y, value 4 to 5 and chroma 2 to 4. The texture is clay loam to clay followed by the B horizon slickensides tilted at an angle of 10-60°. The horizon is having deep wide cracks upto 80 cms.

Geographic setting: Bawanpuri soils have developed on granite alluvium and occur on very gently sloping (1-3%) of Eastern Dandakarnya plateau (Granite Gneiss) at an elevation of 640 m above MSL. The climate is humid with mean annual air temperature of 26.1^{o}C and mean annual rainfall of 1358 mm. The estimated MAST is 28.1^{o}C, MSST -33.0^{o}C and MWST 24.6^{o}C. The difference between MSST and MWST is 8.4^{o}C.

Geographically associated soils: Typic Rhodustalfs, Vertic Haplustepts, Typic Haplustalfs, Typic Plinthustalfs, Typic Haplustepts, Arenic Haplustalfs, Typic Haplusterts.

Land use and vegetation: Cultivated to crops such as paddy, wheat, gram; natural vegetation - mahua, teak, tendu, sarai.

Drainage and permeability: Moderately well drained with slow permeability.

Distribution and extent: Extensive (185,799ha) in tehsil Kondgaon, district Bastar (C.S. 768-773).

Interpretation: Bawanpuri soils have high available water holding and retentive capacity and high fertility status. They are suitable for paddy, wheat, gram, mustard and vegetables.

a) Interpretative grouping:
- i)   Land capability subclass   IIIes
- ii)   Irrigability subclass   3s
- iii) Productivity potential   Medium

b) Yield: Based on data from farmers' fields

Crops	Farmers' practices	Improved practices
	---------------(yield q/ha^{-1})---------------------	
Paddy	7-10	10-15
Wheat	10-12	20-25
Gram	5-7	10-12

Suggested land use: Suitable for paddy, wheat, gram, musturd and vegetables.

Soil datasets:

Horizon	Depth (cm)	Particle size diameter (mm)		
		Sand (2.0- 0.05)	Silt (0.05-0.002)	Clay (<0.002)
		<----------------------(%)------------------------>		
A	0-12	26.0	28.4	45.6
Bw	12-42	22.4	27.4	50.2
Bss1	42-79	21.6	26.0	52.4
Bss2	79-111	18.8	26.0	55.2
Bss3	111-150+	19.2	25.4	56.4

Depth (cm)	Organic Carbon (%)	CaCO$_3$ (%)	E.C. (1 :2.5) (Soil : water dS m^{-1})	pH (1:2.5) Soil:Water	Bulk Density (Mg m^{-3})	Water retention (%)	
						33 kPa	1500 kPa
0-12	0.99	-	<0.2	5.4	1.72	25.4	10.8
12-42	0.46	-	<0.2	6.0	1.73	26.4	12.4
42-79	0.37	-	<0.2	6.2	1.73	27.8	13.4
79-111	0.33	-	<0.2	6.4	1.76	28.9	14.5
111-150+	0.28	-	<0.2	6.6	1.80	30.4	15.6

Depth (cm)	Extractable cations					CEC	Base saturation (%)
	Ca	Mg	Na	K	Sum		
	<--------------------------------- cmol (p+)kg^{-1} ---------------------------->						
0-12	11.0	3.0	0.7	0.4	15.1	17.0	88
12-42	12.0	5.0	0.7	0.4	18.2	19.8	91
42-79	13.0	6.0	0.8	0.5	20.3	22.8	88
79-111	13.0	7.0	0.9	0.6	21.5	23.0	93
111-150+	15.0	4.0	1.0	0.6	20.6	24.0	85

Source: Tamgadge, D.B., Gajbhiye, K. S. and Pande, G. P. (2002). Soil series of Chattisgarh Sate, NBSS Publ. No. 85, NBSS&LUP, Nagpur, 183p.

2.33 Soil Series: AESR 12.2

Eastern Ghats, hot moist subhumid ESR with medium to deep loamy Red and Lateritic soils, medium AWC and LGP 180-210 days (H2Cm6)

2.33.1 BHUBANESWAR SERIES

The Bhubaneswar series is a member of the fine-loamy, mixed, isohyperthermic family of Typic Haplustults. Bhubaneswar soils have yellowish red very strongly acid sandy clay loam A horizons and yellowish red to red, very strongly acid, sandy loam to sandy clay loam B horizons, over hard vesicular lateritic C horizons.
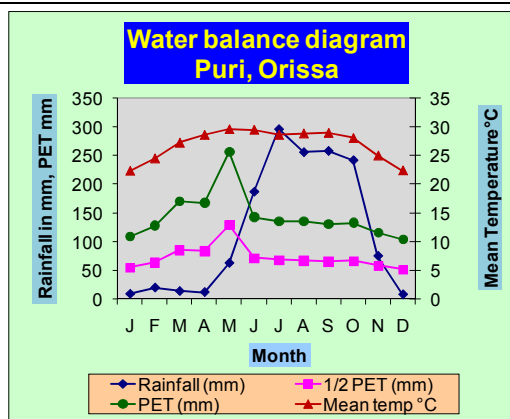
Typifying pedon: Bhubaneswar sandy loam – cultivated

Ap 0-13 cm --- Yellowish red (5 YR 5/8 D) sandy loam, dark red (2.5 YR 3/6 M); moderate medium subangular blocky structure; slightly hard and very friable; many fine and medium fibrous roots; many fine to medium random simple tubular imped pores; very strongly acid (pH 4.7); gradual smooth boundary.

Bw 13-27 cm --- Yellowish red (5 YR 5/8 D) sandy loam, dark red (2.5 YR 3.5/6 M); moderate medium subangular blocky structure; slightly hard, friable, slightly sticky; many fine and fibrous roots; many fine to medium random simple tubular imped pores; very strongly acid (pH 4.8); gradual smooth boundary.

Bt1 27-50 cm --- Yellowish red (5 YR 5/6 D) sandy loam, red (2.5 YR 3.5/6); moderate medium subangular blocky structure; slightly hard, friable and slightly plastic; many fine medium fibrous roots; many fine to medium simple tubular imped pores; few krotovinas; patchy thin clay cutans on ped faces; strongly acid (pH 4.9); gradual smooth boundary.

Bt2 50-78 cm --- Red (2.5 YR 5/8 D, 4.5/6 M) sandy clay loam, moderate medium subangular blocky structure; hard, friable, sticky and slightly plastic; many fine medium fibrous roots; coarse ferruginous fragments 1 to 2 per cent by volume; few 2 to 5 mm size iron-manganese concretions; few krotovinas; patchy thick clay cutans on ped faces; very strongly acid (pH 4.8); clear smooth boundary.

Bt3 78-88 cm --- Red (2.5 YR 5/8 D, 4.5/6 M) gravelly loam; massive; hard, friable, sticky and plastic; coarse ferruginous fragments about 30% by volume; few 2 to 5 mm size iron-manganese concretions; fine interstitial and few medium vesicular pores; patchy thin clay cutans on ped faces; very strongly acid (pH 4.7); abrupt smooth boundary.

C 88-165+ cm --- Hard, gravelly vesicular laterite.

Type location: 20°30′N and 85°50′E; Dryland Research station, O. U. A. T.; Bhubaneswar, District Puri, Orissa.

Range in characteristics: The thickness of the solum ranges from 65 cm to 1 m. The thickness of the A horizon is 10 to 15 cm. Its colour ranges from reddish yellow to strong brown in hue 5 YR and 7.5 YR. Its texture ranges from loamy sand to sandy loam. The thicknesses of the B horizon ranges from 50 to 85 cm. Patchy thin clay cutans are present. The colour of the B2t horizon ranges from reddish brown through yellowish red to red in hues 5 YR and 2.5 YR, moist value 3 to 5 and moist chroma 4 to 6. Its texture ranges from sandy clay loam to clay loam and structure is moderate medium subangular blocky. Soil reaction is strongly to very strongly acidic (pH 4.7 to 5.5). Percentage base saturation (sum of cations) above the paralithic contact is about 25 per cent.

Geographical setting: They have developed on ferruginous sandstone of the Gondwana system in District Puri, Orissa. They occur in upper pediments of 1 to 3 per cent slope at an elevation of 90 to 100 m above MSL. The climate is humid tropical with mean annual air temperature of 27°C and mean annual rainfall of 1520 mm. The estimated MAST is 29.0^{o}C, MSST 30.8^{o}C and MWST 26.7^{o}C. The difference between MSST and MWST is 4.1^{o}C.

Geographically associated soils: Principal associated soils are Andharua series-an Udic Paleustalf on flat ridges, Aiginia series- a Plinthustalf on slope breaks, and Mendhasal series- an Udic Haplustalf on upper pediments.

Drainage and permeability: Well drained with rapid permeability.

Land use and vegetation: Cultivated to rainfed rice, horsegram, groundnut, pigeonpea and jute; natural vegetation- *Mahua, Butea spp., Argimona spp*., and C*alotropics spp*.

Distribution and extent: Extensive in district Puri and adjoining areas in Orissa, parts of West Bengal and Bihar.

Series proposed: Orissa University of Agriculture & Technology, Bhubaneswar, Orissa.

Interpretation: Low availability of moisture in the soil is likely to create stress. Due to crust formation, run-off is considerable. Presence of free iron oxide often leads to phosphate fixation. These soils respond to lime and fertilizer applications.

a) Interpretative grouping :

Land capability sub-class	:	IIIe
Irrigability sub-class :	2s	
Productivity potential	:	Medium

b) Yield: Based on data from farmers′ fields

Crop	Yield Q/ha	
	Farmers' practices	Improved practices
Rice	20	32
Ragi	12	20
Maize	25	35
Jute	-	12
Sesamum	4	6
Sunflower	4	6
Groundnut	6	10
Greengram	6	10
Blackgram	8	13
Horse gram	5	8
Pigeonpea	10	15

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)										Coarse fragments >2mm% of whole
		Total			Sand					Silt		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very Coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)	
		------------------------------% of < 2 mm-------------------------------										
Ap	0-13	77.2	13.7	9.1	1.6	12.8	33.4	23.7	5.7	7.6	6.1	-
Bw	13-27	56.0	28.3	15.7	1.5	8.3	20.3	19.4	6.5	18.0	10.3	-
Bt1	27-50	60.0	20.1	19.9	2.8	11.7	20.4	18.6	6.5	14.1	6.0	-
Bt2	50-78	54.2	24.8	21.0	6.4	11.7	16.4	14.1	5.6	20.2	4.6	1
Bt3	78-88	43.3	42.0	14.7	11.1	8.4	9.5	7.4	6.9	34.8	7.2	20

Depth cm	Organic carbon %	Ext. iron as Fe %	pH		Bulk density g/cc	Water Retention 15-bar %	Micronutrients			
			(1:2.5) H_2O	(1:2.5) KCl			D T P A extractable			
							Zn	Cu	Mn	Fe
							-------------------ppm-------------------			
0-13	0.59	0.29	4.7	3.9	1.57	5.6	0.28	0.49	40	17
13-27	0.54	0.77	4.8	3.9	1.60	6.5	0.40	0.51	92	13
27-50	0.41	1.44	4.9	3.9	1.60	7.9	0.12	0.48	59	10
50-78	0.39	0.06	4.8	3.8	1.56	8.8	0.12	0.46	39	8
78-88	0.39	2.06	4.7	3.8	-	-	0.16	0.64	36	8

Depth (cm)	Extractable bases					Ext. acidity	CEC		Base satura-tion sum of cations %	Ratios to clay		
	Ca	Mg	Na	K	sum		Sum of cations	NH$_4$OAc		CEC NH$_4$OAC	Ext. iron	15-bar water
	------------------------------------me/100g ----------------------------------											
0-13	2.4	0.8	0.3	0.2	3.7	6.2	9.9	6.2	37	0.68	0.03	0.62
13-27	2.8	0.8	0.4	0.1	4.1	7.0	11.1	6.8	37	0.43	0.05	0.41
27-50	2.4	1.2	0.4	0.2	4.2	7.5	11.7	8.4	36	0.42	0.07	0.40
50-78	2.0	0.8	0.3	0.2	3.3	8.4	11.7	8.4	28	0.40	0.05	0.42
78-88	2.4	0.4	0.3	0.2	3.3	8.8	12.1	9.6	27	0.65	0.14	-

Analysed by: C. J. Thampi, A. K. Haldar and D. Sarkar
Micronutrients by: Staff AICSM (ICAR)
Source: Murthy, R. S., Hirekerur, L. R., Deshpande, S. B., VenKata Rao, B. V. and Shankaranarayana, H. S. (1982)
Benchmark soils of India- morphology, characteristics and classification for resource management, National Bureau of soil survey and land use planning, Nagpur, India, p.374.

2.33.2 MOTTO SERIES

The Motto series is a member of the fine, mixed, hyperthermic family of Vertic Halaquepts. Motto soils have dark grayish brown neutral silty clay loam A horizons, grayish brown to dark gray neutral to mildly alkaline clay loam to silty clay B horizons with distinct olive brown to yellowish brown mottles, and gray to dark gray silt loam to silty clay loam C horizons.

Water balance diagram Balasore, Orissa
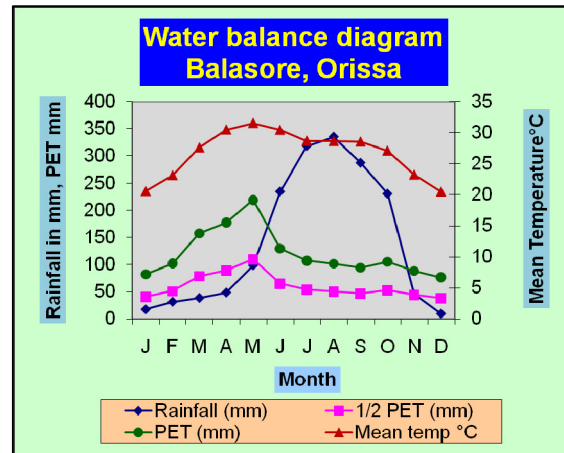
Typifying pedon: Motto silty clay loam - cultivated

Ap 0-14 cm --- Dark grayish brown (10YR 4/2 M) silty clay loam; massive; firm, sticky and plastic; many very fine to fine rots; very few fine iron-manganese concretions; 1 to 2.5 cm wide cracks; neutral (pH 6.6); clear smooth boundary.

Bw1 14-28 cm --- Grayish brown (2.5 YR 5/2 M) silty clay loam; strong coarse angular blocky structure with shiny pressure faces; very firm, very sticky and very plastic; many fine and medium roots; few fine to medium soft to moderately hard iron-manganese concretions; 1 to 2.5 cm wide cracks; many fine vertical tubular pores; neutral (pH 7.3); gradual smooth boundary.

Bw2 28-54 cm --- Grayish brown (2.5 Y 5/2 M) silty clay; strong coarse angular blocky structure with shiny oressure faces; very firm, very sticky and very plastic; common very fine and fine roots; few fine to medium soft to moderately hard iron-manganese concretions; common fine faint olive yellow (2.5 Y 6/6) mottles; many fine vertical tubular pores; mildly alkaline (pH 7.5); gradual smooth boundary.

Bw3 54-73 cm --- Dark gray (2.5 Y 5/4 M) silty clay; moderately strong coarse angular blocky structure with shiny pressure faces; firm, sticky and slightly plastic; a many very fine and fine roots; very few fine faint light olive brown (2.5 Y 5/6) mottles; many fine continuous vertical tubular pores; mildly alkaline (pH 7.8); gradual smooth boundary.

Bw4 73-98 cm --- Gray to dark gray (2.5 Y 4.5 M) silty clay loam; moderately strong coarse angular blocky structure; firm, sticky and slightly plastic; few very fine and fine roots; very few fine to medium soft iron-manganese concretions; common medium distinct yellowish brown (10 YR 5/6) mottles; many fine continuous vertical tubular pores; moderately alkaline (pH 7.9); diffuse smooth boundary.

Bw5 98-129+ cm --- Dark gray (2.5 Y 4/ M) silt loam; stratified; friable, slightly sticky and slightly plastic; very few fine to medium soft iron-manganese concretions; common medium distinct yellowish brown (10 YR 5/8) mottles; many fine continuous vertical tubular pores; moderately alkaline (pH 8.0).

Type location: 20°52′N, 86°46′E; University of Agriculture and Technology Research Farm (Orissa), Village Motto, Police Station Chandbali, District Balasore, Orissa.

Range in characteristics: The thickness of the solum is 60 to 110 cm. the estimated MAST is 26°C. MSST is 28.8°C and MWST is 21.4°C. Moisture regime is aquic; during the monsoon season the lands remain submerged due to inundation by the sea. The A horizon is about 15 cm thick. Its colour is in hue 10 YR, value 4 to 5 and chroma 2 to 4. Its texture is silty clay loam to clay loam. The colour of the B horizon is in hue 2.5 Y, value 4 to 5 and chroma upto 2. Its texture is silty clay loam to silty clay. Faint light olive brown to olive yellow and yellowish brown mottles and iron-manganese concretions are common. Shiny pressure faces on peds are noticed. The gleyed C horizon is in hue 2.5 Y, value 4 and neutral chroma. The texture is silty loam to silty clay loam. Distinct yellowish brown mottles and few iron-manganese concretions are present.

Geographical setting: They have developed in deltaic and coastal alluvium on flat bottomland in Balasore district of Orissa. The climate is subhumid tropical* with mean annual air temperature of 27°C and mean annual rainfall of 1650 m. The estimated MAST is 29.0°C, MSST 31.8°C and MWST 25.5°C. The difference between MSST and MWST is 6.3°C.

Geographically associated soils: Principal associated soils are Nalgunda series- a Typic Haplaquept, Permanandapur series – a Fluventic Eutrochrept, and Nuanai series- a Vertic Halaquept.

Drainage and permeability: Poorly drained with slow permeability.

Land use and vegetation: Cultivated to rice in *kharif* and barley and some adapted pulses in *rabi*; natural vegetation - *Neem, Ficus spp.* and *Pandanus spp.*

Distribution and extent: Extensive in coastal plains of Balasore district, Orissa.

Series proposed: Orissa University of Agriculture and Technology, Bhubaneswar, Orissa.

Interpretation: Motto soils are poorly drained with slow permeability. They have high salt content and high ESP. They are subject to inundation by sea water.

a) Interpretative grouping:
Land capability sub-class : IIIw
Irrigability sub-class : unsuitable for irrigation.
Productivity potential : Low, suited mostly to rice.

b) Yield: Based on data from farmers′ fields

crop	Yield Q/ha	
	Farmers' practice	Improved practices
Rice	25	35

Although, the description of the AESR indicates SHm bioclimatic system however this particular benchmark site represents SHd which demands refinement of AESR boundaries keeping in view the bioclimatic system. NBSS&LUP is carrying out this research work.

Soil datasets:

Hori-zon	Depth cm	Size class and particle diameter (mm)								Silt	
		Total			Sand						
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very Coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
		---% of < 2 mm--									
Ap	0-14	10.7	51.5	37.8	Nil	Nil	0.8	4.5	5.4	22.9	28.6
Bw1	14-28	8.1	52.7	39.2	Nil	Nil	Nil	3.3	4.8	19.8	32.9
Bw2	28-54	5.9	50.7	43.4	Nil	Nil	Nil	2.0	3.9	17.7	33.0
Bw3	54-73	7.5	46.5	46.0	Nil	Nil	Nil	2.2	5.3	14.5	32.0
Bw4	73-98	6.8	54.5	39.0	Nil	Nil	Nil	1.4	5.4	22.6	31.6
Bw5	98-129	8.8	65.0	26.2	Nil	Nil	Nil	1.0	7.8	48.6	16.4

Depth cm	Organic carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	Ext. iron as Fe (%)	pH		Bulk density g/cc	E. C. sat. Ext. mmhos/cm	Micronutrients			
								D T P A extractable			
				(1:2.5) KCl	(1:2.5) H_2O			Zn	Cu	Mn	Fe
								------------ppm--------------			
0-14	0.96	Nil	0.64	5.6	6.6	1.45	1.74	0.76	3.64	46	50
14-28	0.40	Nil	0.63	6.3	7.3	-	1.04	0.21	2.11	15	14
28-54	0.26	Nil	0.53	6.4	7.5	1.60	1.21	0.16	1.56	5	10
54-73	0.19	Nil	0.72	6.9	7.8	1.52	2.34	0.10	0.83	5	8
73-98	0.08	Nil	0.37	7.0	7.9	1.48	2.74	0.09	0.60	4	6
98-129	0.05	Nil	0.22	7.2	8.0	-	5.13	ND	ND	ND	ND

Depth (cm)	Extractable bases					CEC NH_4OAc	Exchan-geable sodium %	Base satura-tion NH_4OAc	Ratios to clay		*Clay fraction mineralogy
	Ca	Mg	Na	K	sum				CEC NH_4OAc	Ext. iron	
	--------------------me/100g ---------------------										
0-14	8.3	6.8	5.1	1.8	22.0	16.8	30	100	0.44	0.02	MT 3 HL 3
14-28	8.7	11.3	4.1	1.4	25.5	17.6	23	100	0.45	0.02	
28-54	8.3	10.8	3.1	1.3	23.5	20.0	16	100	0.46	0.01	
54-73	9.1	9.3	2.8	1.6	22.8	21.2	13	100	0.46	0.02	MT 3 IL 3
73-98	7.8	9.1	2.7	2.0	21.6	21.6	13	100	0.55	0.01	
98-129	7.8	7.1	2.3	1.0	18.2	17.8	13	100	0.68	0.01	

*MT = Montmorillonite   3 = 20-33%
HL = Halloysite
IL= Illite
Analysed by: C. J. Thampi, A. K. Haldar and D. Sarkar
Micronutrients by: Staff AICSM (ICAR)
Clay mineralogy by: Staff G. S. I., Calcutta

Source: Murthy, R. S., Hirekerur, L. R., Deshpande, S. B., VenKata Rao, B. V. and Shankaranarayana, H. S. (1982) Benchmark soils of India- morphology, characteristics and classification for resource management, National Bureau of soil survey and land use planning, Nagpur, India, p.374.

2.34 Soil Series: AESR 12.3

Chhotanagpur Plateau and Garjat Hills, hot, dry subhumid ESR with moderately deep to deep loamy to clayey Red and Lateritic soils, medium AWC and LGP of 150-180 days (J2Cd5)

2.34.1 PUSARO SERIES

The Pusaro series is a member of the fine–loamy, mixed, hyperthermic family of Typic Paleustalfs. Typically, Pusaro soils have strong brown to yellowish red, strongly acid, sandy loam to loam A horizons and yellowish red to reddish yellow, slightly acid, clay loam to clay Bt horizons.

Typifying pedon: Pusaro loam – cultivated
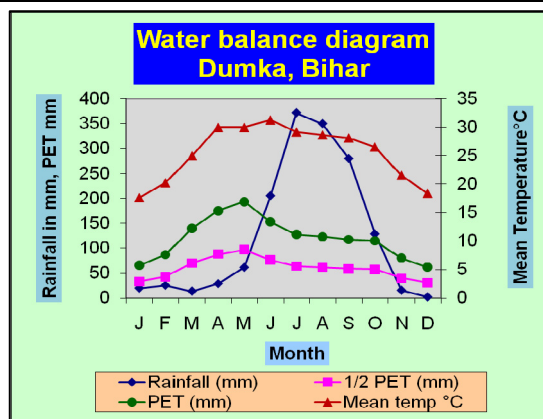
Ap   0-9 cm --- Strong brown (7.5 YR 4.5/6 D) and yellowish red (5YR 4/6 M) loam; massive; very hard, friable, slightly sticky; few fine roots; few very fine pores strongly acid (pH 5.1); clear smooth boundary.

Bt1   9-30 cm --- Yellowish red (5YR 5/6 D) and reddish brown (5YR 4/4 M) loam; moderate medium subangular blocky structure; hard, friable, sticky; few fine roots few very fine pores; few fine iron concretions; strongly acid (pH 5.5); gradual smooth boundary.

Bt2   30-48 cm --- Yellowish red (5YR 5.5/8 D, 4/6 M) clay loam; moderate fine and medium subangular blocky structure; hard, friable, sticky; few fine foots; few very fine pores; few medium iron-manganese concretions; slightly acid (pH 6.3); gradual smooth boundary.

Bt3   48-73 cm --- Yellowish red (5YR 5.5/8 D, 5/6 M) clay loam; strong coarse subangular blocky structure; hard, friable, sticky and plastic; few very fine pores; patchy thick clay cutans; few medium iron-manganese concretions; slightly acid (pH 6.3); gradual smooth boundary.

Bt4   73-91 cm --- Yellowish red (5YR 5.5/8 D, 5/6 M) clay loam; strong coarse subangular blocky structure; hard, friable, sticky and plastic; few very fine pores; patchy moderately thick clay cutans; few medium iron–manganese concretions; slightly acid (pH 6.5); gradual smooth boundary.

Bt5   91-114 cm --- Reddish yellow (5YR 6/8 D) and yellowish red (5YR 4/6 M) clay loam; strong coarse subangular blocky structure; very hard, friable, sticky and plastic; few very fine pores; patchy moderately thick clay cutans; few medium iron-manganese concretions; slightly acid (pH 6.5); gradual smooth boundary.

Bt6   114-141 cm --- Reddish yellow (5YR 6/8 D) and yellowish red (5YR 4/6 M) clay loam; distinct red (2.5 YR 4/8) mottles; strong coarse prismatic structure breaking to angular

blocky; very hard, friable, sticky and plastic; few very fine pores; patchy moderately thick clay cutan; few medium to coarse iron-manganese concretions; slightly acid (pH 6.5); gradual smooth boundary.

Bt7   141-186 cm --- Red (2.5 YR 5.4/6 M) clay; moderate medium subangular blocky structure; friable, very sticky and very plastic; few very fine pores; patchy moderately thick clay cutans; few fine and medium iron-manganese concretions; slightly acid (pH 6.3).

Micromorphology: Thin sections from the B horizons have been studied. There is evidence of clay illuviation from the Bt1 horizon downwards. Only a few argillans and clay infillings are present in the upper part of the Bt horizon. In the lower part of the Bt horizon argillans and clay infillings are common. Sesquioxide concretions are common in the entire B horizon as a result of illuviation. There is no evidence of current accumulation. Some alteration of minerals and rock fragments as occurred throughout the B horizon.

Type location: 24°17'30" N; 87°14'23" E, about 3 km N-NW of Dumka and 0.5 km east of Dumka-Bhagalpur road, village Hathiapathar, tehsil Dumka, District Santal Parganas, Jharkhand.

Range in characteristics: The thickness of the solum is more than 150 cm. The A horizon is 25 to 40 cm thick. The colour of the A horizon is in hue 7.5YR of redder, value 4 or 5 and chroma 4 or more. Its texture is loamy sand to clay loam; structure is massive to subangular blocky. The B horizon is more than 100 cm thick. Its colour ranges from strong brown in 7.5 YR to yellowish red in 5YR or redder hue with moist value 4 or more and chroma 4 or more. Distinct red mottles are present in the lower part of the Bt horizon. The Bt horizon has strong medium and coarse subangular blocky to prismatic structure. Subsurface horizons have 1 to 5 per cent by volume iron-manganese concretions.

Geographic setting: Pusaro soils have developed on weathered granite-gneiss and occur on gently sloping peneplained plateau with less than 5 per cent slope at an elevation of 125 to 500 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 26.0^{o}C and mean annual rainfall of 1090 mm. The estimated MAST is 27.0^{o}C, MSST 29.0^{o}C, MWST 20.0^{o}C and and difference between MSST and MWST is 9.0°C.

Geographically associated soils: The associated soils are Dumka series, a Lithic Ustochrept, on the backslope and Hathiapather series, a Typic Endoaqualf, on the toeslope.

Use and vegetation: Cultivated to upland *kharif* crops such as maize and minor millets; natural vegetation – sal, teak, black berry, jack, mango, *Cynodon spp.* (dhub) and *Saccharum spp.* (kans).

Drainage and permeability: Well drained with moderate permeability.

Distribution and extent: Extensive, covering about 17 per cent of the Mayurakshi catchment and adjoining areas in Bihar.

Series proposed: All India Soil and Land Use Survey, Regional Centre, Kolkata, 1978.

Interpretation: Pusaro soils have good air-water relationship. Initial water intake during early rains is affected by the hard, massive surface soil which causes runoff. With proper soil and moisture conservation measures the soils support a variety of climatically adapted crops.

a) Interpretative grouping:
    i)   Land capability subclass   IIIe
    ii)   Irrigability subclass   2s
    iii) Productivity potential   Medium

b) Yield: Based on data from farmers' fields

Crop	Rainfed (Yield, mg ha^{-1})
Maize	2.0-2.5
Minor millet-kodo	1.2-1.5

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)										Coarse fragm-ents > 2 mm % of whole soil
		Total			Sand					Silt		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)	
		<--- % of < 2 mm --->										
Ap	0-9	51.6	28.5	19.9	1.5	6.3	14.6	20.5	8.7	11.6	16.9	Tr
Bt1	9-30	43.7	29.7	26.6	1.1	6.3	13.4	16.3	6.6	13.1	16.6	Tr
Bt2	30-48	40.2	28.0	31.8	1.2	5.5	10.6	16.2	6.7	14.4	13.6	3
Bt3	48-73	40.8	26.7	32.5	2.3	5.5	10.8	15.4	6.8	11.1	15.6	3
Bt4	73-91	40.4	25.9	33.7	2.2	7.2	10.3	14.4	6.3	12.0	13.9	2
Bt5	91-114	42.1	24.0	33.9	2.6	5.0	11.5	15.3	7.7	9.4	14.6	5
Bt6	114-141	36.7	25.7	37.6	1.4	3.3	9.8	15.0	7.2	11.9	13.8	2
Bt7	141-186	33.6	25.8	40.6	1.3	3.4	11.0	11.7	6.2	12.2	13.6	2

Depth (cm)	Organic Carbon (%)	Extrac-table iron as Fe (%)	pH		Bulk density Mg m^{-3}	Micronutrients			
			(1:2.5) KCl	(1:2.5) H$_2$O		D T P A extractable			
						Zn	Cu	Mn	Fe
						<---------------- ppm ---------------->			
0-9	0.26	1.16	4.3	5.1	1.81	0.20	0.75	98	20
9-30	0.23	1.44	5.0	5.5	1.65	0.12	0.55	67	14
30-48	0.13	2.06	5.7	6.3	-	0.14	0.41	26	7
48-73	0.10	2.12	5.9	6.3	-	0.15	0.37	17	5
73-91	0.10	2.18	5.6	6.5	1.62	0.17	0.42	14	5
91-114	0.08	2.18	5.7	6.5	-	-	-	-	-
114-141	0.07	2.44	5.6	6.5	-	-	-	-	-
141-186	0.05	2.66	5.5	6.3	-	-	-	-	-

Depth (cm)	Extractable bases					CEC NH$_4$OAc	Base saturation NH$_4$OAc	Ratios of clay		*Clay fraction mineralogy
	Ca	Mg	Na	K	Sum			CEC NH$_4$OAc	Ext. iron	
	<---------------------------- cmol (p+)kg^{-1} ---------------------------->									
0-9	2.4	1.6	0.2	0.5	4.7	8.5	55.3	0.43	0.1	IL4 Q23
9-30	3.6	2.0	0.1	0.5	6.2	8.8	70.5	0.33	0.1	
30-48	4.4	2.0	0.1	0.4	6.9	9.1	75.8	0.29	0.1	
48-73	5.6	2.4	0.2	0.4	8.6	9.6	89.6	0.30	0.1	
73-91	6.0	2.4	0.1	0.4	8.9	10.4	85.6	0.31	0.1	IL4 MT3
91-114	6.0	2.8	0.1	0.5	9.4	11.4	82.5	0.34	0.1	
114-141	7.2	2.8	0.1	0.5	10.6	13.3	79.7	0.35	0.1	
141-186	6.8	4.0	0.3	0.7	11.8	14.3	82.5	0.35	0.1	

*IL – Illite   4 = 33-50%
 MT – Montmorillonitic   3 = 20-33%
 QZ – Quartz

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.34.2 PHULKUSMA SERIES

The Phulkusma series is a member of the fine, mixed, hyperthermic family of Typic Haplustalfs. Typically, Phulkusma soils have brown, moderately acid, sandy loam A horizons, and brown to dark brown, slightly acid, sandy clay loam to gravelly sandy clay Bt horizons underlain by weathered granite-gneiss.

Water balance diagram Asansol, West Bengal
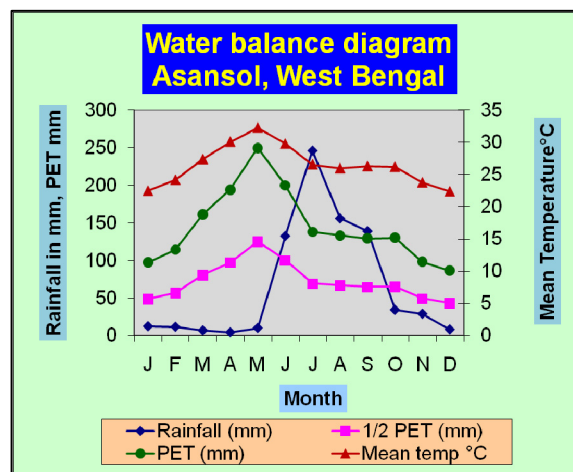
Typifying pedon: Phulkusma sandy loam - cultivated

Ap   0-13 cm --- Brown (7.5YR 5/4 M) sandy loam; massive (puddled); friable, slightly sticky and non-plastic; many fine to medium roots; moderately acid (pH 5.6); clear smooth boundary.

Bt1   13-30 cm --- Brown to dark brown (7.5YR 4/4 M) sandy clay loam; weak to moderate medium subangular blocky structure; friable, sticky and slightly plastic; many fine and few medium roots; patchy thin clay cutans on ped faces; common quartz gravels of 2 to 5 mm size; slightly acid (pH 6.2); gradual wavy boundary.

Bt2   30-87 cm --- Brown to dark brown (7.5YR 4/2) gravelly sandy clay; few faint brown (7.5YR 5/4) mottles; moderate medium blocky structure; firm, sticky and plastic; few fine roots; patchy thin clay cutans on ped faces; common quartz gravels of 2 to 5 mm size; slightly acid (pH 6.2); clear wavy boundary.

Cr   87-100 cm ---Weathered granite-gneiss.

Type location: 23°09' N, 86°50' E; village Phulkusma, P.S. Indpur, district Bankura, West Bengal.

Range in characteristics: The thickness of the solum ranges between 80 and 100 cm. The A horizon ranges in thickness from 12 to 15 cm. Its colour ranges from strong brown to brown in hue 10YR to 7.5YR, value 4 to 5 and chroma 4 to 6. Its texture varies from sandy loam to loam. The Bt horizon is about 80 cm thick. Its colour varies from brown to dark brown in hue 7.5YR, value 4 to 5 and chroma 2 to 4. It has quartz gravels in varying proportion.

Geographic setting: Phulkusma soils have formed in alluvium on very gently to gently sloping upper undulating plain at an elevation of 175 to 185 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 27.0^{o}C and mean annual rainfall of 1550 mm. The estimated MAST is 27.8^{o}C, MSST 28.2^{o}C and MWST 21.9^{o}C. The difference between MSST and MWST is 6.3°C.

Geographically associated soils: The associated soil is Bhulanpur, which is a Typic Haplustalf.

Drainage and permeability: Moderately well drained with moderate permeability.

Use and vegetation: Cultivated to rice; natural vegetation – *Phoenix sylvestris* (date palm) and *Borassus flabellifer* (palmyra palm).

Distribution and extent: Moderately extensive (15,000 ha) in the western part of Bankura district, West Bengal.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Calcutta, 1983.

Interpretation: Soils are moderately coarse textured. The available moisture capacity is moderate. These soils are suited to paddy with intensive soil and water conservation management practices. Field crops may be grown during *rabi* with adequate management practices.

a) Interpretative grouping:

i)	Land capability subclass	IIs
ii)	Irrigability subclass	2s
iii)	Productivity potential	Medium

b**) Yield:** Based on data from farmers' fields

Crop	Farmers' practices	Improved practices
	←---------------Yield, Mg ha^{-1}-------------→	
Kharif rice (local)	1.3	1.5
Kharif rice (HYV)	2.0	2.6

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								Coarse fragments > 2 mm % of whole soil
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
		<------------------------------------- % of < 2 mm ------------------------------------->								
Ap	0-13	66.0	14.3	19.7	6.0	9.2	25.5	20.3	5.0	12
Bt1	13-30	56.0	11.3	32.7	5.2	8.0	24.8	14.0	4.0	13
Bt2	30-87	52.0	9.3	38.7	4.0	5.6	20.4	17.8	4.2	22

Depth (cm)	Organic carbon (%)	pH (1:2.5) H$_2$O	Extractable bases					CEC NH$_4$OAc	Base saturation NH$_4$OAc (%)	Ratio CEC/ Clay
			Ca	Mg	Na	K	Sum			
			<--------------------- cmol (p+)kg^{-1} ---------------------->							
0-13	0.40	5.6	4.4	1.6	0.7	0.3	7.0	9.1	77	0.46
13-30	0.33	6.2	7.2	2.8	0.8	0.4	11.2	14.3	78	0.44
30-87	0.22	6.2	8.0	3.2	1.3	0.8	13.3	16.9	79	0.44

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil Series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.35 Soil Series: AESR 13.1

North Bihar and Avadh Plains, hot dry to moist subhumid transitional ESR with deep, loamy alluvium-derived soils, low to medium AWC and LGP 180-210 days (O8Cd/Cm6)

2.35.1 BARATOL SERIES

The Baratol series is a member of the fine-loamy, mixed, hyperthermic family of Typic Haplustepts. Typically, Baratol soils have olive, moderately acid, silty clay loam A horizons and olive gray to olive, slightly acid to neutral, silt loam to silty clay B horizons.

Water balance diagram Darbhanga, Bihar
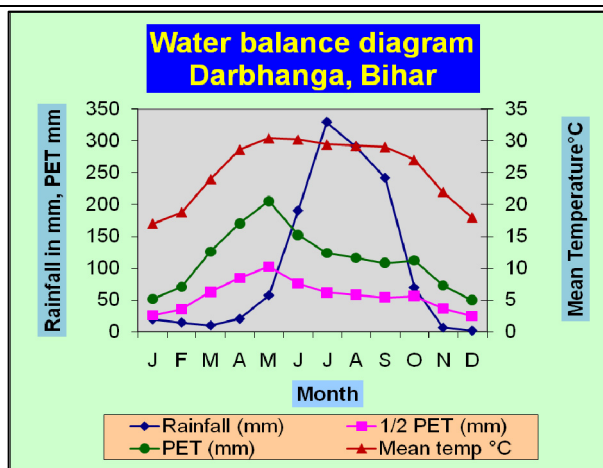
Typifying Pedon: Baratol silty clay loam – cultivated

Ap   0-23 cm --- Pale olive (5Y 6/3 D) and olive (5Y 5/3 M) silty clay loam; massive structure breaking into moderate medium subangular blocks; hard, friable, sticky and plastic; common fine roots; moderately acid (pH 5.7); clear smooth boundary.

Bw1   23-44 cm --- Olive gray (5Y 4/2 M) silty clay; coarse strong subangular blocky structure; friable, very sticky and very plastic; common fine roots, slightly acid (pH 6.5); gradual smooth boundary.

Bw2   44-68 cm --- Olive (5Y 5/4 M) silty clay loam; moderate medium subangular blocky structure; friable, sticky and plastic; few fine roots; neutral (pH 6.8); diffuse smooth boundary.

Bw3   68-150 cm --- Olive (5Y 5/4 M) silt loam; moderate medium subangular blocky structure; friable, sticky and plastic; neutral (pH 6.8).

Type location: 26º31'45" N, 85º53' E; village Baratol, P.S. Benipatti, district Madhubani, Bihar.

Range in characteristics: The thickness of the solum ranges from 117 to 130 cm. The A horizon is 13 to 24 cm thick. Its colour is in hue 5Y, value 5 to 6 and chroma 2 to 4. Its texture ranges from clay loam to silty clay loam. Its structure is massive breaking into moderate medium subangular blocks. The texture of the B horizon ranges from silt loam to clay. Its colour is in hue 5Y and 2.5Y, value 4 to 5 and chroma 2 to 4. Its structure is moderate weak subangular blocky to moderate medium subangular blocky.

Competing series and their differentiae: Rahitol series is also Typic Haplustepts which has hue of 2.5Y and distinct yellowish brown (10YR 5/8) to brownish yellow (10YR 6/8) mottles in the B horizons. The texture becomes lighter downwards.

Geographical setting: Baratol soils are formed in old alluvium and occur on nearly level to gently sloping (0-5%) plain lands at an elevation of 50 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 25.2ºC and mean annual rainfall of 1257.5 mm. The estimated MAST is 26.2ºC, MSST is 30.8ºC, MWST is 18.8ºC and the soil temperature regime is "hyperthermic" (MSST-MWST=12.0).

Geographically associated soils: Baratol soils are associated with the soils of Hirapatti and Basuki which belong to Fluventic Haplustepts and Typic Ustifluvents, respectively.

Drainage and permeability: Moderately well drained with moderate permeability.

Land use and vegetation: Mostly cultivated to paddy in *kharif* season and wheat in *rabi* season. Natural vegetation includes *Dondrocalamus* spp. (bamboo).

Distribution and extent: Extensive (30417 ha) in Ladania, Benipatti and Khajauli P.S., district Madhubani, Bihar.

Series proposed: National Bureau of Soil Survey and Land Use Planning (ICAR), Regional Centre, Kolkata, 1997.

Interpretation: The soils have moderate available water capacity. They are slightly acidic. Rice and sugarcane can be grown well in these soils.

Interpretative grouping:

i)	Land capability subclass	IIw
ii)	Irrigability subclass	2d
iii)	Productivity potential	Medium to High

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)							
		Total			Sand				
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)
		------------------------------- % of < 2 mm -----------------------------------							
Ap	0-23	8.4	62.1	29.5	0.15	0.20	0.11	1.46	6.48
Bw1	23-44	8.6	47.5	43.9	1.57	0.40	0.23	0.83	5.57
Bw2	44-68	13.2	57.7	29.1	0.27	0.31	0.15	1.44	11.03
Bw3	68-150	12.0	64.6	23.4	Nil	0.04	nil	1.33	10.63

Depth (cm)	Organic Carbon (%)	pH		E.C. (1:2.5) Water (dS m^{-1})	CaCO$_3$ equivalent (%)
		(1:2.5) Water	(1:2.5) 1.0 *M KCl*		
0-23	0.65	5.7	4.6	0.46	2.4
23-44	0.35	6.5	5.3	0.48	3.7
44-68	0.25	6.8	5.6	0.46	3.0
68-150	0.18	6.8	5.7	0.32	2.8

Depth (cm)	Exchangeable bases					CEC NH$_4$OAc (pH 7.0)	CEC/ Clay Ratio	Base saturation (NH$_4$OAc)[1] (%)	ESP (%)
	Ca	Mg	Na	K	Total	-- cmol(+)kg^{-1} soil --			
0-23	9.5	5.7	0.6	0.2	16.0	23.7	0.80	68	2
23-44	11.0	6.5	0.8	0.1	18.4	25.0	0.57	74	3
44-68	9.2	5.5	0.6	0.1	15.4	20.3	0.69	76	3
68-150	7.2	5.6	0.6	0.1	13.5	17.2	0.73	78	3

Depth (cm)	Available nutrients						
	N	P$_2$O$_5$	K$_2$O	Fe	Mn	Cu	Zn
	-------- kg ha^{-1} ---------			------------- mg kg^{-1} soil -----------			
0-23	141	15.3	247.2	20.0	8.2	2.3	0.3
23-44	ND	ND	ND	6.7	2.0	0.8	0.2
44-68	ND	ND	ND	6.2	2.0	0.6	0.6
68-150	ND	ND	ND	8.5	1.5	0.5	0.6

[1] [Total exchangeable bases/CEC by NH$_4$OAc] x 100

*ND- Not done

Source: Sarkar, D., Velayutham, M and Bhattacharyya, T. (1999). Soils of Madhubani district for optimizing land use. NBSS Publ. 76, NBSS&LUP (ICAR), Nagpur, 177p.

2.35.2 HIRAPATTI SERIES

The Hirapatti series is a member of the fine-loamy, mixed, hyperthermic family of Fluventic Haplustepts. Typically, Hirapatti soils have grayish brown, moderately alkaline, silt loam A horizon and light brownish gray to pale brown, neutral to moderately alkaline, silt loam B horizons.
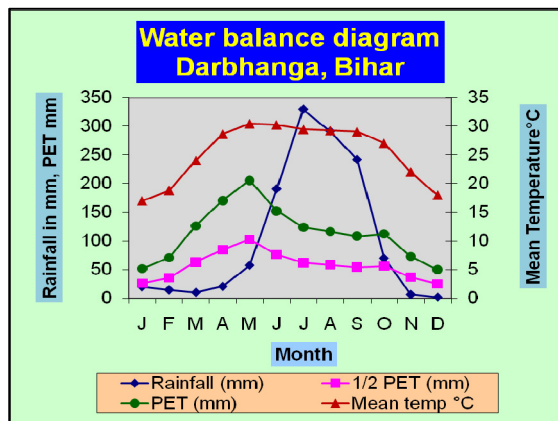
Typifying Pedon: Hirapatti silt loam – cultivated

Ap   0-18 cm --- Grayish brown (2.5Y 5/2 M) silt loam; common fine distinct strong brown (7.5 YR 5/6) mottles; massive; friable, slightly sticky and slightly plastic; common fine and few medium roots, common fine and few medium pores; slightly effervescent; common mica particles; moderately alkaline (pH 7.9); clear wavy boundary.

Bw1   18-35 cm ---Light brownish gray (10YR 6/2 M) silt loam; common fine faint brownish yellow (10YR 6/6 M) and yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; friable, slightly sticky and slightly plastic; common fine and medium roots; common fine and medium pores; common soft iron manganese concretions of 1 to 2 mm size; slightly effervescent; few mica particles; moderately alkaline (pH 8.0); gradual wavy boundary.

Bw2   35-58 cm --- Pale brown (10YR 6/3 M) silt loam; common fine faint yellowish brown (10YR 5/4) mottles; weak coarse subangular blocky structure; very thin stratified layer present; friable, sticky and slightly plastic; common fine and medium roots; few coarse and medium pores; few soft iron and manganese concretions of 1.0 mm size; slightly effervescent; common mica particles; moderately alkaline (pH 8.0); gradual wavy boundary.

Bw3   58-71 cm --- Pale brown (10YR 6/3 M) silt loam; few fine faint yellowish brown (10YR 5/4) mottles; weak coarse subangular blocky structure; very thin stratified layer present; friable, sticky and slightly plastic; common fine and few medium roots; few coarse and few medium pores; slightly effervescent; few mica particles; moderately alkaline (pH 8.0); gradual smooth boundary.

Bw4   71-103 cm --- Pale brown (10YR 6/3 M) silt loam; few fine faint dark yellowish brown (10YR 4/6 M) mottles; weak coarse subangular blocky structure; very thin stratified layer present; friable, slightly sticky and slightly plastic; few fine roots; common coarse and few medium pores; slightly effervescent; few mica particles; mildly alkaline (pH 7.7); gradual smooth boundary.

BC   103-150 cm --- Light yellowish brown (10YR 6/4 M) silt loam; few fine faint dark yellowish brown (10YR 4/6) mottles; massive, friable, slightly sticky and slightly plastic; common coarse, few medium pores; common mica particles; slightly effervescent; neutral (pH 7.3).

Type location: 26º25'45" N, 86º10'15" E; village Hirapatti, P.S. Rajnagar, district Madhubani, Bihar.

Range in characteristics: The soils are deep. The thickness of the A horizon is 17 to 32 cm. Its colour is in hue 10YR to 2.5Y, value 5 to 7 and chroma 2 to 4. Its texture is silt loam to silty clay loam. It has distinct stong brown mottles. The thickness of the B horizon is 61 to 109 cm. The colour of the B horizon is in hue 10YR, value 5 to 6 and chroma 2 to 4. It has faint yellowish brown mottles.

Competing series and their differentiae: Mutanja series (Fluventic Haplustepts) has a hue of 2.5Y and no mottles throughout the profile. The texture follows no regular trend down the profile and did not show effervescence with dil. HCl.

Geographical setting: Hirapatti soils are formed in alluvium on nearly level (0-1% slope) old alluvial plain at an elevation of 60 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 25.2ºC and mean annual rainfall of 1257.5 mm. The estimated MAST is 26.2ºC, MSST is 30.8ºC, MWST is 18.8ºC and the soil temperature regime is "hyperthermic", Difference between MSST and MWST is 12.0°C.

Geographically associated soils: Associated soils are Keolpatti and Baratol series which belong to Aquic Ustifluvents and Typic Haplustepts, respectively.

Drainage and permeability: Imperfectly drained with moderately slow permeability.

Land use and vegetation: Mainly under paddy cultivation; lentil, sugarcane also cultivated at places. Natural vegetation – *Phoenix sylvestris* (date palm), *Accacia* spp. (babul), *Dalbergia sissoo* (sisam).

Distribution and extent: Extensive (47232 ha.) in Rajnagar, Pandaul, P.S. of Madhubani district, Bihar.

Series proposed: National Bureau of Soil Survey and Land Use Planning (ICAR), Regional Centre, Kolkata, 1997.

Interpretation: Hirapatti soils respond well to management practices. Soils are under ustic moisture regime. Besides paddy, they are suitable for wheat and sugarcane under irrigation.

Interpretative grouping:
i)	Land capability subclass	IIIw
ii)	Irrigability subclass	3d
iii)	Productivity potential	Medium

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)							
		Total			Sand fractions				
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)
		------------------------------- % of < 2 mm ----------------------------------							
Ap	0-18	9.2	70.9	19.9	nil	nil	0.13	1.72	7.35
Bw1	18-35	2.4	77.5	20.1	0.18	0.06	0.03	0.20	1.93
Bw2	35-58	0.8	75.3	23.9	0.16	0.03	nil	0.11	0.50
Bw3	58-71	0.6	78.0	21.4	nil	nil	nil	0.06	0.54
Bw4	71-103	12.8	62.2	25.0	nil	nil	0.01	2.01	10.78
BC	103-150	30.2	54.5	15.3	nil	nil	nil	6.10	24.10

Depth (cm)	Organic Carbon (%)	pH		E.C. (1:2.5) Water (dS m^{-1})	CaCO$_3$ equivalent (%)
		(1:2.5) Water	(1:2.5) 1.0 M KCl		
0-18	1.14	7.9	6.7	0.63	3.8
18-35	0.40	8.0	6.6	0.45	3.7
35-58	0.51	8.0	6.5	0.46	4.0
58-71	0.42	8.0	6.7	0.43	3.5
71-103	0.42	7.7	6.4	0.37	3.1
103-150	0.32	7.3	6.2	0.28	2.9

Depth (cm)	Exchangeable bases					CEC NH$_4$OAc (pH 7.0)	CEC/ Clay Ratio	Base saturation (NH$_4$OAc)[3]	ESP
	Ca	Mg	Na	K	Total				
	-- cmol(+)kg^{-1} soil --							(%)	(%)
0-18	6.3	1.3	0.7	0.2	8.5	9.0	0.45	94	8
18-35	5.5	1.1	0.6	0.1	7.3	7.5	0.37	97	8
35-58	7.0	1.6	0.6	0.1	9.3	9.6	0.40	97	6
58-71	6.4	1.5	0.5	0.1	8.5	8.8	0.41	96	6
71-103	7.3	1.6	0.5	0.1	9.5	10.3	0.41	92	5
103-150	4.5	0.9	0.4	0.1	5.9	6.9	0.45	85	6

Depth (cm)	Available nutrients						
	N	P$_2$O$_5$	K$_2$O	Fe	Mn	Cu	Zn
	-------- kg ha^{-1} ---------			------------- mg kg^{-1} soil -----------			
0-18	237	25.6	121.2	18.7	16.0	3.0	0.3
18-35	ND	ND	ND	8.7	11.7	1.5	0.2
35-58	ND	ND	ND	9.0	13.4	1.4	0.6
58-71	ND	ND	ND	9.3	12.7	1.5	0.6
71-103	ND	ND	ND	14.7	13.5	1.6	0.6
103-150	ND	ND	ND	7.7	14.7	1.0	0.5

[1] [Total exchangeable bases/CEC by NH$_4$OAc] x 100

*ND- Not done

Source: Sarkar, D., Velayutham, M and Bhattacharyya, T. (1999). Soils of Madhubani district for optimizing land use. NBSS Publ. 76, NBSS&LUP (ICAR), Nagpur, 177p.

2.36 Soil Series: AESR 13.2

Foothills of Central Himalayas, warm to hot moist subhumid ESR with deep loamy to clayey Tarai soils, high AWC and LGP 180-210 days (B10Cm6)

2.36.1 BAHRAICH SERIES

Bahraich soil is a member of the fine-loamy over sandy (calcareous) mixed hyperthermic family of Typic Udifluvents. Bahraich soils have light yellowish brown, strongly alkaline, silty clay loam A horizons and brown to yellowish brown, strongly alkaline silt-loam to silty clay loam sandy C horizon.
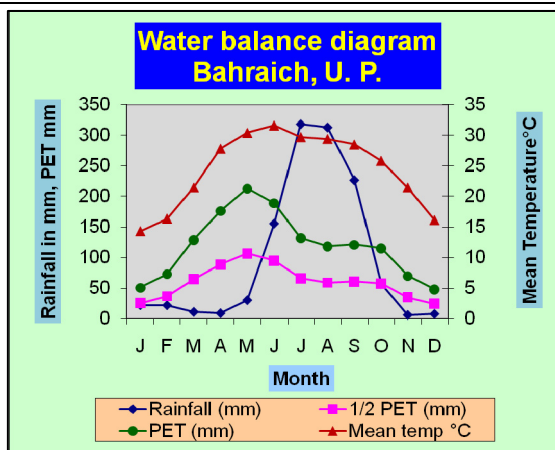
Typifying pedon: Bahraich silty clay loam-cultivated.

Ap	0-16 cm -- Dark grayish brown (2.5 Y 4/2 M) silty clay loam; moderate medium to coarse subangular blocky structure; firm, sticky and plastic; strongly effervescent, few fine roots; strongly alkaline (pH 8.8); gradual smooth boundary.
A12	16-39 cm -- Grayish brown (10 YR 5/2 M) silty loam; moderate medium coarse subangular blocky structure; friable sticky and plastic; violently effervescent; few fine roots; strongly alkaline (pH 8.8); clear smooth boundary.
IIC1	39-56 cm -- Brown (10 YR 5/3 M) sandy loam; weak fine subangular blocky structure; friable; violently effervescent; strongly alkaline (pH 8.8), clear smooth boundary.
IIIC2	56-142 cm -- Brown to pale brown (10 YR 5.5/3 M) sandy single grain; strongly effervescent; very strongly alkaline (pH 9.1).

Type location: About 400 meters south east of flood check post near Awasavi Purawa in Guria village in field no. 17487 tehsil Kesarganj, district Bahraich, U. P.

Range in characteristics: The estimated MAST is 25.4^{o}C and MWST is 19.2^{o}C. The thickness of the A horizon varies from 16 to 20 cm and its colour is in 10 YR and 2.5 Y hues, value 4 to 5, chroma 2 to 4. The thickness of silt loam and silty clay loam layers veries from 39 to 60 cm depth and the sand and loamy sand (coarse textured material) underlying it is intervened with the very fine layers of silt at variable depths.

Geographic setting: The soils have developed on nearly level to very gently sloping concave active flood plain of the Ghagra river in district Bahraich U. P. The climate is sub-humid subtropical with mean annual air temperature of 24.4^{o}C and mean annual rainfall of 1179 mm.

The estimated MAST is 26.4ºC, MSST is 30.1ºC, and MWST is 20.5ºC The difference between MSST and MWST is 9.6°C.

Geographically associated soils: The principal associated soil is Kesarganj soil which is also a Typic Udifluvent.

Drainage and permeability: Imperfectly drained with moderately slow permeability.

Land use and vegetation: The soil is cultivatea for sugarcane, paddy and wheat. Natural vegetation consists of mainly *Acacia arabica* (Babool), *Ficus religiosa* (Pipal) and *cynodon dactylon* (Doob)

Distribution and extent: The extent of this soil is 65.38 ha in the project area and may extend also in the adjoining area.

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very Coarse (2.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
Ap	0-16	1.8	65.7	32.5	-	0.1	0.1	0.5	1.1	0.8	64.9
A12	16-39	23.4	53.3	24.3	-	-	0.3	13.4	9.7	5.6	46.7
IIC1	39-56	62.5	28.7	8.8	-	-	0.2	35.2	27.1	8.5	20.2
IIIC2	56-142	95.0	2.0	3.0	-	-	0.6	91.7	2.7	1.0	1.0

Depth (cm)	O. C. (%)	CaCO$_3$ (%)	pH (1:2.5) H$_2$O	E. C. (1:2.5) H$_2$O	Water retention	
					1/3 bar	15 bar
0-16	0.71	4.1	8.8	0.26	42.49	14.85
16-39	0.46	4.8	8.8	0.16	31.93	9.65
39-56	0.19	7.6	8.8	0.13	19.20	3.24
56-142	0.04	5.2	9.1	0.08	3.90	0.62

Depth (cm)	Exchangeable bases me/100 g					CEC NaOAC (me/100 g)	B.S. (%)
	Ca	Mg	Na	K	Sum		
0-16	11.5	9.5	0.5	0.2	21.7	22.6	96
16-39	7.2	5.7	1.0	0.4	14.3	15.8	91
39-56	2.7	1.7	0.5	0.5	5.4	7.0	77
56-142	0.7	0.2	0.2	0.1	1.2	1.9	63

Source: NBSS&LUP Staff (1984). Soil Survey and Land Evaluation of Operational Research Project Flood Prone Area, Kandela Village, Kesarganj Tehsil, Bahraich District, Uttar Pradesh, Report No. 461 (ICAR), Regional Centre Delhi, NBSS&LUP, Nagpur, p15.

2.36.2 KESARGANJ SERIES

Kesarganj soil is a member of the coarse-loamy over sandy, also (calcareous) hyperthermic family of Typic Udifluvents. Kesarganj soils have grayish brown to light olive brown, very strongly alkaline, silt loam to loam A horizon and brown to dark yellowish brown, very strongly alkaline, loam, silt loam to sandy C horizons.
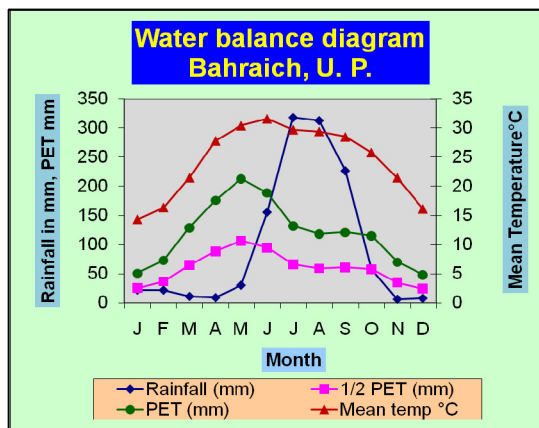
Typifying pedon: Kesarganj silt loam-cultivated

Ap   0-20 cm -- Grayish brown to light olive from (2.5 Y 5/3 M) silt loam; moderate medium subangular blocky structure; firm, sticky and plastic; violently effervescent; few fine roots; very strongly alkaline (pH 9.2); clear smooth boundary.

A12   20-39 cm -- Brown (10 YR 5/3 M) loam; moderate medium subangular blocky structure; firm, sticky and plastic; violently effervescent; few fine roots; strongly alkaline (pH 9.0); clear smooth boundary.

A13   39-75 cm -- Dark yellowish brown (10 YR 4/4 M) silt loam; weak medium subangular blocky structure; friable, slightly plastic; violently effervescent; common coarse mottles of yellowish brown colour; few fine roots; strongly alkaline (pH 9.0); abrupt smooth boundary.

IIC1   75-95 cm -- Brown (10 YR 5/3) sandy; single grain; loose; strongly effervescent; very strongly alkaline (pH 9.2); abrupt smooth boundary.

IIC2   95-138 cm -- Brown (10 YR 5/3 M) sand; single grain; loose strongly effervescent; strongly alkaline (pH 8.9); abrupt smooth boundary.

IIC3   138-160 cm -- Brown (10 YR 5/3 M) sand; single grain; loose strongly effervescent; very strongly alkaline (pH 9.2)

Type location: About 400 meters west of flood check post near Kaharan Purwa in village Guria No. 2, field no. 19828 tehsil Kesarganj, district Bahraich, U. P.

Range in characteristics: The estimated MAST is 25.4oC MSST is 29.5oC and MWST is 19.2^{o}C. The thickness of the A horizon varies from 15 to 21 cm. its colour is in 10 YR and 2.5 Y hues, value to 5, chroma 2 to 3. The thickness of loam to silt loam material varies from 60 to 75 cm depth. Sand and loamy sand strata occur below this depth with very layers of silt.

Geographic setting: They have developed on nearly level to gently sloping recent flood plain of Ghaghara river in district Bahraich, U. P. The climate is sub-humid subtropical with mean annual rainfall of 1179 mm and mean annual air temperature of 24.4^{o}C. The estimated MAST is 26.4ºC, MSST is 30.1ºC, MWST is 20.5ºC The difference between MSST and MWST is 9.6°C.

Geographically associated soils: The principal associated soil is Bahraich which is Typic Udifluvents.

Drainage and permeability: Imperfectly drained with moderately slow permeability.

Use and vegetation: The soil is cultivated for sugarcane, paddy and wheat. Natural vegetation consists of mainly *Acacia Arabica* (Babool), *Ficus-religiosa* (Pipal) and *Cyndon dactyon* (Doob)

Distribution and extent: The extent of this soil is 152.84 ha the project area but it may occur extensively in the other areas also specially along the Ghaghara river.

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very Coarse (2.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
Ap	0-20	17.6	62.1	20.3	-	0.1	0.8	8.3	8.4	8.4	53.7
A12	20-39	37.3	47.4	15.3	-	-	0.1	20.7	16.5	7.9	39.5
A13	39-75	29.9	56.1	14.0	-	-	0.1	11.7	18.1	16.1	40.0
IIC1	75-95	93.3	4.0	3.8	-	0.1	3.1	84.2	4.8	2.0	2.0
IIC2	95-138	86.4	8.1	5.5	-	0.1	1.0	57.4	27.9	4.6	3.5
IIC3	138-160	94.5	1.5	4.0	-	0.1	1.5	89.4	3.5	0.5	1.0

Depth (cm)	O. C. (%)	CaCO$_3$ (%)	pH (1:2.5) H$_2$O	E. C. (1:2.5) H$_2$O	Water retention	
					1/3 bar	15 bar
0-20	0.84	5.9	9.2	0.29	37.2	8.2
20-39	0.37	6.5	9.0	0.22	28.1	5.3
39-75	0.25	7.6	9.0	0.17	25.4	5.0
75-95	0.06	4.8	9.2	0.07	5.1	1.1
95-138	0.12	6.0	8.9	0.24	10.0	1.2
138-160	0.08	4.6	9.2	0.08	4.5	0.7

Depth (cm)	Exchangeable bases me/100 g					CEC NaOAC	ESP
	Ca	Mg	Na	K	Sum	(me/100 g)	
0-20	3.5	1.7	1.3	0.3	6.8	8.0	16
20-39	5.2	2.0	1.3	0.3	8.8	10.5	12
39-75	4.2	2.7	1.1	0.2	8.2	9.3	12
75-95	1.2	0.7	0.8	0.4	3.3	3.5	23
95-138	2.5	0.7	0.5	0.4	4.1	4.6	11
138-160	1.2	0.5	1.0	0.4	3.1	3.9	25

Source: NBSS&LUP Staff (1984). Soil Survey and Land Evaluation of Operational Research Project Flood Prone Area, Kandela Village, Kesarganj Tehsil, Bahraich District, Uttar Pradesh, Report No. 461 (ICAR), Regional Centre Delhi, NBSS&LUP, Nagpur, p15.

2.37 Soil Series: AESR 14.1

South Kashmir and Punjab Himalayas, cold and warm by dry semi-arid/dry subhumid ESR with shallow to medium deep loamy Brown Forest and Podzolic soils, low to medium AWC and LGP 90-120 days (A15Dd/Cd3)

2.37.1 BATHAL SERIES

Bathal series is a member of medium deep, loamy-skeletal, mixed, calcareous, cryic (like) family of Typic Cryorthents. Typically, Bathal soils have light gray, slightly alkaline, gravelly loam A horizons and light gray, moderately alkaline, gravelly sandy loam C horizon underlain by coarse stones.

Water balance diagram
Bathal, Himachal Pradesh
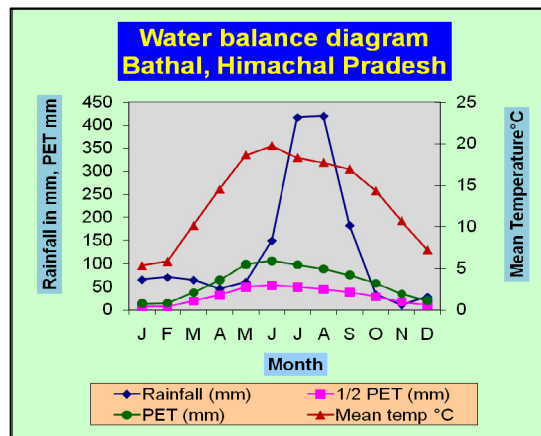
Typifying pedon: Bathal loam – Forests

A1 0-12 cm -- Light gray (10 YR 7/2 M), gravelly loam; weak, fine, subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; coarse gravels (30-40%); slightly alkaline (pH 7.9); clear smooth boundary.

A2 12-24 cm -- Light gray (10 YR 7/1 M), gravelly loam; weak, fine, subangular blocky; slightly sticky and slightly plastic; coarse gravels (30-40%); slightly alkaline (pH 7.9); abrupt smooth boundary.

C1 24-46 cm -- Light gray (10 YR 7/1 M), gravelly sandy loam; slightly hard, friable; non-sticky and non-plastic; weak, fine, subangular blocky; coarse stone (80%); slightly alkaline (pH 8.1); abrupt smooth boundary.

C2 46-66 cm -- Coarse stones (more than 80%).

Type location: Village: Berthal; Tehsil: Kazha; District: Lahaul and Spiti; Himachal Pradesh.

Range in characteristics: The thickness of solum is 24 cm. The estimated MAST is 5.1°C, MSST is 10.0°C and MWST is 3°C. The moisture regime is aridic (cold) and temperature regime is cryic (like). The A horizon is 24 cm thick. Its colour is in hue of 10 YR, value 7 and chroma 1 to 2. The texture is gravelly sandy loam. The thickness of the C horizon is 42 cm. Its colour is in hue of 10 YR, value 7, and chroma 1 to 2. The texture is gravelly sandy loam. The C horizon is followed by stones (> 80%).

Competing soils and their taxonomy:
Leo series: Medium deep, coarse-loamy, mixed, cryic(like), Typic Cryorthents (Status report on Kinnaur and Spiti Catchments of Satluj River in H.P. by HPKVV, Palampur,1991).

Geographic setting: Bathal series developed on limestone/slate and occur on steeply sloping (30-50%) at an elevation of 2500-3000 m above MSL, and mean annual rainfall of 200 mm. The

estimated MAST is 5.1°C. The MSST and MWST are 10.0°C and 3°C respectively. The difference between MSST and MWST is 7°C.

Geographically associated soils: Rock out crops.

Drainage and permeability: Excessive with rapid permeability.

Use and vegetation: Alpines bushes and trees.

Distribution and extent: Extensive in Spiti area of H.P. State (2,82,000 ha).

Interpretation: These soils are medium deep having high stoniness (>80%) in sub-soils which creates problem for penetration of roots.

Interpretative groupings:

     i)   Land capability sub class   VIIIes
     ii)   Land irrigability subclass   Not suitable (N2)
     iii)   Productivity potential   Low

Soil datasets:

Horizon	Depth (cm)	Particle size diameter (mm)				Coarse fragments (>2mm) % of whole soil
		Sand (2.0-0.05)	Silt (0.002-0.02)	(0.02-0.05)	Clay (· 0.002)	
A1	0-12	64.1	25.0	5.4	5.5	30-40
A2	12-24	61.6	27.5	2.4	8.5	30-40
C1	24-46	65.9	23.0	3.1	8.0	>80
C2	46-66	72.4	15.5	4.1	8.0	>80

Depth (cm)	Organic carbon (%)	CaCO$_3$ (%)	E.C. (1:2.5, soil:water) dSm^{-1}	pH Soil: water (1:2.5)	C.E.C. (Cmol(p+)/kg)
0-12	0.22	Nil	0.12	7.9	3.0
12-24	0.28	Nil	0.10	7.9	3.6
24-46	0.24	Nil	0.10	8.1	3.5
46-66	0.22	Nil	0.10	7.5	3.3

Source: Anonymus, (2002). Soil series of Himachal Pradesh, 2002. NBSS Publ. No. 91, NBSS&LUP, Nagpur, 177 p.

2.37.2 KALPA SERIES

Kalpa series is a member of deep, fine-loamy, mixed, thermic family of Typic Dystrudepts. Typically Kalpa soils have dark yellowish brown to dark brown, slightly acidic, loamy A horizons, yellowish brown to dark brown, slightly acidic, loamy B horizons and brown, slightly acidic, loamy C horizon.
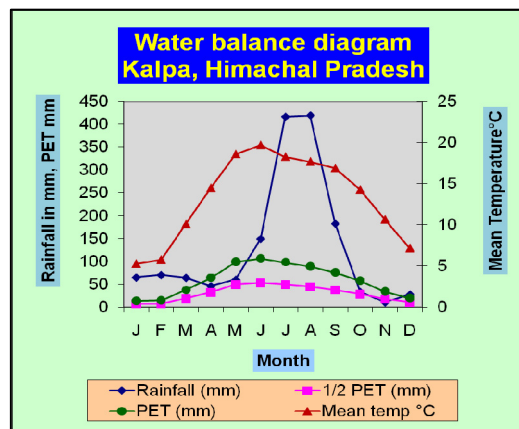
Typifying pedon: Kalpa loam- cultivated

Ap	0-18 cm	Dark yellowish brown (10 YR 3/4D) to dark brown (10 YR 3/3M) loam; weak, fine, sub-angular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; fine, many roots; pH 5.6; clear smooth boundary.
A12	18-33 cm	Dark brown (10 YR 3/3M) loam; weak, medium, sub-angular blocky structure; friable, slightly sticky and slightly plastic; very to fine common roots; pH 5.9; clear smooth boundary.
Bw1	33-56 cm	Yellowish brown (10 YR 5/4M) loam; moderate, medium, sub-angular blocky structure; firm, slightly sticky and slightly plastic; very fine, few roots; pH 6.3; gradual smooth boundary.
Bw2	56-76 cm	Dark yellowish brown (10 YR 4/4M) loam; moderate, medium, sub-angular blocky structure; firm, slightly sticky and slightly plastic; very fine, few roots; pH 6.4; gradual smooth boundary.
Bw3	76-91 cm	Dark brown (7.5 YR 3/4M) loam; weak, medium, subangular blocky structure; firm, sticky and plastic; very fine, few roots; pH 6.2; gradual smooth boundary.
C1	91-110 cm	Brown (7.5 YR 4/4M) loam; weak, medium, subangular blocky structure; friable, sticky and plastic; few, very fine, roots; pH 6.4; gradual smooth boundary.

Type location: Village: Kalpa; Tehsil: Kalpa; District: Kinnaur; Himachal Pradesh.

Range in characteristics: The thickness of solum is 110 cm. The A horizon is 33 cm thick. Its colour is in hue of 10 YR, value 3 and chroma 3. The texture is loam. The B horizon is 58 cm thick. Its colour is in hue of 7.5 YR to 10 YR, value 3 to 4 and chroma 3 to 4. The texture is loam. The structure is medium, moderate, subangular blocky.The C horizon is 19 cm thick. Its colour is in hue of 7.5 YR, value 4 and chroma 4.

Competing soils and their taxonomy: These are Palchan series which are deep, coarse-loamy, mixed, mesic, Typic Dystrudepts.

Geographic setting: Kalpa series developed in colluvium of phyllite/slate and occur on moderately steeply sloping (15.30%) at an elevation of 2000-3000 m above MSL. and mean

annual rainfall of 2000 mm. The moisture regime is udic. The estimated MAST is 5.1^{o}C. The MSST and MWST are 10.0^{o}C and 3°C, respectively.

Geographically associated soils: Jajwad series: Medium deep, coarse-loamy, mixed, thermic, Typic Udifluvents.

Drainage and permeability: Well drained with moderate permeability.

Land use and vegetation: Barley, potato and apple orchard.

Distribution and extent: Extensive in Kinnaur district of H.P. State (13,000 ha).

Interpretation: These soils are deep and medium texture soils. They have medium water holding capacity and high content of organic carbon.

Interpretative groupings:
i)	Land capability sub class	IVes
ii)	Land irrigability subclass	Not suitable (N2)
iii)	Productivity potential	Medium

Soil datasets:

Horizon	Depth (cm)	Particle size diameter (mm)				Coarse fragments (>2mm) % of whole soil
		Sand (2.0-0.05)	Silt (0.002-0.02)	(0.02-0.05)	Clay (· 0.002)	
Ap	0-18	48.0	31.0	0.5	20.5	5-10
A12	18-33	47.1	24.5	5.4	23.0	5-10
Bw1	33-56	44.7	24.5	7.8	23.0	10-15
Bw2	56-76	40.7	28.5	8.3	22.5	10-15
Bw3	76-91	43.3	27.0	8.6	21.0	10-15
C1	91-110	33.5	33.5	11.0	22.0	10-15

Depth (cm)	Organic carbon (%)	CaCO$_3$ (%)	E.C. (1:2.5, soil:water) dSm^{-1}	pH Soil: water (1:2.5) H$_2$O	C.E.C. (Cmol(p+)/kg)
0-18	2.5	Nil	0.18	5.62	15.35
18-33	1.3	Nil	0.11	5.90	12.78
33-56	0.8	Nil	0.10	6.30	12.45
56-76	1.0	Nil	0.10	6.40	16.43
76-91	0.9	Nil	0.10	6.15	13.03
91-110	0.5	Nil	0.10	6.35	12.45

Sourse: Anonymus, (2002). Soil series of Himachal Pradesh, 2002. NBSS Publ. No. 91, NBSS&LUP, Nagpur, 177 p.

2.38 Soil Series: AESR 14.2

South Kashmir and Kumaun Himalayas, warm moist to dry subhumid transitional ESR with medium to deep loamy to clayey Brown Forest and Podzolic soils, medium AWC and LGP 150-210 days (A15Cd/Cm6)

2.38.1 ROPRI SERIES

Ropri series is a member of coarse-loamy, mixed, hyperthermic family of Typic Haplustepts. Typically, Ropri soils have brown, neutral, sandy-loam A horizon underlain by weathered sand stone.
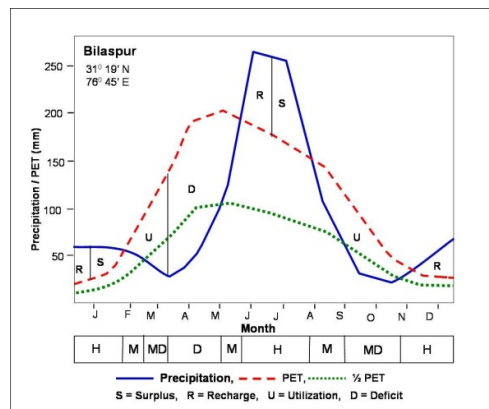
Water Balance Diagram – Bilaspur, Himachal Pradesh

Typifying pedon: Ropri sandy loam – grassland

A1   0-9 cm --- Dark yellowish brown (10YR 4/4 M) sandy loam; weak fine granular structure; very friable, non-sticky; common fine and medium roots; fine, many pores; 10 to 15% coarse fragments of 2 to 4 cm size; neutral (pH 7.2); clear and smooth boundary.

Bw   9-20 cm --- Dark yellowish brown (10YR 4/4 M) sandy loam; weak fine granular structure; friable and non-sticky; fine many pores; 10 to 15% coarse fragments of 2 to 4 cm size; neutral (pH 7.2); abrupt wavy boundary.

Cr   20-45 cm --- Weathered sandstone.

R   45+cm --- Sandstone.

Type location: 31°20' N, 76°52.5' E; village Sai Brahmna, district Bilaspur, Himachal Pradesh.

Range in characteristics: The soils are shallow. The A horizon is 15 to 20 cm thick. The colour is in hue 7.5YR to 10YR, value 4 and chroma 3 to 4. The texture is sandy loam or loam. The coarse fragments are 10 to 15 per cent.

Competing series and their differentiae: Competing series are those of Hariala which is coarse-loamy, Typic Udorthents.

Geographic setting: Ropri series are developed in sand stone and occur on steep to very steep hill slopes at an elevation of more than a 1000 m above MSL. The climate is humid sub-tropical with mean annual air temperature of 22°C and mean annual rainfall of 1250 mm. The estimated MAST is 22.3°C. The MSST and MWST are 28°C and 10.2°C, respectively. The soil moisture regime is Udic.

Geographically associated soils: The principal associated soils are Jadona (fine-loamy, Typic Udorthents), Hariala (coarse-loamy, Lithic Udorthents), Borpokhar (coarse-loamy, Typic Udorthents) and Kutaila (fine-loamy, Typic Eutrudepts).

Drainage and permeability: Excessively drained with moderately high permeability.

Use and vegetation: Mostly under grasslands. The natural vegetation are *Acacia catechu, Euphorbia sp. a*nd *Murrya sp.*

Distribution and extent: These soils are very extensive (23,598 ha) on the steep to very steep hill slopes of Bilaspur, Una and Hamirpur districts of Himachal Pradesh (20.4% area of the district).

Series proposed: National Bureau of Soil Survey and Land Use Planning (ICAR), Regional Centre, New Delhi, 1986.

Interpretation:
- The soil depth and slope are the main limitations.
- The soils should be kept under permanent vegetation cover.
- The existing vegetation should not be disturbed. It should be strengthened by grasses etc.

Interpretative groupings:

i.	Land capability sub class	VIIes
ii.	Land irrigability subclass	6t
iii.	Productivity potential	Very low

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)										Coarse fragments >2 mm % of whole soil
		Total			Sand					Silt		
		Sand 2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.10)-	Very fine (0.1-0.0.05	(0.05-0.02)	(0.02-0.002)	
		<-- < 2 mm % --->										
A1	0-9	66.1	22.1	11.8	--	12.8	10.5	29.0	13.8	5.2	16.9	8
Bw	9-20	62.9	18.2	18.9	0.80	26.0	13.3	15.0	7.8	4.8	13.4	10

Depth cm	O.C. (%)	CaCO$_3$ < 2mm (%)	pH (1:2.5) H$_2$O	E.C. (1:2.5) H$_2$O (dS m^{-1})	Water Retention	
					33 kPa	1500 kPa
					--------------%-----------------	
0-9	1.10	-	7.2	0.2	15.5	4.6
9-20	1.14	-	7.2	0.2	16.9	5.9

Depth (cm)	Exchangeable cations					CEC	Base Saturation (%)
	Ca	Mg	Na	K	Sum		
	←--- [cmol(p+) kg^{-1}] --------------------→						
0-9	2.8	3.7	0.2	1.2	7.9	9.7	81
9-20	2.6	1.3	0.3	0.2	4.4	6.9	64

Source: Walia, C.S., Rana, K.P.C. and Tarsem Lal (1998). The Soils of Bilaspur district, Himachal Pradesh for Land Use Planning. NBSS Publ.536, NBSS&LUP, Nagpur, pp.122.

2.38.2 DEHRA SERIES

Dehra series is a member of fine-loamy, mixed, hyperthermic family of Typic Haplustalfs. Dehra series have yellowish brown to dark yellowish brown, moderately acid, loamy A horizon and brown to dark brown, neutral, loam to clay loam with distinct dark brown to brown mottles and iron manganese concretions in B horizon. The C horizon is dark brown, neutral, sandy loam with medium subangular blocky structure.
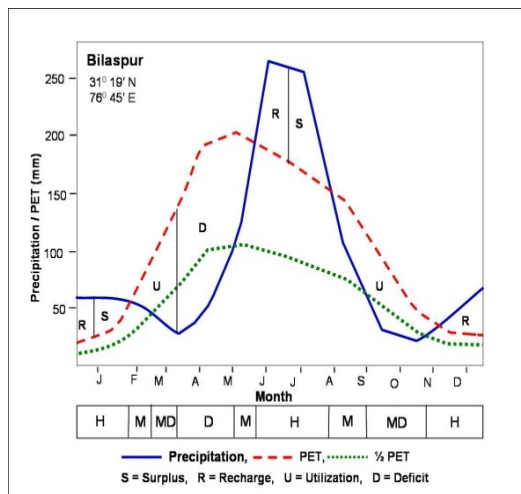
Water Balance Diagram – Bilaspur, Himachal Pradesh

Typifying pedon: Dehra loam – cultivated

Ap   0-12 cm --- Yellowish brown (10YR 5/4 M) loam; weak fine granular to sub angular blocky structure; friable, slightly plastic; many fine and medium roots; moderately acid (pH 5.7); clear smooth boundary.

Bt1   12-20 cm--- Brown to dark brown (10YR 4/3 M) loam; weak medium sub angular blocky structure; firm, slightly sticky and slightly plastic; plentiful fine roots; neutral (pH 6.6); clear smooth boundary.

Bt2   20-43 cm--- Brown to dark brown (10YR 4/3 M) clay loam; moderate, medium sub angular blocky structure; firm, sticky and plastic; many medium distinct mottles of 7.5 YR 4/4 colour; common fine Fe-Mn concretions, common fine roots; neutral (pH 6.6); clear smooth boundary.

Bt3   43-80 cm – Brown to dark brown (10 YR 4/3 M) clay loam; moderate medium sub angular blocky structure; firm, sticky and plastic; many medium distinct mottles of 7.5 YR 4/4 and common Fe Mn concretions; few fine roots; neutral (pH 6.7); clear smooth boundary.

Bw   80-108 cm--- Dark yellowish brown (10YR 4/4 M) clay loam; moderate medium sub angular blocky structure; firm, sticky and plastic; medium many distinct mottles of 7.5YR 5/4 colour; few fine roots; neutral (pH 6.7).

C   108-130 cm----Dark brown (7.5YR 4/4 M) sandy loam; weak medium sub angular blocky structure; friable, slightly sticky and non-plastic; neutral (pH 6.7).

Type location: 31°33' N, 76°42.5' E; village Dehra, district Bilaspur, Himachal Pradesh.

Range in characteristics: The soils are deep. The thickness of the A horizon varies from 7 to 12 cm. The colour is in the hue 10YR, values 4 to 3 and chroma 4. The texture is silt loam to loam. The thickness of the B horizon is more than 80 cm. The colour is in hue 10YR, value 4 to 5 and chroma 3 to 6. The texture is loam or clay loam with distinct dark brown to brown mottles and presence of Fe-Mn concretions. The structure is moderate medium subangular blocky. The

C horizon appears below 1 m with dark brown with hue 7.5YR, value 4 and chroma 4. The texture is sandy loam with medium subangular blocky structure.

Competing series and their differentiae: Competing series is Dasgaon which is Dystric Eutrudepts and free of mottles and Fe-Mn concretions.

Geographic setting: Dehra soils have developed in alluvium occurring on nearly level, lower piedmont plains at an elevation of 400 to 450 m above MSL. The climate is sub-tropical with mean annual air temperature of 22.8^{o}C and mean annual rainfall of 1250 mm. The estimated MAST is 22.5^{o}C. The MSST and MWST are 28°C and 10.2^{o}C respectively. The soil moisture regime is Udic.

Geographically associated soils: The principal associated soils are Dasgaon (Dystric Eutrudepts) and Tursu (Fluventic Eutrudepts).

Drainage and permeability: Moderately well drained with moderate slow permeability.

Use and vegetation: Mostly cultivated to paddy and wheat rotations. The natural vegetation consists of *Dalbergia sissoo, Morus alba, Azadirachta indica* and *Mangifera indica.*

Distribution and extent: The series is restricted to lower piedmont along river side and its extent is 2012 ha area of the district.

Series proposed: National Bureau of Soil Survey and Land Use Planning (ICAR), Regional Centre Delhi, 1986.

Interpretation:
- The moisture and nutrient retention capacity of soil is good.
- They are excessively wet in rainy season.
- Suited to paddy in *Kharif* season and other upland crops in *Rabi* season.

Interpretative groupings:
i)	Land capability sub class	-	IIw
ii)	Land irrigability subclass	-	I
iii)	Productivity potential	-	Medium to high

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)										Coarse fragments >2 mm % of whole soil
		Total			Sand					Silt		
		Sand 2.0-0.05	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.10)-	Very fine (0.1-0.0.05	(0.05-0.02)	(0.02-0.002)	
		<-- < 2 mm % -->										
Ap	0-12	34.8	46.7	18.5	-	-	1.0	15.5	18.3	16.2	30.5	Nil
Bt1	12-20	31.9	34.3	23.8	-	-	1.7	14.6	15.6	4.1	30.2	Nil
Bt2	20-43	28.0	42.7	29.3	-	1.4	1.2	10.4	15.0	15.0	27.7	Nil
Bt3	43-80	23.0	44.7	32.3	-	1.4	1.3	8.3	12.0	13.0	31.7	Nil
BW	80-108	36.2	35.9	27.9	-	0.8	1.9	13.9	19.6	5.1	30.8	Nil
C	108-130	64.8	15.9	19.3	-	0.3	3.5	46.4	14.6	3.7	12.2	Nil

Depth cm	O.C. (%)	CaCO₃ < 2mm (%)	pH (1:2.5) H₂O	E.C. (1:2.5) H₂O (dS m⁻¹)	Water Retention	
					33 kPa	1500 kPa
					--------------%-----------------	
0-12	0.41	-	5.7	0.1	27.6	6.5
12-20	0.29	-	6.6	0.1	26.7	9.9
20-43	0.23	-	6.6	0.05	26.3	12.1
43-80	0.27	-	6.7	0.05	27.7	13.2
80-108	0.10	-	6.8	0.05	26.9	11.9
108-130	0.10	-	6.7	0.05	23.2	7.8

Depth (cm)	Exchangeable cations					CEC	Base Saturation (%)
	Ca	Mg	Na	K	Sum		
	←----------------------------- [cmol(p+) kg⁻¹] -----------------------------→						
0-12	2.2	2.2	0.1	0.8	5.3	9.4	56
12-20	3.3	3.3	0.1	1.2	7.9	10.5	75
20-43	3.0	2.2	0.1	1.4	6.7	11.8	57
43-80	3.7	3.3	0.2	1.7	8.9	14.1	63
80-108	3.8	2.8	0.1	1.8	8.5	10.2	83
108-130	3.2	2.0	0.1	1.8	7.1	9.1	78

Source: Walia, C.S., Rana, K.P.C. and Tarsem Lal (1998). The Soils of Bilaspur district, Himachal Pradesh for Land Use Planning. NBSS Publ.536, NBSS&LUP, Nagpur, pp.122.

2.39 Soil Series: AESR 14.3

Punjab Himalayas, warm humid to perhumid transitional ESR with shallow to medium deep loamy brown forest and podzolic soils, low to medium AWC and LGP 270-300+ days (A15BA9)

2.39.1 MATAUR SERIES

The Mataur series is a member of the fine-loamy, mixed, thermic family of Dystric Eutrochrepts. Typically, Mataur soils have very pale brown to dark brown, neutral, silt loam A horizons and brown to dark yellowish brown, slightly acid to neutral, loam to clay loam B horizons.
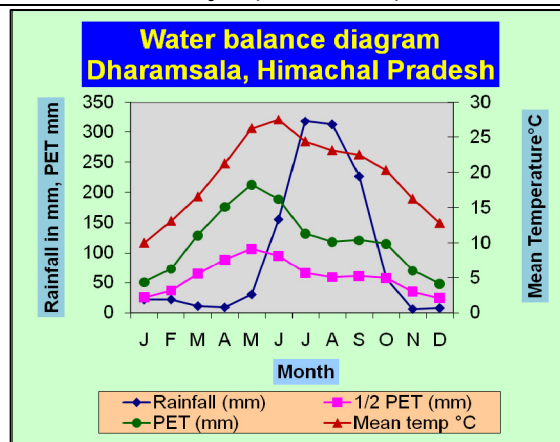
Typifying pedon: Motaur silt loam – cultivated

Ap   0-21 cm --- Very pale brown (10YR 7/3 D) and brown to dark brown (10YR 4/3 M) silt loam; moderate medium subangular blocky structure; hard, friable sticky and plastic; many fine roots; many fine imped pores; neutral (pH 6.6); gradual smooth boundary.

BA   21-38 cm --- Brown (10YR 5/3 M) silt loam; moderate medium subangular blocky structure; hard, friable, sticky and plastic; many fine roots; may fine imped pores; neutral (pH 6.9); gradual smooth boundary.

Bw1   38-68 cm --- Dark yellowish brown (10YR 4/4 M) loam; moderate medium subangular blocky structure; hard, friable, sticky and plastic; few fine roots; many fine to medium imped pores; neutral (pH 6.8); gradual smooth boundary.

Bw2   68-90 cm --- Dark yellowish brown (10YR 4/4 M) clay loam; moderate medium subangular blocky structure; hard, friable, sticky and plastic; many fine to medium pores; slightly acid (pH 6.4).

Type location: 32º08' N, 76º18' E; about 100 metre north of Mataur village on Kangra-Dharamshala road, distict Kangra, Himachal Pradesh.

Range in characteristics: The soils are moderately deep to deep. The A horizon is 11 to 21 cm thick. Its colour is in hue 10YR, value and chroma 3 to 4. The B horizon is more than 60 cm thick. Its colour is in hue 10YR, value 3 to 5 and chroma 3 to 4. Its texture is generally loam to clay loam.

Competing series and their differentiae: The competing series is Kangra soils which are very deep and belong to Dystric Eutrochrepts.

Geographic setting: Mataur soils are formed in alluvium on very gently to moderately sloping piedmont plain at an elevation of about 1200 m above MSL. The large size boulders on the

surface as well as inside the soil indicated the past glacial activity due to which the piedmont plain landscape is developed. The climate is humid with mean annual air temperature of 19.0ºC and mean annual rainfall of 1744 mm. The estimated MAST is 20.0ºC, MSST 24.0ºC and MWST 14.0ºC.

Geographically associated soils: Mataur soils are associated with those of Kangra series, a Dystric Eutrochrept.

Drainage and permeability: Well drained with moderate permeability.

Use and vegetation: Cultivated to rice, maize and wheat crops; natural vegetation – *Dendrocalamus spp.* (bamboo), *Cedrela toona* (tun) and *Bombax malabaricum* (semul).

Distribution and extent: Extensive in Kangra vally of Kangra district, Himachal Pradesh.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Delhi, 1978.

Interpretation: The soils are moderately deep to deep. They are also subject to erosion due to gentle to moderate slopes. They are capable of producing good crop yields under proper management and suitable soil conservation measures.

Interpretative grouping:

i)	Land capability subclass	IIe
ii)	Irrigability class	2t
iii)	Productivity potential	Medium

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)			Coarse fragments > 2 mm % of whole soil
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	
		<------------------------ % of < 2 mm ------------------------>			
Ap	0-21	16.9	67.4	15.7	-
BA	21-38	26.4	60.5	13.1	-
B1	38-68	45.6	40.6	13.8	-
B2	68-90	35.9	37.0	27.1	-

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})
0-21	0.51	-	6.6	<0.2
21-38	0.25	-	6.9	<0.2
38-68	0.20	-	6.8	<0.2
68-90	0.20	-	6.4	-

Depth (cm)	Extractable bases					CEC NH_4OAc	Base saturaion NH_4OAc (%)	Ratio CEC/ Clay
	Ca	Mg	Na	K	Sum			
	<------------------------ cmol (p+)kg^{-1} ------------------------>							
0-21	5.0	0.3	0.7	0.4	6.4	8.2	78	0.52
21-38	3.0	2.0	0.5	0.3	5.8	7.3	79	0.56
38-68	3.0	1.8	0.8	0.3	5.9	7.3	81	0.53
68-90	4.1	2.2	1.0	0.4	7.7	8.9	87	0.33

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.39.2 RAJPURA SERIES

The Rajpura series is a member of the fine-silty, mixed, thermic family of Typic Paleudalfs. Typically, Rajpura soils have light yellowish brown to dark yellowish brown, slightly acid, loam A horizons, and brownish yellow to dark brown, strongly to moderately acid, clay loam to silty clay loam B horizons.

**Water balance diagram
Palampur, Himachal Pradesh**
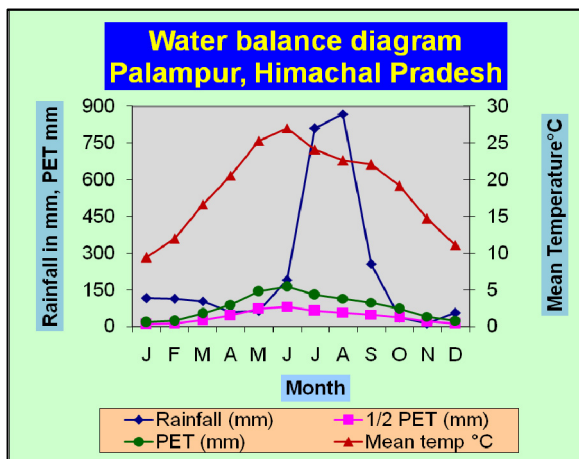
Typifying pedon: Rajpura loam – cultivated

Ap   0-15 cm --- Light yellowish brown (10YR 6/4 D) and dark yellowish brown (10YR 4/4 M) loam; moderate medium subangular blocky structure; hard, firm, sticky and plastic; common very fine to medium roots; common fine imped pores; slightly acid (pH 6.3); clear smooth boundary.

Bw   15-43 cm --- Light yellowish brown (10YR 6/4 D) and dark yellowish brown (10YR 4/4 M) clay loam; moderate medium subangular blocky structure; very hard, very firm, very sticky and very plastic; common very fine to medium roots; common fine imped pores; moderately acid (pH 5.6); gradual wavy boundary.

Bt1   43-72 cm --- Brownish yellow (10YR 6/6 D) and brown to dark brown (7.5YR 4/4 M) silty clay loam; few fine faint mottles; strong coarse angular blocky structure; extremely hard, very frim, very sticky and very plastic; common fine to medium roots; many fine imped pores; clay bridges on sand grains; strongly acid (pH 5.5); gradual wavy boundary.

Bt2   72-107 cm --- Brownish yellow (10YR 6/6 D) and brown to dark brown (7.5YR 4/4 M) silty clay loam; common medium faint mottles; strong coarse angular blocky structure; extremely firm, very sticky and very plastic; common fine roots; few very fine to fine imped pores; broken moderately thick clay bridges on sand grains; strongly acid (pH 5.4); gradual wavy boundary.

Bt3   107-150 cm --- Light yellowish brown (10YR 6/4 D) and dark yellowish brown (10YR 4/4 M) silty clay loam; common medium faint mottles; moderate medium to coarse subangular blocky structure; extremely hard, extremely firm, very sticky and very plastic; few fine roots; few fine to medium imped pores; patchy thin clay cutans; strongly acid; (pH 5.3).

Type location: 32º06' N, 76º32' E; about 0.5 km before Rajpura village on Palampur to Rajpura road, tehsil Palampur, district Kangra, Himachal Pradesh.

Range in characteristics: The soils are very deep. The A horizon is 13 to 19 cm thick. Its colour is in hue 10YR or 7.5YR, value 5 to 7 and chroma 4 to 6. Its texture is loam to silt loam.

The B horizon is more than 130 cm thick. Its colour is in hue mostly 10YR or 7.5 YR but sometimes in 5YR also, value 4 or 5, and chroma 4 to 6. Its texture is generally clay loam to silty clay loam.

Geographic setting: Rajpura soils are developed on very gently to moderately sloping piedmont plain of lesser Himalayas at an elevation of about 1200m above MSL. The climate is subhumid temperate with mean annual air temperature of 19.0ºC and mean annual rainfall of 1744 mm. The estimated MAST is 20.0ºC, MSST 24.0ºC and MWST 14.0ºC. The moisture regime is udic since the moisture control section is usually moist throughout the year due to well distributed rainfall from July to September and January to March.

Geographically associated soils: These are Kangra soils which are Dystric Eutrochrepts.

Drainage and permeability: Well drained with moderately slow permeability.

Use and vegetation: Cultivated to maize and wheat crops, tea is also grown in Palampur tehsil; natural vegetation – *Acacia catechu* (khair), *Acacia spp.* (babul) and *Pinus spp.* (pine).

Distribution and extent: Extensively occurring in Palampur and Kangra tehsil of Kangra district, Himachal Pradesh.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Delhi, 1979.

Interpretation: These soils are very deep but are subject to erosion due to gentle to moderate slopes. They are capable of producing high crop yields under proper soil conservation measures.

Interpretative grouping:
   i)   Land capability subclass   IIe
   ii) Irrigability subclass   2t
   iii) Productivity potential   Medium to high

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)			Coarse fragments > 2 mm % of whole soil
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	
		<------------------------- % of < 2 mm ------------------------->			
Ap	0-15	34.5	44.8	20.7	-
Bw	15-43	22.4	49.8	27.8	-
Bt1	43-72	10.4	53.6	36.0	-
Bt2	72-107	8.8	57.9	33.3	-
Bt3	107-150	8.8	61.6	29.6	-

Depth (cm)	Organic Carbon (%)	pH (1:2.5) H_2O	Extractable bases					CEC NH_4OAc	Base saturaion NH_4OAc (%)	Ratio CEC/ Clay
			Ca	Mg	Na	K	Sum			
			←-------------------cmol (p+)kg^{-1} -------------------→							
0-15	0.60	6.3	4.8	4.0	0.9	0.3	10.0	10.6	94	0.51
15-43	0.45	5.6	5.3	3.5	0.9	0.4	10.1	10.3	98	0.37
43-72	0.30	5.5	6.8	5.2	0.9	0.4	13.3	13.7	97	0.38
72-107	0.20	5.4	4.8	2.4	0.8	0.4	8.4	10.2	82	0.31
107-150	0.20	5.3	5.0	4.0	0.8	0.4	10.2	13.6	75	0.46

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.40 Soil Series: AESR 14.4

Kumaun Himalayas, warm humid to perhumid transitional ESR with shallow to medium deep loamy Red and Yellow soils, low AWC and LGP 270-300+ days (A3B/A9)

2.40.1 GAJELI SERIES

Gajeli soils are a member of the loamy-skeletal, mixed, thermic family of Typic Dystrudepts. Typically, Gajeli soils have brown to dark brown, slightly acidic to neutral gravelly loam A horizons; dark yellowish brown, slightly acidic, gravelly loam B horizons and dark yellowish brown, slightly acidic, weathered phyllite with gravelly loam Cr horizons.
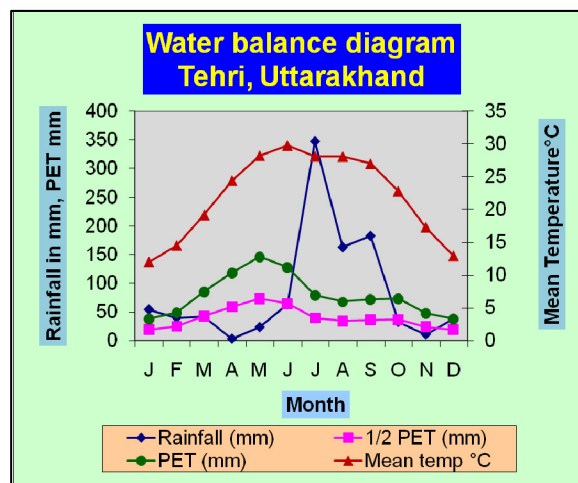
Typifying pedon: Gajeli- gravelly loam on moderately steep hill slope, (terrace slope 1-3 percent), moderately eroded – cultivated.

A 0-13 cm -- Brown (10 YR 4/3 M) gravelly loam; weak fine subangular blocky structure; friable, slightly sticky and slightly plastic; Phyllite fragments 35 to 40 per cent by volume; many very fine to fine roots; few fine pores; neutral (pH 6.6); clear smooth boundary.

BA 13-27 cm -- Dark yellowish brown (10 YR 4/4 M) gravelly loam; weak medium subangular blocky structure; friable, sticky and slightly plastic; Phyllite fragments 25 to 35 per cent by volume; many very fine roots; common very fine pores; slightly acidic (pH 6.5); gradual smooth boundary.

Bw1 27-44 cm -- Dark yellowish brown (10 YR 4/4 M) gravelly loam; weak medium subangular blocky structure; friable, sticky and slightly plastic; phyllite fragments 35 to 40 per cent by volume; common very fine roots; common very fine pores, slightly acidic (pH 6.2); gradual smooth boundary.

Bw2 44-66 cm -- Dark yellowish brown (10 YR 4/4 M) gravelly loam; weak medium subangular blocky structure; friable, sticky and slightly plastic; phyllite fragments 40 to 45 per cent by volume; common very fine roots; common very fine pores, slightly acidic (pH 6.2); gradual smooth boundary.

BC 66-94 cm -- Dark yellowish brown (10 YR 4/4 M) gravelly loam; weak fine subangular blocky structure; very friable, sticky and slightly plastic; phyllite fragments 60 to 65 per cent by volume; few very fine roots; few very fine pores, slightly acidic (pH 6.0); gradual smooth boundary.

Cr 94-118 cm -- Dark yellowish brown (10 YR 4/4 M); weathered phyllite with little amount of gravelly loam soil.

R 118+ cm

Type Location: Village Gajeli, tehsil Devprayag, district-Tehri Garhwal, Uttaranchal; about 300 M west from village.

Range in characteristics: The solum is 76 to 94 cms thick. The A horizon is 10-15 cms thick. Its colour is in hue 10 YR, value 3 to 4 and chroma 2 to 3. Its structure varies from gravelly sandy loam to gravelly loam. Its structure is weak, fine to medium subangular blocky. The B horizon is 65 to 81 cm thick. Its colour is in hue 10 YR, value 3 to 4 and chroma 3 to 4. Its texture is gravelly sandy loam to gravelly loam. Its structure is weak to moderate, fine to medium, subangular blocky. The Cr horizon consist of gravels of weathered phyllite (78 per cent by volume) with little (<20 per cent by volume) gravelly sandy loam gravelly loam soil and its colour is in hue 10 YR, value 3 to 4 and chroma 4 to 6.

Geographic setting: Gajeli soils are developed in phyllite and occur on moderately steep hill slopes. The climate is subhumid warm temperate with mean annual air temperature of 22.0°C and mean annual rainfall of 1250 mm. The estimated MAST is 23.0ºC, MSST 27.6ºC and MWST 18.0ºC. The difference between MSST and MWST is 9.6°C.

Geographically associated soils: Gajeli soils are associated with Rumdhar soils which moderately deep Dystric Eutrudepts.

Drainage and permeability: Somewhat excessively drained with rapid permeability.

Land use and vegetation: Gajeli soils are dominantly under terraced cultivation and cultivated to wheat, paddy, mustard, soyabean, masur, millets, vegetables etc. Natural vegetation consist trees like *Pinus roxburghii* (Pine), *Cedrela toona* (Toon), *Celtis australis* (Khark), shrubs like *Carisa carandas* (Karaunda), *Zizipus nummuleria* (Jharberi) and grasses like *Cynodon dactylon* (Doob).

Interpretation: Gajeli soils have problems due to gravelly texture, moderate erosion hazards and low to medium moisture holding capacity. The soils may be cultivated with careful selection of crops adapted to soil limitations with special attention to soil erosion and water conservation measures.

Interpretative grouping:

i)	Land capability sub-class	:	IVes
ii)	Irrigability sub-class	:	4st
iii)	Productivity potential	:	Medium

Land Use Suggested:
Agri-horticulture

Soil datasets:

Hori-zon	Depth (cm)	Size, class and particle diameter (mm) (%)								Coarse fragments >2 mm of whole soil (%)
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very Coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
Ap	0-13	51.50	40.50	8.00	7.30	12.70	14.50	10.50	6.50	37.5
BA	13-27	48.60	43.25	8.15	7.40	11.80	12.75	10.40	6.25	30.0
Bw1	27-44	47.00	44.75	8.25	8.50	10.00	12.10	10.25	6.15	37.5
Bw2	44-66	47.25	44.25	8.50	7.10	10.80	12.60	10.25	6.50	42.5
BC	66-94	44.75	45.50	9.75	6.75	9.50	11.60	9.70	7.20	62.5

Depth (cm)	O. C. (%)	CaCO$_3$ (<2mm) (%)	pH (1:2.5) H$_2$O	E. C. (1:2.5) H$_2$O (dSm^{-1})	Exchangeable bases					CEC NH$_4$OAc
					Ca	Mg	Na	K	Sum	
					←----------------------cmol(p+)kg^1-------------------→					
0-13	1.65	Nil	6.64	0.25	1.44	0.67	0.24	0.12	2.47	4.08
13-27	1.21	Nil	6.53	0.15	1.02	0.57	0.24	0.09	1.88	3.48
27-44	0.66	Nil	6.20	0.08	1.28	0.49	0.28	0.09	2.14	4.08
44-66	0.56	Nil	6.23	0.05	1.33	0.52	0.28	0.15	2.28	4.20
66-94	0.40	Nil	6.03	005	0.89	0.65	0.32	0.12	1.98	2.28

DTPA Extractable Micronutrients (ppm)

Depth (cm)	Zn	Cu	Mn	Fe
0-13	1.64	1.81	21.57	22.49
13-27	0.82	1.81	22.46	24.75
27-44	0.40	1.84	14.96	24.57
44-66	0.32	2.09	15.14	25.46
66-94	0.30	0.96	7.72	16.14

Source: NBSS&LUP Staff (2003). Soils of Danda Watershed, Tehri Garhwal, Uttaranchal for Land Use Planning (March 2003), NBSS Report No.634. Regional Centre Delhi, NBSS&LUP, Nagpur, p40.

2.40.2 TAYARI SERIES

Tayari soils are a member of the loamy-skeletal, mixed, thermic family of Typic Udorthents. Typically, Tayari soils have brown to dark brown, slightly acidic, gravelly sandy loam A horizons and brown to dark yellowish brown, slightly acidic to neutral, gravelly sandy loam to gravelly loam AC horizons underlain by Cr horizons of weathered phyllite.

Water balance diagram
Tehri, Uttarakhand
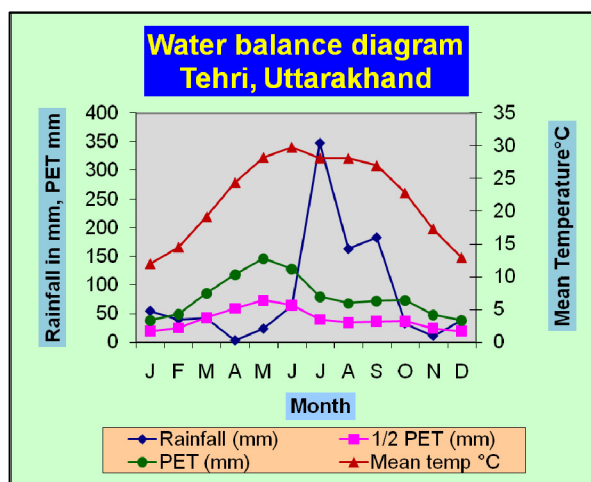
Typifying pedon: Tayari- gravelly sandy loam -cultivated.

Ap   0-8 cm --- Brown (10 YR 5/3 D) and dark brown (10 YR 4/3 M) gravelly sandy loam; weak fine granular structure; soft, very friable, non-sticky and non-plastic; phyllite fragments 20 to 25 per cent by volume; many very fine and fine roots; common fine pores; slightly acidic (pH 6.48); clear smooth boundary.

A12   8-17 cm --- Dark brown (10 YR 4/3 M) gravelly sandy loam; weak fine subangular blocky structure; very friable, slightly sticky and non-plastic; phyllite fragments 30 to 40 per cent by volume; many very fine roots; few very fine pores; slightly acidic (pH 6.54); clear smooth boundary. .

AC   17-28 cm --- Dark yellowish brown (10 YR 4/4 M) gravelly sandy loam; weak fine subangular blocky structure; friable, slightly sticky and non-plastic; phyllite fragments 60 to 70 per cent by volume; few very fine roots; few very fine pores; slightly acidic (pH 6.51); clear smooth boundary..

Cr   28-62 cm --- Weathered phyllite with little gravelly sandy loam soil.

Type location: Village Tayari, tahsil Devprayag, district-Tehri Garhwal, Uttaranchal; about 250 M south east from the village.

Range in characteristics: The thickness of the A horizon ranges from 11 to 28 cms. Its colour is dark grayish brown to very dark grayish brown, brown to dark brown and dark yellowish brown in hue 10 YR and 7.5 YR, value 3 to 5 and chroma 2 to 4. Its texture ranges from gravelly sandy loam to gravelly loam with its structure ranges from weak, fine to medium granular to weak, fine subangular blocky. The AC horizon is 10 to 35 cm thick and its colour is brown to dark brown and dark yellowish brown in hue 10 YR and 7.5YR, value 3 to 5 and chroma 3 to 4. Its texture ranges form gravelly sandy loam to gravelly loam. The structure ranges from weak, fine to medium granular and /or weak to moderate, fine subangular blocky. The Cr horizon mostly consisting of weathered phyllite with little gravelly sandy loam soils with its colour in hue 10 YR and 7.5 YR, value and chroma 3 to 4

Geographic setting: Tayari soils are formed on weathered phyllite and occur on moderately steep to very very steep hill slope. The climate is subhumid warm temperate with mean annual air

temperature of 22.0°C and mean annual rainfall of 1250 mm. The estimated MAST is 23.0ºC, MSST 27.6ºC and MWST 18.0ºC. The difference between MSST and MWST is 9.6°C.

Geographically associated soils: Tayari soils are associated with Gajeli soils which are shallow Typic Udorthents, and Danda soils which are moderately shallow Dystric Eutrudepts.

Drainage and Permeability: Excessively drained with very rapid permeability.

Land use and vegetation: Dominantly under shrubs and forest however at places terraces (3-5% slope) are cultivated to minor millets (like Kodo, Mandwa etc.), wheat, maize, kulthi, soyabean etc. Natural vegetation consist trees of *Pinus roxburghii* (Pine), *Acacia catechu*, (Khasir), *Holoptelia intergrifolia* (Kanju), *Madhuka latifolia* (Mahua).

Interpretation:

Interpretative grouping:
  i)   Land capability sub-class   :   VIes
  ii)   Irrigability sub-class   :   6st
  iii)   Productivity potential   :   low

Land Use Suggested:
       Silvipausture and silvi-haorticulture and silviculture under moderate to severe rockiness/ stoniness.

Soil datasets:

Horizon	Depth (cm)	Size, class and particle diameter (mm) (%)								Coarse fragments >2 mm of whole soil (%)
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very Coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
Ap	0-8	65.3	23.0	11.7	4.75	11.00	17.50	25.00	7.00	22.5
A12	8-17	71.3	16.5	12.3	6.25	16.50	19.75	17.50	11.25	35.0
AC	17-28	61.3	25.5	13.3	3.75	13.50	13.50	18.50	12.00	65.0

Depth (cm)	O. C. (%)	CaCO$_3$ (<2mm) (%)	pH (1:2.5) H$_2$O	E. C. (1:2.5) H$_2$O (dsm^{-1})	Exchangeable bases					CEC NH$_4$OAc
					Ca	Mg	Na	K	Sum	
					←----------------------cmol(p+)kg^1-------------------→					
0-8	2.17	Nil	6.48	0.09	2.37	0.91	0.80	0.30	4.39	5.52
8-17	1.29	Nil	6.54	0.08	2.49	1.10	0.60	0.30	4.19	5.34
17-28	1.05	Nil	6.51	0.09	2.11	1.25	0.80	0.15	4.36	5.58

DTPA Extractable Micronutrients (ppm)				
Depth (cm)	Zn	Cu	Mn	Fe
0-8	0.98	1.26	21.54	38.34
8-17	1.32	1.37	16.36	21.72
17-28	0.78	1.41	17.18	26.48

Source: NBSS&LUP Staff (2003). Soils of Danda Watershed, Tehri Garhwal, Uttaranchal for Land Use Planning (March 2003), NBSS Report No.634. Regional Centre Delhi, NBSS&LUP, Nagpur, p40.

2.41 Soil Series: AESR 14.5

Foothills of Kumaun Himalayas (Subdued), warm moist subhumid ESR with medium to deep, loamy arai soils, medium AWC and LGP 270-300 days (A10A9)

2.41.1 HALDI SERIES

The Haldi series is a member of the coarse-loamy, mixed, hyperthermic family of Typic Hapludolls. Typically, Haldi soils have grayish brown to very dark grayish brown, neutral, loam A horizons; dark brown to very dark grayish brown, neutral, loam B horizons, and dark grayish brown, mildly alkaline, sandy loam C horizons.
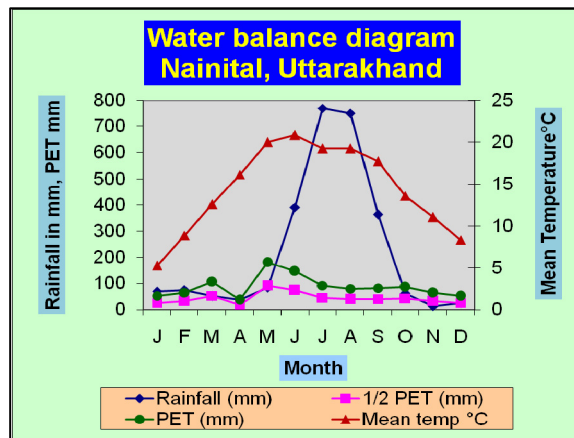
Typifying pedon: Haldi loam - cultivated

Ap   0-20 cm --- Grayish brown (10YR 5/2 D) and very dark grayish brown (10YR 3/2 M) loam; moderate fine to coarse granular structure; soft, friable; many fine and medium fibrous roots; many very fine to fine discontinuous random open tubular imped pores.; neutral (pH 7.1); clear smooth boundary.

A   20-27 cm --- Brown to dark brown (10YR 4/3 D) and very dark grayish brown (10YR 3/2 M) loam; moderate medium to coarse granular structure; hard, firm, slightly sticky; many fine and medium fibrous roots; many very fine to fine discontinuous vertical open tubular imped pores; upper 5 cm compact and firm traffic pan; neutral (pH 7.1); clear wavy boundary.

AB   27-43 cm --- Dark brown and very dark grayish brown (10YR 3/3, 3/2 M) loam; moderate medium to coarse granular structure tending to subangular blocky; firm, slightly sticky; common fine fibrous roots; many fine to very fine discontinuous vertical tubular open imped pores; patchy thin clay cutans; neutral (pH 7.0); clear wavy boundary.

Bw1   43-67 cm --- Dark brown and very dark gray (10YR 3/3, 3/1 M) loam; moderate medium to coarse subangular blocky structure; friable, slightly sticky and slightly plastic; common fine fibrous roots; many fine to very fine discontinuous vertical open tubular imped pores; patchy thin clay cutans; neutral (pH 7.0); clear wavy boundary.

Bw2   67-80 cm --- Brown to dark brown and very dark grayish brown (10YR 4/3, 3/2 M) loam; few fine distinct dark reddish brown (5YR 3/2) mottles; moderate medium to coarse subangular blocky structure; friable, slightly sticky and slightly plastic; common fine fibrous roots; many fine to very fine discontinuous vertical open tubular imped pores; neutral (pH 7.1); clear wavy boundary.

BC 80-106 cm --- Brown and very dark grayish brown (10YR 4.5/3, 3/2 M) loam; common fine distinct dark yellowish brown (10YR 3/4) mottles; moderate medium subangular blocky structure; friable, slightly sticky; common fine fibrous roots; many fine to very fine discontinuous random open tubular imped pores; neutral (pH 7.3); clear smooth boundary.

C1 106-119 cm --- Dark grayish brown (2.5Y 4/2 M) sandy loam; many medium distinct dark reddish brown (5YR 3/2) and dark yellowish brown (10YR 4/6) mottles; weak fine to medium subangular blocky structure; very friable; common fine fibrous roots; many fine to very fine discontinuous random and oblique open tubular imped pores; mildly alkaline (pH 7.5); gradual smooth boundary.

2C2 119-128 cm --- Dark grayish brown (2.5Y 4/2 M) gravelly sandy loam; massive; very friable; about 30 to 35 per cent by volume gravel and few pebbles; mildly alkaline (pH 7.7).

Micromorphology: In the master A horizon of this pedon good fragmentation, decomposition and mixing of organic matter with mineral material have taken place. The resulting humus form is a typical mull, a stable organo-mineral complex. Soil animals are mainly responsible for the mixing of organic and mineral material in the A horizon. The faunal activity results in homogenization. Cutans of fine-grained material are found from the AB horizon to the Bw2 horizon. These cutans become finer grained and less well developed with depth. In this pedon small accumulation of sesquioxides has taken place, starting at a depth of about 60 cm, and increasing in quantity and size with depth. They are the result of redox-reactions, correlated with periodic saturation of the soil with water.

Type location: 29°01'20" N, 79°29'20" E; No. H1 Crop Research Centre, G.B. Pant University of Agriculture and Technology; village Pantnagar, tehsil Kichha, district Nainital, Uttar Pradesh.

Range in characteristics: The thickness of the solum is 100 to 120 cm. The A horizon is 40 to 50 cm thick. Its colour is in hue 10YR, value dry 3 to 5 and moist mostly 3, and chroma dry 2 to 3 and moist 1.5 to 2. Its texture is dominantly loam. The epipedon is mollic. The B horizon is 55 to 65 cm thick. Its colour is in hue 10YR, value moist 3 to 4.5 and chroma moist 1.5 to 3. The texture is loam to silt loam. There are dark reddish brown mottles below 75 cm. There are some patchy clay cutans in the AB and Bw1 horizons. The subsurface horizon is cambic. The colour of the C horizon is in hue 2.5Y and the texture is sandy loam to loam, followed by gravelly sandy loam to loam. Lithological discontinuity is a common feature in the C horizon.

Competing series and their differentiae: Patharchtta series which is coarse-loamy. It is also a Typic Hapludoll.

Geographic setting: Haldi soils are formed in alluvium in the sub-montane (*Tarai)* region of Uttar Pradesh at an elevation of 200 to 250 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 23.2°C and mean annual rainfall of 1380 mm. The estimated MAST is 24.7°C, MSST 32.5°C and MWST 15.9°C. The difference between MSST and MWST is 16.6°C.

Geographically associated soils: Haldi soils are associated with Phoolbag series which is a Typic Endoaquoll, and Beni series, an Aquic Hapludoll.

Drainage and permeability: Moderately well to well drained with moderate permeability.

Land use and vegetation: Cultivated to maize and soybean in *kharif,* and wheat in *rabi;* natural vegetation – tiger grass, reed grass and *Phragmites spp.* (common reed).

Distribution and extent: Extensive on the G.B. Pant University of Agriculture and Technology farm and adjoining *Tarai* area of Uttar Pradesh.

Series proposed: G.B. Pant University of Agriculture and Technology, Pantnagar, Uttar Pradesh, 1969.

Interpretation: Haldi soils have good air-water relationship and are highly productive. They are by far the best soils of the *Tarai* region. Water table is at about 160 cm depth. Available soil moisture is medium to high. Under mechanical cultivation, a compact layer (traffic pan) of about 5 cm is formed below the Ap horizon.

a) Interpretative grouping:
i)	Land capability subclass	I
ii)	Irrigability subclass	1
iii)	Productivity potential	High

b**) Yield:** Based on data from farmers' fields

Crop	Medium management practices	Improved practices
	←----------------Yield, Mg ha^{-1}--------------→	
Wheat	3.5-4.5	5.0-5.3

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)										Coarse fragm-ents > 2 mm % of whole soil
		Total			Sand					Silt		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)	
		<------------------------------------ % of < 2 mm ------------------------------------>										
Ap	0-20	36.8	45.4	17.8	0.2	3.8	6.4	14.6	11.8	11.0	34.4	-
A	20-27	35.3	47.2	17.5	0.3	3.3	4.8	13.7	13.2	11.3	35.9	-
AB	27-43	36.6	45.6	17.8	0.1	2.3	4.3	15.2	14.7	10.7	34.9	-
Bw1	43-67	37.2	44.1	18.7	0.2	2.3	4.9	14.7	15.1	11.9	32.2	-
Bw2	67-80	34.9	49.1	16.0	1.3	3.6	3.3	11.0	15.7	15.7	33.4	-
BC	80-106	35.2	47.3	17.5	0.3	1.3	1.7	11.5	20.4	19.0	28.3	-
C1	106-119	59.8	28.5	11.7	0.3	1.3	3.3	25.3	29.6	10.8	17.7	-
2C2	119-128	56.7	31.8	11.5	--	--	--	--	--	--	--	13.0

Depth (cm)	Organic Carbon (%)	Carbon-ate as $CaCO_3$ < 2 mm (%)	Ext. iron as Fe (%)	pH (1:2.5) H_2O	Bulk density (Mg m^{-3})	Water retention		Micronutrients			
						33 kPa	1500 kPa	D T P A extractable			
								Zn	Cu	Mn	Fe
								<---------- ppm ---------->			
0-20	0.71	-	0.91	7.1	1.47	23.2	7.0	1.86	1.99	47	59
20-27	0.72	-	0.80	7.1	1.56	22.6	7.6	0.42	2.90	15	38
27-43	0.48	-	0.80	7.0	1.46	21.0	8.4	0.36	2.61	16	32
43-67	0.42	-	0.30	7.0	1.46	21.0	8.6	0.39	1.99	22	20
67-80	0.33	-	0.30	7.1	1.51	21.2	7.8	0.30	1.25	19	16
80-106	0.20	-	0.31	7.3	1.53	20.2	7.8	0.23	0.80	16	10
106-119	0.21	Tr	0.41	7.5	1.56	14.4	4.8				
119-128	0.15	Tr	-	7.7	-	16.8	5.4				

Depth (cm)	Extractable bases					CEC NH$_4$OAc	Base saturation NH$_4$OAc (%)	Ratios to Clay			Clay fraction mineralogy
	Ca	Mg	Na	K	Sum			CEC NH$_4$OAc	Ext. iron	1500 kPa water	
	<------------------ cmol (p$^+$)kg^{-1} ------------------>										
0-20	3.5	1.5	0.5	0.8	6.3	7.4	85	0.42	0.05	0.39	IL 5 CH 4
20-27	4.2	2.0	0.4	0.4	7.0	8.0	88	0.46	0.05	0.43	
27-43	4.0	2.5	0.5	0.4	7.4	8.0	93	0.45	0.04	0.47	
43-67	4.0	3.1	0.5	0.4	8.0	9.0	89	0.48	0.02	0.46	IL 5 CH 4 VM 1
67-80	3.2	2.5	1.2	0.7	7.6	8.9	85	0.56	0.02	0.49	IL 5 CH 4 VM 1
80-106	3.0	2.7	0.8	0.9	7.4	9.1	81	0.52	0.02	0.45	IL 5 CH 4
106-119	3.5	0.5	1.0	0.7	5.7	5.9	97	0.50	0.04		
119-128	2.2	0.9	1.1	1.0	5.2	5.5	95	0.48	-	0.47	

IL = Illite	5 = >50%
CH = Chloriite	4 = 33-50%
VM = Vermiculite	1 = < 5%

2.41.2 NAINITAL SERIES

The Nainital series is a member of the fine-loamy, mixed, hyperthermic family of Typic Endoaquoll. Typically, Nainital soils have black to very dark gray, neutral to slightly alkaline, clay loam A horizons; very dark gray to gray, loamy B horizons, and dark gray to dark greenish gray, loamy C horizons.

Water balance diagram Nainital, Uttarakhand
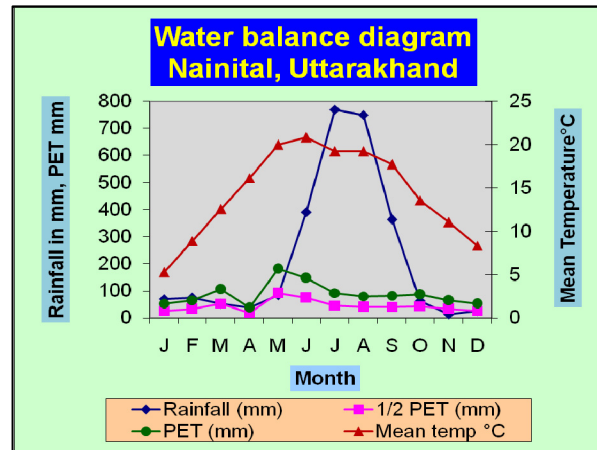
Typifying pedon: Nainital, clay loam-forest

A1   0-15 cm -- Black to very dark gray (10YR 2/1 to 3/1M) and gray (10YR5/1D), clay loam; cloddy with weak to moderate medium granular structure; firm; abundant roots; neutral (pH 7.1); clear smooth boundary.

A2   15-38 cm -- Very dark gray (10YR 3/1M) and gray (10YR5/1D) clay loam; few fine faint dark yellowish brown (10 YR 3/4) mottles; moderate medium granular structure; firm, slightly compact in upper 8-10 cm; common roots; moderately alkaline (pH 8.0); clear smooth boundary.

B1g   38-53 cm -- Very dark gray to dark gray (10YR 3/1 to 4/1M) heavy loam, gray (10YR5/1 to 6/1 D); common fine distinct dark yellowish brown (10 YR 3/4) and dark brown (7.5YR 3/2) mottles; moderate medium granular to weak medium angular blocky structure; slightly firm, calcareous; common roots; moderately alkaline (pH 8.3); clear smooth boundary.

B2g   53-66 cm -- Dark gray to gray (10YR 4/1 to 5/1 M) loam, common fine distinct dark yellowish brown (10 YR 3/4 and 4/4 D) mottles; weak fine subangular blocky to moderate medium granular structure; friable, calcareous; common roots; moderately alkaline (pH 8.3); gradual smooth boundary.

C1g   66-94 cm -- Dark gray (5Y 4/1) loam, common fine prominant dark yellowish brown (10 YR 3/4 and 4/4) mottles; moderate medium angular blocky to weak coarse granular structure; friable, strongly calcareous; occasional roots; moderately alkaline (pH 8.4); gradual smooth boundary.

C2g   94-135 cm -- Gray (5Y 5/1) loam, common fine prominant dark yellowish brown (10 YR 4/4 and 4/4) mottles; massive; friable, strongly calcareous; occasional roots; moderately alkaline (pH 8.4).

IIC3g   135+ cm -- Dark greenish gray (5GY 4/1) sand and gravel; single grain; calcareous.

Type location: $29^o00'00"N$, $79^o27'00"E$; No. Uttar Pradesh Agricultural University experimental farm, district Nainital, Uttar Pradesh.

Geographic setting: Nainital soils are developed from mica and chorite schists, gabbro, gneiss, sandstone, shales and slates washed from the mountains and occur on very gently sloping land (1-3 percent slope). The climate is subhumid subtropical with mean annual air temperature of 22.9^oC and mean annual rainfall of 1405 mm. The estimated MAST is 24.4^oC.

Drainage and permeability: Poorly drained

Land use and vegetation: Sal *(Shorea robusta)*, simul *(Salamalia malabaria)*, dhak *(Butea monosperma)*, and khair *(Acacia catechu)*.

Series proposed: Deshpande *et al.* (1971)

Interpretation: Physical properties of these soils are similar to many nearly developed dark coloured soils (Mollisols) of USA. All though these soils have mollic epipedons, they tend to be somewhat lower in organic matter content than many similar dark coloured soils in the USA. Base saturation of these soils appears to be slightly higher than in some similar soils in the more humid sections of the USA, but dominance of calcium and distribution of other cations on the exchange complex are comparable.

Soil datasets:

Horizon	Depth (cm)	Amount of entire sample >2mm (%)	Particle size distribution of <2mm fraction (%)											
			Sand						Silt			Clay		
			VC 2.0-1.0 mm	C 1.0-0.5 mm	M 0.5-0.25 mm	F 0.25-0.10 mm	VF 0.10-0.05 mm	Total	C 0.05-0.02 mm	F 0.02-0.002 mm	Total	C 0.002-0.0002 mm	F <0.0002 mm	Total
A1	0-15	0.7	0.7	1.5	2.0	7.9	11.4	23.5	16.1	30.7	46.8	21.6	8.0	29.6
A2	15-38	0.7	1.0	1.1	1.7	9.0	13.5	26.3	16.3	29.3	45.6	21.1	7.0	28.1
B1g	38-53	0.9	1.3	1.3	1.6	9.9	16.0	30.1	16.2	29.4	45.6	19.1	5.2	24.3
B2g	53-66	1.8	1.8	0.9	1.4	12.8	21.6	38.5	19.3	23.9	43.2	14.5	3.7	18.2
C1g	66-94	1.4	1.0	1.0	1.9	19.2	25.9	49.0	19.6	18.3	27.9	10.8	2.3	13.1
C2g	94-135	1.1	0.6	0.7	2.0	18.4	27.4	49.1	21.1	18.6	39.7	9.0	2.1	11.1

Depth (cm)	Bulk density (g/cm³)	Moisture content (%)	
		1/3 atm.	15 atm.
0-15	1.39	33.4	12.4
15-38	1.48	29.5	11.8
38-53	1.55	29.9	10.6
53-66	1.52	26.2	7.5
66-94	1.58	22.5	5.3
94-135	1.55	21.5	4.5

Depth (cm)	Org. matter (%)	pH	CaCO$_3$ Equiv. (%)	Free iron (%)	CEC (me/100g)	Exchangeable cations (me/100g)					Base sat. (%)	Ca/Mg ratio	Soil test values (kg/ha)		
						Ca	Mg	K	Na	Sum			Phosphorus		
													P1	P2	K
0-15	3.6	7.1	0	1.5	26.9	21.1	6.3	0.30	0.20	27.9	>100	3.4	48	150+	250+
15-38	2.4	8.0	0	1.6	24.3	17.1	7.3	0.20	0.23	24.83	>100	2.3	4	112	172
38-53	1.8	8.3	1.2	1.7	21.5	17.7	8.4	0.17	0.22	26.49	>100	2.1	1	103	148
53-66	1.2	8.3	2.7	1.3	13.9	21.1	4.8	0.05	0.16	26.11	>100	4.4	1	68	104
66-94	0.8	8.4	2.5	0.9	10.0	20.4	2.9	0.05	0.13	23.48	>100	7.0	1	56	89
94-135	0.7	8.4	2.6	1.4	8.9	21.8	2.2	0.04	0.13	24.04	>100	9.9	1	51	83

Source: Deshpande, S. B., Fehrenbacher, J. B. and Beavers, A. H. (1971). Mollisols of tarai region of Uttar Pradesh, Northern India, 1. Morphology and mineralogy, Geoderma, 6, 179-193.

2.42 Soil Series: AESR 15.1

Bengal basin and North Bihar Plain, hot moist subhumid ESR with deep loamy to clayey alluvium-derived soils, medium to high AWC and LGP 210-240 days (08Cm7)

2.42.1 AMARPUR SERIES

The Amarpur series is a member of the fine-silty, mixed, hyperthermic family of Typic Haplustalfs. Typically, Amarpur soils have brown, neutral, silt loam A horizons, and light olive brown to olive brown, neutral to moderately alkaline, silt loam to silty clay loam B horizons underlain by light olive brown to brown, mildly alkaline, silt loam 2C horizons.

Water balance diagram Kolkata, W. B.
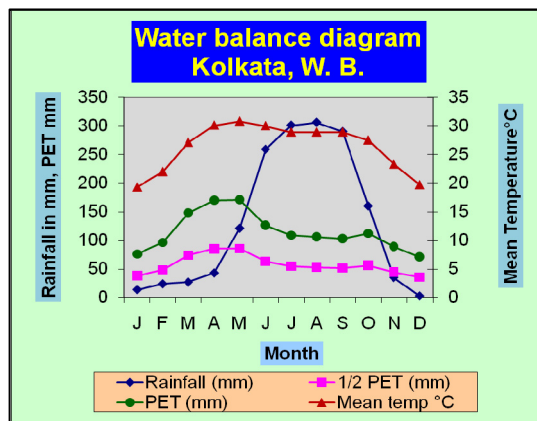
Typifying pedon: Amarpur silt loam - cultivated

Ap   0-10 cm --- Pale brown (10YR 6/3 D) and brown (10YR 5/3 M) silt loam; massive; slightly hard, friable, slightly sticky; many medium and fine roots; many fine pores and root channels; neutral; (pH 7.0); clear smooth boundary.

Bt1   10-25 cm --- Light olive brown (2.5Y 5/4 M) silt loam; weak medium subangular blocky structure; friable, slightly sticky; few coarse and many medium to fine roots; many fine impeded pores; slightly effervescent; strong biological activity; common earthworm channels; neutral (pH 6.9); diffuse wavy boundary.

Bt1   25-62 cm --- Light olive brown (2.5Y 5/4 M) silty clay loam; weak medium sub angular structure; friable, slightly sticky; many medium to coarse and few fine roots; few coarse and many fine imped and exped pores; strongly effervescent; common insect channels; mildly alkaline (pH 7.6); clear smooth boundary.

Bt2   62-94 cm --- Olive brown (2.5Y 4/4 M) clay loam; weak medium subangular blocky structure; friable, slightly sticky; few medium to coarse and few fine roots; few coarse and many medium and fine imped pores; few insect channels; strongly effervescent; few lime nodules; moderately alkaline (pH 8.0); clear wavy boundary.

2BC1   94-132 cm --- Light olive brown (2.5Y 5/4 M) silt loam; common very fine distinct brown to dark brown (10YR 4/3 M) mottles; weak medium subangular blocky structure; friable, slightly sticky; few coarse and fine roots; common fine and medium pores; few medium and coarse lime nodules; violently effervescent; moderately alkaline (pH 8.0); clear wavy boundary.

2BC2   132-150 cm --- Brown (10YR 5/3 M) silt loam; few fine faint dark yellowish brown (10YR 4/4) mottles; massive; very friable, non-sticky; few, fine pores; few fine lime nodules; violently effervescent; moderately alkaline (pH 7.9).

Type location: 22°54' N, 88°21' E; mouza Amarpur, P.S. Palba, district Hooghly, West Bengal.

Range in characteristics: The solum is 90 to 100 cm thick. The thickness of the A horizon is 10 to 15 cm. Its colour is in hue 10YR, value 5 to 6 and chroma 3. Its texture ranges from loam to silt loam. The thickness of the B horizon is 80 to 100 cm. Its colour ranges from light olive brown to

olive brown in hue 2.5Y, value 4 to 5 and chroma 4 to 5. The texture ranges from silt loam to silty clay loam.

Geographic setting: Amarpur soils are formed in alluvium and occur on very gently to gently sloping natural levees of the river Hooghly and its tributaries at an elevation of 5 to 10 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 27.5^{o}C and mean annual rainfall of 1810 mm. The estimated MAST is 29.5^{o}C. The difference between MSST and MWST is more than 5°C.

Geographically associated soils: Principal associated soils are Moktarpur and Kanagarh series which are Typic Endoaquept and Aeric Fluvaquent, respectively.

Drainage and permeability: Well drained with moderate permeability.

Land use and vegetation: Mainly under banana orchards; natural vegetation - *Mangifera indica* (mango) and *Altocarpus integrifolia* (jackfruit).

Distribution and extent: Extensive in Hooghly district of West Bengal.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Calcutta, 1985.

Interpretation: Amarpur soils are silty in nature and have fairly good soil-air-water relationship. The available moisture capacity is medium. The soils are under orchards. They can grow a variety of crops with irrigation facilities.

a) Interpretative grouping:

i)	Land capability subclass	IIe
ii)	Irrigability subclass	1
iii)	Productivity potential	High

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)				
		Total			Silt	
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	(0.05-0.02)	(0.02-0.002)
		<----------------------- % of < 2 mm -------------------------->				
Ap	0-10	12.0	67.7	20.3	33.4	34.3
Bt1	10-25	11.2	62.5	26.3	31.2	31.3
Bt2	25-62	10.8	60.9	28.3	29.6	31.3
Bt3	62-94	23.6	48.1	28.3	25.8	22.3
2BC1	94-132	8.8	70.9	20.3	40.6	30.3
2BC2	132-150	20.8	63.9	15.3	46.6	17.3

Depth (cm)	Organic Carbon (%)	pH (1:2.5) H_2O	CEC NH$_4$OAc (cmol(p^{+})kg^{-1})	Base saturation NH$_4$OAc (%)	Ratio CEC/Clay
0-10	0.49	7.0	7.5	71	0.37
10-25	0.37	6.9	12.1	73	0.46
25-62	0.31	7.6	13.2	83	0.47
62-94	0.08	8.0	7.0	94	0.25
94-132	0.08	8.0	8.4	87	0.41
132-150	0.18	7.9	7.0	84	0.46

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.42.2 ANANTAPUR SERIES

The Anantapur series is a member of the fine, mixed, hyperthermic family of Typic Endoaqualfs. Typically Anantapur soils have gray, slightly to strongly acid, clay loam A horizons, and gray to dark gray, mottled, slightly acid to neutral, silty clay B horizons.

Water balance diagram Bardhaman, W. B.
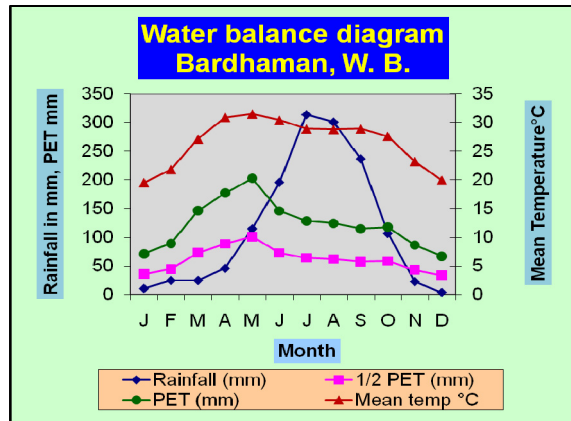
Typifying pedon: Anantapur clay loam - cultivated

Ap   0-12 cm --- Gray (10YR 5.5/1 M) clay loam; rusty specks of brown to dark brown (7.5YR 4/4) and red (2.5YR 5/6) colour; massive (puddled); friable, slightly sticky; many fine roots; common medium pores; few iron-manganese concretions; strongly acid (pH 5.1); clear smooth boundary.

A   12-21 cm --- Gray (10YR 5/1 M) clay loam; common medium faint dark brown (10YR 3/3) and dark yellowish brown (10YR 4/4) mottles; moderate fine subangular blocky structure; friable, sticky; common fine roots; common fine and medium imped pores; common soft iron-manganese concretions; slightly acid (pH 6.1); abrupt smooth boundary.

Bt1   21-48 cm --- Gray (N 5/0 M) silty clay; common distinct light olive brown (2.5Y 5/6) mottles; moderate fine sub angular blocky structure; firm, sticky and plastic; common fine roots; common fine imped pores; continuous thin clay cutans on ped faces; few soft iron-manganese concretions; neutral (pH 6.7); clear smooth boundary.

Bt2   48-99 cm --- Gray (N 5/0 M) silty clay; common fine faint olive brown (2.5Y 4/4 M) mottles; strong coarse angular blocky structure; firm, sticky; few fine roots; few medium pores; thick clay cutans on ped faces; few soft and hard iron-manganese concretions; neutral (pH 7.0); gradual smooth boundary.

Bt3   99-150 cm --- Dark gray (N 4/0 M) silty clay; common fine faint light olive brown (2.5Y 5/4) mottles; strong coarse angular blocky structure; very firm, very sticky; few fine roots; slightly acid (pH 6.4).

Type location: 23°44' N, 88°07' E; village Anantapur, P.S. Ketugram, district Barddhaman, West Bengal.

Range in characteristics: The thickness of the solum is 150 cm or more. The A horizon is 18 to 25 cm thick. Its texture varies from sandy clay loam to clay loam and the colour has hue 10YR or 2.5Y, value 5 or 6 moist and chroma 1 or less. The thickness of the B horizon is more than 100 cm. The texture of the B horizon varies from silty clay to clay. Its colour has hue 2.5Y, value 4 to 6 and chroma 2 or less. Iron-manganese concretions are observed throughout the solum. The B horizon has faint to distinct mottles of light olive brown colour.

Competing series and their differentiae: Kanksa soils, also Typic Endoaqualfs, have mottles in 10YR hue unlike of Anantapur in 2.5Y in the B horizon.

Geographic setting: Anantapur soils are formed in alluvium on nearly level to very gently sloping plain at an elevation of 20 m above MSL. The climate is subhumid subtropical with mean annual air temperature of 26.6°C and mean annual rainfall of 1400 mm. The estimated MAST is 28.6°C, MSST 31.5°C and MWST 20.5°C. The difference between MSST and MWST is 11°C.

Geographically associated soils: The associated soil is Banpara series, which is a Typic Endoaquept.

Drainage and permeability: Poorly drained with moderately slow permeability.

Land use and vegetation: Cultiyated to rice; natural vegetation - *Artocarpus integrifolia* (jack-fruit), *Phoenix sylvestris* (date palm) and *Aegle marmelos* (bel).

Distribution and extent: Moderately extensive (12,000 ha) in Ketugram and Khandaghosh police stations of Barddhaman district, West Bengal.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Calcutta, 1977.

Interpretation: Anantapur soils are poorly drained. They are highly suitable for rice cultivation.

a) Interpretative grouping:
i)	Land capability subclass	IIw
ii)	Irrigability subclass	2d
iii)	Productivity potential	High

b) Yield: Based on data from farmers' fields
  Crop: Paddy (Kharif)

Management level	←---------------Yield, Mg ha^{-1}-------------→
Medium	3.0-3.5
High	4.5-5.0

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)					Coarse fragments > 2 mm % of whole soil
		Total			Silt		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	(0.05-0.02)	(0.02-0.002)	
		<------------------------ % of < 2 mm ------------------------>					
Ap	0-12	29.8	42.7	27.5	17.2	25.5	-
A	12-21	20.2	52.3	27.5	25.8	26.5	2
Bt1	21-48	16.3	43.2	40.5	16.7	26.5	3
Bt2	48-99	13.6	40.9	45.5	16.4	24.5	3
BC	99-150	11.6	45.9	42.5	18.4	27.5	2

Depth (cm)	Organic Carbon (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O (dS m^{-1})
0-12	0.49	5.1	-
12-21	0.30	6.1	-
21-48	0.14	6.7	0.3
48-99	0.13	7.0	0.2
99-150	0.09	6.4	-

Depth (cm)	Extractable bases					CEC NH$_4$OAc	Base saturation NH$_4$OAc (%)	Ratio CEC/ clay
	Ca	Mg	Na	K	Sum			
	<------------------------ cmol (p+)kg^{-1} ------------------------>							
0-12	4.2	2.2	1.0	0.5	7.9	13.6	58	0.49
12-21	5.2	2.8	1.0	0.6	9.6	13.6	71	0.49
21-48	8.4	6.2	1.6	0.6	16.8	21.8	77	0.54
48-99	10.8	8.0	2.1	0.8	21.7	26.6	82	0.58
99-150	7.2	4.4	0.9	0.2	12.7	17.0	75	0.40

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.43 Soil Series: AESR 15.2

Middle Brahmaputra Plain, hot humid ESR with deep, loamy to clayey alluvium-derived soils, medium AWC and LGP 240-270 days (Q8B8)

2.43.1 MORIGAON SERIES

The Morigaon series is a member of the fine loamy, mixed, hyperthermic Typic Fluvaquents. Morigaon soils have dark gray moderately acidic sandy loam A horizons and dark gray to gray, slightly acidic loamy sand sub-surface horizons over dark gray to grayish brown sandy C horizons.

Water balance diagram
Morigaon, Assam
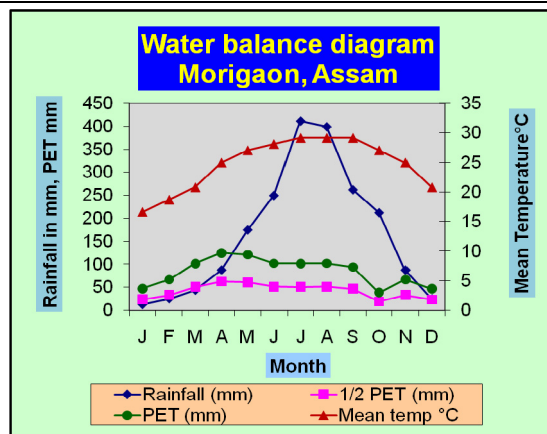
Typifying pedon: Morigaon sandy loam – cultivated.

Apg   0-10 cm … Dark gray (10YR 4/1 M) loam; weak fine subangular blocky structure; friable, non sticky and non plastic; many very fine to fine medium roots; root mottles; strongly acid (pH 5.2); gradual smooth boundary.

A12g   10-26 cm … Gray (10YR 5/1 M) sandy clay loam; weak fine subangular blocky structure; friable, non sticky and non plastic; many very fine medium roots; few fine faint yellowish brown (10YR 5/6) mottles; slightly acid (pH 6.2); gradual wavy boundary.

A13g   26-56 cm … Dark gray (10YR 4/1 M) sandy loam; weak fine subangular blocky structure; friable, non-sticky and non plastic; common very fine fine medium roots; few medium faint dark yellowish brown (10YR 4/6) mottles; slightly acid (pH 6.3); gradual smooth boundary.

2C1g   56-80 cm … Dark gray (10YR 4/1 M) sandy loam; structureless; loose, non sticky and non plastic; few very fine fine roots; many medium faint dark yellowish brown (10YR 4/6) mottles; neutral (pH 6.5); gradual smooth boundary.

2C2g   80-105 cm … Dark gray (10YR 4/1 M) loam; structureless; loose, non sticky and non plastic; many medium faint yellowish brown (10YR 5/6) mottles; neutral (pH 6.8); gradual smooth boundary.

2C3g   105-130 cm … Grayish bown (10YR 5/2 M) clay loam; structureless; loose, non sticky and non plastic; many coarse distinct strong brown (7.5YR 5/8) mottles; neutral (pH 6.9).

Type location: 26°19'17" N, 92°18'56" E; Village Baruakhat, District Morigaon, Assam.

Range in characteristics: The thickness of the solum ranges from 150 to 200 cm or more. The soil moisture control section remains saturated with water. The thickness of the A horizons ranges

from 10 to 15 cm, the hue 10YR, value 4 and chroma 1 to 2. The depth of occurrence of sand varies from 30 to 65 cm and continues up to a greater depth. The depth of the C horizons ranges from 100-150 cm or more and the colour is in hue of 10YR, value ranges from 4 to 5 and chroma 1 to 2. The texture is sandy.

Competing series and their differentiae: Competing soils are those of Kobaikota series which are dark gray to grayish brown and have relatively higher cation exchange capacity than Morigaon soils.

Geographic setting: Morigaon soils are developed in recent Brahmaputra alluvium on very gently sloping alluvial floodplain on the central part of Morigaon district, Assam at an elevation of 50-60 m above msl. The estimated MAST is 25.9°C, MSST is 27.8°C and MWST is 20.4°C. The difference between MSST and MWST is 7.4°C.

Geographically associated soils: These are Barbhagia, Haldibari, Bhaluka, Dighalbari and Mikirbheta soils which are Typic Epiaquepts, Aeric Epiaquepts, Typic Epiaquepts, Typic Epiaquepts and Aeric Epiaquepts, respectively.

Drainage and permeability: Poorly drained soils due to higher ground water level.

Use and vegetation: Cultivated for paddy, natural vegetation – shimul, ahat, bamboo, kadam.

Distribution and extent: Extensive in the central and both eastern and western part of Morigaon district, Assam.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Jorhat, Assam, 1993.

Interpretation: Morigaon soils are coarse textured and occur in low land situations causing the problem of soil-air relationship. They are subject to stagnation of water during rainy seasons. These soils are suited for rice.

Interpretative grouping:
   i. Land capability subclass   :   IIw2
   ii. Irrigability subclass   :   2sd
   iii. Productivity potential   :   High

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (1.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.1)	Coarse silt (0.05-0.02)	Fine silt (0.02-0.002)
		←--------------------------------- (% of <2 mm) ---------------------------------→									
Apg	0-10	47.4	33.6	19.0	0.2	0.7	24.7	15.4	6.5	26.6	7.0
A12g	10-26	51.2	23.8	25.0	-	0.7	21.7	19.0	10.0	15.8	8.0
A13g	25-56	59.4	21.6	19.0	0.2	0.4	26.8	21.6	10.4	14.1	7.5
2C1g	56-80	78.8	8.7	12.1	0.3	0.8	39.5	26.4	11.7	5.2	3.5
2C2g	80-105	40.5	36.0	23.5	-	0.3	26.5	9.3	4.5	26.0	10.0
2C3g	105-130	26.3	39.7	34.0	0.1	0.4	18.6	4.7	2.5	28.2	11.5

Depth (cm)	Organic Carbon (%)	pH(1:2.5)	
		H_2O	KCl
0-10	1.0	5.2	4.0
10-26	0.6	6.2	4.7
25-56	0.3	6.3	4.6
56-80	0.2	6.5	4.6
80-105	0.2	6.8	4.4
105-130	0.3	6.9	4.6

Depth (cm)	Extractable bases					CEC NH_4OAC	Base saturation %	Ratio CEC/Clay
	Ca	Mg	Na	K	Sum			
	←----------------------------cmol(+)kg-1----------------------------→							
0-10	1.6	0.8	0.3	0.1	2.8	3.2	87	0.17
10-26	2.4	1.0	0.1	0.1	3.6	3.8	95	0.15
25-56	2.2	0.8	0.3	0.1	3.4	3.8	89	0.20
56-80	2.0	0.6	0.2	0.1	2.9	3.1	93	0.26
80-105	3.4	0.6	0.3	0.1	4.4	4.8	92	0.20
105-130	3.8	0.8	0.3	0.1	5.0	5.2	96	0.15

Source: Vadivelu, S., Sen, T. K., Bhaskar, B. P., Baruah, U., Sarkar, D., Maji, A. K. And K. S. Gajbhiye (2004). Soil series of Assam, NBSS Publ. No. 101, NBSS&LUP, Nagpur,229p.

2.43.2 BARBHAGIA SERIES

Barbhagia series is a member of the fine loamy, mixed, hyperthermic family of Typic Epiaquepts. Barbhagia soils have very dark gray, slightly acidic, silty clay loam A horizons, dark gray nuetral silty clay B horizons on gray sandy lithologically discontinuous C horizons.

Water balance diagram Morigaon, Assam
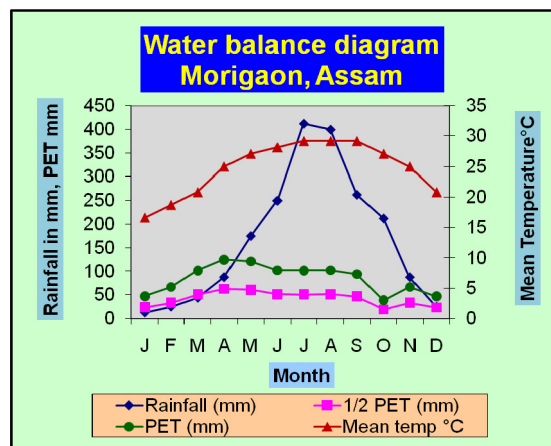
Typifying pedon: Barbhagia loam– cultivated.

Ap1g   0-6 cm … Very dark gray (10YR 3/1 M) loam; weak fine subangular blocky structure; friable, slightly sticky and slightly plastic; fine very fine roots; moderately acidic (pH 5.6); gradual smooth boundary.

Ap2g   6-16 cm … Very dark gray (10YR 2.5/1 M) clay; medium moderate subangular blocky structure; friable, sticky and plastic; few very fine roots; slightly acidic (pH 6.0); gradual smooth boundary.

B21g   16-40 cm … Dark gray (7.5YR 4/0 M) clay loam; medium moderate subangular blocky structure; friable, sticky and plastic; few fine faint strong brown (7.5YR 4/6) mottles; neutral (pH 6.9); gradual smooth boundary.

B22g   40-60 cm … Dark gray (10YR 4/1 M) clay loam; medium moderate subangular blocky structure; friable, sticky and plastic; few fine faint dark yellowish brown (10YR 4/6) mottles; neutral (pH 7.1); abrupt smooth boundary.

2C1g   60-110 cm … Dark gray (10YR 4.5 M) loamy sand; single grain structure; loose, non sticky and non plastic; few fine faint dark yellowish brown (10YR 4/6) mottles; neutral (pH 6.8); diffuse sooth boundary

2C2g   110-135 cm … Gray (10YR 5/1 M) sandy loam; single grain structure; loose, non sticky and non plastic; few fine distinct strong brown (7.5YR 5/6) mottles; neutral (pH 6.7).

Type location: 26º20'11" N, 92º27'48" E; Village Loubhanga, District Morigaon, Assam.

Range in characteristics: The thickness of the solum ranges from 135 to 200 cm or more. The soil moisture control section remains saturated with water. The thickness of A horizons ranges from 11 to 16 cm. The colour is of hue 10YR, value 3 to 4, chroma 1 to 2. Its texture varies from silty loam to silty clay loam. The thickness of B horizons ranges from 40 to 70 cm, the hue varies from 7.5YR to 2.5Y, value 2 to 4, chroma 1 to 2. Its texture varies from silty clay loam to silty clay. The thickness of C horizons ranges from 50 to 100 cm or more. The hue varies from 10YR to 2.5Y, value 4 to 5, chroma 1 to 2. Its texture is sandy.

Competing series and their differentiae: Dighalbari soils are competing series which are coarse loamy Typic Epiaquepts.

Geographic setting: Barbhagia soils are developed in the Brahmaputra alluvium on very gently sloping floodplain on the central part of the Morigaon district, Assam at an elevation of 70 m above msl. The climate is humid subtropical with mean annual soil temperature of 24.9^{o}C and mean annual rainfall of 1860 mm. The estimated MAST is 25.9^{o}C, MSST is 27.8^{o}C and MWST is 20.4^{o}C. The difference between MSST and MWST is 7.4°C.

Geographically associated soils: These are Sonaipara, Haldibari, Bhaluka, Nijgerua, Sholmarigaon, Mayang, Jargaon and Katani which are Typic Fluvaquents, Aeric Epiaquepts, Typic Epiaquepts, Typic Epiaquepts, Vertic Endoaquepts, Aeric Fluvaquents, Typic Epiaquepts and Vertic Epiaquepts, respectively.

Drainage and permeability: Poorly drained soils, moderately slow permeability.

Use and vegetation: Cultivated for paddy, natural vegetation – shimul, ahat, imli, bamboo, ber.

Distribution and extent: Extensive in the central part of Morigaon district, Assam.

Series proposed: National Bureau of Soil Survey and Land Use Planning, North Eastern Regional Centre, Jorhat, Assam, 1993.

Interpretation: Barbhagia soils are fine textured with a sandy subsurface horizon starting from 50 to 100 cm. These soils occur in low lying areas and are imperfectly drained and are subject to hydromorphic conditions. Water stagnation in these soils are common during rainy season due to high ground water table. These soils are suitable for paddy cultivation.

Interpretative grouping:
    i.   Land capability subclass   :   IIw2
    ii. Irrigability subclass   :   2ds
    iii. Productivity potential   :   High

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (1.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.1)	Coarse silt (0.05-0.02)	Fine silt (0.02-0.002)
		-------------------------------------- (% of <2 mm) --------------------------------------									
Ap1g	0-6	36.0	33.5	30.5	0.5	0.5	6.6	18.3	10.1	19.0	14.5
Ap2g	6-16	26.5	32.0	41.5	0.7	0.3	3.9	14.6	7.0	17.5	14.5
B21g	16-40	29.0	31.0	40.0	1.1	0.2	3.7	15.6	8.4	20.0	11.0
B22g	40-60	30.8	41.7	27.5	0.7	0.4	4.5	16.4	8.8	21.2	20.5
2C1g	60-110	80.7	10.3	9.0	0.8	0.3	11.4	49.3	18.9	8.3	2.0
2C2g	110-135	75.5	15.0	9.5	-	0.3	8.7	37.3	29.2	10.0	0.5

Depth (cm)	Organic Carbon (%)	pH(1:2.5)	
		H_2O	KCl
0-6	0.9	5.6	4.4
6-16	1.6	6.0	4.8
16-40	0.4	6.9	5.1
40-60	0.3	7.1	5.1
60-110	0.1	6.8	4.5
110-135	0.2	6.7	4.5

Depth (cm)	Extractable bases					CEC NH_4OAC	Base saturation %	Ratio CEC/Clay
	Ca	Mg	Na	K	Sum			
	----------------------------cmol(+)kg-1--------------------------------							
0-6	7.2	4.0	1.0	0.2	12.4	12.8	97	0.42
6-16	8.2	6.0	0.9	0.1	15.2	15.6	97	0.37
16-40	4.6	6.6	0.7	0.1	12.0	12.8	94	0.32
40-60	7.2	3.8	0.8	0.1	11.9	12.0	99	0.44
60-110	1.9	1.0	0.6	-	3.5	3.6	97	0.40
110-135	2.4	1.2	0.6	-	4.2	4.3	98	0.45

Source: Vadivelu, S., Sen, T. K., Bhaskar, B. P., Baruah, U., Sarkar, D., Maji, A. K. And K. S. Gajbhiye (2004). Soil series of Assam, NBSS Publ. No. 101, NBSS&LUP, Nagpur,229p.

2.44 Soil Series: AESR 15.3

Teesta, lower Brahmaputra Plain and Barak Valley, hot moist humid to perhumid ESR with deep, loamy to clayey alluvium- derived soils, medium AWC and LGP 270-300 days (Q8A9)

2.44.1 BONGAIGAON SERIES

Bongaigaon series is a member of coarse-loamy, mixed, isohyperthermic Typic Endoaquepts. Bongaigaon soils have dark grayish brown moderately acid, sandy loam A horizons, very dark grayish brown to gray, slightly acid or moderately acid sandy loam or loamy sand B horizons and yellowish brown, slightly acid, loamy sand C horizon.
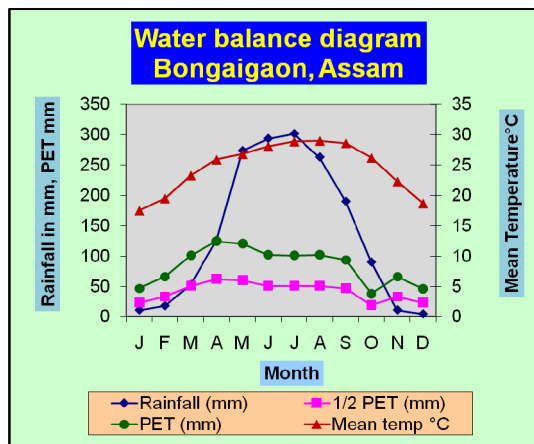
Typifying pedon: Bongaigaon sandy loam – cultivated

Ap 0 – 15 cm -- Dark grayish brown (10YR 4/2 M) sandy loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and non plastic; few, fine roots; moderately acid (pH 5.9); diffuse smooth boundary.

Bw1 15 – 34 cm -- Very dark grayish brown (10YR 3/2 M) sandy loam; moderate medium subangular blocky structure; friable, slightly sticky and non plastic; few, fine roots; slightly acid (pH 6.2); diffuse smooth boundary.

Bw2 34 – 47 cm -- Dark grayish brown (10YR 4/2 M) sandy loam; moderate, medium, subangular blocky structure; friable, slightly sticky and non plastic; few, fine roots; slightly acid (pH 6.1); diffuse smooth boundary.

Bw3 47 – 66 cm -- Light brownish gray (10YR 6/2 M) sandy loam; few, fine faint brownish yellow (10YR 6/6) mottles; massive structure; very friable, slightly sticky and non plastic; slightly acid (pH 6.3); diffuse smooth boundary.

BC 66 – 84 cm -- Light gray to gray (10YR 6/1 M) loamy sand; few, fine, faint brownish yellow (10YR 6/6) mottles; massive structure; very friable, non sticky and non plastic; moderately acid (pH 6.0); clear smooth boundary.

C 84 – 155 cm -- Yellowish brown (10Y 5/4 M) loamy sand; few fine faint brownish yellow (10YR 6/6) mottles; massive structure; very friable, non sticky and non plastic; slightly acid (pH 6.1).

Type location: 26°19'00"N, 93°30'00" E; Village: Kaitpara, District: Bongaigaon, Assam.

Range in characteristics: Bongaigaon soils are very deep. The A horizon is 15 to 20 cm thick. It has colours is in the hue 10YR, value 4 to 5, chroma 1 to 2. The texture is sandy loam or loamy sand. The structure is weak, medium or fine, subangular blocks. The B horizon is 50 to 75 cm thick and has two or more subhorizons. Its colour is in the hue 10YR, value 3 to 6, chroma 1 to 2. The texture is generally sandy loam. However, loamy sand is observed in the lower part of the B

horizon in some locations. The C horizon is generally below a depth of 80 cm. It has colours in the hue 10YR, value 4 to 6, chroma 3 to 4. The texture is generally loamy sand, however sandy loam is also observed. High chroma (10YR 6/6) mottles are common in the C horizon. The C horizon does not have structural development. Bongaigaon soils are moderately acid in the surface horizon and slightly acid in subsoils.

Geographic setting: Bongaigaon soils are developed in the alluvium on nearly level to very gently sloping floodplain at an elevation of 20 to 40 m above msl. The climate is humid with mean annual soil temperature of 24.6°C and mean annual rainfall of 2044 mm. The estimated MAST is 26.1°C, MSST is 28.0°C and MWST is 22.5°C. The difference between MSST and MWST is 5.5°C.

Geographically associated soils: The associated soil is Jogighopa series which is typic Psammaquents.

Land use and vegetation: Cultivated for crops such as rice, mustard, potato, cabbage.

Drainage and permeability: Poor in rainy season and well drained in post rainy period. Saturated hydraulic conductivity is moderately high.

Distribution and extent: Extensive in Bongaigaon district (26,425 ha)

Competing series: No competing series is identified.

Interpretation:

Suitability to crops

Crops	Suitability class	Limitations
Rice	Moderately suitable	Coarse texture, low organic matter, low fertility
Cabbage, potato, mustard, tomato, peas, beans, cowpea	Moderately suitable	Low organic matter, low fertility
Wheat	Marginally suitable	Coarse texture, low water availability

Soil datasets:

Horizons	Depth (cm)	Particle size distribution (Particle size in mm, soil seperates in %)		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)
Ap	0-15	76.6	9.1	14.3
Bw1	15-34	79.0	5.1	15.9
Bw2	34-47	80.1	3.5	16.4
Bw3	47-66	78.7	6.2	15.1
BC	66-84	84.3	2.6	13.1
C	84-155	85.5	2.7	11.8

Depth (cm)	O.C. (%)	pH (1:2.5 H$_2$O)	Extractable bases			Extractable acidity	Extractable Al	CEC	Base saturation (%)	CEC/ Clay
			Ca+Mg	Na	K					
			cmol (p$^+$)kg^{-1}							
0-15	0.97	5.9	1.64	0.26	0.24	3.2	2.0	5.34	40	0.37
15-34	1.04	6.2	2.76	0.30	0.16	2.8	1.2	6.02	53	0.38
34-47	0.70	6.1	2.82	0.28	0.20	3.1	1.2	6.40	52	0.39
47-66	0.30	6.3	2.51	0.26	0.22	2.8	1.0	5.79	52	0.38
66-84	0.20	6.0	1.66	0.36	0.20	3.0	1.2	5.22	43	0.39
84-155	0.16	6.1	1.46	0.22	0.45	2.9	1.2	5.03	42	0.43

Source: Vadivelu, S., Sen, T. K., Bhaskar, B. P., Baruah, U., Sarkar, D., Maji, A. K. and K. S. Gajbhiye (2004). Soil series of Assam, NBSS Publ. No. 101, NBSS&LUP, Nagpur,229p.

2.44.2 JOGIGHOPA SERIES

Jogighopa series is a member of mixed, isohyperthermic family of Typic Psammaquents. Jogighopa soils have grayish brown, moderately acid, sandy loam A horizons and light brownish gray to light yellowish brown, slightly acidic to moderately acid, sandy loam or loamy sand C horizons.
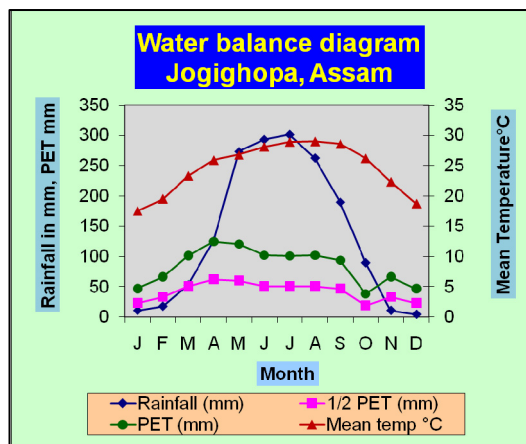
Typifying pedon: Jogighopa sandy loam – cultivated.

Ap   0 – 18 cm -- Grayish brown (10YR 5/2 M) sandy loam; weak, fine, subangular blocky structure; soft, friable, slightly sticky and non plastic; common fine roots; moderately acid (pH 5.8); clear smooth boundary.

C1   18– 43 cm -- Light brownish gray (10YR 6/2 M) sandy loam; single grain structure; soft, friable, non sticky and non plastic; few fine roots; moderately acid (pH 6.0); gradual smooth boundary.

C2   43– 98 cm -- Light brownish gray (10YR 6/2 M) loamy sand; single grain structure; soft, very friable, non sticky and non plastic; slightly acid (pH 6.1); gradual smooth boundary.

C3   98–139 cm -- Light yellowish brown (10Y 6/4 M) loamy sand; few fine faint dark yellowish brown (10YR 4/4) mottles; single grain structure; soft, very friable, non sticky and non plastic; slightly acid (pH 6.2); clear smooth boundary.

Type location: $26^{o}28'24"$ N, $93^{o}30'29"$ E; Village Dhantola, District Bongaigaon, Assam.

Range in characteristics: The Jogighopa soils are very deep. The A horizon is 15 to 20 cm thick. Its colour is in the hue 10YR, value 4 to 6 and chroma 1 to 3. The texture is sandy loam or loamy sand. The structure is weak, fine, subangular blocks. The C horizon generally occurs below the depth of 20 cm thick and has 3 or more subhorizons. Its colour is in the hue 10YR, value 5 to 6, chroma 2 to 4. High chroma (4 to 6) mottles are observed in the lower parts of the C horizon (below 100 cm). The texture is generally loamy sand, however a thin horizon of sandy loam is observed immediately below the Ap horizon in some locations. The structure is single grain. These soils are moderately acid in the surface up to a depth of 20 cm and occasionally up to 40 cm. They are slightly acid below the depth of 40 to 50 cm. The roots are common in the surface and decreases in the lower horizon.

Geographically associated soils: The associated soil is Bongaigaon series

Geographic setting: Jogighopa soils are developed in the alluvium on very gently sloping active flood plains at an elevation of 30 to 50 m above msl. The climate is humid with mean annual soil temperature of 24.6^{o}C and mean annual rainfall of 2044 mm. The estimated MAST is 26.1^{o}C, MSST is 28.0^{o}C and MWST is 22.5^{o}C. The difference between MSST and MWST is 5.5°C.

Land use and vegetation: Cultivated crops such as rice, jute, mustard, tomato, potato, cabbage.

Drainage and permeability: Poor in rainy season improve to well drained in post rainy period and the saturated hydraulic conductivity is moderately high.

Distribution and extent: Extensive in Bongaigaon district (8,617 ha)

Competing series: The Dhansiri series identified in Darrang district is competing series. Dhansiri soils have colours with chroma 1 or less. They have pH between 6.1 and 6.8.

Interpretation:

Suitability to crops

Crops	Suitability class	Limitations
Rice	Marginally suitable	Coarse texture, low organic matter, low fertility
Cabbage, potato	Suitable	No limitations
Mustard, tomato, beans, peas, cowpea	Moderately suitable	Coarse texture, low organic matter, low fertility
Wheat	Marginally suitable	Coarse texture, low water availability

Soil datasets:

Horizons	Depth (cm)	Particle size distribution (Particle size in mm, soil seperates in %)		
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)
Ap	0-18	79.20	8.00	12.80
C1	18-43	80.00	9.00	11.00
C2	43-98	86.00	4.15	9.85
C3	98-139	86.75	3.55	9.70

Depth (cm)	O.C. (%)	pH (1:2.5 H$_2$O)	Extractable bases			Extractable acidity	Extractable Al	CEC	Base saturation (%)	CEC/ Clay
			Ca+Mg	Na	K					
			cmol (p$^+$)kg^{-1}							
0-18	0.99	5.8	2.60	0.30	0.28	3.0	2.0	6.16	52	0.48
18-43	0.39	6.0	2.49	0.26	0.18	2.5	1.4	5.43	54	0.49
43-98	0.16	6.1	1.75	0.26	0.16	2.2	1.4	4.37	50	0.44
98-139	0.46	6.2	1.68	0.21	0.19	2.2	1.0	4.28	49	0.44

Source: Vadivelu, S., Sen, T. K., Bhaskar, B. P., Baruah, U., Sarkar, D., Maji, A. K. And K. S. Gajbhiye (2004). Soil series of Assam, NBSS Publ. No. 101, NBSS&LUP, Nagpur,229p.

2.45 Soil Series: AESR 15.4

Upper Brahmaputra Plain, warm to hot perhumid ESR with moderately deep to deep loamy, alluvium-derived soils, medium AWC and LGP 300 days (Q8A10)

2.45.1 SONARI SERIES

Sonari series is a member of fine-loamy, mixed, hyperthermic Oxyaquic Dystrudepts. Sonari soils have dark brown to dark yellowish brown, very strongly acid, sandy clay loam A horizons and yellowish brown to brownish yellow, strongly acidic or very strongly acid, sandy clay loam or clay loam B horizons with yellowish red or light gray mottles.
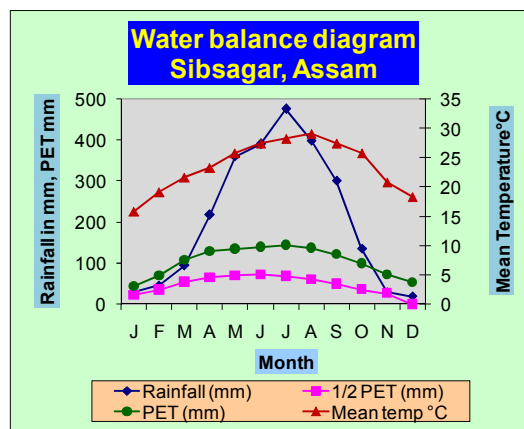
Typifying pedon: Sonari sandy clay loam – cultivated.

Ap   0-22 cm … Dark yellowish brown (10YR 4/4 M) sandy clay loam; moderate fine subangular blocky structure; friable, slightly sticky and slightly plastic; many fine fibrous roots; very strongly acid (pH 4.9); clear smooth boundary.

Bw1   22-77 cm … Yellowish brown (10YR 5/8 M), sandy clay loam; moderate medium subangular blocky structure; friable, moderately sticky and slightly plastic; many fine prominent yellowish red (5YR 4/6) mottles; common fine fibrous roots; very strongly acid (pH 5.0); clear smooth boundary.

Bw2   77-100 cm … Brownish yellow (10YR 6/8 M) clay loam; moderate medium and coarse subangular blocky structure; friable, moderately sticky and slightly plastic; many fine iron-manganese concretions; prominent light gray (10YR 7/1) mottles; few fine fibrous roots; strongly acid (pH 5.2); gradual smooth boundary.

Bw3   100-150 cm … Brownish yellow (10YR 6/6 M), clay loam; strong medium subangular blocky structure; friable, moderately sticky and slightly plastic; common fine to medium distinct light gray (10YR 7/2) mottles; few fine fibrous roots; very strongly acid (pH 5.0).

Type location: Mathurapur Tea Estate, P.S. Sonari, District Sibsagar, Assam.

Range in characteristics: The soils are very deep. The A horizon is 15 to 25 cm thick. The colour is in hue 10YR, value 4 to 5 and chroma 4 to 6. The texture is sandy clay loam or loam and structure is granular and or subangular blocky. The B horizon is more than 100 cm thick. The colour is in hue 10YR, value 5 to 6 and chroma 6 to 8. The texture is sandy clay loam or clay loam. The structure is medium and or coarse subangular blocky. Distinct mottles and iron-manganese concretions are present.

Competing series and their differentiae: These are soils of Biptaghat series which are fine loamy Typic Dystrudepts.

Geographic setting: Sonari soils have developed in alluvium on nearly level lands at an elevation of 180 m above MSL. The climate is humid subtropical with mean annual air temperature of 23.7°C and mean annual rainfall of 2504 mm. The estimated MAST is 24.7°C, MSST 27.6°C and MWST is 17.9°C. The difference between MSST and MWST is 9.7°C. The water table is generally at a depth of about 1.5 m.

Geographically associated soils: These are soils of Naharbari series which are fine Typic Kanhapludalfs.

Drainage and permeability: Moderately well drained with moderately slow permeability.

Use and vegetation: Cultivated for tea

Distribution and extent: Extensive in the flood plains of the district.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Jorhat, Assam, 1984.

Interpretation: Mathurapur soils have good air-water relationship.

Interpretative grouping:
    i.   Land capability subclass   IIw1
    ii.   Irrigability subclass   2sd
    iii.   Productivity potential   High

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (1.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.1)	Coarse silt (0.05-0.02)	Fine silt (0.02-0.002)
		-- (% of <2 mm) ---									
Ap	0-22	50.5	25.6	24.5	-	0.6	22.7	14.4	12.7	21.0	3.9
Bw1	22-77	54.0	20.5	25.5	-	0.7	22.7	16.7	13.8	14.6	5.9
Bw2	77-100	43.5	29.4	27.1	-	0.5	14.4	16.0	12.4	17.3	13.2
Bw3	100-150	43.0	29.6	27.4	-	1.2	16.1	13.0	12.7	23.9	6.4

Depth (cm)	Organic Carbon (%)	pH(1:2.5) H_2O
0-22	0.60	4.9
22-77	0.37	5.0
77-100	0.11	5.2
100-150	0.19	5.0

Depth (cm)	Extractable bases					H^+	Al^{3+}	CEC NH_4OAC	Base saturation %
	Ca	Mg	Na	K	Sum				
	------------------------------------- cmol(+)kg^{-1}-------------------------------------								
0-22	1.2	1.7	0.5	0.2	3.6	2.1	1.5	9.6	38
22-77	1.2	1.4	0.4	0.1	3.1	2.5	1.6	8.8	35
77-100	1.1	1.7	0.4	0.1	2.6	2.6	1.9	7.9	32
100-150	1.1	1.1	0.4	0.1	2.8	1.3	1.8	8.4	44

Source: NBSS&LUP Staff (1995). Soil Survey Report of Sisagar District, Assam. Ner Centre Jorhat. Report No. 529 (ICAR), Regional Centre Jorhat, NBSS&LUP, Nagpur, 80p.

2.45.2 AMGURI SERIES

Amguri series is a member of fine loamy, mixed, hyperthermic Dystric Eutrudepts. Amguri soils have light gray brown moderately acid loam or clay loam A horizons, yellowish moderately acid clay loam or loam, mottled B horizon and yellowish brown, moderately acid, sandy loam C horizon.
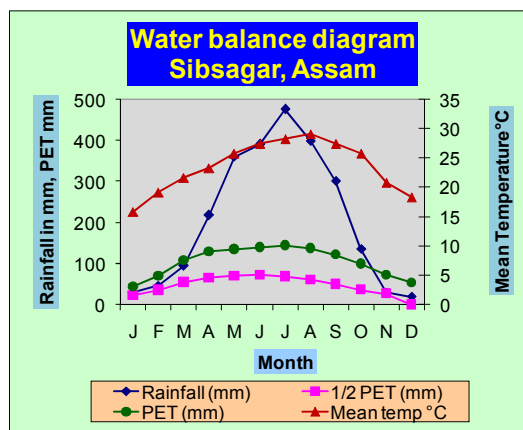
Typifying pedon: Amguri clay loam – cultivated.

Ap   0-14 cm … Gray (10YR 5/1 M) clay loam; weak medium subangular blocky structure; hard, firm and moderately sticky and slightly plastic; many fine and medium roots; moderately acid (pH 5.7); abrupt smooth boundary.

Bw1   14-37 cm … Yellowish brown (10YR 5/8 M) clay; moderate medium subangular blocky structure; fine, moderately sticky and moderately plastic; many fine and medium roots; many coarse distinct red (2.5YR 5/8) mottles; moderately acid (pH 5.6); clear smooth boundary.

Bw2   37-73 cm … Yellowish brown (10YR 5/6) loam; moderate medium subangular blocky structure; firm, slightly sticky and slightly plastic; common medium prominent reddish yellow (7.5YR 6/6) mottles; moderately acid (pH 5.6); gradual smooth boundary.

C   73-120 cm … Yellowish brown (10YR 5/6) sandy loam; weak medium subangular blocky structure; friable, slightly sticky and non plastic; common fine strong brown (7.5YR 5/8) mottles; moderately acid (pH 5.9).

Type location: Village Bhuyabasti, P.S. Sibsagar, District Sibsagar, Assam.

Range in characteristics: The soils are very deep. The A horizon is 15-18 cm thick and its colour is in hue of 10YR, value 5 to 6 and chroma 1. The texture is loam or clay loam. The colour of the B horizon is in hue of 10YR, value 5 to 6 and chroma 6 to 8. The texture is loam or clay loam. The B horizons have high chroma mottles. The C horizon has colours of hue in 10YR, value 5 to 6 and chroma 6. The texture is sandy loam. It has high chroma mottles.

Competing series and their differentiae: These are the soils of Disang series which have lower pH ranging between 4.3 and 5.0. They also have slightly higher sand content ranging between 45 and 65.1 percent.

Geographic setting: Bhuyabasti soils have developed in alluvium on the old floodplains of the river Brahmaputra. The soils occur on nearly level to level lands at an elevation of 150 m above MSL. The climate is humid subtropical with mean annual air temperature of 23.7°C and mean annual rainfall of 2504 mm. The estimated MAST is 24.7°C, MSST 27.6°C and MWST is 17.9°C. The difference between MSST and MWST is 9.7°C.

Geographically associated soils: These are the soils of Romagaon series which are coarse loamy Typic Udorthents.

Drainage and permeability: Moderately well drained with slow permeability.

Use and vegetation: Mostly cultivated for paddy.

Distribution and extent: Extensive (36217 hectares) in the Sibsagar district of Assam.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Jorhat, Assam, 1984.

Interpretation: The soils of Amguri series are subject to flooding during rainy season. They are, therefore, suitable for paddy cultivation. They can, however, support pulses during winter season as well as winter vegetables.

Interpretative groupings:

i)	Land capability subclass	-	IIw2
ii)	Irrigability subclass	-	2d
iii)	Productivity potential	-	Medium.

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								
		Total			Sand					Silt	
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (1.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.1)	Coarse silt (0.05-0.02)	Fine silt (0.02-0.002)
		--- (% of <2 mm) ---									
Ap	0-14	35.6	32.4	31.0	-	-	3.6	15.4	16.6	20.6	11.9
Bw1	14-37	32.8	24.6	42.6	-	-	5.8	12.8	14.2	16.2	7.6
Bw2	37-73	36.2	44.2	19.6	-	6.2	6.4	16.0	7.6	14.5	30.7
C	73-120	54.5	36.0	10.5	-	14.8	7.2	22.0	10.5	12.6	24.0

Depth (cm)	Organic Carbon (%)	pH(1:2.5) H_2O
0-14	1.6	5.7
14-37	1.1	5.6
37-73	0.6	5.6
73-120	0.4	6.9

Depth (cm)	Extractable bases					H	Al	CEC NH_4OAC	Base saturation %
	Ca	Mg	Na	K	Sum				
	-------------------------------- cmol(+)kg^{-1}------------------------------------								
0-14	4.3	1.2	0.5	0.1	6.3	0.8	1.2	10.6	59
14-37	3.6	1.1	0.5	0.1	5.4	0.5	0.8	8.5	63
37-73	3.0	0.9	0.4	0.1	4.4	0.3	0.2	7.2	62
73-120	2.4	0.7	0.3	0.1	3.6	Tr	Tr	5.4	67

Source: NBSS&LUP Staff (1995). Soil Survey Report of Sisagar District, Assam. Ner Centre Jorhat. Report No. 529 (ICAR), Regional Centre Jorhat, NBSS&LUP, Nagpur, 80p.

2.46 Soil Series: AESR 16.1

Foot-hills of Eastern Himalayas (Bhutan foot-hills), warm to hot perhumid ESR with shallow to medium, loamy-skeletal to loamy Tarai soils, low to medium AWC and LGP 270-300 days (C10A9)

2.46.1 DARRANG SERIES

The Darrang series is a member of fine-loamy, mixed, hyperthermic family of Typic Endoaquepts. Typically, Darrang soils have gray, moderately acid, clay loam A horizon and dark gray to gray, moderately acid, clay loam to sandy clay loam B horizon.
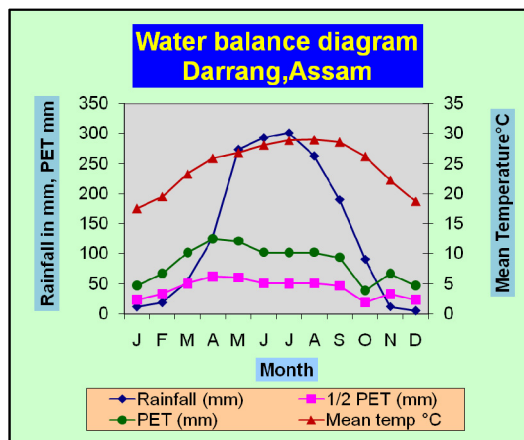
Typifying pedon: Darrang silty clay loam - forest

Ap   0-28 cm --- Gray (10YR 5/1 M) clay loam; moderate, medium, subangular blocky structure; firm, sticky and plastic; many very fine and fine roots; moderately acid (pH 5.6), diffused smooth boundary.

Bwg1   28-46 cm --- Dark gray (10YR 4/1 M) clay loam; moderate, medium subangular blocky structure; firm, sticky and plastic; few very fine and fine, roots; moderately acid (pH 5.7); diffused smooth boundary.

Bwg2   46-71 cm --- Light brownish gray (10YR 6/2 M) clay loam; few fine distinct red mottles(2.5YR 5/6); massive structure; firm, sticky and plastic; few fine roots; moderately acid (pH 5.7); diffused smooth boundary.

Cg   71-108 cm --- Gray ((10YR 5/1 M) sandy clay loam; massive structure; friable slightly sticky and slightly plastic; few, fine, iron-manganese concretion; moderately acid (pH 6.0).

Type location: 26°37'38" N and 91°49'35" E; village Khairabari, district Darrang, Assam.

Ranges in characteristics: The Darrang soils are very deep. The A horizon is 15 to 30 cm thick. Its colour is in the hue 10YR or 2.5Y, value 3 to 5, chroma 1 to 2. The texture is clay loam or silty clay loam. The structure is moderate medium or coarse subangular blocks. The B horizon is 50 to 75 cm thick and has 2 or more sub-horizons. It has colours in the hue 10YR or 2.5Y, value 3 to 6, chroma 1 to 2. It has high chroma (4 to 6) mottles, in the hue of 7.5YR or redder. The texture is clay loam or sandy clay loam. The structure is generally moderate medium subangular blocks, however massive structure is observed in the lower parts of B horizon in some locations. The C horizon is generally below 70 to 100 cm. Its colour is in hue 10YR or 2.5Y or 5Y, value 4 to 6 and chroma 1 to 2. The texture is clay loam or sandy clay loam. This horizon does not have well developed structure. Darrang soils are moderately acid throughout depth.They have soft Fe-Mn concretions below the depth of 75 cm. The roots are concentrated in the surface. However few roots are observed upto the depth of 70 cm.

Competing series and their differentiae: The Barpeta soil series identified in Barpeta district is a competing series. Barpeta soils have sand content of about 25 percent. The pH ranges between 6.7 and 7.0 and base saturation between 83 and 92 percent.

Geographic setting: Darrang soils are formed in alluvium and occur on nearly level to gently sloping flood plains (0-1% slope) at an elevation of 40-60 m above MSL, and mean annual rainfall of 1590 mm.

Geographically associated soils: The associated soil is Dhansiri series.

Drainage and permeability: Poor in rainy season, improves in post rainy period and saturated hydraulic conductivity is low.

Land use and vegetation: Rice, mustard, cabbage, potato, tomato.

Distribution and extent: Extensive in Darrang district (20,706 ha), Assam.

Interpretation: They are moderately acid and have low available potassium content.

Suitability to crops:

Crop	Suitability class	Limitations
Rice	Suitable	No limitations
Mustard, cabbage, tomato, potato, wheat, beans, pea, cowpea	Moderately suitable	Low pH, low organic matter, low fertility

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)		
		Total		
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)
Ap	0-28	43.0	29.0	28.0
Bwg1	28-46	44.5	26.0	29.5
Bwg2	46-71	44.0	25.0	31.0
Cg	71-108	56.0	21.0	23.0

Depth (cm)	Organic carbon (%)	pH (1:2.5) Water	Exchangeable bases			Extractable acidity	Extractable Al	CEC	Base saturation (%)	CEC/Clay
			Ca + Mg	Na	K					
			cmol (p$^+$)kg^{-1}							
0-28	1.04	5.6	4.1	0.28	0.14	2.50	1.10	8.12	55.6	0.29
28-46	0.90	5.7	4.4	0.34	0.20	2.40	1.80	9.14	54.0	0.31
46-71	0.84	5.7	4.9	0.41	0.18	2.40	1.80	9.69	56.6	0.31
71-108	0.29	6.0	2.5	0.22	0.16	2.50	1.50	6.88	41.9	0.30

Source: Vadivelu, S., Sen, T. K., Bhaskar, B. P., Baruah, U., Sarkar, D., Maji, A. K. And K. S. Gajbhiye (2004). Soil series of Assam, NBSS Publ. No. 101, NBSS&LUP, Nagpur,229p.

2.46.2 DHANSIRI SERIES

The Dhansiri series is a member of mixed, hyperthermic family of Typic Psammaquents. Typically, Dhansiri soils have gray to dark grayish brown, slightly acid, sandy loam A horizons and gray to grayish brown, neutral, loamy sand C horizon.

Water balance diagram Dhansiri, Assam
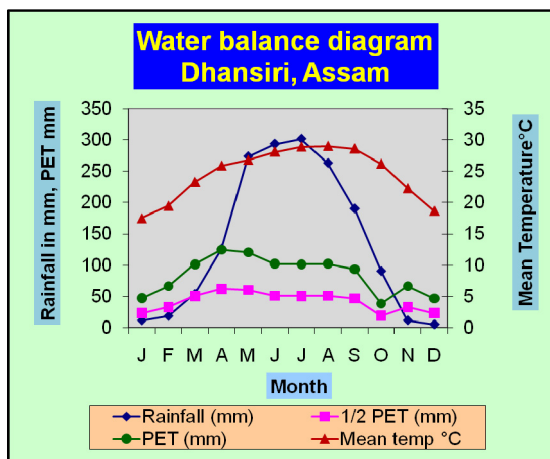
Typifying pedon: Dhansiri sandy loam – cultivated.

Ap   0-7 cm -- Gray (10YR 5/1 M) sandy loam; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many fine and very fine and common medium roots; slightly acid (pH 6.1); gradual smooth boundary.

A2   7-18 cm -- Dark gray to dark grayish brown (2.5Y 4/1 M) sandy loam; weak fine subangular blocky structure; friable, slightly sticky and non plastic; common fine and very fine roots; slightly acid (pH 6.2); gradual smooth boundary.

C1   18-40 cm -- Gray to grayish brown (2.5Y 5/1 M) loamy sand; single grain structure; friable, non sticky and non plastic; few fine roots; neutral (pH 6.8); gradual smooth boundary.

C2   40-110 cm -- Gray (2.5Y 5/0 M) loamy sand; few, fine, faint brown to dark brown (7.5 YR 4/4) mottles; single grain structure; friable, non sticky and non plastic; few fine roots; neutral (pH 6.8).

Type location: 26°32'46" N and 92°23'25" E; village Kazabil, district Darrang, Assam.

Ranges in characteristics: The Dhansiri soils are very deep. The A horizon is 15 to 20 cm thick. Its colour is in the hue 10YR or 2.5Y, value 4 to 6, chroma 1 to 2. The texture is sandy loam or loamy sand. The structure is weak, fine subangular blocks. The C horizon is generally below 20 cm and has 2 or more subhorizons. The colour is in the hue 10YR or 2.5Y, value 4 to 6, chroma 1 to 2. It has high chroma (4 to 6) mottles, in the hue of 7.5YR or redder. The structure is generally single grain. These soils are slightly acid upto the depth of 20 cm and thereafter neutral. The roots are many in the surface horizon and few roots are observed upto the depth of 100 cm.

Competing series and their differentiae: The Jogighopa series identified in Bongaigaon district is a competing series. Jogighopa soils have colours with chroma 2 to 4. The surface soil pH is less than 6.0.

Geographic setting: Dhansiri soils are formed in alluvium and occur on nearly level to gently sloping (0-1% slope) at an elevation of 40-60 m above MSL, and mean annual rainfall of 1590 mm.

Geographically associated soils: The associated soil is Darrang series, Assam.

Drainage and permeability: Somewhat poorly drained in rainy season, improves to well drained in post rainy period and saturated hydraulic conductivity is moderately high.

Land use and vegetation: Rice, mustard, cabbage.

Distribution and extent: Extensive in Darrang district (18,781 ha), Assam.

Interpretation: They are slightly acid to neutral. They have low organic matter and low available potassium content.

Suitability to crops:

Crop	Suitability class	Limitations
Rice	Marginally suitable	Coarse texture, low fertility
Cabbage	Moderately suitable	Low organic matter, coarse txxture, low fertility
Mustard, tomato, wheat, beans, pea, cowpea	Marginally suitable	Low organic matter, coarse texture, low water availibility

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm) Total			Coarse fragments (>2mm) (%)
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	
Ap	0-7	70.0	13.1	16.9	-
A2	7-18	75.6	10.7	13.7	-
C1	18-40	80.6	10.6	8.8	-
C2	40-110	84.3	7.5	8.2	-

| Depth (cm)	Organic carbon (%)	pH (1:2.5) Water	Exchangeable bases			Extractable acidity	Extractable Al	CEC	Base saturation (%)	CEC/Clay
			Ca + Mg	Na	K					
			cmol (p$^+$)kg^{-1}							
0-7	0.58	6.1	2.24	0.30	0.08	1.10	1.92	4.64	47	0.27
7-18	0.35	6.2	1.86	0.28	0.08	1.00	0.80	4.02	55	0.29
18-40	0.20	6.8	1.96	0.11	0.06	0.80	0.30	3.23	66	0.37
40-110	0.14	6.8	1.91	0.12	0.04	0.80	0.20	3.07	67	0.37

Source: Vadivelu, S., Sen, T. K., Bhaskar, B. P., Baruah, U., Sarkar, D., Maji, A. K. And K. S. Gajbhiye (2004). Soil series of Assam, NBSS Publ. No. 101, NBSS&LUP, Nagpur,229p.

2.47 Soil Series: AESR 16.2

Darjeeling and Sikkim Himalayas, warm perhumid ESR with shallow to medium deep loamy Brown and Red Hill soils, low to medium AWC and LGP 300 days (C11A10)

2.47.1 RAYONG SERIES

The Rayong series is a member of fine-loamy, mixed, thermic family of Mollic Hapludalfs. Typically, Rayong soils have dark brown, extremely acid, silty clay loam A horizons and dark brown to dark yellowish brown, extremely to very strongly acid, silt loam to gravelly silty clay loam B horizon.
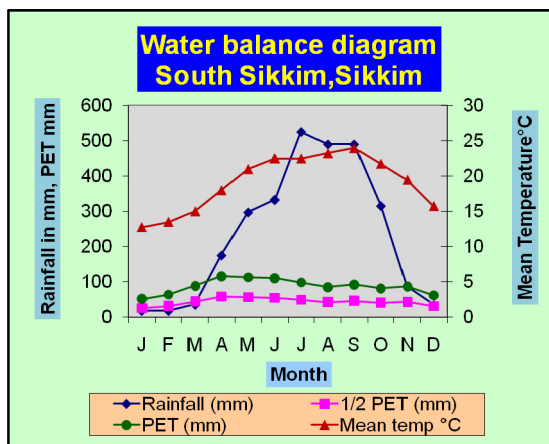
Typifying pedon: Rayong silty clay loam - forest

A   0-17 cm --- Dark brown (10YR 3/3 M) silty clay loam; weak fine granular structure; soft, friable, sticky and plastic; many fine, medium and coarse roots; few medium and many coarse pores; extremely acid (pH 4.3), clear smooth boundary.

Bw   17-27 cm --- Dark brown (10YR 3/3 M) silt loam; weak medium granular to sub-angular blocky structure; friable, sticky and plastic; many fine, common medium and coarse roots; extremely acid (pH 4.4); gradual smooth boundary.

Bt1   27-55 cm --- Dark brown (10YR 3/3 M) silty clay loam; weak medium granular to sub-angular blocky structure; friable, sticky and plastic; many fine, common medium and coarse roots; extremely acid (pH 4.1); gradual smooth boundary.

Bt2   55-81 cm --- Dark yellowish brown (10YR 4/4 M) silty clay loam; firm, sticky and plastic; few medium and coarse roots; extremely acid (pH 4.1); gradual smooth boundary.

Bt3   81-150 cm --- Dark yellowish brown (10YR 4/4 M) gravelly silty clay loam; firm, sticky and plastic; few medium and coarse roots; very strongly acid (pH 4.8).

Type location: 27°15'40" N and 88°21'50" E; circle Damthang, district South Sikkim, Sikkim.

Ranges in characteristics: The solum is 90-100 cm thick. The thickness of A horizon varies from 16 to 25 cm. The colour of A horizon is in hue 10YR, value 3 and chroma 3. Its texture is silty clay loam. The thickness of B horizon varies from 80 to 85 cm. Its colour is in hue 10YR, value 3 to 4 and chroma 3 to 4. Its textural class ranges from silt loam to silty clay loam.

Competing series and their differentiae: Competing soils are those of Suiram series, a Humic Dystrudepts which are deep, slightly acidic with low CEC and low base saturation. The dominant chroma of Suiram soils is 3 where as that in Rayong soils; it ranges from 3 to 4.

Geographic setting: Rayong soils are formed in granite and gneiss and occur on moderately sloping (8-10% slope) summit and ridges of Himalayan Mountain at an elevation of 900-1000 m above MSL. The climate is temperate with mean annual air temperature of 18.7°C and mean

annual rainfall of 2450 mm. The estimated MAST is 19.7^{o}C, MSST 24.1^{o}C and MWST 13.1^{o}C. The difference between MSST and MWST is 11.0^{o}C.

Geographically associated soils: The associated soils are Namprik series (Typic Udorthents), Chalumthang series (Typic Hapludalfs), Doling series (Typic Argiudolls), Damthang series (Humic Hapludults) and Tinkitam series (Typic Hapludolls).

Drainage and permeability: Well drained with medium permeability.

Land use and vegetation: Forest and its vegetations are champa (*Micheliachampaka*), utis (*Almus nepalensis*), buk (*Quercus lamellose*), banmara, dhupi (*Eryptimera japonica*).

Distribution and extent: Widely (9,937 ha) distributed in South Sikkim district of Sikkim.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Kolkata, 2003.

Interpretation: Rayong soils are deep, silty clay loam in texture with good water holding capacity and low to medium CEC. The soils are under forest and may be cultivated with proper conservation measures.

Interpretative groupings:
  i) Land capability sub-class   IIIe
  ii) Land irrigability classification   6t
  iii) Productivity potential   Medium

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)			Coarse fragments (>2mm) (% of whole soil)
		Total			
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	
		--------------- % of <2 mm ---------------			
A	0-17	6.0	64.5	29.5	5
Bw	17-27	4.4	73.2	22.4	5-10
Bt1	27-55	4.4	65.1	30.5	5-10
Bt2	55-81	4.0	63.5	32.5	5-10
Bt3	81-150	4.0	57.5	38.5	20-30

Depth (cm)	Organic carbon (%)	pH (1:2.5) Water	Exchangeable bases					CEC cmol(+) kg^{-1} soil	Base Saturation[1] (NH$_4$OAc)
			Ca	Mg	Na	K	Total		
0-17	3.8	4.3	3.1	4.0	0.2	0.1	7.4	16.5	45
17-27	3.4	4.4	2.9	3.8	0.2	0.2	7.1	15.8	45
27-55	3.0	4.1	2.7	2.9	0.1	0.2	5.9	14.5	41
55-81	2.5	4.1	2.5	2.8	0.2	0.1	5.6	13.6	41
81-150	1.5	4.8	2.9	3.1	0.2	0.1	6.3	12.5	50

[1][Total exchangeable bases/CEC by NH$_4$OAc] x 100

Source: Das, T.H., Sarkar, D. and Gajbhiye, K.S. (2003). Soil Series of Sikkim. NBSS Publ. No.105, NBSS&LUP, Nagpur, 86p.

2.47.2 MANIRAM SERIES

The Maniram series is a member of loamy-skeletal, mixed, thermic family of Typic Hapludolls. Typically, Maniram soils have very dark grayish brown, strongly acid, silt loam A horizons, dark brown to yellowish brown, slightly to medium acid, gravelly silt loam B horizons and yellowish, medium acid, gravelly silt loam C horizons.
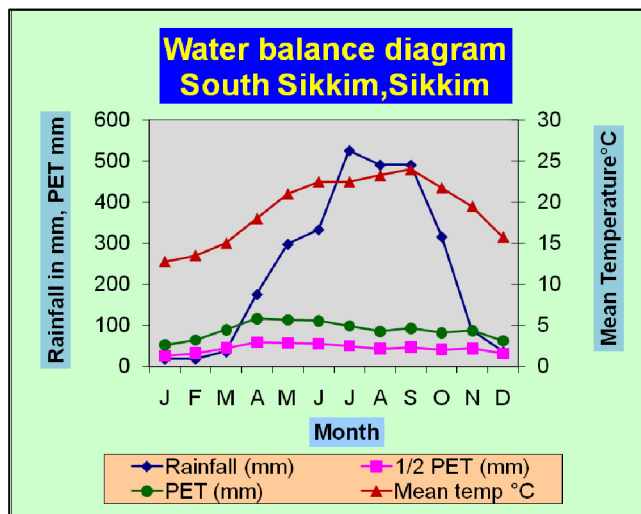
Typifying pedon: Maniram gravelly silt loam – cultivated

Ap   0-12 cm --- Very dark grayish brown (10YR 3/2 M) silt loam; weak, fine granular structure; soft, friable, slightly sticky and slightly plastic; many fine and medium, pores; many fine and medium roots; strongly acid (pH 5.1); clear smooth boundary.

Bw1   12-27 cm --- Dark brown (10YR 3/3 M) gravelly silt loam; weak, fine crumb structure; very friable, slightly sticky and slightly plastic; many medium and coarse roots; medium acid (pH 5.6); gradual smooth boundary.

Bw2   27-54 cm --- Dark brown (10YR 3/3 M) gravelly silt loam; weak, fine crumb structure; very friable, slightly sticky and slightly plastic; few fine and medium gravels; many medium roots; medium acid (pH 5.9); gradual smooth boundary.

Bw3   54-83 cm --- Yellowish brown (10YR 5/6 M) gravelly silt loam; weak, fine granular structure; very friable, slightly sticky and slightly plastic; few fine and medium gravels; many medium roots; slightly acid (pH 6.1); gradual smooth boundary.

2C   83-150+ cm --- Yellowish brown (10YR 5/6 M) gravelly silt loam; very friable, non-sticky and non-plastic; common fine and medium gravels and stones; few fine roots; medium acid (pH 6.0).

Type location: 27°10'05" N and 88°24'40" E; village Maniram, circle Maniram, district South Sikkim, Sikkim.

Ranges in characteristics: The thickness of solum ranges from 80 to 110 cm. The thickness of A horizon is 10 to 15 cm. Its colour is in hue 10 YR and value 3 and chroma 2. Its texture is silty loam to loam. The thickness of B horizon varies from 40 to 45 cm with colour hue 10YR, value 3 to 5 and chroma 3 to 4. Textural class is gravelly silt loam. The thickness of the C horizon is more than 50 cm, colour is in hue of 10 YR, value is 5 and chroma is 6.

Competing series and their differentiae: Competing soils are those of Yangang series, which belongs to Typic Hapludoll and are deep soils with low CEC, strong acidity and medium base saturation ranges 50-60 %. The Yangang soils have silt loam texture with absence of gravels upto 50 cms, whereas the Maniram soils have gravelly silt loam texture throughout the control section.

Geographical setting: Maniram soils are formed in granites and gneisses and occur on very steeply sloping (15-25% slope) medium hills of the Himalayan Mountain at an elevation of 1770 m above MSL. The climate is temperate with mean annual air temperature 18.7°C and mean annual rainfall of 2450 mm. The estimated MAST is 19.7°C, MSST 24.1°C and MWST 13.1°C. The difference between MSST and MWST is 11.0°C.

Geographically associated soils: The associated soils are Doling series (Typic Argiudolls) and Damthang series (Humic Hapludults)

Drainage and permeability: Somewhat excessively drained with rapid permeability.

Land use and vegetation: Mostly cultivated for maize and rice on terraced lands. The tree species includes chilaune, Utis (*Almus nepalensis*).

Distribution and extent: Extensively distributed in West Sikkim (2240 ha) and South Sikkim (1209 ha) districts of Sikkim State.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Kolkata, 2003.

Interpretation: Deep soils of Maniram series have been rated as marginally suitable for maize and rice due to its gravelly textural class and steeply sloping terrain conditions. Soil conservation measures should be adopted to arrest soil erosion.

Interpretative groupings:

i) Land capability sub-class	VIIes
ii) Land irrigability classification	6t
iii) Productivity potential	Medium

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)			Coarse fragments (>2mm) (% of whole soil)
		Total			
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	
		--------------- % of <2 mm ---------------			
Ap	0-12	24.0	61.8	14.2	15
Bw1	12-27	22.0	62.9	15.1	30
Bw2	27-54	23.6	64.4	12.0	40
Bw3	54-83	26.5	61.3	12.2	40
2C	73-150	40.4	46.6	13.0	45

Depth (cm)	Organic carbon (%)	pH (1:2.5) Water	Exchangeable bases					CEC cmol(+) kg⁻¹ soil	Base saturation[1] (NH₄OAc)
			Ca	Mg	Na	K	Total		
0-12	3.1	5.1	5.1	2.0	0.0	0.4	7.5	13.0	58
12-27	2.6	5.6	3.8	3.1	0.0	0.3	7.2	10.9	66
27-54	2.3	5.9	3.1	2.9	0.0	0.3	6.3	9.5	66
54-83	1.1	6.1	2.6	1.2	0.1	0.2	4.1	6.0	68
73-150	1.0	6.0	2.6	1.2	0.1	0.3	4.2	6.4	66

[1][Total exchangeable bases/CEC by NH₄OAc] x 100

Source: Das, T.H., Sarkar, D. and Gajbhiye, K.S. (2003). Soil Series of Sikkim. NBSS Publ. No.105, NBSS&LUP, Nagpur, 86p.

2.48 Soil Series: AESR 16.3

Arunachal Pradesh (Subdued Eastern Himalayas), warm to hot perhumid ESR with deep, loamy to clayey Red Loamy soils, low to medium AWC and LGP 300 days (C1A10)

2.48.1 LONGSOM SERIES

The Longsom series is a member of fine loamy, mixed isohyperthermic family of Typic Dystrudepts. Typically, Longsom soils have a brown to dark brown, strongly acidic, silty clay loam to loam A horizon and dark yellowish brown to yellowish brown, medium acidic, clay loam B horizon. The C horizon is yellowish brown and gravelly in nature.
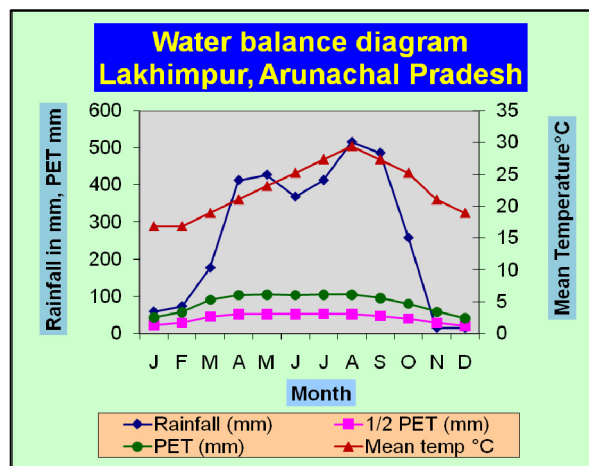
Typifying pedon: Longsom - loam – Jhum.

A1   0-15 cm … Brown to dark brown (10YR 4/3 M) loam; strong medium granular blocky structure; friable and slightly sticky; many fine common medium and few coarse roots; 3 to 4 cm wide cracks; common fine and few medium pores; strongly acidic (pH 5.4); clear wavy boundary.

Bw1   15-40 cm … Dark yellowish brown (10YR 4/4 M), clay loam; moderate medium subangular blocky structure; friable and sticky; common fine and medium and few coarse roots; 2.3 cm wide cracks; common fine pores; moderately acidic (pH 5.6); gradual smooth boundary.

Bw2   40-68 cm … Yellowish brown (10YR 5/6 M) clay loam; weak medium subangular blocky structure; friable and sticky; few fine and medium roots; common coarse fragments of size 5 to 10 cm; moderate acidic (pH 5.8); abrupt smooth boundary.

C   68cm+ Partially weathered rocks.

Type location: 26°56'30"N; 95°18'45"E, village Longsom, Circle Longding, District Tirap, Arunachal Pradesh.

Range in characteristics: Thickness of solum is 50 to 72 cm. The thickness of A horizon is 12 to 18 cm. Its colour is in hue 10YR, value 3 to 4 and chroma 3. The texture is loam to silty clay loam. The thickness of the B horizon is 45-55 cm. Its colour is in hue 10YR, value 4 to 5 and chroma 4 to 6. The texture is clay loam to silty clay loam or gravelly silty clay loam.

Geographic setting: Longsom soils are developed on shale and sandstone on the high hill slopes with a slope of 5 to 15% at an elevation of 600 to 800m above msl. The climate is humid subtropical with mean annual temperature of 29.0°C and mean annual rainfall of 2800 mm. The

estimated MAST is 31.0°C, MSST 24.7°C and MWST 21.0°C. The difference between MSST and MWST is 3.7°C.

Geographically associated soils: Geographically associated soil series is Longphong which is Typic Udorthents.

Drainage and permeability: Well drained with moderately slow permeability.

Use and vegetation: These areas are mostly under shifting cultivation.

Distribution and extent: Mostly on the rolling hill slopes and extensive. They cover an area of 8054 ha.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Jorhat, Assam, 1984.

Interpretation: Longsom soils are medium textured, well drained on moderately steep to steep slopes and highly erodible. Suitable for plantation and other vegetation.

Interpretative grouping:

i)	Land capability subclass	:	IVe
ii)	Irrigability subclass	:	6t
iii)	Productivity potential	:	Medium

Soil datasets:

Hori zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (1.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.1)	Coarse silt (0.05-0.02)	Fine silt (0.02-0.002)
		--- (% of <2 mm) --									
A	0-15	27.0	46.6	26.4	-	1.8	1.7	2.8	20.7	31.3	15.3
Bw1	15-40	29.0	35.0	36.0	-	1.3	2.0	3.7	22.0	18.6	16.4
Bw2	40-68	20.0	45.9	34.1	-	0.8	0.3	0.5	18.4	26.6	19.3
C	68+	--Weathered rocks--									

Depth (cm)	Organic Carbon (%)	pH(1:2.5)	
		H_2O	KCl
0-15	1.54	5.4	4.1
15-40	1.40	5.6	4.1
40-68	1.38	5.8	4.2
68+	--------------------Weathered rocks--------------------		

Depth (cm)	Extractable bases					H^+	Al^{+++}	CEC NH$_4$OAC	Base saturation %
	Ca	Mg	Na	K	Sum				
	--- cmol(+)kg^{-1}---								
0-15	2.21	4.9	0.20	0.22	7.53		3.2	10.60	70.75
15-40	1.30	4.5	0.20	0.26	6.26		3.1	11.90	50.42
40-68	1.5	4.5	0.20	0.10	6.30		2.4	11.80	53.38
68+	--Weathered rocks--								

Source: Chamuah, G.S., Walia, C.S., Baruah, U. and Dutta, A.K. (1984). Soil Survey Report of Longding and Wakka Circle under N.E.C. Project, District Tirap, Arunachal Pradesh. NBSS Publ. No.512, NBSS&LUP, Nagpur, i-iiip.

2.48.2 WAKKA SERIES

The Wakka series is a member of coarse loamy, mixed isohyperthermic family of Lithic Udorthents. Typically, Wakka soils have a very dark grayish brown to dark yellowish brown, strongly acidic, sandy loam A horizon and yellowish brown, strongly acidic, sandy loam C horizon.

Water balance diagram
Lakhimpur, Arunachal Pradesh
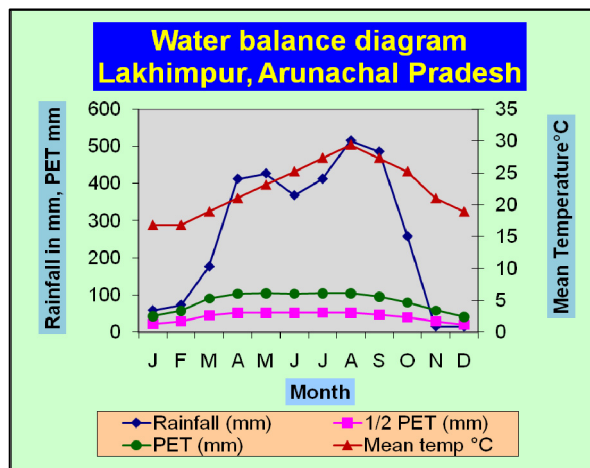
Typifying pedon: Wakka - sandy loam – Jhum.

A   0-16 cm … Very dark grayish brown (10YR 8/2 M) sandy loam; weak medium granular structure; friable and non sticky; many fine few and coarse roots; many fine and medium pores; strong acidic (pH 5.3) clear wavy boundary.

AC   16-36 cm … Dark yellowish brown (10YR 4/4 M), sandy loam; friable and non sticky; common fine; massive; few medium roots; common coarse fragments of 10to 20 cm size; common fine and medium pores; strongly acidic (pH5.5); clear irregular boundary.

C   36 cm+ … Yellowish brown (10YR 5/6 M) sandy loam; massive; very friable; few fine roots; many coarse fragments of more than 25 cm size; strongly acidic (pH 5.3).

Type location: 26°47'38"N; 95°27'15"E, village Wakka, Circle Wakka, District Tirap, Arunachal Pradesh.

Range in characteristics: Thickness of solum is 30 to 43 cm. The thickness of the A horizon is 15 to 25 cm. Its colour is in hue 10YR, value 3 and chroma 2 to 3. The texture is sandy loam to loam occasionally, silty clay loam. The C horizon is coarse texture with coarse fragments of more than 20 cm size.

Geographic setting: Wakka soils are developed in shale and sand stone hill tops with very steep slopes at an elevation of 1400 m or more above msl. The climate is humid sub-tropical with mean annual temperature of 29°C and mean annual rainfall of 2800 mm. The estimated MAST is 31.0°C, MSST 24.7°C and MWST 21.0°C. The difference between MSST and MWST is 3.7°C.

Geographically associated soils: Geographically associated soil series are Senua which is a Typic Udorthents.

Drainage and permeability: Excessively drained with rapid to moderately rapid permeability.

Use and vegetation: These areas are mostly under jhum cultivation.

Distribution and extent: Mostly on the upper reaches and top of very high hill. They cover an area of 8373 ha.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Jorhat, Assam, 1984.

Interpretation: Strongly acidic and extensively drained, coarse textured and occur on steep hills and erodible. Suitable for putting under permanent vegetation.

Interpretative grouping:

Land capability subclass	:	IVe
Irrigability subclass	:	6t
Productivity potential	:	Medium

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)								
		Total			Sand					Silt	
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (1.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.1)	Coarse silt (0.05-0.02)	Fine silt (0.02-0.002)
		------------------------------ (% of <2 mm) ------------------------------									
A	0-16	55.0	29.6	15.4	-	13.3	12.9	11.9	16.9	26.8	2.77
AC	16-36	62.5	26.0	11.5	-	1.6	20.4	23.9	16.4	14.4	11.51
C	36+	71.0	22.8	6.2	-	17.2	28.3	14.2	11.3	19.7	3.07

Depth (cm)	Organic Carbon (%)	pH(1:2.5)	
		H_2O	KCl
0-16	3.80	5.3	4.1
16-36	2.55	5.5	4.3
36+	0.74	5.3	4.5

Depth (cm)	Extractable bases					H^+	Al^{+++}	CEC NH₄OAC	Base saturation %
	Ca	Mg	Na	K	Sum				
	-- cmol(+)kg^{-1}----------------------------------								
0-16	0.81	1.60	0.29	0.20	2.9		4.2	10.1	28
16-36	0.41	0.30	0.20	0.10	1.1		5.1	11.6	9
36+	0.25	0.10	0.15	0.10	0.60		3.3	6.5	9

Source: Chamuah, G.S., Walia, C.S., Baruah, U. and Dutta, A.K. (1984). Soil Survey Report of Longding and Wakka Circle under N.E.C. Project, District Tirap, Arunachal Pradesh. NBSS Publ. No.512, NBSS&LUP, Nagpur, i-iiip.

2.49 Soil Series: AESR 17.1

Meghalaya Plateau and Nagaland Hill, warm to hot moist humid to perhumid ESR with medium to deep loamy to clayey Red and Lateritic soils, medium AWC and LGP 270-300+ days (D2A9)

2.49.1 MAWLYNDAIR SERIES

The Mawlyndair series is a member of loamy skeletal, mixed, thermic, family of Humic Dystrochrepts. Typically Mawlyndair soils have black, strongly acidic, sandy loam A horizon with granular structure, dark brown to reddish yellow, very strongly acidic, sandy clay loam to sandy loam B horizon and reddish yellow, strongly acidic, sandy loam C horizon.
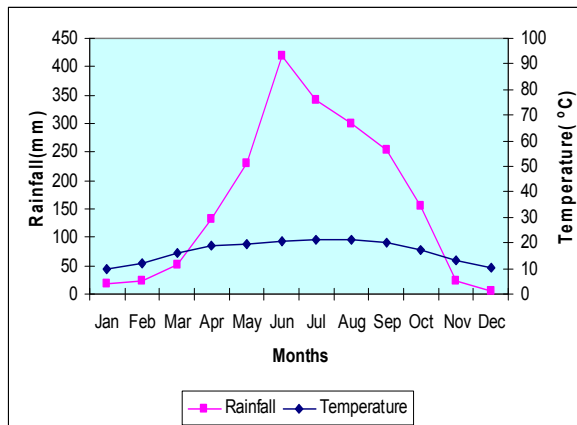
Typifying pedon: Mawlyndair –sandy loam – forest.

A   0-17 cm -- Black (10YR 2/1 M) sandy loam; moderate fine, granular structure; friable, non sticky and non plastic; abundant, medium and fine roots; 10% coarse fragments; many fine, discontinuous pores: very strongly acidic (pH 4.5); gradual smooth boundary.

BW1   17-37 cm -- Dark brown (10YR 4/3 M) sandy clay loam; moderate, fine granular structure; friable, non sticky and non plastic; abundant, medium roots; 40% coarse fragment; common discontinuous pores; very strongly acidic (pH 4.8); gradual smooth boundary.

BW2   37-75 cm -- Reddish yellow (7.5YR 6/8M) sandy clay loam; single grain structure; loose, common coarse roots; 50% coarse fragments; very strongly acidic (pH 5.0); gradual smooth boundary.

C   75-140 cm -- Reddish yellow (7.5YR 6/6 M), sandy loam; single grain structure; very coarse roots; 80% coarse fragments, strongly acidic (pH 5.1); gradual smooth boundary.

R   140 cm+ -- Parent materials – sand stone.

Type location: 25°18'22"N; 91°0'30"E; Mowlyndair village, East Khasi Hills district, Meghalaya.

Range in characteristics: These soils are deep to very deep. The solum is 35 to 60 cm thick. The A horizon is 15 to 20 cm thick. Its colour is hue 10YR, value 2 to 3 and chroma 1 to 2. The texture is sandy loam to loam and structure is granular. The B horizon is 15-30 cm thick. Its colour is in hue 10YR, value 3 to 4 and chroma 3 to 5. The C horizon is 60-100 cm thick. Its colour is in hue 7.5YR, value 4 to 6 and chroma 6 to 8. Abundant coarse fragment occur in the soil with percentage incrasing down the depth.

Geographic setting: Mawlyndair soils are developed on sandstone and occur on steep to very steep escarpments in Chrrapunji part of Meghalaya plateau at an elevation of 1000-1400 m above MSL. The climate is humid and subtropical monsoonic with mean annual air temperature of 17.5^{o}C and mean annual precipitation of 11418.7 mm. The estimated MAST is 20.0 ^{o}C. The MSST is 21.1 ^{o}C and MWST is 11.1 ^{o}C. The soil moisture regime is Udic and soil moisture control section lies between 30 and 60 cm depth of the profile.

Geographically associated soils: The principal associated soils are those of Cherrapunji series and which is a member of loamy, mixed thermic, shallow family of Typic Udorthents.

Drainage and permeability: Well drained with very rapid permeability.

Use and vegetation: These areas are mostly under fairly dense forest with occasional jhum. Lower slopes are cultivated to orange, pineapple etc.

Distribution and extent: Extensive in the gorges of Cherrapunji, East Khasi Hills district, Meghalaya. They cover an area of 484.5 sq. km.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Jorhat, Assam.

Interpretation: Very strongly acidic, well drained soils on steep escarpment, best left in their natural condition. Even jhum cultivation must be discouraged as it results in severe soil erosion and exposure of bare rock under the existing high rainfall.

Interpretative grouping:

i.	Land capability subclass	:	VIIes
ii.	Irrigability subclass	:	6t
iii.	Productivity potential	:	Poor.

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (1.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.1)	Coarse silt (0.05-0.02)	Fine silt (0.02-0.002)
		------------------------------------- (% of <2 mm) -------------------------------------									
A	0-17	79.50	2.00	18.00	0.80	5.20	40.00	29.50	4.0	0.5	1.5
Bw1	17-37	75.35	1.90	21.50	2.30	6.90	34.20	28.85	3.1	1.25	0.65
Bw2	37-75	74.55	5.45	20.00	2.30	8.00	37.90	23.75	2.6	2.95	2.50
C	75-140	75.50	11.50	10.0	2.60	8.00	32.20	29.60	3.1	3.00	8.50
R	140+	--Parent materials--									

Depth (cm)	Organic Carbon (%)	pH(1:2.5)	
		H₂O	KCl
0-17	3.86	4.5	3.1
17-37	3.50	4.8	3.5
37-75	0.49	5.0	3.5
75-140	tr	5.1	3.1
140+	--------------Parent materials--------------		

Depth (cm)	Extractable bases					H⁺	Al	CEC NH₄OAC	Base saturation %
	Ca	Mg	Na	K	Sum				
	--- cmol(+)kg⁻¹--								
0-17	1.1	0.11	0.156	0.176	1.54	4.08	3.3	6.69	23
17-37	0.61	tr	0.162	0.058	0.83	3.55	2.85	5.29	16
37-75	0.85	tr	0.163	0.045	1.06	2.69	2.25	3.06	34
75-140	0.85	tr	0.135	0.019	1.00	1.73	1.42	1.53	65
140+	--Parent materials--								

Source: Nair, K. M., Baruah, U. and Chamuah, G. S. (1992). Soil SurveyRreport of East Khashi Hills district of Meghalaya. NBSS Publ. No. 522, NBSS&LUP, 108-111p.

2.49.2 LAILAD SERIES

The Lailad series is a member of fine, mixed thermic family of Typic Kanhaplohumult. Typically, Lailad soils have very dark gray, moderately acidic, clay A horizon with granular structure, dark brown to yellowish red to red, strongly acidic, clay B horizon with granular to sub angular blocky structure and yellowish red, strongly acidic, sandy clay loam C horizon. The lower horizon has 10 to 20% coarse fragments.
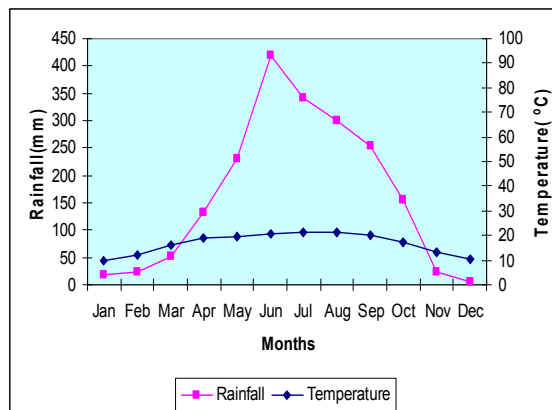
Typifying pedon: Lailad clay - forest

A 0-23 cm -- Very dark gray (10 YR 3/1 M) clay; moderate, fine granular structure; friable, non sticky and non plastic; abundant medium and fine roots; many, fine continuous pores; moderately acidic(pH 6.0); gradual smooth boundary.

Bt1 23-47 cm -- Dark brown (10 YR 3/3 M) clay; weak, fine, granular structure; friable, non sticky and non plastic; abundant, medium and fine roots; common, fine pores; strongly acidic (pH 5.3); gradual smooth boundary.

Bt2 47-68 cm -- Yellowish red (5 YR 5/6 M) clay; moderate, fine subangular blocky structure; friable, slightly sticky and slightly plastic; common, fine roots; strongly acidic (pH 5.4); gradual smooth boundary.

Bt3 68-103 cm -- Yellowish red (5 YR 5/8 M) clay; strong fine subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; strongly acidic (pH 5.2); gradual smooth boundary.

Bt4 103-130 cm -- Red (2.5 YR 5/8 M) Clay; strong, fine subangular blocky structure; friable, slightly sticky and slightly plastic; few, fine roots; strongly acidic (pH 5.2); gradual smooth boundary.

Bt5 130-163 cm -- Red (2.5 YR 5/7 M) clay; moderate, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; strongly acidic (pH 5.2); gradual smooth boundary.

C 163-240 cm -- Yellowish red (5 YR 4/6 M) sandy clay loam; single grain structure; loose, strongly acidic (pH5.3); gradual smooth boundary.

R 240 cm + -- Parent material consolidated granite gneiss.

Type location: 25°56′10″N; 91° 46′25″E; Lailad village, Nangpoh sub-division, East Khasi Hills, Meghalaya.

Range in characteristics: These soils are very deep. The solum is 150 – 200 cm thick. The A horizon is 20 to 30 cm thick. Its colour is in hue 10 YR, value 2 to 3 and chroma 1 to 2. The

texture is clay to clay loam and structure granular. The B horizon is 100 to 150 cm thick. Its colour is in hue 10 YR to 2.5 YR, value 3 to 5 and chroma 3 to 8. The texture is clay and structure granular to subangular blocky. The C horizon is 50 to 80 cm thick. Its colour is in hue 5 YR and sandy clay loam texture. Lower horizons have 10 to 20 % coarse fragments.

Geographic setting: These soils are developed on granite gneiss and occur on moderately steep to steep hills at an elevation of 300- 1000 m above MSL. The climate is humid and subtropical monsoonic with mean annual air   temperature of 16.6^{o}C and mean annual precipitation of 2415 mm. The estimated MAST is 19.1^{o}C. The MSST is 21.7^{o}C and MWST 14.8^{o}C. The soil moisture regime is Udic.

Geographically associated soils: Geographically associated soils are those of Nongpoh and Jirang series which are Typic Kandihumult but very fine in texture and fine loamy, mixed, thermic family of Typic Dystrochrepts respectively.

Drainage and permeability: Well drained with moderate permeability.

Land use and vegetation: Mixed deciduous and evergreen forest. Jhum cultivation is prevalent.

Distribution and extent: Very extensive in Nongpoh sub division of East Khasi Hills district, Meghalaya. They cover an area of 787.04 sq. km.

Series proposed: National Bureau of Soil Survey and Land Use Planning (ICAR), Regional Centre, Jorhat.

Interpretation: Moderately acidic to strongly acidic, well drained soils on moderately steep to steep hills landscape under proper soil conservation measures. These soils are highly suited for plantation and horticultural crops.

Interpretative grouping:
- i) Land capability subclass   IVe
- ii) Irrigability subclass   4st
- iii) Productivity potential   Medium

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (1.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.1)	Coarse silt (0.05-0.02)	Fine silt (0.02-0.002)
		-- (% of <2 mm) --									
A	0-23	42.0	15.5	40.5	0.95	6.40	18.70	12.50	3.50	2.00	13.45
Bt1	23-47	54.4	2.5	51.0	2.40	8.00	18.00	13.50	3.20	1.00	1.50
Bt2	47-68	42.0	1.5	56.5	2.20	7.90	16.70	12.60	2.60	1.50	-
Bt3	68-103	38.2	1.0	60.8	1.90	7.75	15.45	10.70	3.00	1.00	-
Bt4	103-130	44.6	1.0	54,4	2.45	8.55	18.80	11.45	3.35	1.00	-
Bt5	130-163	49.5	2.3	48.2	9.65	11.60	17.40	11.85	4.00	1.80	0.50
C	163-249	68.6	4.0	27.4	4.35	10.36	29.30	20.50	3.75	4.00	-
R	240+	--Parent materials--									

Depth (cm)	Organic Carbon (%)	pH(1:2.5)	
		H$_2$O	KCl
0-23	1.78	6.00	4.85
23-47	1.22	5.35	3.85
47-68	0.90	5.45	3.55
68-103	0.69	5.25	3.55
103-130	0.62	5.20	3.40
130-163	0.45	5.20	3.45
163-240	0.23	5.30	3.40
240+	--------------Parent materials------------		

Depth (cm)	Extractable bases					H	Al	CEC NH$_4$OAC	Base saturation %
	Ca	Mg	Na	K	Sum				
	-- cmol(+)kg^{-1}-------------------------- --------------------								
0-23	2.00	0.6	0.12	1.84	4.56	0,24	0.07	10.53	43
23-47	1.71	0.61	0.24	0.85	3.29	0.64	0.52	7.47	44
47-68	1.22	T*	0.14	0.70	2.06	1.30	1.12	6.88	30
68-103	1.34	T	0.10	0.50	1.94	1.10	0.82	7.00	28
103-130	1.10	T	0.11	0.46	1.67	1.20	0.97	1.06	24
130-163	0.86	T	0.11	0.50	1.47	1.06	0.90	5.06	29
163-240	0.98	T	0.11	0.37	1.46	1.30	1.05	3.06	48
240+	--Parent materials--								

*T= Traces

Source: Nair, K. M., Baruah, U. and Chamuah, G. S. (1992). Soil SurveyRreport of East Khashi Hills district of Meghalaya. NBSS Publ. No. 522, NBSS&LUP, 108-111p.

2.50 Soil Series: AESR 17.2

Purvachal (Eastern Range), warm to hot perhumid ESR with medium to deep loamy Red and Yellow soils, low to medium AWC and LGP 300 days (D3A10)

2.50.1 LONGOL-5 SERIES

Longol-5 series is a member of fine, mixed hyperthermic family of Typic Dystrudepts. The soils have light brown to brown, silty clay, very strongly acid A horizons; reddish brown to yellowish red, silty clay, very strongly to extremely acid B horizons with 2 to 10 percent coarse fragments.

Typifying pedon: Longol-5 silty clay; cultivated.
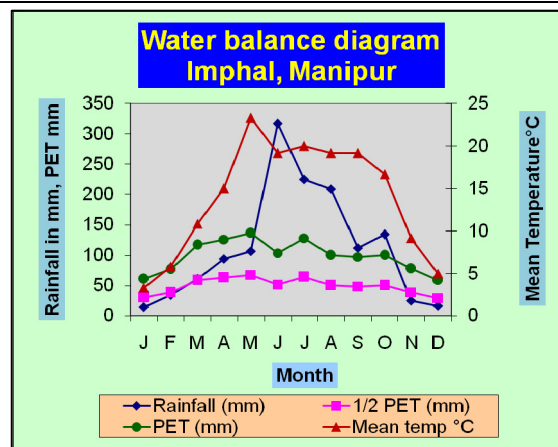
Ap   0-15 cm ---- Light brown (7.5YR 6/4 D) and brown (7.5YR 5/4 M) silty clay; weak medium sub angular blocky structure; slightly hard, friable, sticky and plastic; common medium and few coarse pores; many very fine, fine and medium roots; 2 percent by volume fine gravels; very strongly acid (pH 4.9); clear wavy boundary.

Bw1   15-40 cm ---- Brown (7.5YR 4/4M) silty clay; moderate medium sub angular blocky structure; friable, sticky and plastic; common fine and medium pores; common fine and medium and few very fine roots; 2 percent by volume fine gravels; very strongly acid (pH 4.5); clear smooth boundary.

Bw2   40-71 cm ---- Reddish brown (5YR 4/4M) silty clay; moderate medium sub angular blocky structure; friable very sticky and very plastic; common fine and few very fine pores; many very fine and few fine roots; 3 percent by volume fine gravels; very strongly acid (pH 4.6); gradual smooth boundary.

Bw3   71-99 cm ---- Reddish brown (5 YR 4/4 M) silty clay; moderate medium sub angular blocky structure; friable very sticky and very plastic; few very fine and fine pores; many very fine and few fine roots; 5 percent by volume fine gravels; very strongly acid (pH 4.7); gradual smooth boundary.

Bw4   99-127 cm ---- Yellowish red (5YR 4/6M) silty clay; moderate medium sub angular blocky structure; friable very sticky and very plastic; common fine and few very fine pores; many very fine and few fine roots; 7 percent by volume coarse fragments; extremely acid (pH 4.1); gradual smooth boundary.

Bw5   127-150 cm ---- Yellowish red (5YR 4/6 M) silty clay; moderate medium subangular blocky structure; friable very sticky and very plastic; common fine and few very fine pores; common very fine and few fine roots; 10 percent by volume coarse fragments; very strongly acid (pH 4.9).

Type location: 93°55′35″; 93°56′14″E longitude and 24°50′03″; 24°50′11″N latitude, Krishnagiri farm, Longol hill, ICAR Research Complex for NEH, Imphal.

Range in characteristics: The thickness of the solum is more than 150 cm. The texture of surface A horizon is silty clay or clay or clay loam. Its colour is in hue 7.5YR or 10YR, value 4 to 6 and chroma 3

to 4. The texture of the B horizon is clay or silty clay. Its colour is in hue 7.5YR or 5YR, value 3 to 4 and chroma 3 to 6. It contains 2 to 10 percent coarse fragments.

Competing series and their differentiae: Nil

Geographic setting: These soils have developed on colluvium and alluvium drawn from high hill slopes and occur on moderately sloping lower hill slopes. The climate is humid with mean annual air temperature of 13.9°C and mean annual precipitation of 1350 mm. The estimated MAST is 15.9° C. The MSST is 19.3° C and MWST 9.6°C. The difference between MSST and MWST is 9.7°C.

Geographically associated soils: Nil

Drainage and permeability: Well drained with slow permeability.

Use and vegetation: Most of the area is under cultivation of pulses, oilseed, fodder crops, vegetable and perennial fruit crops.

Distribution and extent: Very extensive in Krishnagiri farm, Langol hills. They cover an area of 10.07 ha and 17.4% of the total farm area

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Kolkata and Jorhat.

Interpretation:

Interpretative grouping:

Land capability subclass	:	IIIes
Irrigability subclass	:	4t

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)							
		Total			Sand				
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (1.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.1)
		--------------------------------- (% of <2 mm) ---------------------------------							
A	0-15	2.5	48.8	48.7	0.4	1.0	0.6	0.4	0.1
Bw1	15-40	2.9	46.3	50.8	0.3	1.1	0.8	0.5	0.2
Bw2	40-71	4.5	52.3	43.2	0.9	1.5	1.3	0.8	0.0
Bw3	71-99	2.0	41.4	56.6	0.1	0.7	0.7	0.4	0.1
Bw4	99-127	3.0	47.8	49.2	0.8	1.3	0.5	0.3	0.1
Bw5	127-150	1.9	41.0	57.1	0.4	0.4	0.6	0.4	0.1

Depth (cm)	Organic Carbon (%)	pH(1:2.5) H_2O
0-15	2.34	4.9
15-40	1.64	4.5
40-71	1.71	4.6
71-99	0.97	4.7
99-127	0.93	4.1
127-150	0.35	4.9

Depth (cm)	Extractable bases					CEC NH_4OAC	Base saturation %
	Ca	Mg	Na	K	Sum		
	--------------------------------------- cmol(+)kg^{-1}----------------------------------						
0-15	1.7	2.0	0.1	0.2	4.0	14.7	27
15-40	0.8	0.4	0.1	0.1	1.4	12.8	11
40-71	0.8	0.4	0.1	0.1	1.4	12.4	11
71-99	0.7	0.3	0.1	0.1	1.2	12.0	10
99-127	0.7	0.3	0.1	0.2	1.3	11.7	11
127-150	0.5	0.3	0.1	0.1	1.0	10.6	9

Source: Sarkar, D., Baruah, U. and Sahoo, A. K. (2005). Soils of Krishnagiri Farm, Longol Hill, ICAR Complex, Manipur, NBSS Publ. No. 851, NBSS&LUP (ICAR), Nagpur 55p.

2.50.2 LONGOL-6 SERIES

Longol-6 series is a member of fine, mixed hyperthermic family of Typic Kandiudults. The soils have light brown to reddish brown, clay, extremely acid surface A horizons; yellow red, clay, very strongly to extremely acid B horizons with thin or moderately thick argillans.

Water balance diagram Imphal, Manipur

Typifying pedon: Longol-6 clay- cultivated.
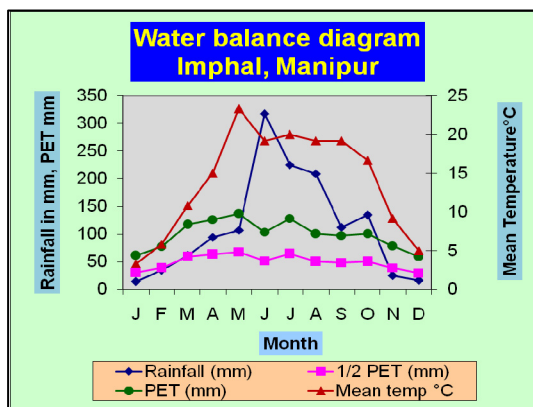
Ap   0-15 cm -- Light brown (7.5YR 6/4 D) and reddish brown (5YR 4/4 M) clay; weak medium sub angular blocky structure; slightly hard, friable, sticky and plastic; common fine and medium and few very fine pores; common very fine and few fine roots; extremely acid (pH 4.4); clear smooth boundary.

Bw   15-40 cm -- Yellowish red (6YR 4/4M) clay; moderate medium sub angular blocky structure; friable, very sticky and very plastic; few fine and medium pores; thin broken argillans; common very fine roots; extremely acid (pH 4.4); gradual smooth boundary.

Bt1   40-66 cm -- Yellowish red (5YR 4/6M) clay; moderate medium sub angular blocky structure; friable very sticky and very plastic; few very fine and fine pores; thin broken argillans; few very fine roots; extremely acid (pH 4.2); gradual smooth boundary.

Bt2   66-93 cm -- Yellowish red (5YR 4/6M) clay; moderate medium sub angular blocky structure; friable very sticky and very plastic; few fine roots; moderately thick patchy argillans; few very fine roots; extremely acid (pH 4.3); gradual smooth boundary.

Bt3   93-124 cm -- Yellowish red (5YR 4/6M) clay; moderate medium sub angular blocky structure; friable very sticky and very plastic; common very fine pores; moderately thick continuous argillans; few fine and medium roots; very strongly acid (pH 4.6); gradual smooth boundary.

BC   124-160 cm --Yellowish red (5YR 4/6M) clay; moderate medium sub angular blocky structure; friable sticky and very plastic; few fine pores; few fine roots; very strongly acid (pH 4.55).

Type location: $93^o55'35''$; $93^o56'14''$E longitude and $24^o50'03''$; $24^o50'11''$N latitude, Krishnagiri farm, Longol hill, ICAR Research Complex for NEH, Imphal

Range in characteristics: The thickness of the solum is more than 150 cm. The texture of surface A horizon is clay or silty clay. Its colour is in hue 10YR or 7.5YR, value 3 to 6 and chroma 3 to 4. The texture of B horizon is clay or silty clay. Its colour is in hue 7.5YR or 5YR, value 4 and chroma 4 to 6. Thin to moderately thick clay skin is observed in the B horizon.

Competing series and their differentiae: Nil

Geographic setting: These soils have developed on alluvium and colluvium drawn from upper hill slopes and occur on moderately steeply sloping lower hill slopes. The climate is sub humid with mean annual air temperature of 13.9^oC and mean annual precipitation of 1350 mm. The estimated MAST is 15.9^o C. The MSST is 19.3^o C and MWST 9.6^o C. The difference between MSST and MWST is 9.7°C.

256

Geographically associated soils: Nil

Drainage and permeability: Well drained with slow permeability.

Use and vegetation: Most of the area is under cultivation of pulses, oilseed, fodder crops, vegetable and perennial fruit crops.

Distribution and extent: Very extensive in Krishnagiri farm, Langol hills. They cover an area of 6.17 ha and 10.7% of the total farm area.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Kolkata and Jorhat.

Interpretation:

Interpretative grouping:

Land capability subclass	:	IVe
Irrigability subclass	:	6t

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)							
		Total			Sand				
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (1.0-1.0)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.1)
		------------------------------------- (% of <2 mm) -------------------------------							
Ap	0-15	6.1	39.4	54.5	0.7	1.4	2.4	1.4	0.2
Bw	15-40	6.0	38.0	56.0	1.3	1.2	2.1	1.2	0.2
Bt1	40-66	5.6	30.4	64.0	1.3	1.2	1.8	0.9	0.4
Bt2	66-93	4.8	34.2	61.0	0.7	0.9	1.7	0.9	0.6
Bt3	93-124	7.4	35.1	57.5	0.7	1.0	2.0	1.2	2.5
BC	124-160	5.8	37.5	56.5	0.9	1.0	2.1	1.3	0.5

Depth (cm)	Organic Carbon (%)	pH(1:2.5) H$_2$O
0-15	2.21	4.4
15-40	1.10	4.4
40-66	0.85	4.2
66-93	0.64	4.3
93-124	0.55	4.6
124-160	0.47	4.6

Depth (cm)	Extractable bases					CEC NH$_4$OAC	Base saturation
	Ca	Mg	Na	K	Sum		%
	------------------------ cmol(+)kg^{-1}-------------------------------						
0-15	2.16	0.34	0.31	0.10	2.91	15.9	18
15-40	1.35	0.11	0.29	0.08	1.83	14.3	13
40-66	1.62	0.26	0.31	0.07	2.26	14.5	16
66-93	1.08	0.59	0.27	0.07	2.01	20.9	10
93-124	1.35	0.53	0.30	0.07	2.25	14.7	15
124-160	1.35	0.11	0.27	0.07	1.80	15.0	12

Source: Sarkar, D., Baruah, U. and Sahoo, A. K. (2005). Soils of Krishnagiri Farm, Longol Hill, ICAR Complex, Manipur, NBSS Publ. No. 851, NBSS&LUP (ICAR), Nagpur 55p.

2.51 Soil Series: AESR 18.2

North Tamil Nadu Plains (Coastal), hot moist semi-arid ESR with deep, clayey and cracking Coastal land Deltaic alluvium- derived soils, high AWC and LGP 120-150 days (S7Dm4)

2.51.1 KALATHUR SERIES

The Kalathur series is a member of the fine, smectitic, isohyperthermic family of Sodic Haplusterts. Typically, Kalathur soils have dark grey to very dark grey, very strongly alkaline, clay loam to clay A horizons, and dark grey, very strongly alkaline, clay B horizons over dark greyish brown, very strongly alkaline, clay C horizons.

Typifying pedon: Kalathur clay loam - cultivated

Ap   0-14 cm --- Dark grey (10YR 4/1 D) and dark grey to very dark grey (10YR 3.5/1 M) clay loam; strong coarse subangular blocky structure; very hard, friable, very sticky and very plastic; common fine roots; common medium discontinuous vertical tubular pores; few 2 to 3 per cent rounded lime nodules; slightly effervescent; very strongly alkaline (pH 9.1); clear smooth boundary.

Bw   14-49 cm --- Dark grey (10YR 4/1 D) and dark grey to very dark grey (10YR 3.5/1 M) clay; strong coarse subangular blocky structure with slickensides; hard, firm, very sticky and very plastic; common fine roots inside peds; few discontinuous vertical tubular pores; 2 per cent lime nodules; slightly effervescent; few quartz fragments; very strongly alkaline (pH 9.7); diffuse smooth boundary.

Bss1   49-87 cm --- Dark grey (10YR 4/1 M) clay; strong coarse angular blocky structure with prominent intersecting slickensides; firm, very sticky and very plastic; 3 to 5 per cent lime nodules; slightly effervescent; few quartz fragments; very strongly alkaline (pH 9.4); clear smooth boundary.

Bss2   87-104 cm --- Dark grey (10YR 4/1 M) clay; strong coarse angular blocky structure with prominent intersecting slickensides; firm, very sticky and very plastic; 7 to 10 per cent lime nodules and quartz fragments; slightly effervescent; very strongly alkaline (pH 9.2); clear wavy boundary.

Bss3   104-120 cm --- Dark greyish brown (10YR 4/2 M) clay; moderate coarse angular blocky structure; firm, very sticky and very plastic; 15 per cent lime nodules and quartz fragments; strongly effervescent; very strongly alkaline (pH 9.2).

Type location: 10°56' N, 78°56' E; about 1 km east of Annappanpettai near Jambukolam, Papanasam tehsil, Thanjavur district, Tamil Nadu.

Range in characteristics: The A horizon is 45 to 55 cm thick. Its colour is in hue 10YR, value 3 to 4 and chroma 1 to 1.5. Its texture ranges from clay loam to clay. Lime nodules are present. The structure is strong subangular and angular blocky. The B horizon is 50 to 60 cm thick. Its colour is similar to that of the A horizon. Its texture is clay and it has intersecting slickensides. The C
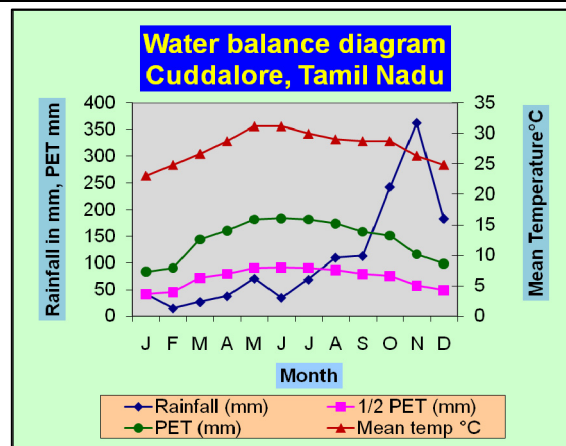
horizon is also in hue 10YR, value 3 to 4 and chroma 2 or less. It is also clayey in texture. The soils develop cracks during dry season.

Geographic setting: Kalathur soils are formed in alluvium on nearly level to very gently sloping Cauvery delta plain at an elevation of 80 m above MSL. The climate is semiarid tropical with mean annual air temperature of 26.8°C and mean annual rainfall of 870 mm. The estimated MAST is 30.3°C. The difference between MSST and MWST is 3.3°C.

Geographically associated soils: The associated soil is Adanpur series, which is a Vertic Haplustepts.

Drainage and permeability: Moderately well drained with slow to very slow permeability

Use and vegetation: Cultivated mainly to rice and occasionally to green gram and black gram; natural vegetation - *Acacia spp.* (babul) and grasses.

Distribution and extent: Extensive in the Cauvery delta plain, Thanjavur district of Tamil Nadu.

Series proposed: State Soil Survey and Land Use Planning Organisation, Tamil Nadu

Interpretation: Kalathur soils are important in the delta area. They are liable to stagnation during rainy season. The subsoils are sodic and ESP increases with depth. Adapted crops like rice, green gram and black gram are raised. Rice is the main crop in sodic phases.

a) Interpretative grouping:

i)	Land capability subclass	IIIs
ii)	Irrigability subclass	3s
iii)	Productivity potential	Medium

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)								Coarse frag-ments > 2 mm % of whole soil
		Total			Sand					
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
		<----------------------------- % of < 2 mm ----------------------------->								
Ap	0-14	43.4	17.9	38.7	3.7	7.8	13.4	13.0	5.5	4
Bw	14-49	38.6	16.3	45.1	4.0	7.1	12.0	11.1	4.4	10
Bss1	49-87	27.1	16.5	56.4	2.0	5.0	8.7	7.8	3.6	9
Bss2	87-104	22.6	18.7	58.7	2.0	3.8	6.8	6.4	3.6	11
Bss3	104-120	24.1	17.6	58.3	22.6	4.2	7.1	6.5	3.7	12

Depth (cm)	Organic Carbon (%)	Carbonate as $CaCO_3$ < 2 mm (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O dS m^{-1}
0-14	0.90	8.2	9.1	0.23
14-49	0.29	8.4	9.7	0.46
49-87	0.21	8.5	9.4	0.80
87-104	0.21	9.0	9.2	0.90
104-120	0.11	10.4	9.2	0.97

Depth (cm)	Extractable bases					CEC NaOAc	Exchangeable Sodium	Ratio CEC/Clay
	Ca	Mg	Na	K	Sum			
	<----------- cmol (p$^+$)kg^{-1} ----------------->						%	%
0-14	21.1	15.9	2.4	0.4	39.8	38.9	6	1.01
14-49	15.0	17.4	12.3	0.5	45.2	43.9	28	0.97
49-87	9.0	26.2	19.9	0.5	55.6	54.1	37	0.96
87-104	14.3	21.0	25.0	0.5	60.8	57.9	43	0.99
104-120	14.4	19.8	25.5	0.5	60.2	52.8	48	0.91

Source: Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

2.51.2 THIRUNALLAR SERIES

Thirunallar series is a member of the fine, smectitic, isohyperthermic family of Typic Haplusterts. Typically, Thirunallar soils have dark brown to very dark greyish brown, neutral, clayey A horizons, and very dark greyish brown to greyish brown, moderately to strongly alkaline, clayey B horizons over brown, moderately alkaline, clayey C horizons.

Water balance diagram Karaikal, U. T. Pudducherry
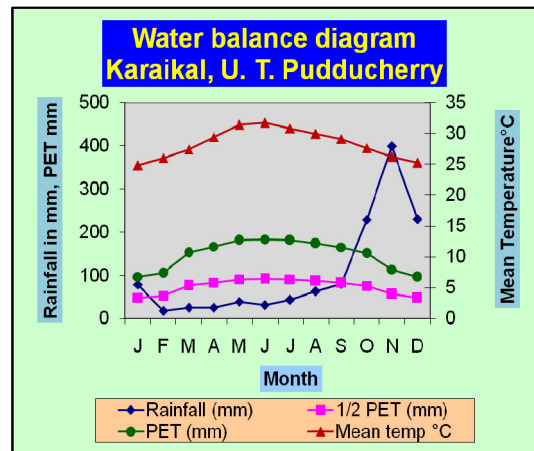
Typifying pedon: Thirunallar clay – cultivated

Ap   0-16 cm -- Dark brown (10 YR3.4/3 D); very dark grayish brown (10 YR 3/2 M); clay; strong coarse subangular blocky structure; dry hard; firm, sticky and plastic; many fine roots; common medium pores; cracks 2 to 3 cm wide; neutral (pH 7.1); clear smooth boundary.

Bw   16-53 cm -- Very dark grayish brown (10 YR 3/2 M); clay; strong coarse subangular blocky structure; firm, very sticky and very plastic; common, fine roots; common, fine pores; few fine iron concretions and few medium lime nodules; cracks 2 to 3 cm wide; non-intersecting slickensides; moderately alkaline (pH 8.1); gradual smooth boundary.

Bss1   53-73 cm -- Very dark grayish brown (10 YR 3/2 M); clay; moderate medium angular blocky structure; firm, very sticky and very plastic; few, fine roots; few, fine pores; few fine iron concretions; intersecting slickensides; strongly alkaline (pH 8.6); gradual smooth boundary.

Bss2   73-131 cm -- Very dark grayish brown (10 YR 3/2 M); clay; moderate medium angular blocky structure; firm, very sticky and very plastic; few, fine roots; few fine iron concretions; intersecting slickensides; moderately alkaline (pH 8.4); clear wavy boundary.

Bss3   131-181 cm -- Grayish brown (10 YR 5/2 M); clay; few, medium distinct brown or dark brown (7.5 YR 4/4 M) mottles; moderate medium angular blocky structure; friable, sticky and plastic; moderately alkaline (pH 8.4); clear wavy boundary.

2C   181-183 cm -- Brown (10 YR 5/3); clay; massive; moderately alkaline (pH 8.4).

Type location: East of Agricultural Research Farm, Madur, 20 m south-east of habitation, Karaikal Region, Union Territory of Puducherry, Survey No. 92.

Range in characteristics: The thickness of solum is more than 160 cm. The Ap horizon is 12 to 18 cm thick, has colour is in hue 10 YR, value 3 or 4, chroma 3, and is either silty clay or clay texture. Sometimes faint fine root mottles are present. The AC horizon is more than 125 cm thick, has colour is in hue 10 YR, value 3, chroma 2 and has texture of clay, and strong to moderate subangular blocky and angular blocky structure. Sand occurs below 180 cm.

Competing series and their differentiae: The competing series is Villianur series. Villianur soils have very dark greyish brown colour throughout. Villianur series is also a fine, Typic Haplusterts.

Geographic setting: Thirunallar soils are developed in river alluvium and occur on nearly level to very gently sloping floodplains in Karaikal Region of the Union Territory of Puducherry at an elevation of less than 5 m above MSL. The climate is tropical monsoonal with mean annual temperature of 28.3°C and mean annual rainfall of 1259 mm. The estimated MAST is 31.8° C. The MSST is 32.4° C and MWST 28.8° C. The difference between MSST and MWST is 3.6°C.

Geographically associated soils: The associated soil is Karaikal series, which is a Vertic Haplustepts.

Drainage and permeability: Poorly drained, slow to very slow permeability.

Land use and vegetation: Cultivated mainly to rice followed by green gram and black gram. Common rotation is with cotton. Natural vegetation consists of *Acacia spp.* (babul) and grasses.

Distribution and extent: Extensive in the Karaikal Region of the Union Territory of Puducherry.

Interpretative grouping:

i)	Land capability subclass	IIIws
ii)	Irrigability subclass	4sd
iii)	Productivity potential	Good

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)							
		Total			Sand				
		Sand (2-0.05)	Silt (0.05-0.002)	Clay (· 0.002)	Very coarse (2-1)	Coarse (1-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)
		---------------------------------------% of · 2 mm---------------------------------------							
Ap	0-16	16.8	23.6	59.6	0.4	0.9	2.7	6.1	6.7
Bw	16-53	16.3	22.0	61.7	0.2	1.0	2.8	5.9	6.4
Bss2	53-73	13.5	24.9	61.6	0.2	0.7	1.3	4.5	6.8
Bss3	73-131	12.5	33.3	54.2	0.1	0.5	0.7	3.8	7.4
Bss4	131-181	12.1	34.9	53.0	0.3	0.6	2.1	4.2	4.9
2C	181-183	25.8	32.2	42.0	0.1	0.4	1.3	13.3	10.7

Depth (cm)	Organic carbon (%)	CaCO₃ Equivalent (%)	pH (1:2.5 water)	E.C. (1:2.5 water) dSm⁻¹	C.E.C Cmol(p+)/kg soil NH₄OAc pH 7.0/ NaOAc pH 8.2	Extractable bases cmol(p+)/kg soil					B.S. (%)	ESP
						Ca	Mg	Na	K	Sum		
0-16	1.00	2.1	7.1	0.14	33.0	19.1	16.9	1.6	1.8	39.4	119	5
16-53	0.67	2.7	8.1	0.16	33.6	20.0	17.2	2.4	1.9	41.5	124	7
53-73	0.39	3.1	8.6	0.22	34.4	20.1	16.6	4.2	2.0	42.9	125	12
73-131	0.28	2.6	8.4	1.00	32.4	17.4	14.2	3.0	1.5	36.1	111	9
131-181	0.33	2.7	8.4	1.00	32.5	18.1	15.2	1.8	1.2	36.3	112	5
181-183	0.29	2.0	8.4	0.70	26.3	14.1	12.7	3.6	1.2	31.6	120	14

Source: Vadivelu, S., Ramesh Kumar, S. C., Thayalan, S. and Sarkar, D. (2008). Perspective land use plan 2015 and 2025 for the union territory of Pudducherry. NBSS Publication No. 142, Nagpur.pp.196.

2.52 Soil Series: AESR 18.3

Andhra Plain, hot dry subhumid ESR with deep, clayey Coastal and Deltaic alluvium-derived soils, low to medium AWC and LGP 150-180 days (S7Cd5)

2.52.1 KOVVUR SERIES

The Kovvur series is a member of the fine, mixed, isohyperthermic Aquic Haplustepts. Kovvur soils have brown and dark grayish brown, mildly alkaline, sandy loam A horizons, dark grayish brown to yellowish brown and grey, moderately to strongly alkaline, sandy clay loam to clayey B horizons.
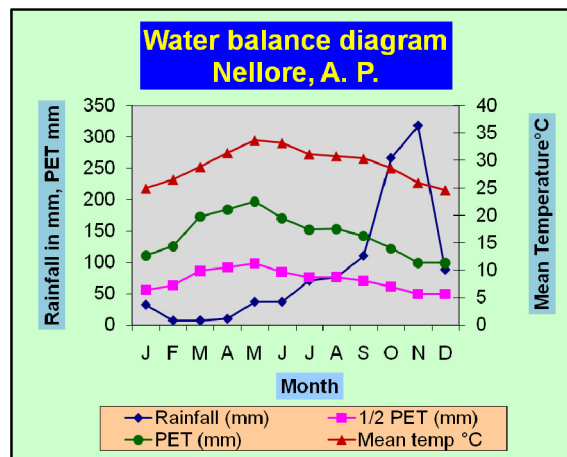
Typifying pedon: Kovvur sandy loam – cultivated

Ap   0-14 cm -- Brown (10YR 5/3 D) and dark grayish brown (10 YR 4/2) sandy loam; moderate fine subangular blocky structure; slightly hard, friable slightly sticky and slightly plastic; common fine roots; mildly alkaline (pH 7.6); clear smooth boundary.

Bw1   14-46 cm -- Dark grayish brown (10 YR 4/2 M) sandy clay loam; moderate medium subangular blocky structure; firm, sticky and plastic; few very fine roots; moderately alkaline (pH 8.2); gradual smooth boundary.

Bw2   46-81 cm -- Yellowish brown (10 YR 5/6 M) and grey (2.5 Y 6/0 M) clay; strong medium subangular blocky structure; firm, sticky and plastic; moderately alkaline (pH8.4); abrupt smooth boundary.

Bw3   81-112 cm -- Yellowish brown (10 YR 5/6 M) and grey (2.5 Y 6/0 M) clay; strong medium subangular blocky structure; firm, sticky and plastic; strongly alkaline (pH 8.8).

112 cm -- Water table.

Type location: 15º6′30″N and 80º2′30″E; Village Chakicherla; tehsil Kaveli; district Nellore.

Geographically associated soils: Typic, Ustipsamments; Fine-silty, mixed, Typic Haplustepts; Fine, mixed, Typic Haplustepts; Fine, smectitic, Typic Haplusterts; Fine, smectitic, Typic Sulfaquepts.

Geographical setting: Kovvur soils are formed in deltaic alluvium on flat land with pluffy white tones (very gently sloping plains) at an elevation of 10 m above MSL. The climate is subhumid with mean annual air temperature of 29.2ºC and mean annual rainfall of 1110 mm. The estimated MAST is 32.7ºC, MSST is 34.0ºC, MWST is 29.0ºC and the soil temperature regime is "isohyperthermic".

Drainage and permeability: Imperfectly drained with slow permeability.

Land use and vegetation: Paddy, green gram, black gram
Distribution and extent: Extensive (76896 ha)

Nellore (37066 ha), Krishna (16723 ha), Prakasam (10511 ha), Guntur (4011 ha), Warangal (27190), Visakhapatnam (2552 ha), West Godavari (2496 ha), East Godavari (1559) Chittor (1214 ha) and Srikakulam (764 ha)

Interpretation: These are very deep and clayey soils. Drainage, subsoil heavy texture, salinity sodicity are the major problems for normal crop production.

a) Interpretative grouping:

i) Land capability sub-class   :   Iiws
ii) Land irrigability sub-class   :   2ds
iii) Length of growing period   :   150-210 days
iv) Productivity potential   :   High to medium

b) Yield: Based on data from farmers′ fields

Crops	Yield (q/ha)	
	Farmers' practices	Improved practices
Bajra	15.02	25
Black gram	3.17	13
Cotton	2.36	11
Green gram	3.14	12
Groundnut	8.96	18
Rice	22.60	60
Tobacco	11.71	14

c) Land suitability for crops:

Crops	Rice	Black gram	Green gram	Cotton	Groundnut
Suitablity class	S1	S1	S1	S2wt	S3w

Soil datasets:

Depth (cm)	Horizon	Particle size distribution			Texture	pH		OC (%)
		Sand (2-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002mm)		Water (1:2.5)	KCl (1:2.5)	
		-----------------------(USDA)-----------------------						
0-14	Ap	80.4	3.7	15.9	sl	7.6	6.6	0.85
14-46	Bw1	57.9	9.0	33.1	scl	8.2	6.8	0.32
46-81	Bw2	45.8	5.8	48.4	sc	8.4	6.9	0.12
81-112	Bw3	36.7	4.6	58.7	c	8.8	6.9	0.14

Depth (cm)	Cation exchange capacity cmol(+)kg^{-1}		CEC/Clay ratio	Base Saturation (%)	
	NH$_4$OAc (pH 7.0)	Sum of cations		CEC (pH 7.0)	CEC (pH 8.2)
0-14	6.9	8.8	0.43	112	88
14-46	16.3	15.5	0.49	64	68
46-81	23.2	22.5	0.48	76	79
81-112	27.6	23.0	0.47	64	77

Depth (cm)	Exchangeable bases {cmol(+)kg^{-1}}					ESP
	Ca	Mg	Na	K	Total	
0-14	3.7	2.9	0.5	0.6	7.7	7.2
14-46	3.7	5.6	0.4	0.8	10.5	2.5
46-81	4.7	11.1	0.9	1.0	17.7	3.9
81-112	4.1	11.8	0.6	1.1	17.6	2.2

Source: Reddy, R. S., Budihal, S. L., Ramesh Kumar, S. C. and Naidu, L. G. K. (2005). Benchmark Soils of Andhra Pradesh. NBSS Publ. No.128, NBSS&LUP, Nagpur, 143p.

2.52.2 KAVELI SERIES

The Kaveli series is a member of the mixed, isohyperthermic family of Typic Ustipsamments. Kaveli soils have light yellowish brown brown, neutral, sandy A horizons and dark yellowish brown, neutral, sandy C horizons.

Water balance diagram Nellore, A. P.
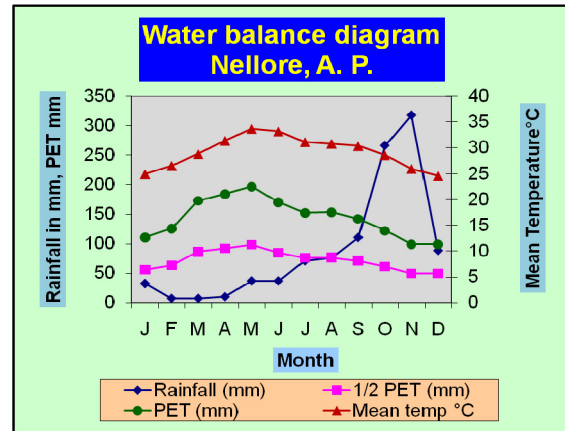
Typifying pedon: Kaveli sand – cultivated

Ap 0-17 cm -- Light yellowish brown (10YR 6/4 M) sand; weak very fine single grained structure; very friable non-sticky and non-plastic; few fine roots; neutral (pH 7.0); clear smooth boundary.

C1 17-53 cm -- Dark yellowish brown (10 YR 4/4 M) sand; weak very fine single grained structure; very friable, non-sticky and non-plastic; few very fine roots; neutral (pH 6.9); clear smooth boundary.

C2 53-93 cm -- Dark yellowish brown (10 YR 4/4 M) sand; weak, very fine, single grained structure; very friable, non-sticky and non-plastic; neutral (pH 7.3); clear smooth boundary.

C3 93-132 cm -- Dark yellowish brown (10 YR 4/4 M) sand; weak very fine single grained structure; very friable, non-sticky and non-plastic; few, very fine roots; neutral (pH 7.1); clear smooth boundary.

C4 132-150 cm -- Dark yellowish brown (10 YR 4/4 M) sand; weak, very fine, single grained structure; very friable, non-sticky and nonplastic; neutral (pH 7.1).

Type location: 15°6'30" N and 80°2'30" E; village: Chakicherla, district Nellore, Andhra Pradesh.

Geographic setting: Kaveli soils are formed in marine alluvium and occur on flat land (gently sloping, 3-5% slopes) at an elevation of 10 m above MSL. The climate is subhumid with mean annual air temperature of 29.2ºC and mean annual rainfall of 1110 mm. The estimated MAST is 32.7ºC, MSST is 34.0ºC, MWST is 29.0ºC and the soil temperature regime is "isohyperthermic"

Geographically associated soils: Fine-loamy, mixed, Typic Haplustepts, Fine-loamy, mixed, Fluventic Haplustepts, and Fine, mixed, Aquic Haplustepts

Drainage and permeability: Excessively drained with rapid permeability.

Land use and vegetation: Groundnut, paddy nursery, cashew, casuarina.

Distribution and extent: Extensive (71658 ha) in Krishna (18250 ha), Nellore (15950 ha), East Godavari (9793), Prakasam (7599 ha), West Godavari (5950 ha), Srikakulam (5525 ha), Guntur (4216 ha), Visakhapatnam (3186 ha), and Viziangaram (1189 ha) districts.

Interpretation: These are deep and coastal sandy soils. Low AWC, high sand content, low nutrient status and erosion hazard are the major constraints for crop production; have high potential for growing casuarinas, cashew and raising paddy nursery.

a) Interpretative grouping:

Land capability sub-class	:	IVes
Land irrigability sub-class	:	4s
Length of growing period	:	120-150 days
Productivity potential	:	Low

b) Yield: Based on data from Farmers' field:

Large area covered by sands and some areas are under paddy nursery, casuarinas etc.

Soil datasets:

Horizon	Depth (cm)	Particle size distribution (%)			pH		OC (%)	CaCO$_3$ (%)
		Sand (2-0.05 mm)	Silt (0.05- 0.002 mm)	Clay (<0.002mm)	Water (1:2.5)	KCl (1:2.5)		
		------------------------(USDA)----------------------						
Ap	0-17	94.2	3.9	1.9	7.0	6.4	0.20	1
C2	17-53	95.6	2.6	1.8	6.9	5.8	0.03	0
C3	53-93	96.3	2.1	1.6	7.1	6.1	0.03	0
C4	93-132	95.4	1.5	3.1	7.3	6.2	0.03	0
C5	132-150	92.2	3.2	4.6	7.1	6.0	0.03	1

Depth (cm)	Exchangeable bases {cmol(+)kg^{-1}}					ESP
	Ca	Mg	Na	K	Total	
0-17	0.8	0.5	0.2	0.2	1.7	11.8
17-53	0.6	0.3	0.2	0.1	1.2	20.0
53-93	0.7	0.8	0.2	0.1	1.8	16.7
93-132	1.1	0.6	0.2	0.1	2.0	10.5
132-150	1.2	0.8	0.3	0.1	2.4	14.3

Depth (cm)	Cation exchange capacity cmol(+)kg^{-1}	CEC/Clay ratio	Per cent Base Saturation
	NH$_4$OAc (pH 7.0)		CEC (pH 7.0)
0-17	1.7	0.89	100
17-53	1.0	0.56	120
53-93	1.2	0.75	150
93-132	1.9	0.61	105
132-150	2.1	0.46	114

Source: Reddy, R. S., Budihal, S. L., Ramesh Kumar, S. C. and Naidu, L. G. K. (2005). Benchmark Soils of Andhra Pradesh. NBSS Publ. No.128, NBSS&LUP, Nagpur, 143p.

2.53 Soil Series: AESR 18.4

Utkal Plain and East Godavari Delta, hot dry subhumid ESR with deep, loamy to clayey Coastal and deltaic alluvium- derived soils, medium AWC and LGP 180-210 days (S7Cd6)

2.53.1 SRIKAKULAM SERIES

The Srikakulam series is a member of the, fine, mixed, isohyperthermic Typic Haplustalfs. Typically, Srikakulam soils have dark yellowish brown, slightly acid, sandy loam A horizons and reddish brown to dark reddish brown, slightly acid, clay loam to clay B horizons.
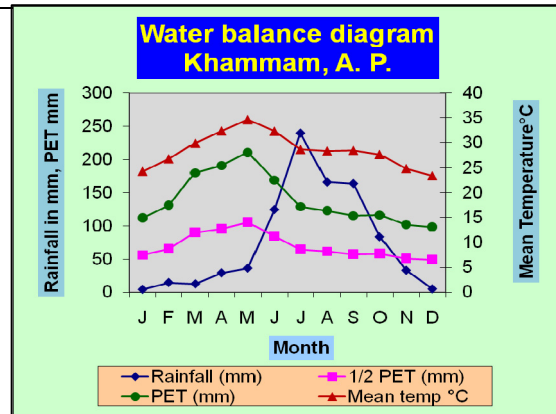
Typifying pedon: Srikakulam sandy loam-cultivated

Ap   0-12 cm -- Dark yellowish red (10YR4/4 M) sandy loam; weak medium subangular blocky structure; friable, slightly sticky and non-plastic; common fine to very fine roots; slightly acid (pH 6.2); clear smooth boundary.

Bt1   12-36 cm -- Reddish brown (5YR4/3 M) clay loam; weak to moderate medium subangular blocky structure; friable, slightly sticky and slightly plastic; thin patchy clay cutans; few very fine roots; slightly acid (pH 6.1); gradual smooth boundary.

Bt2   36-75 cm -- Dark reddish brown (5YR3/4 M) clay; moderate medium subangular blocky structure; friable, sticky and plastic; thin patchy clay cutans; few very fine roots; slightly acid (pH 5.9); gradual smooth boundary.

Bt3   75-108 cm -- Reddish brown (5YR4/4 M) clay; moderate medium subangular blocky structure; friable, sticky and plastic; patchy thin clay cutans; few very fine roots; slightly acid (pH 6.0); gradual smooth boundary.

Bt4   108-150 cm -- Dark reddish brown (2.5YR3/4 M) clay; moderate medium subangular blocky structure; friable, sticky and plastic; patchy thin clay cutans; slightly acid (pH 6.0); gradual smooth boundary.

Type location: $17^o44'12''$N, $77^o31'30''$E; village Lokkavaram; tehsil Chintur; district Khammam; Andhra Pradesh.

Competing series and their differentiae: Nil

Geographic setting: Srikakulam soils are developed from granite on 1-3 per cent slope at an elevation of 70 m above MSL. The climate is subhumid with mean annual air temperature of 28.5^oC and mean annual precipitation of 911mm. The estimated MAST is 30.5^o C. The MSST is 34.3^oC and MWST 28.7^o C. The difference between MSST and MWST is $5.6°C$.

Geographically associated soils: Fine mixed Typic Rhodustalfs; Loamy-skeletal, mixed, Typic Haplustepts; Fine-loamy, mixed, Typic Haplustepts; Fine, mixed, Typic Haplustepts; Fine-loamy, mixed, Typic Paleustalfs; Fine, mixed, Typic Paleustalfs.

Drainage and permeability: Moderately well drained with moderate permeability.

Land use and vegetation: Most of the area is under cultivation of paddy, green gram, black gram.

Distribution and extent: Extensive in Srikakulam (108512 ha), Nellore (100646 ha), Krishna (83094 ha), Khammam (72127 ha), Vishakhapatanam (52536 ha), West Godawari (50819 ha), Prakasam (33005 ha), Vizianagaram (30586 ha), East Godawari (8812 ha) and Guntur (5108 ha), districts of Andhra Pradesh.

Interpretation: These are very deep and clayey in texture. Have high potential for growing mango, chashew, tobacco and other horticultural, medicinal and aromatic plants.

a) Interpretative grouping:

Land capability sub-class	:	IIs
Land irrigability sub-class	:	2s
Length of growing period	:	150-210 days
Productivity potential	:	High

b) Yield: Based on data from Farmers' field:

Crops	Yield (q/ha)	
	Farmers' practices	Improved practices
Black gram	05.4	13
Cotton	02.14	11
Green gram	03.47	12
Groundnut	07.64	18
Horse gram	02.27	12
Jowar	10.29	35
Red gram	04.35	18
Rice	22.60	60

c) Land suitability for crops:

Crops	Red gram	Horse gram	Groundnut	Green gram	Black gram	Sorghum	Cotton	rice
Suitability class	S1	S1	S2n	S2t	S2t	S2t1	S3tn	S2tw

Soil datasets:

Depth (cm)	Hori-zon	Particle-size distribution (%)			Tex-ture	pH		OC (%)	ECe (1:2.5) dSm^{-1}
		Sand (2-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)		Water (1:2.5)	KCl (1:2.5)		
		<--------------------------(USDA)-------------------------->							
0-12	Ap	64.5	17.6	17.9	sl	6.2	5.0	0.95	0.0
12-36	Bt1	43.3	19.1	37.6	cl	6.1	4.9	0.43	0.1
36-75	Bt2	31.8	21.6	46.6	c	5.9	5.0	0.52	0.1
75-108	Bt3	29.2	20.9	49.9	c	6.0	5.0	0.41	0.1
108-150	Bt4	27.5	19.8	52.7	c	6.0	5.2	0.35	0.1

Depth (cm)	ESP	Exchangeable bases cmol(+) kg^{-1}					Extractable acidity {cmol(+) kg^{-1}}		
		Ca	Mg	Na	K	Total	BaCl$_2$-TEA	1.0 N KCl	
								H+Al	Al^{3+}
0-12	3.1	2.4	1.0	0.2	0.7	4.3	4.9	0.0	0.0
12-36	2.2	2.8	1.3	0.2	0.7	5.0	7.9	0.1	0.0
36-75	2.9	3.3	1.3	0.3	1.0	5.9	8.1	0.1	0.0
75-108	2.4	4.6	1.1	0.3	1.0	7.0	8.3	0.0	0.0
108-150	1.5	5.2	1.0	0.2	0.9	7.3	8.0	0.1	0.0

Depth (cm)	Cation exchange capacity cmol(+) kg^{-1}			CEC/Clay ratio	Base saturation (%)	
	ECEC	NH$_4$OAc (pH 7.0)	Sum of Cations		CEC (pH 7.0)	CEC (pH 8.2)
0-12	4.3	6.4	9.2	0.36	67	47
12-36	5.1	8.9	12.9	0.23	56	39
36-75	6.0	10.4	14.0	0.22	57	42
75-108	7.0	12.6	15.3	0.25	56	46
108-150	7.4	13.0	15.3	0.25	56	48

Source: Reddy, R. S., Budihal, S. L., Ramesh Kumar, S. C. and Naidu, L. G. K. (2005). Benchmark Soils of Andhra Pradesh. NBSS Publ. No.128, NBSS&LUP, Nagpur, 143p.

2.53.2 SURYAPET SERIES

The Suryapet series is a member of the, fine, loamy, mixed, (superactive), isohyperthermic Inceptic Haplustalfs. Typically, Suryapet soils have very dark greyish brown to brown, slightly alkaline, sandy clay loam to sandy loam A horizons and brown, slightly alkaline to moderately alkaline, sandy clay to sandy clay loam B horizons.
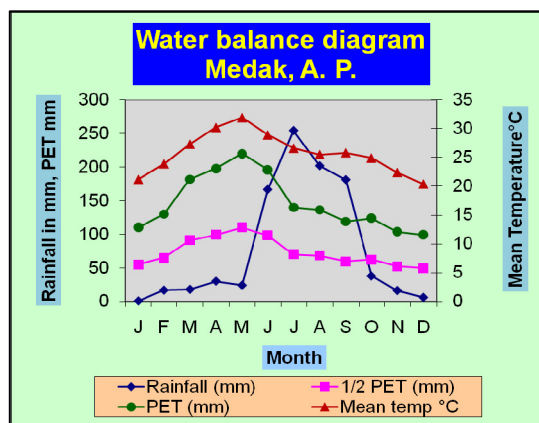
Typifying pedon: Suryapet sandy clay loam - cultivated

Ap   0-16 cm -- Very dark grayish brown (10YR3/2 D&M) sandy clay loam; moderate coarse subangular blocky structure; slightly hard, friable, sticky and plastic; few fine common roots; slightly alkaline (pH 7.9); clear smooth boundary.

AC   16-31 cm -- Brown (10YR3/2 M) sandy loam; moderate medium subangular blocky structure; friable, slightly sticky and slightly plastic; fine common roots; slightly alkaline (pH 7.9); gradual smooth boundary.

Bw1   31-52 cm -- Brown (10YR3/2 M) sandy clay; moderate medium subangular blocky structure; friable, sticky and plastic; few fine roots; slightly alkaline (pH 7.9); gradual smooth boundary.

Bw2   52-75 cm -- Brown (10YR4/3 M) sandy clay; moderate medium subangular blocky structure; friable, sticky and plastic; few fine roots; slightly alkaline (pH 7.8); gradual smooth boundary.

2Bw3   75-100 cm -- Brown (10YR5/3 M) sandy clay loam; moderate medium subangular blocky structure; friable, sticky and plastic; few fine roots; moderately alkaline (pH 8.6); gradual smooth boundary.

2Bw4   100-130 cm -- Brown (10YR5/3 M) sandy clay loam; moderate medium subangular blocky structure; friable, sticky and plastic; few fine roots; strong effervescence with dilute HCl; slightly alkaline (pH 8.5).

Type location: Village Issepet, Tehsil Andole-Jogipet, District Medak, Andhra Pradesh; 18°3'8" N 78°8'7" E.

Range in characteristics: The thickness of the solum ranges from 104 to 150 cm. The A horizon is 9 to 18 cm thick. Its colour is in hue 10YR, value 4 to 3 and chroma 4 to 1. Its texture ranges from sandy loam to clay. Its structure is medium and coarse subangular blocky. The B horizon is 89 to 139 cm thick. Its colour is in hue 10YR, value 5 to 6 and chroma 6 to 2. Texture is gravelly sandy clay loam to gravelly sandy clay.

Geographical setting: The Suryapet soils are developed in colluvium and alluvium of weathered granite-gneiss and occur on very gently sloping (1-3%) valleys at an elevation ranges from 440 to 520 m above MSL. The climate is semi-arid with mean annual air temperature of 25.8^{o}C and mean annual precipitation of 953mm. The estimated MAST is 27.8^{o} C. The MSST is 31.4^{o}C and MWST 25.8^{o} C. The difference between MSST and MWST is 5.6°C.

Geographically associated soils: Fine, mixed, (calc.), Aquic Haplustepts; fine-loamy, mixed, Typic Haplustepts; fine, mixed, Typic Haplustepts; mixed Ustipsamments.

Drainage and permeability: Well drained with moderate permeability.

Land use and vegetation: Mainly cultivated to crops like paddy, sorghum (jowar), sugarcane, pigeon pea (tur), wheat, etc. Natural vegetation is *Azadirachta indica* (neem), *Acacia* spp. (babul).

Distribution and extent: Extensive in Nalgonda (144208 ha), Mahbubnagar (88372 ha), Warangal (50243 ha), Karimnagar (34199 ha), Srikakulam (29007 ha), Medak (28105 ha), Nellore (22763 ha), Krishna (22471 ha), Prakasam (20992 ha), Nizamabad (16018 ha), Vizianagaram (14580 ha), Guntur (12203 ha), West Godavari (9970 ha), Khammam (7597 ha), Chittoor (7199 ha), East Godavari (4588 ha), Randareddi (4405 ha), Anantapur (3478 ha) and Visakhapatnam (2311 ha)

Interpretation: These are deep, moderately alkaline, sandy and clayey stratified soils and moderate erodibility are the major constraints for normal crop husbandry.

a) **Interpretative groupings:**

Land capability sub-class	: IIs
Land irrigability sub-class	: 2s
Length of growing period	: 150 – 180 days
Productivity potential	: High

b) **Yield: Based on data from Farmers' fields:**

Crops	Yield (q/ha)	
	Farmers' practices	Improved practices
Bajra	15.02	25
Cotton	2.81	11
Green gram	3.93	13
Groundnut	9.48	18
Jowar	9.14	35
Maize	26.92	45
Red gram	4.17	18
Rice	23.10	85

c) **Land suitability for crops:**

Crops	Maize	Green gram	Groundnut	Sorghum	Rice	Cotton
Suitability class	S1	S1	S2t	S2t	S2tw	S3t

Soil datasets:

Depth (cm)	Horizon	Particle-size distribution (%)			Tex-ture	pH		OC (%)
		Sand (2-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)		Water (1:2.5)	KCl (1:2.5)	
		<----------------------------(USDA)---------------------------->						
0-16	Ap	61.9	15.9	22.2	scl	7.9	6.9	0.78
16-31	AC	70.6	13.1	16.3	sl	7.9	6.8	0.19
31-52	Bw1	50.4	11.8	37.8	sc	7.9	6.7	0.12
52-75	Bw2	56.2	7.9	35.9	sc	7.8	6.6	0.09
75-100	2Bw3	63.6	8.1	28.3	g scl	8.6	7.4	0.16
100-130	2Bw4	55.7	9.5	34.8	g scl	8.5	7.3	0.05

Depth (cm)	ECe (1:2.5) dSm^{-1}	Exchangeable bases cmol(+) kg^{-1}				
		Ca	Mg	Na	K	Total
0-16	0.00	14.5	5.3	0.8	0.2	20.8
16-31	0.00	7.0	2.9	0.4	0.2	10.5
31-52	0.00	13.0	4.7	0.8	0.2	18.7
52-75	0.00	15.3	6.0	0.8	0.2	22.3
75-100	0.23	nd	5.3	0.6	0.2	nd
100-130	0.20	nd	4.7	0.7	0.3	nd

Depth (cm)	Cation exchange capacity cmol(+) kg^{-1}		CEC/Clay ratio	Per cent Base Saturation
	NH$_4$OAc (pH 7.0)	Sum of Cations		CEC (pH 7.0)
0-16	20.6	25.7	0.82	100
16-31	13.3	16.2	0.82	79
31-52	20.8	26.0	0.55	90
52-75	25.5	32.3	0.71	87
75-100	23.1	nd	0.82	nd
100-130	22.0	nd	0.63	nd

Source: Reddy, R. S., Budihal, S. L., Ramesh Kumar, S. C. and Naidu, L. G. K. (2005). Benchmark Soils of Andhra Pradesh. NBSS Publ. No.128, NBSS&LUP, Nagpur, 143p.

2.54 Soil Series: AESR 18.5

Gangetic Delta, hot moist subhumid to humid ESR with deep, loamy to clayey Coastal and deltaic alluvium-derived soils, medium AWC and LGP 240-270 days (S7Cm7)

2.54.1 RANTRAPUR SERIES

The Rantrapur series is a member of the fine loamy, mixed, hyperthermic Typic Haplustalfs. Typically, Rantrapur soils have yellowish brown, slightly acid, sandy loam A horizons, strong brown to yellowish red, neutral, sandy loam to sandy clay loam B horizons.
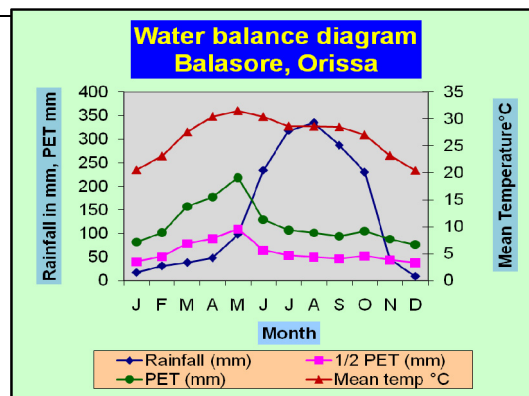
Typifying pedon: Rantrapur sandy loam – cultivated

Ap	0-11 cm	Yellowish brown (10YR 5/6M) sandy loam; fine weak subangular blocky structure; friable, non sticky and non plastic; many fine and few medium pores; common fine and medium roots; slightly acidic (pH 6.4); clear smooth boundary.
Bt1	11-41 cm	Strong brown (7.5YR 5/8M) sandy loam; weak medium subangular blocky structure; friable, slightly sticky and non plastic; many fine and few medium pores; thin broken clay cutans; common fine and few medium roots; neutral (pH 6.7); gradual smooth boundary.
Bt2	41-89 cm	Yellowish red (5YR 4/6M) sandy clay loam; moderate medium subangular blocky structure; friable, slightly sticky and slightly plastic; moderately thick patchy clay cutans; few fine roots; neutral (pH 6.8); gradual smooth boundary.
Bt3	89-147 cm	Yellowish red (5YR 4/6M) sandy clay loam; moderate medium subangular blocky structure; friable, slightly sticky and plastic; moderately thick patchy clay cutans; few fine roots; neutral (pH 7.0).

Type location: $19^o53' 00"N, 84^o05'30" E$; Village: Rantrapur, Tehsil: Jaleswar, District: Balasore, Odisa.

Range in characteristics: The thickness of the solum is 121 to 143 cm. The A horizon is 9 to 14 cm thick. Its colour is in hue 10YR value 5 to 6 and chroma 6 to 8. Its texture is loamy sand to sandy loam. The B horizon is 9 to 130 cm thick. Its colour is in hue 5YR and 7.5 YR, value 4 to 5, chroma 6 to 8. Its texture is sandy loam to sandy clay loam.

Competing series and their differentiae: Nil.

Geographical setting: The Rantrapur soils are developed in alluvium and occur on very gently sloping (1-3%) at an elevation of 40 m above MSL. The climate is humid with mean annual air temperature of 26.7^oC and mean annual precipitation of 1690 mm. The estimated MAST is 28.7^o C. The MSST is 31.8^oC and MWST 25.5^o C. The difference between MSST and MWST is $6.3°C$.

Geographically associated soils: Harinasal series which is classified as coarse loamy, Typic Haplustalfs.

Drainage and permeability: Moderately well drained with moderate permeability.

Land use and vegetation: Paddy, neem, babul.

Distribution and extent: It is distributed in Mayurbhanj (43.90%) and Balasore (56.10%) districts of Odisa covering an area of about 1.3751lakh ha

Interpretation: Rantrapur soils are light in texture and available moisture holding capacity is moderate. The soils have good air water relationship.

Interpretative grouping:
  i)   Land capability subclass   : IIIs
  ii)   Land Irrigability subclass   : 3s

Yield (based on data from Farmers' field) and productivity potential:

Crops	Farmers' practices	Improved practices	Productivity potential
	----------------------q ha⁻¹----------------------		
Paddy	8-10	12-15	Medium

Suggested land use: The land is suitable for groundnut, pulses and vegetables.

Soil datasets:

Horizon	Depth (cm)	Sand (2.0-0.05 mm) (%)	Silt (0.05-0.002 mm) (%)	Clay (< 0.002 mm) (%)	Texture	Coarse fragments vol. (%)	pH1:2.5 water	EC 1:2.5 water (dS/m)
Ap	0-11	68.5	19.2	12.3	sl	-	6.4	0.69
Bt1	11-41	62.3	19.5	18.2	sl	-	6.7	0.53
Bt2	41-89	56.2	18.7	22.1	scl	-	6.8	0.50
Bt3	89-147	57.6	16.1	26.3	scl	-	7.0	0.42

Depth (cm)	Org. C. (%)	CaCO₃	Exchangeable cations					CEC	Base Saturatiopn (%)
			Ca	Mg	Na	K	Sum		
			----------------------cmol (+) / kg soil------------------------						
0-11	0.20	-	2.6	0.6	0.1	0.1	3.4	4.8	71
11-41	0.11	-	4.0	1.0	0.1	0.1	5.2	6.8	76
41-89	0.10	-	4.2	1.6	0.1	0.2	6.1	7.8	78
89-147	0.09	-	5.0	1.9	0.1	0.2	7.2	9.0	80

Source: Sarkar, D., Sah, K. D., Sahoo, A. K. and Gajbhiye, K. S. (2005a), "Soil series of Orissa" NBSS Publ. No. 119, NBSS&LUP (ICAR), Nagpur, 254p.

2.54.2 SAGAR ISLAND SERIES

The Sagar Island series is a member of the fine, mixed isohyperthermic family of Vertic Endoaquepts. Typically, Sagar Island soils have light yellowish brown to olive brown, strongly acid, silty clay A horizon, and dark to very dark grayish brown, slightly to strongly alkaline, Bwn horizon distinctly mottled.
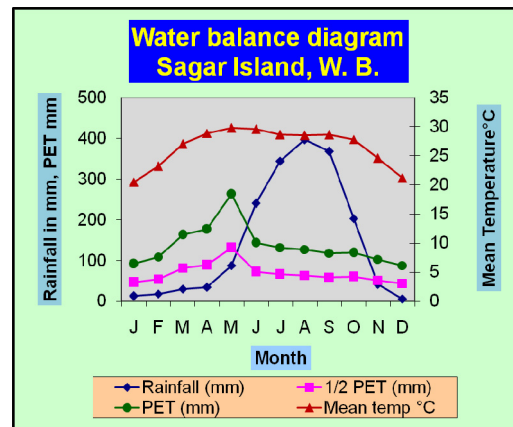
Typifying pedon: Sagar Island - silty clay – cultivated

Ap 0-19 cm -- Light yellowish brown (2.5Y 6/4 D) and olive brown (2.5Y 4/4 M) silty clay; massive structure; hard, firm sticky and plastic; common very fine and fine roots; 5 to 10 mm wide cracks; common fine and medium pores; strongly acid (pH 5.1); clear smooth boundary.

Bwn1 19-43 cm -- Very dark grayish brown (2.5Y 3/2 M) silty clay loam; few fine faint dark yellowish brown (10YR 4/6) mottles; moderate medium subangular blocky structure; firm very sticky and very plastic; few fine and common very fine roots; many very fine and fine pores; strongly acid (pH 8.6); gradual smooth boundary.

Bwn2 43-70 cm -- Very dark grayish brown (2.5Y 3/2 M) silty clay loam; common medium distinct yellowish brown (10YR 5/8) mottles; moderate medium subangular blocky structure; friable very sticky and very plastic; few very fine roots; common very fine pores; few very fine and fine Mn nodules; strongly alkaline (pH 8.6); gradual smooth boundary.

Bwn3 70-89 cm -- Very dark grayish brown (2.5Y 3/2 M) silty clay loam; common medium distinct yellowish brown (10YR 5/8) mottles; moderate medium subangular blocky structure; friable very sticky and very plastic; few very fine roots; few very fine pores; few very fine and fine Mn nodules; strongly alkaline (pH 8.6); gradual smooth boundary.

Bwn4 89-118 cm -- Dark grayish brown (2.5Y 4/2 M) silty clay loam; common medium distinct yellowish brown (10YR 5/8) to brownish yellow (10YR 6.8) mottles; strong medium angular blocky structure; firm very sticky and very plastic; few very fine and fine Mn nodules; slightly alkaline (pH 7.7); gradual smooth boundary.

Bwn5 118-160+ cm -- Very dark grayish brown (2.5Y 3/2 M) silty clay loam; common medium distinct strong brown (7.5YR 4/6) and brownish yellow (10YR 6.8) mottles; strong medium angular blocky structure; very firm very sticky and very plastic; moderately alkaline (pH 8.2).

Type location: 21°41'67" N, 88°04'37.6" E; village Natendrapur, tehsil Sagar, District 24-Parganas (South), West Bengal.

Range in characteristics: The average thickness of the solum is more than 150 cm. The thickness of A horizon ranges from 15 to 20 cm. Its colour is in hue 2.5Y, value 4 to 6 and chroma 4. Texture is silty clay. Structure is massive. The thickness underlying Btn horizon is 140 cm or more. Its colour is in hue 2.5Y, value 3 to 4 and chroma 2. The texture is dominantly silty clay loam. The structure ranges from moderate medium subangular blocky in the upper part to strong medium angular blocky in the lower part of the B horizon. Distinct dark yellowish brown (10YR 4/6) and strong brown (7.5YR 4/6) mottles are present in this horizon. These soils develops few cracks in summer.

Geographic setting: The Sagar Island soils are formed in Gengetic deltaic alluvial plain and occur on nearly level to gently slope at an elevation of 10-11 m above MSL. Mean annual temperature is 26.5^{o}C and mean annual rainfall is 1800-2100 mm. The estimated MAST is 28.5^{o}C, MSST 30.6^{o}C and MWST 25.4^{o}C.

Competing series and their differentiae: The competing series are Kirtankhali and Haradhanpur. Sagar Island soils differ from Kirtankhali in having prominent mottles and from Haradhanpur not containing concretions.

Drainage and permeability: Imperfectly drained with slow permeability.

Use and vegetation: Cultivated for paddy, potato, mustard, sunflower and also under betalwine. Natural vegetation: *Phoenix sylevestris* (date palm), *Acacia arabica* (babul), *Magnifera indica* (mango).

Distribution and extent: Moderately extensive (cover approximately 20% of total area) and found to occur in northern and southern portions of the Island.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Kolkata.

Interpretation:

a)   **Interpretative grouping:**

    i)   Land capability subclass
    ii)   Irrigability class
    iii)   Productivity potential

b)   **Yield: Based on data from farmers' fields**
Crop : Paddy (Kharif)

Management level	Yield, Mg ha^{-1}
Medium	
High	

Soil datasets:

Lab. No	Hori-zon	Depth (cm)	Size class and particle diameter (mm) Total			Fine clay (%)	FC/TC ratio	BD Mg/m³ Oven dry	COLE				Weighted mean (WM) 0-100 cm	HC* mm/hr	WDC (%)	Textural class
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)				Room temp.	40ºC	Oven dry					
			←-----(% of <2 mm) ---→													
3977	Ap	0-19	0.5	54.0	45.5	31.0	0.7	1.1	0.04	0.13	0.13		0.38	6.63	sic
3978	Bwn1	19-43	0.3	64.4	35.3	25.1	0.7	1.2	0.08	0.13	0.14	0.133	0.37	4.34	sicl
3979	Bwn2	43-70	0.7	61.9	37.4	22.4	0.6	1.2	0.02	0.11	0.12		0.11	3.99	sicl
3980	Bwn3	70-89	0.2	60.8	39.0	22.3	0.6	1.1	0.03	0.14	0.15		0.10	3.97	sicl
3981	Bwn4	89-118	0.7	61.0	38.3	23.0	0.6	1.1	0.80	0.12	0.13		1.15	3.05	sicl
3982	Bwn5	118-160+	0.7	61.9	37.4	22.2	0.6	1.1	0.06	0.11	0.11		0.08	2.73	sicl

Depth (cm)	pH water (1:2)	CaCO₃ (%)	OC (%)	Extractable bases					CEC	Clay CEC cmol(p+)kg⁻¹	B.S. (%)
				Ca	Mg	Na	K	Sum			
				←--------------------cmol(p+)/kg⁻¹--------------------→							
0-19	5.1	1.4	1.30	2.9	9.0	2.73	1.0	15.6	19.9	44	78
19-43	8.6	3.7	0.37	2.4	9.2	3.94	1.7	17.3	20.0	57	86
43-70	8.6	3.1	0.30	4.0	10.0	5.31	1.9	21.2	23.2	62	91
70-89	8.6	2.8	0.29	3.2	10.2	5.42	1.9	20.7	22.9	59	90
89-118	7.7	1.9	0.38	2.0	9.5	11.20	1.8	24.5	24.5	64	100
118-160+	8.2	2.7	0.42	2.8	8.8	7.60	1.7	20.9	25.2	67	83

Depth (cm)	Exch. Ca/Mg	ECP	EMP	ESP	CO₃ clay (%)	Org.C arbon% on WDClay basis
0-19	0.3	14	45	14	0.68	0.074
19-43	0.3	12	46	20	nd	0.024
43-70	0.4	17	43	23	0.34	0.049
70-89	0.3	14	45	24	nd	0.012
89-118	0.2	8	39	46	0.68	0.036
118-160+	0.3	11	35	30	0.51	0.036

Depth (cm)	Soluble cations (meq/l)						Soluble anions (meq/l)					RSC	SAR
	Sat %	ECe	Ca	Mg	Na	K	Sum	CO₃	HCO₃	Cl	SO₄	Sum		
0-19	53.67	4.51	6.00	22.75	26.08	0.97	55.80	tr	2.00	47.50	6.30	55.80		6.88
19-43	50.85	3.66	3.00	4.50	29.56	0.78	37.84	tr	3.00	23.00	11.84	37.84		15.27
43-70	51.09	7.76	4.00	7.00	84.34	0.54	95.88	tr	5.00	58.00	32.88	95.88		35.97
70-89	53.28	7.15	2.00	3.80	66.20	1.97	73.97	tr	2.50	61.00	10.47	73.97		38.87
89-118	53.27	17.95	8.00	15.00	140.7	3.12	166.82	tr	3.00	159.00	4.82	166.82		41.31
118-160+	45.27	4.69	3.75	5.00	26.52	0.39	35.66	tr	5.00	27.00	3.66	35.66		12.68

Source: Pal, D.K., Sohan Lal, Bhattacharyya, T., Chandran, P., Ray, S.K., Satyavathi, P.L.A., Raja, P., Maurya, U.K., Durge, S.L. and Kamble, G.K. (2010). "Pedogenic thresholds in Benchmark soils under rice-wheat cropping system in a climosequence of the Indo-Gangetic Alluvial Plains" Final Project Report, Division of Soil Resource Studies, NBSS&LUP, Nagpur, p.193.

2.55 Soil Series: AESR 19.1

North Sahyadris and Konkan Coast, hot humid ESR with medium to deep loamy to clayey mixed Red and Black soils, medium to high AWC and LGP 210-240 days (E6B8)

2.55.1 PATI SERIES

The Pati series is a member of clayey-skeletal, smectitic, isohyperthermic Lithic Haplustepts. Typically, Pati soils have dark reddish brown, slightly acid, gravelly clay A horizons, reddish brown to dark reddish brown, slightly acid, gravelly clay B horizons and dark reddish brown Cr horizon of weathered basalt.
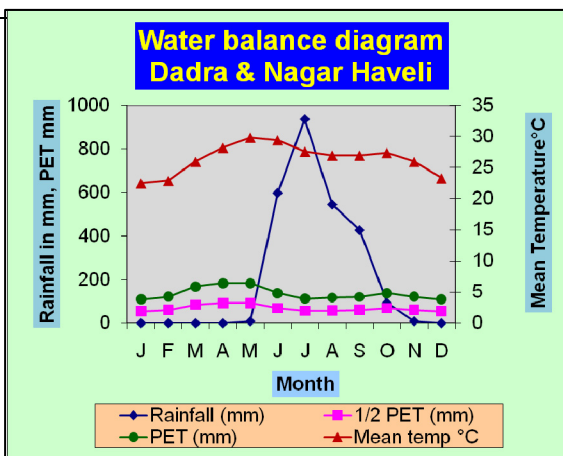
Typifying pedon: Pati gravelly clay – cultivated

Ap 0-12 cm --- Dark reddish brown (5YR 3/4 D&M) gravelly clay; moderate medium sub-angular blocky, slightly hard; friable, slightly sticky and slightly plastic, common fine roots, many fine imped and exped pores; 0.5 to 20.0 cm size basaltic fragments about 22 per cent by volume; slightly acid (pH 6.4); clear smooth boundary.

Bw 12-25 cm --- Reddish brown to dark reddish brown (5YR 3.5/4 D&M) gravelly clay; weak medium to fine sub-angular blocky; slightly hard; friable, sticky and plastic; few fine roots, many fine irregular pores; 2 to 20 cm size coarse basaltic fragments about 24 per cent by volume; slightly acid (pH 6.3); gradual smooth boundary.

Cr 25-43 cm --- Dark reddish brown (5YR 3.5/4 D&M) weathered basaltic parent material.

R 43+ --- Hard rock.

Type location: 20°06'71" N, 73°05'00" E; Village Rudana, Dadra and Nagar Haveli, U.T.

Range in characteristics: The thickness of the solum is 25 to 35 cm. The colour of the A horizon is in hue 5YR value 3 to 4 and chroma 4. The texture is gravelly clay to gravelly clay loam. The structure is moderate medium sub-angular blocky. The colour of the AC horizon is in hue 5YR and 2.5YR value 3 and chroma 4. The C horizon is dark reddish brown.

Competing series and their differentiae: Nil.

Geographical setting: The Pati soils are developed over basalt and weathered basalt and occur on gently to moderately sloping (8-15%) on flat-topped hillocks at an elevation ranging from 200 to 600 m above MSL. The climate is humid with mean annual air temperature of 26.3°C and

mean annual rainfall of 2616 mm. The estimated MAST is 28.3°C; MSST is 26.5°C and MWST 25.4°C. The difference between MSST and MWST is 1.1°C.

Geographically associated soils: Tinoda series which is classified as clayey-skeletal, smectitic, isohyperthermic Typic Haplustepts.

Drainage and permeability: Well drained with moderate permeability.

Use and vegetation: Cultivated to nagli, sorghum, pigeonpea, teak.

Distribution and extent: Occurs extensively (5498 ha) on gently to moderately sloping flat topped hillocks and distributed in north eastern, eastern and southern regions of Union Territory (1:5000 scale of mapping).

Series proposed: National Bureau of Soil Survey and Land Use Planning, Nagpur, 1980.

Interpretation:

    Interpretative grouping:

i.	Land capability subclass	IIIs - IVes
ii.	Land Irrigability sub class	3s - 4s
iii.	Productivity potential	4 - 5

- These soils are suitable for minor millets.

Soil datasets:

Horizon	Depth (cm)	Particle size class and its range of diameter (mm)								Coarse fragments >2mm % of whole soil
		Total			Sand					
		Sand (2.0-0.5)	Silt (0.5-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
Ap	0-12	34.0	24.1	41.9	6.2	8.1	7.2	5.3	7.2	58
Bw	12-25	24.3	21.9	53.8	3.2	3.6	4.1	3.9	9.5	64
Cr	25-43	------------------------------------- Weathered basalt -------------------------------------								

Depth (cm)	Organic carbon (%)	CaCO$_3$ (%)	EC.(1:2.5, soil : water) (dS m^{-1})	pH soil : water (1:2.5) H$_2$O	Bulk density (Mg m^{-3})	Water retention		Ratio	
						0.03 Mpa (%)	1.5 Mpa (%)	CEC/ Clay	1.5 Mpa/ Clay
0-12	2.12	Nil	<0.2	6.4	Nd	30.7	14.2	0.96	0.33
12-25	1.13	Nil	<0.2	6.3	Nd	32.6	21.2	0.78	0.39
25-43	--------------------------------------- Weathered basalt ---------------------------------------								

Depth (cm)	Exchangeable cations					CEC	Base saturation (%)
	Ca	Mg	Na	K	Sum		
	<------------------------------------- cmol(+)kg^{-1}------------------------->						
0-12	23.0	6.0	0.48	1.42	30.90	40.4	76.0
12-25	24.0	6.0	0.72	1.02	31.74	41.9	76.0
25-43	--------------------------------------- Weathered basalt ---------------------------------------						

Source: Challa, O. (2008). Soil Series of Dadra and Nagar Haveli. NBSS Publ. NBSS&LUP, Nagpur, 59p.

2.55.2 TINODA SERIES

The Tinoda series is a member of the clayey-skeletal, smectitic, isohyperthermic Typic Haplustepts. Typically, Tinoda soils have dark reddish brown, moderately acid gravelly clay A and B horizons and dark reddish brown, moderately acid, gravelly clay C horizons with partially weathered basalt.

Water balance diagram
Dadra & Nagar Haveli
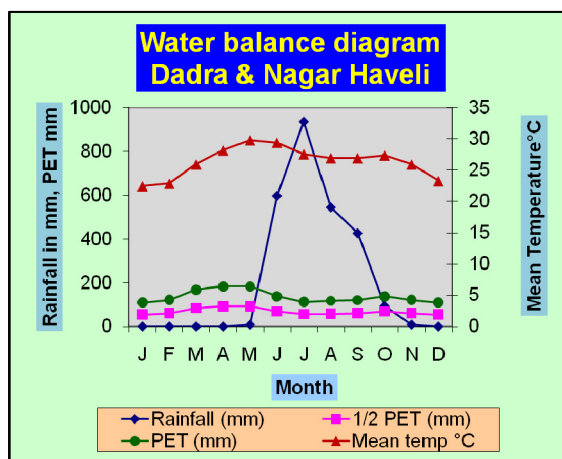
Typifying pedon: Tinoda gravelly clay – forest

A   0-17 cm --- Dark reddish brown (5YR 3/4 D) & (5YR 3/3 M) gravelly clay; weak, fine to medium sub-angular blocky; slightly hard, friable, slightly sticky and slightly plastic; many fine and medium roots, many fine imped and exped pores; 0.5 to 5 cm basaltic coarse fragments about 22 per cent by volume; moderately acid (pH 5.7); gradual smooth boundary.

Bw1   17-36 cm --- Dark reddish brown (5YR 3/3 M) gravelly clay; moderate medium sub-angular blocky; slightly hard, friable, slightly sticky and slightly plastic; many medium roots; 0.5 to 5 cm basaltic coarse fragments, about 20 per cent by volume; moderately acid (pH 5.6); gradual smooth boundary.

Bw2   36-60 cm --- Dark reddish brown (2.5 YR 3/4 M) gravelly clay; weak medium sub-angular blocky; hard, friable, sticky and plastic, many medium roots; 0.5 to 4 cm basaltic coarse fragments about 20 per cent by volume; moderately acid (pH 5.7); clear smooth boundary.

C1   60-80 cm --- Dark reddish brown (2.5 YR 3/4 M) moderate medium to weak subangular sticky and plastic, few very fine, fine, medium roots; moderately acid (pH 5.8).

Type location: 20°06'00" N, 73°05'00" E; Village Rudana, Dadra and Nagar Haveli, U.T.

Range in characteristics: The thickness of the solum is 18 to 42 cm. The colour of the A horizon is in hue 5YR value 3 to 4 and chroma 4 and the texture ranges from gravelly clay to clay loam. The structure ranges from weak to moderate, fine to medium sub-angular blocky. The colour of the B horizon is in hue 5YR, value 3 and chroma 3. The texture ranges from clay loam to gravelly silty clay loam. The structure ranges from weak to moderate, fine to medium sub-angular blocky. The colour of C horizon is in hue 2.5YR and 5 YR with value 4 to 6 and chroma 3. Basaltic fragments and gravels are present through out the profile.

Competing series and their differentiae: Nil.

Geographical setting: The Tinoda soils are developed over basaltic colluvium and occur on steeply sloping (30-50%) toluscones at an elevation ranging from 200 to 600 m above MSL. The climate is humid with mean annual air temperature of 26.3°C and mean annual rainfall of 2616

mm. The estimated MAST is 28.3^{o}C, MSST is 26.5^{o}C and MWST is 25.45^{o}C. The difference between MSST and MWST is 1.1^{o}C.

Geographically associated soils: Pati series which is classified as clayey-skeletal, smectitic, isohyperthermic Lithic Ustorthents.

Drainage and permeability: Well drained with moderately slow permeability.

Use and vegetation: Forest and grasslands.

Distribution and extent: Occurs extensively (4678 ha) on gently to steeply sloping toluscones and distributed in north eastern, eastern and southern regions of Union Territory (1:5000 scale of mapping).

Series proposed: National Bureau of Soil Survey and Land Use Planning, Nagpur, 1980.

Interpretation:
   Interpretative grouping:
   i)   Land capability subclass   VIes
   ii)   Land Irrigability sub class   6t
   iii)   Productivity potential   5
- These soils are suitable for grasses, millets.

Soil datasets:

Horizon	Depth (cm)	Particle-size class and its range of diameter (mm)								Coarse fragments >2mm % of whole soil
		Total			Sand					
		Sand (2.0-0.5)	Silt (0.5-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	
A	0-17	25.6	25.0	53.4	1.2	1.3	1.9	3.1	14.1	59
Bw1	17-36	16.7	29.0	54.3	0.5	0.8	1.3	2.6	11.5	52
Bw2	36-60	14.9	27.0	58.1	1.2	1.1	1.6	2.8	8.2	52
C1	60-80	17.5	23.2	59.3	1.8	1.6	2.3	3.2	8.6	65

Depth (cm)	Organic carbon (%)	CaCO$_3$ (%)	EC.(1:2.5, soil : water) (dS m^{-1})	pH soil : water (1:2.5) H$_2$O	Bulk density (Mg m^{-3})	Water retention		Ratio	
						0.03 Mpa (%)	1.5 Mpa (%)	CEC/ Clay	1.5 Mpa/ Clay
0-17	2.40	Nil	<0.2	5.7	1.60	33.8	18.9	0.78	0.35
17-36	1.61	Nil	<0.2	5.6	1.61	33.3	22.2	0.79	0.40
36-60	0.93	Nil	<0.2	5.7	1.60	34.6	24.0	0.76	0.41
60-80	0.59	Nil	<0.2	5.8	Nd	38.4	24.2	0.76	0.40

Depth (cm)	Exchangeable cations					CEC	Base saturation (%)
	Ca	Mg	Na	K	Sum		
	<------------------------------------ cmol(+)kg^{-1}------------------------------>						
0-17	23.0	8.0	0.40	0.64	32.14	41.7	77.0
17-36	26.0	7.0	0.50	0.50	34.00	42.9	79.0
36-60	28.0	6.0	0.54	0.47	35.01	43.9	79.7
60-80	27.0	6.0	0.54	0.40	33.94	45.2	75.1

Source: Challa, O. (2008). Soil Series of Dadra and Nagar Haveli. NBSS Publ. NBSS&LUP, Nagpur, 59p.

2.56 Soil Series: AESR 19.2

Central and South Sahyadris, hot moist subhumid to humid transitional ESR with deep, loamy to clayey Red and Lateritic soils, low to medium AWC and LGP 210-270 days (E2Cm/ B7(9)

2.56.1 CHIMPUKKAD SERIES

The Chimpukkad series is a member of the fine-loamy, mixed, isohyperthermic family of Ultic Haplustalfs. Typically, Chimpukkad soils have yellowish red, very strongly acid Ap horizons and dark brown, strongly to very strongly acid, sandy loam to sandy clay loam B horizons over hard iron stone.

Water balance diagram
Palakkad, Kerala
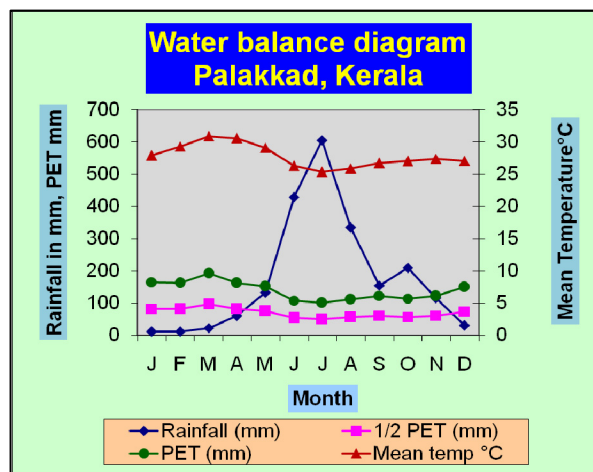
Typifying pedon: Chimpukkad sandy clay loam – cultivated

Ap   0-15 cm --- Yellowish red (5YR 4/6 M) sandy clay loam; moderate medium subangular blocky structure; friable, sticky and slightly plastic; few fine roots; few fine iron concretions; very strongly acid (pH 4.1); clear smooth boundary.

AB   15-40 cm --- Dark brown (7.5YR 3/4M) sandy loam; moderate medium subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; few fine iron concretions; very strongly acid (pH 4.7); clear smooth boundary.

Bt1   40-68 cm --- Dark brown (7.5YR 4/4 M) sandy clay loam; moderate medium subangular blocky structure; friable, sticky and slightly plastic; few fine roots; thin continuous clay cutans; few fine iron concretions; very strongly acid (pH 4.9); clear smooth boundary.

Bt2   68-95 cm --- Dark brown (7.5YR 4/4 M) sandy clay loam; moderate medium subangular blocky structure; friable, sticky and slightly plastic; thin broken clay cutans; common fine and medium iron concretions; strongly acid (pH 5.1); abrupt smooth boundary.

R   95 cm --- Hard iron stone.

Type location: 10°44'03" N, 76°31'22" E; village Chimpukkad, panchayat Kuthannur, tehsil Alathur, district Palakkad, Kerala.

Range in characteristics: The thickness of the solum ranges from 60 to 95 cm. The Ap horizon is 13 to 19 cm thick. Its texture is gravelly sandy loam to sand clay. Its colour is in the hue 10YR and 5YR, value 3 to 4 and chroma 4 to 6. The structure is dominantly sub-angular blocky. The B horizon is 41 to 80 cm thick. Its texture ranges from sandy clay loam to clay. The colour of the B

horizon is in hue 7.5YR and 5YR, value 3 to 4 and chroma 4 to 6. The clay cutans in this horizon are thin and broken to continuous.

Competing series and their differentiae: Competing soils are those of Padappanal series which are very deep (>150 cm), fine, mixed, isohyperthermic Ultic Haplustalfs.

Geographical setting: The Chimpukkad soils are developed over weathered granite and occur on gently to moderately sloping terrain at an elevation ranging from 60 to 100 m above MSL. The climate is humid tropical with mean annual air temperature of 28°C and mean rainfall of 1842 mm. The estimated MAST is 29.7°C, and the difference between MSST and MWST is 2.1°C.

Geographically associated soils: Paddappanal series which is classified as fine, mixed, isohyperthermic Ultic Haplustalfs.

Drainage and permeability: Well drained with moderate permeability.

Use and vegetation: Extensively cultivated to tapioca.

Distribution and extent: Occurs extensively (1044 ha) on gently to moderately sloping lands and distributed in Kuthannur, Kuzhalmannam and Kottayai panchayat, Kerala (1:50,000 scale of mapping).

Series proposed: National Bureau of Soil Survey and Land Use Planning, Kerala Soil Survey Organisation and Kerala Agricultural University, (January, 2006).

Interpretation:
   Interpretative grouping

i.	Land capability subclass	IIIs
ii.	Land Irrigability sub class	3s

- These soils are suitable for plantation crops under bench terraces.
- Fertility capability classification unit : Laeio (Loamy texture, Al toxicity, low CEC, P fixation, low organic carbon content)

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
		<-- % of <2 mm -->									
Ap	0-15	65.1	14.1	20.8	7.8	13.5	15.3	19.4	9.1	5.3	8.8
AB	15-40	72.3	9.0	18.7	12.9	19.2	15.3	17.9	7.0	3.0	6.0
Bt1	40-68	64.4	8.3	27.3	11.7	14.8	14.1	16.5	7.3	2.7	5.6
Bt2	68-95	60.5	6.9	32.6	16.3	14.3	14.1	10.4	5.4	2.1	4.8

Depth (cm)	Organic carbon (%)	pH			E.C. (dS m^{-1})
		(1:2.5) Water	(1:5) 0.01 M CaCl$_2$	(1:2.5) 1.0 M KCl	
0-15	0.46	4.1	4.0	4.0	0.07
15-40	0.31	4.7	4.2	4.2	0.03
40-68	0.24	4.9	4.4	4.3	0.03
68-95	0.32	5.1	4.6	4.4	0.03

Depth (cm)	Exchangeable bases					Acidity			CEC			Ratio CEC/ Clay	Base saturation (NH$_4$OAc)[3]	Base saturation (sum of cations)[4]
	Ca	Mg	Na	K	Total	BaCl$_2^-$ TEA extract	1.0 N KCl exch.		NH$_4$OAc (pH 7.0)	Sum of cations[1]	ECEC[2]			
							H$^+$	Al^{3+}						
	<------------------------- cmol (+) kg^{-1} soil ------------------------->												-------- (%) -----------	
0-15	0.8	0.4	0.01	0.14	1.35	5.8	0.2	1.9	5.8	7.15	3.25	0.28	23	19
15-40	1.7	0.8	0.03	0.12	2.65	5.7	0.1	0.4	5.0	8.35	3.05	0.27	53	32
40-68	2.8	1.4	0.06	0.12	4.38	7.7	0.1	0.2	7.1	12.08	4.58	0.26	62	36
68-95	4.0	2.4	0.11	0.11	6.62	7.9	0.2	0.1	9.0	14.52	6.72	0.28	74	46

Depth (cm)	Available nutrients								
	N	P$_2$O$_5$	K$_2$O	S	Fe	Mn	Cu	Zn	B
	kg ha^{-1}			mg kg^{-1} soil					
0-15	284.2	58.2	151.2	42.5	16.58	24.89	0.50	0.78	0.14
15-40	299.2	50.4	117.4	113.3	26.38	49.11	0.90	0.52	0.07
40-68	314.0	48.2	110.1	54.2	27.00	45.49	0.62	0.32	0.13
68-95	--	--	--	--	--	--	--	--	--

[1]Summation of total of exchangeable bases plus BaCl$_2$ - TEA extractable acidity
[2]Summation of total exchangeable bases plus 1.0 N KCl exchangeable Al^{3+}.
[3][Total exchangeable bases/CEC by NH$_4$OAc] x 100
[4][Total exchangeable bases/CEC by cations] x 100

Source: Nair, K.M., Niranjana, K.V., Rajendra Hegde, Sujatha, K., Balachandra, P.V., Padmakumar, D., Premachandran, P.N. and Vadivelu, S. (2006) Soils of Kuthannur Panchayat, NBSS Publ. No. 959, National Bureau of Soil Survey and Land Use Planning, Nagpur, India, p.56.

2.56.2 KARINGANTHODE SERIES

The Karinganthode series is a member of the fine, mixed, isohyperthermic family of Ultic Paleustalfs. Typically, Karinganthode soils have dark reddish brown, strongly acid sandy clay loam Ap horizon and dark red to dark reddish brown, very strongly acid sandy clay loam to sandy clay B horizons.
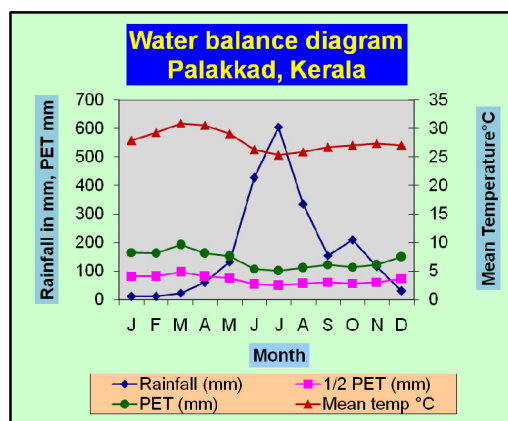
Typifying pedon: Karinganthode sandy clay loam - cultivated

Ap   0-19 cm --- Dark reddish brown (5YR 3/3 M) sandy clay loam; moderate medium subangular blocky structure; friable, sticky and plastic; many very fine and fine roots; strongly acid (pH 5.3); clear smooth boundary.

Bt1   19-48 cm --- Dark red (2.5YR 3/6 M) sandy clay; moderate medium subangular blocky structure; friable, sticky and plastic; common very fine and fine roots; many thick continuous cutans; very strongly acid (pH 4.9); clear smooth boundary.

Bt2   48-76 cm --- Red (2.5YR 4/6 M) sandy clay loam; moderate medium subangular blocky structure; friable, sticky and plastic; common very fine and fine roots; many thick continuous cutans; very strongly acid (pH 4.8); clear smooth boundary.

Bt3   76-98 cm --- Dark reddish brown (5YR 3/4 M) sandy clay; moderate medium subangular blocky structure; friable, sticky and plastic; few very fine and fine roots; many thick continuous cutans; very strongly acid (pH 4.9); gradual smooth boundary.

Bt4   98-125 cm --- Dark reddish brown (5YR 3/3 M) sandy clay; moderate medium subangular blocky structure; friable, sticky and plastic; few very fine and fine roots; many thick continuous cutans; very strongly acid (pH 5.0); gradual smooth boundary.

Bt5   125-152 cm --- Dark reddish brown (5YR 3/4 M) sandy clay; moderate medium subangular blocky structure; friable, sticky and plastic; many thick continuous cutans; very strongly acid (pH 5.0).

Type location: 10°42'38" N, 76°29'59" E; village Karinganthode, panchayat Kuthannur, tehsil Alathur, district Palakkad, Kerala.

Range in characteristics: The thickness of the solum is more than 150 cm. The thickness of Ap horizon is 7 to 22 cm thick. Its texture is loamy sand to clay. Its colour is in the hue 7.5YR to 2.5YR with value 3 to 4 and chroma 4 to 6. The thickness of the B horizon is 129 to 142 cm. Its texture is sandy clay to clay. Its colour is in 5YR to 2.5YR hue with value 3 to 4 and chroma 3 to 6.

Geographical setting: The Karinganthode soil series are formed on granitic rocks and occur on gently to moderately sloping land at an elevation of 80 to 155 m above MSL. The climate is humid subtropical with mean annual air temperature of 28.0°C and mean annual rainfall of 1842

mm. The estimated MAST is 29.7^{o}C, MSST 31.7^{o}C and MWST 29.6^{o}C. The difference between MSST and MWST is 2.1^{o}C.

Geographically associated soils: These are soils of Chimpukkad, fine-loamy, mixed, isohyperthermic Ultic Haplustalfs.

Drainage and permeability: Well drained with moderate permeability.

Use and vegetation: Larger area is under forest and some patches are under rubber plantations.

Distribution and extent: Occurs extensively (2692 ha) on gently to moderately sloping lands and distributed in Kuthannur and Kuzhalmannam panchayat, Palakkad district, Kerala.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Kerala Soil Survey Organisation and Kerala Agricultural University, (January, 2006).

Interpretation:
   Interpretative grouping
   i)   Land capability subclass   IIIs
   ii)   Land Irrigability sub class   4st
- These soils are suitable for plantation crops under bench terraces.
- Fertility capability classification unit: LCai (Loamy and clayey, Al toxicity, P fixation).

Soil datasets:

Hori-zon	Depth (cm)	Size class and particle diameter (mm)									
		Total			Sand					Silt	
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Very coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	Fine (0.25-0.1)	Very fine (0.1-0.05)	(0.05-0.02)	(0.02-0.002)
		<-- % of <2 mm -->									
Ap	0-19	55.5	11.0	33.5	5.5	12.2	13.4	15.5	8.9	4.0	7.0
Bt1	19-48	51.7	11.9	36.4	5.3	9.9	13.7	17.7	5.1	3.3	8.6
Bt2	48-76	56.0	10.3	33.7	6.6	13.0	13.4	16.6	6.4	2.1	8.2
Bt3	76-98	53.1	9.8	37.1	6.0	9.2	12.5	18.1	7.3	2.4	7.4
Bt4	98-125	49.9	10.8	39.3	5.9	9.0	13.8	14.4	6.8	2.1	8.7
Bt5	125-152	52.5	8.9	38.6	8.2	12.5	13.3	13.1	5.4	1.2	7.7

Depth (cm)	Organic carbon (%)	pH			E.C. (dS m^{-1})
		(1:2.5) Water	(1:5) 0.01 M CaCl$_2$	(1:2.5) 1.0 M KCl	
0-19	0.93	5.3	4.8	4.4	0.03
19-48	0.85	4.9	4.5	4.3	0.03
48-76	0.98	4.8	4.4	4.2	0.03
76-98	1.04	4.9	4.4	4.3	0.02
98-125	1.14	5.0	4.5	4.3	0.03
125-152	1.03	5.0	4.6	4.3	0.02

Depth (cm)	Exchangeable bases					Acidity			CEC			Ratio CEC/Clay	Base saturation (NH$_4$OAc)[3]	Base saturation (sum of cations)[4]
	Ca	Mg	Na	K	Total	BaCl$_2$-TEA extract	1.0 N KCl exch.		NH$_4$OAc (pH 7.0)	Sum of cations[1]	ECEC[2]			
							H$^+$	Al^{3+}						
	-------------------------- cmol (+) kg^{-1} soil --------------------------											--------- (%) ------------		
0-19	3.5	1.6	0.05	0.14	5.29	--	0.1	0.3	10.1	--	5.59	0.30	52	--
19-48	2.9	1.5	0.05	0.11	4.56	--	0.1	0.6	10.2	--	5.16	0.28	45	--
48-76	2.0	1.4	0.05	0.10	3.55	--	0.1	0.9	9.7	--	4.45	0.29	37	--
76-98	3.1	1.4	0.07	0.11	4.68	--	0.2	0.7	10.7	--	5.78	0.29	44	--
98-125	4.8	1.5	0.09	0.12	6.51	--	0.2	0.5	11.9	--	7.01	0.30	55	--
125-152	4.3	1.5	0.07	0.13	6.00	--	0.2	0.4	10.7	--	6.40	0.28	56	--

Depth (cm)	Available nutrients								
	N	P$_2$O$_5$	K$_2$O	S	Fe	Mn	Cu	Zn	B
	kg ha^{-1}			mg kg^{-1} soil					
0-19	336.6	48.2	121.9	48.3	12.4	22.6	0.5	1.2	0.3
19-48	351.5	44.4	100.9	25.0	14.3	34.1	0.5	1.0	0.2
48-76	269.3	39.2	93.0	57.5	14.4	22.9	0.5	1.0	0.2
76-98	--	--	--	--	--	--	--	--	--
98-125	--	--	--	--	--	--	--	--	--
125-152	--	--	--	--	--	--	--	--	--

[1]Summation of total of exchangeable bases plus BaCl$_2$ - TEA extractable acidity
[2]Summation of total exchangeable bases plus 1.0 N KCl exchanageable Al^{3+}.
[3][Total exchangeable bases/CEC by NH$_4$OAc] x 100
[4][Total exchangeable bases/CEC by cations] x 100

Source: Nair, K.M., Niranjana, K.V., Rajendra Hegde, Sujatha, K., Balachandra, P.V., Padmakumar, D., Premachandran, P.N. and Vadivelu, S. (2006) Soils of Kuthannur Panchayat, NBSS Publ. No. 959, National Bureau of Soil Survey and Land Use Planning, Nagpur, India, p.56.

2.57 Soil Series: AESR 19.3

Konkan, Karnataka and Kerala Coastal plain, hot humid to per humid transitional ESR with deep, clayey to loamy acidic coastal alluvium-derived soils, low AWC and LGP 240-270 days (R7A(B8(7)

2.57.1 PALGHAR SERIES

The Palghar series is a member of the fine, montmorillonitic (cal), isohyperthermic family of Vertic Halaquepts. Typically, Palghar soils have dark grayish brown, moderately saline, clayey A horizon, dark grayish brown, moderately to strongly saline, clayey B horizon underlying by weathered basalt (Cr horizon).
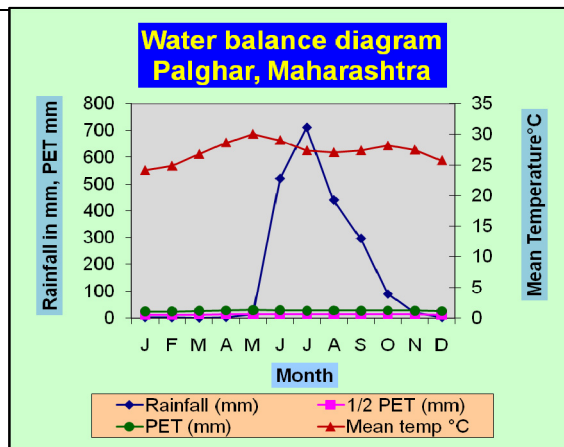
Typifying pedon: Palghar Clay – cultivated

Ap   0-15 cm -- Dark grayish brown (10YR 3/2 D & M) clay; coarse strong subangular blocky structure, hard, firm, very sticky and very plastic; fine many roots; slight effervescence; (pH 6.9), clear smooth boundary, moderately saline.

Bw1   15-35 cm -- Dark grayish brown (10YR 3/2 M) clay; coarse subangular blocky structure, firm, very sticky and very plastic; slight effervescence; (pH 7.6) gradual smooth boundary, moderately saline.

Bw2   35-53 cm -- Dark grayish brown (10 YR 3/2 M) clay; coarse strong angular blocky structure with pressure faces; firm, very sticky and very plastic; slight effervescence; (pH 7.8) gradual smooth boundary, moderate tom strong salinity.

Cr   53 cm -- Weathered basalt

Type location: 19°32'00″ N, 72°45'30″E; Village Bhurapada, Tehsil Palghar, District Thane, Maharashtra.

Range in characteristics: The solum is 53 cm thick. The estimated MAST is 28.8°C, MSST is 27.9°C and MWST is 25.3°C. Moisture regime is ustic. The A horizon is 15 cm thick. Its colour is in hue 10 YR, value 3 and chroma 2. The texture is clayey. The structure in the surface layer is coarse, strong subangular blocky. The B horizon is 15 to 53 cm thick. Its colour is in hue 10 YR value 3 and chroma 2. The texture is clayey with pressure faces. The B horizon is underlain by C horizon of weathered basalt.

Competing soils and their taxonomy:
- Masoli series: Fine-loamy mixed, isohyperthermic, calcareous, Typic Haplustepts. (Rep. No. 96/03/449, Agric. Dept. M. S.)

- Kawadkurd series: fine, smectitic, isohyperthermic, Vertic Haplustepts (Rep. No. 417; ICAR)
- Arjunli series: Fine, smectitic, isohyperthermic, Vertic Haplustepts (Rep. No. 417; ICAR)
- Akloli series: Fine, smectitic, isohyperthermic, Vertic Haplustepts (Rep. No. 47; ICAR)

Geographic setting: The Palghar soil series are formed in Basaltic alluvium and occur on very gently sloping (1-3%) land at an elevation of 70 m above MSL. The climate is humid with mean annual air temperature of 27.3°C and mean rainfall of 2477 mm. The estimated MAST is 29.3°C, MSST 31.1°Cand MWST 28.2°C. The difference between MSST and MWST is 2.9°C.

Geographically associated soils: Tanashi series: Fine, mixed, calcareous, isohyperthermic Vertic Haplustepts

Drainage and permeability: Poorly drained, slow permeability.

Land use and vegetation: Paddy; Khair, Vad, Mangrove.

Distribution and extent: Extensive in Thane (67,290 ha) and Raigad (22,710 ha) districts. (Mapping unit 004)

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Nagpur.

Interpretation: These soils have 53 cm deep solum and are developed near the creeks. These are moderately to strongly saline and the salinity is developed due to inundation of these soils during high tide. These are poorly drained soils.

a) Interpretative grouping:
   i)   Land capability sub-class   IIIs
   ii) Irrigability class   Marginally suitable (S3)
   iii) Productivity potential   Moderate

b)   Yield: based on data from Farmers' field:

Crops	Farmer,s practice	Improved practice
	-----------------------(yieldq/ha)----------------------------	
Paddy	10-12	20-21

Soil datasets:

Horizon	Depth (cm)	Particle size diameter (mm)			Coarse fragments (>2mm) % of whole soil
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	
		◄-------------------(%)----------------►			
Ap	0-15	13.9	30.7	55.4	2-3
Bw1	15-35	11.8	30.2	58.4	2-3
Bw2	35-53	9.4	28.9	61.7	5-8
Cr	53+	------------------Weathered basalt------------------			

Depth (cm)	Organic carbon (%)	CaCO$_3$ (%)	E. C. (1:2.5, soil: water dSm^{-1})	pH soil: water (1:2.5) H$_2$O	Water retention	
					33 kPa	1500 kPa
0-15	0.79	3.9	6.5	6.9	33.2	23.9
15-35	0.67	2.9	5.3	7.6	33.5	24.3
35-53	0.51	4.0	8.5	7.8	34.9	24.8
53+	--------------------------------Weathered basalt---------------------------------------					

Depth (cm)	Exchangeable cations					C.E.C.	Base saturation (%)
	Ca	Mg	Na	K	Sum		
	◄---------------------------------cmol(+)kg^{-1}----------------------------►						
0-15	11.00	15.01	17.25	1.50	44.76	46.3	96.6
15-35	8.6	10.72	21.50	2.25	42.95	47.5	90.4
35-53	9.1	13.03	29.25	2.50	53.88	54.7	98.5
53+	---------------------------------Weathered basalt------------------------						

Source: Challa, O., Gajbhiye, K. S. And Velayutham, M. (1999). "Soil series of Maharashtra" NBSS Publ. No. 79, NBSS&LUP, Nagpur, 428p.

2.57.2 VIRTHAN SERIES

The Virthan series is a member of the fine, smectitic, isohyperthermic family of Entic Haplusterts. Typically, Virthan soils have brown to dark grayish brown, slightly alkaline, clayey A horizon and dark grayish brown, slightly alkaline, clayey B horizons.
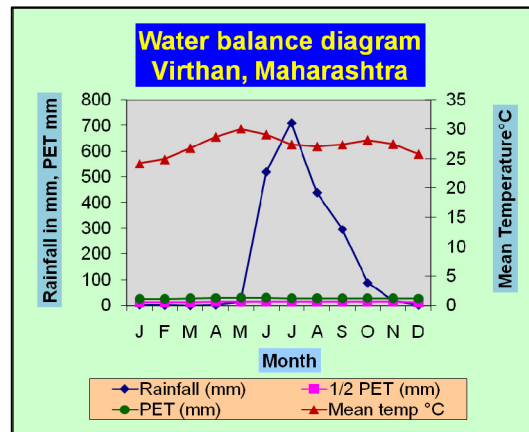
Typifying pedon: Virthan Clay – cultivated

Ap 0-17 cm -- Brown (10YR 5/3 D) and dark grayish brown (10 YR 3/2 M); clay, medium, moderate subangular blocky structure; hard, friable, very sticky and very plastic; fine many roots; (pH 7.8) strong effervescence; clear smooth boundary.

Al2 17-43 cm -- Dark grayish brown (2.5Y 4/2 D & M) clay; medium , moderate subangular blocky structure; hard, friable very sticky and very plastic; fine common roots; fine many roots; (pH 8.0) strong effervescence; gradual smooth boundary.

Bw 43-61 cm -- Dark grayish brown (2.5 Y 4/2 D & M) clay; medium, moderate, subangular blocky structure with pressure faces; very hard, friable, very sticky and very plastic; fine common roots; fine , many roots; (pH 8.1) strong effervescence; clear wavy boundary..

Bss 1 61-85 cm -- Dark grayish brown (2.5 Y 4/2 D & M) clay; coarse, strong angular blocky structure with slickensides; very hard, friable, very sticky and very plastic; fine many roots; pH 8.1; strong effervescence; clear wavy boundary.

Bss2 85 cm -- Dark grayish brown (2.52 Y 4/2 D & M) clay; coarse strong angular blocky structure with slickensides; very hard, friable, very sticky and very plastic; fine many roots; (pH 8.1) strong effervescence.

Type location: $19^o32'20''$ N, $72^o44'30''$E; Village Virthan, Tehsil Palghar, District Thane, Maharashtra.

Range in characteristics: The thickness of solum is more than 85 cm. The estimated MAST is 28.8^oC, MSST 27.9^oC and MWST 25.3^oC. Moisture regime is udic. The A horizon is 43 cm thick. Its colour is in hue of 10 YR and 2.5 Y, value 4 and chroma 2 to 3. The texture is clayey. The structure is subangular blocky to angular blocky. The B horizon is 42 cm thick. Its colour is in hue 2.5 Y, value 4 and chroma 2. The texture is clayey and the structure is angular blocky with pressure faces and slickensides. Both the A and the B horizon show strong effervescence.

Competing soils and their taxonomy:
• Savad series: Fine, smectitic, isohyperthermic, Typic Haplusterts (Rep. No. 417, ICAR)

Geographic setting: The Virthan soil series are formed in basaltic alluvium and occur on gently sloping (3-8%) land at an elevation of 30 m above MSL. The climate is humid with mean annual air temperature of 27.3^oC and mean rainfall of 2477 mm. The estimated MAST is 29.3^oC, MSST 31.1°Cand MWST 28.2°C. The difference between MSST and MWST is 2.9^oC.

Geographically associated soils: Palghar series: Fine, smectitic (cal.), isohyperthermic Vertic Halaquepts.

Drainage and permeability: Moderately well drained and moderately slow permeability.

Land use and vegetation: Paddy, Groundnut, Nachni; Khair,

Distribution and extent: Extensive in Thane (45,540 ha) and Raigad (17,500 ha) districts. (Mapping unit 004)

Interpretation: The solum is very deep and soils are developed due to the alluvial deposits near the swampy areas of creeks. These soils are moderately well drained with moderately slow permeability. These soils can be used for paddy under low tide.

a) Interpretative grouping:
  i) Land capability sub-class   IIs
  ii) Irrigability class   moderately suitable (S2)
  iii) Productivity potential   Good

b) Yield: Based on data from Farmers' field:

Crops	Farmers' practices	Improved practices
	←---------------(yield q/ha)-------------------- →	
Paddy	10-12	20.2-20.5
Groundnut	8-10	9.0-11.0
Nachni	8-10	8.8-8.9

Soil datasets:

Horizon	Depth (cm)	Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Coarse fragments (>2mm) % of whole soil
		←----------------(%)-------------------→			
Ap	0-17	16.7	31.4	51.9	1-2
Al2	17-43	15.0	29.9	55.1	1-2
Bw	43-61	14.6	29.0	56.4	1-2
Bss 1	61-85	13.8	27.6	56.6	1-2
Bss2	85+	12.2	25.8	56.6	1-2

Depth (cm)	Organic carbon (%)	CaCO$_3$ (%)	E. C. (1:2.5, soil: water dSm^{-1})	pH H$_2$O	pH KCl	Bulk density (Mg m^{-1})	Water retention 33 kPa	Water retention 1500 kPa
0-17	1.89	3.8	0.38	7.9	-	1.30	28.9	17.3
17-43	0.71	3.8	0.35	8.1	-	1.24	29.4	17.0
43-61	0.64	3.6	0.20	8.4	-	1.86	29.7	18.1
61-85	0.58	3.5	0.20	8.4	-	1.47	30.2	18.7
85+	0.49	4.1	0.20	8.4	-	1.94	32.4	21.7

Depth (cm)	Ca	Mg	Na	K	Sum	C.E.C.	Base saturation (%)
	←-------------------cmol(+)kg^{-1}--------------→						
0-17	28.4	4.62	0.55	0.51	34.08	38.9	87.6
17-43	27.3	4.12	0.54	0.50	32.46	37.6	86.3
43-61	28.8	4.45	0.33	0.40	33.98	40.8	83.3
61-85	27.5	4.78	0.42	0.36	33.06	41.8	79.7
85+	27.4	4.62	0.52	0.38	32.96	36.3	90.7

Source: Challa, O., Gajbhiye, K. S. And Velayutham, M. (1999). "Soil series of Maharashtra" NBSS Publ. No. 79, NBSS&LUP, Nagpur, 428p.

2.58 Soil Series: AESR 20.1

Andaman and Nicobar group of Islands, hot perhumid ESR with shallow to medium deep, loamy to clayey Red and Yellow and Red Loamy soils, low to medium AWC and LGP 300 days (T3A10)

2.58.1 BASANTHIPUR SERIES

The Basanthipur series is a member of the fine-loamy, mixed, isohyperthermic family of Typic Tropudalfs. Typically, Basanthipur soils have brown, strongly acidic, silty clay loam A horizon; dark yellowish brown to yellowish brown, very strongly acidic, silty clay loam to silty clay B horizons and yellowish brown, very strongly acidic, silty clay loam C horizon.

Water balance diagram Port Blair, Andaman & Nikobar
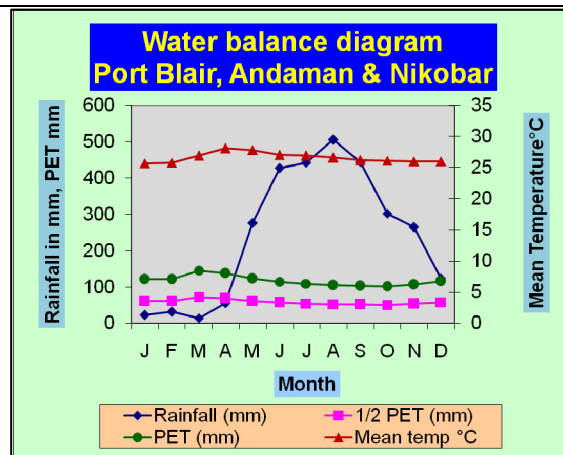
Typifying pedon : Basanthipur series -

A   0-7 cm -- Brown (10 YR 4/3 M); silty clay loam; strong medium subangular blocky structure; firm, sticky and slightly plastic; fine and medium roots common; coarse and medium pores common; 10 to 15 per cent fine gravels; strongly acidic (pH 5.3); clear wavy boundary.

Bt1   7-29 cm -- Dark yellowish brown (10YR 4/4 M); silty clay loam; strong medium subangular blocky structure; firm, sticky and slightly plastic; medium and coarse pores common; fine and medium common roots; common and few coarse roots; thin argillans in patches; 20 to 25 per cent fine gravels; very strongly acidic (pH 4.9); gradual wavy boundary.

Bt2   29-50 cm -- Yellowish brown (10 YR 5/6 M); silty clay; strong medium subangular blocky structure; common medium and few coarse roots; fine and medium pores common; thin argillans in patches; 30-35 per cent fine gravels; very strongly acidic (pH 4.7) gradual wavy boundary.

B3   50-75 cm -- Yellowish brown (10 YR 5/6 M); silty clay; moderate medium subangular blocky structure; firm, sticky and plastic; few coarse and many fine pores; many fine and few coarse roots; 30 to 35 per cent fine gravels; very strongly acidic (pH 4.9) gradual wavy boundary.

C   75-100 cm -- Yellowish brown (10 YR 5/6 M); silty clay loam; weathered parent materials: very strongly acidic (pH 4.9)

Type Location: 12°44′N, 92°52′45″E; Village Basanthipur; Tehsil Mayabunder; District North Andaman; Andaman & Nicobar Island

Geographic setting: The Basanthipur soil series are formed on weathered sandstone and occur on gently sloping land (3-5 per cent slope) at an elevation of 95 m above MSL. The climate is humid with mean annual air temperature of 26.6°C and mean rainfall of 2477 mm. The estimated MAST is 30.1°C, MSST 29.8°Cand MWST 28.6°C. The difference between MSST and MWST is 1.2°C.

Drainage and permeability **:** Well drained

Land use and vegetation: Mixed forest species

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)		
		Total		
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)
		(% of <2mm)		
A	0-7	25.2	42.5	32.3
Bt1	7-29	26.9	40.0	33.1
Bt2	29-50	11.7	44.6	43.7
B3	50-75	10.5	47.5	42.0
C	75-100	6.2	58.0	35.8

Depth (cm)	Organic carbon (%)	Carbonate as $CaCO_3$	pH Soil:water (1:2.5)
0-7	4.1	nil	5.3
7-29	0.91	nil	4.9
29-50	1.74	nil	4.7
50-75	0.72	nil	4.9
75-100	0.41	nil	4.9

Depth (cm)	Exchangeable cations					CEC (cmol $(p+)kg^{-1}$)	Base saturation (%)
	Ca	Mg	Na	K	Sum Bases		
	-------------------me/100g soil--------------------						
0-7	10.45	7.08	0.28	0.26	18.07	17.43	103.7
7-29	5.96	5.81	0.28	0.17	12.22	24.24	50.4
29-50	5.75	7.3	0.0	0.0	13.05	24.9	52.4
50-75	6.01	8.81	0.45	0.36	15.63	18.5	84.5
75-100	5.89	11.0	0.5	0.41	17.8	23.13	77.0

Source: Anonymous, Soil survey report of Andaman and Nicobar Island

2.58.2 GOVINDAPUR SERIES

The Govindpur series is a member of the fine-loamy, mixed, hyperthermic family of Typic Hapludalfs. Typically, Govindpur soils have dark grayish brown, very strongly acidic, silty clay loam A horizon and brown to yellowish brown, strongly acidic to very strongly acidic, silty loam to silty clay loam B horizons underlined by weathered sanstone.
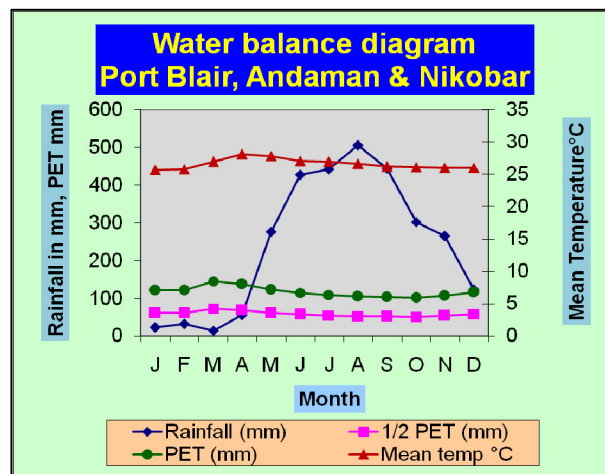
Typifying pedon: Govindapur series -

A   0-5 cm -- Dark grayish brown (10 YR 4/2 M); silty clay loam; weak medium subangular structure; firm, sticky and slightly plastic; many medium and coarse pores; many medium and few coarse roots; 5 to 10 per cent fine gravels; very strongly acidic (pH 4.9) clear smooth boundary.

Bw   5-21 cm -- Brown (10 YR 4/3 M); silty loam; moderate medium subangular blocky structure; firm, sticky and plastic; fine many pores; many coarse and medium roots; 10 to 15 per cent fine gravels; thin patches argillans in patches; strongly acidic (pH 5.2) gradual wavy boundary.

Bt1   21-42 cm -- Yellowish brown (10 YR 5/6 M); silty clay loam, moderate medium subangular blocky structure; firm, sticky and plastic; few coarse and common medium and few coarse roots; 10 to 15 per cent fine gravels; thin argillans in patches; strongly acidic (pH 5.1) gradual wavy boundary.

Bt2   42-66 cm -- Yellowish brown (10 YR 5/8 M); silty clay loam; moderate medium subangular blocky structure; firm, sticky and plastic few fine pores; few coarse and many fine roots; 20 to 25 per cent fine gravels; thin patches; very strongly acidic (pH 5.0) gradual wavy boundary.

Bt3   66-95 cm -- Yellowish brown (10 YR 5/6 M); silty clay loam; moderate medium subangular blocky structure; firm, sticky and plastic fine many pores; few coarse and many fine roots; 20 to 25 per cent coarse and fine gravels; thin argillans in patches; very strongly acidic (pH 5.0) gradual wavy boundary .

C   95-125 cm -- Weathered sandstone

Type Location: Village Govindpur; Tehsil Mayabunder; District North Andaman; Andaman & Nicobar Island

Geographic setting: The Govindpur soils are formed on weathered sandstone and occur on gently sloping land (3-5 per cent slope) at an elevation of 45 m above MSL. The climate is humid

with mean annual air temperature of 26.6^{o}C and mean rainfall of 2477 mm. The estimated MAST is 30.1^{o}C, MSST 29.8°Cand MWST 28.6°C. The difference between MSST and MWST is 1.2^{o}C.

Drainage and permeability : Well drained

Land use and vegetation: Mixed forest vegetation

Soil datasets:

Horizon	Depth (cm)	Size class and particle diameter (mm)			Coarse fragments > 2 mm % of whole soil	Textural class (USDA)
		Total				
		Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
		(% of <2mm)				
A	0-5	35.9	37.3	26.8	10	cl
Bw	5-21	40.1	34.2	25.7	15	cl
Bt1	21-42	27	41.9	31.8	15	cl
Bt2	42-66	29.1	36.5	34.4	20	cl
Bt3	66-95	30.5	35.7	33.8	25	cl
C	95-125	7	51.8	41.2		

Depth (cm)	Organic carbon (%)	Carbonate as CaCO$_3$	pH Soil:regent (1:2.5)
0-5	3.02	nil	4.9
5-21	1.86	nil	5.2
21-42	1.05	nil	5.1
42-66	0.84	nil	5.0
66-95	0.56	nil	5.0
95-125	0.49	nil	5.7

Depth (cm)	Exchangeable cations					CEC (cmol(p$^+$)kg^{-1}) soil	Base saturation (%)
	Ca	Mg	Na	K	Sum Bases		
	------------------me/100g soil-------------						
0-5	12.16	5.22	0.31	0.45	18.14	28.2	64.3
5-21	11.2	4.18	0.34	0.39	16.11	21.2	76.0
21-42	12.48	6.82	0.33	0.36	19.99	16.83	118.8
42-66	9.53	7.86	0.38	0.36	18.13	25.1	72.2
66-95	8.83	9.04	0.46	0.34	18.67	26.2	71.3
95-125	12.04	16.36	1.06	0.35	29.81	15.06	197.9

Source: Anonymous, Soil survey report of Andaman and Nicobar Island

2.59 Soil Series: AESR 20.2

Level Lakshadweep and group of Island, hot humid ESR with shallow to medium deep loamy to sandy Black, sandy and Littoral soils, low to medium AWC and LGP 240-270 days (U16B8)

2.59.1 KAVARATTI SERIES

Kavaratti series is a member of the carbonatic, isohyperthermic family of Typic Ustipsamments. These soils are deep and have very dark grayish brown, grayish brown and dark brown Ap horizons and very dark grayish brown, grayish brown and light brownish grey to white C horizons over hard coral limestone.

Water balance diagram Minicoy, Lakshdweep
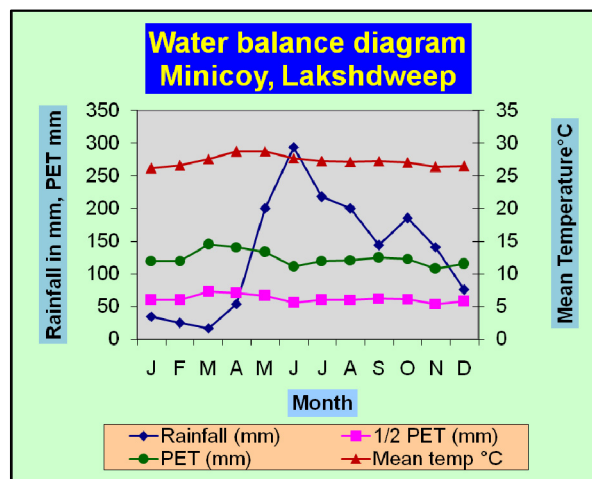
Typifying pedon: Kavaratti sand – cultivated

Ap   0-24 cm -- Greyish brown (10 YR 5/2D) very dark grayish brown (10 YR 4/2), sand; single grain, loose, non-sticky and non-plastic; many coarse pores; above 5% fine gravel, fine common roots; pH 8.4; violent effervescence; clear smooth boundary.

C1   24-50 cm -- Greyish brown (10 YR 5/2D) very dark grayish brown (10 YR 4/2 M), sand; single grain, loose, non-sticky and non-plastic; many fine pores; about 10% fine gravel, common fine roots; pH 8.6; violent effervescence; clear smooth boundary.

C2   50-80 cm -- Light brownish grey (10 YR 6/2D) greyish brown (10 YR 5/2 M), sand; single grain, loose, non-sticky and non-plastic; common fine roots; pH 8.9; violent effervescence; clear smooth boundary.

C3   80-110 cm -- Greyish brown (10 YR 5/2D) dark grayish brown (10 YR 4/2 M), sand; single grain, loose, non-sticky and non-plastic; common fine roots; pH 8.9; violent effervescence; abrupt smooth boundary.

R   Coral rock.

Type location: Plot No. 4P of Kavaratti Island.

Range in characteristics: The solum depth ranges from 101-150 cm. The colour of Ap horizon range from very dark grayish brown to dark brown; colours of the C horizon ranges from dark grayish brown to light brownish grey and white. Colours are in 10 YR hue and values range from 3 to 6 and chroma from 1 to 3 for Ap horizon. Colour of the C horizon ranges from 4 to 8 and chroma from 1 to 3.

Geographic setting: Kavaratti soils occur on nearly level to gently sloping landscape at an elevation of less than 5 m above MSL in the islands of Agatti, Kalpeni, Minicoy, Andrott, Amini,

and Kavaratti. The climate is humid tropical with a mean annual rainfall of 1255 mm (Agatti) to 1934 mm (Andrott) and mean annual temperature of 27.3° to 27.9°C. The estimated MAST is 31.1°C, MSST 30.6°Cand MWST 29.3°C. The difference between MSST and MWST is 1.3°C.

Geographically associated soils: Principal associated soils are Chetlat series, which is very deep, but otherwise similar in texture and colour.

Drainage and permeability: These soils are excessively drained with rapid permeability.

Land use and vegetation: Cultivated to coconut, banana, bread fruit and drumstick.

Distribution and extent: Distributed in the islands of Kavaratti, Kalpeni, Agatti, Minicoy, Amini and Andrott islands.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Banglore, 1995.

Interpretation: The soils are very deep and are of coral material. The calcium carbonate equivalent range from 92 to 98 per cent. The sandy nature of soil and the presence of high amounts of calcium carbonate limits the choice of crops. Other than cocnut, bread fruit, drumstick, ber and lime (with special root stock) can be cultivated. Coconut needs application of 500 g N and 1200g K20 per palm.

Interpretative groupings:
      i) Land capability subclass   -   IVs
      ii) Irrigability subclass   -   4s
      iii) Productivity potential   -   Poor

Soil datasets:

Horizon	Depth (cm)	Sand (2.0-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)	Coarse fragments (Vol. %)	Texture	pH 1:2.5 water	ECe 1:2.5 (dSm^{-1})
Ap	0-24	85.7	5.7	8.6	5.0	s	8.4	0.40
C1	24-50	88.0	6.0	6.0	10.0	s	8.6	0.24
C2	50-80	94.9	2.3	2.9	-	s	8.9	0.15
C3	80-110	92.3	2.7	5.0	-	s	8.9	0.18

Depth (cm)	Organic Carbon (%)	CaCO$_3$ equivalent (%)	Ca	Mg	Na	K	CEC cmol(p+)kg^{-1} soil	Base saturation (%)
			------------cmol(p+)kg^{-1} soil-----------					
0-24	0.97	90.9	6.11	0.50	0.45	0.12	3.2	100
24-50	0.69	81.7	6.06	0.37	0.35	0.08	2.1	100
50-80	0.31	92.3	5.05	0.36	0.47	0.02	1.0	100
80-110	0.32	98.3	5.04	0.36	0.37	0.02	1.6	100

Depth (cm)	Organic Carbon (%)	Avail. P$_2$O$_5$ (kg/ha)	Avail. K$_2$O (kg/ha)	Avail. Fe (ppm)	Avail. Mn (ppm)	Avail. Zn (ppm)	Avail. Cu (ppm)
0-24	0.97	445	71	1.67	1.65	0.45	0.33

*Includes   N NH$_4$OAc soluble compounds

Source: Krishnan, P., Naidu, L. G. K., Shamsuddin, V. M., Raghu Mohan, N. G., ehgal, J. and Velayutham, M. (1997). Soils of Lakshdweep: Their kinds, distribution, characterization and interpretations for optimum land use. pp 1-65.

2.59.2 ANDROTT SERIES

Andrott series is a member of th.e coarse loamy, carbonatic, isohyperthermic family of Typic Ustorthents. These soils are moderately shallow to moderately deep and have very dark grayish brown to dark grey and brown Ap horizons and pale brown to light brownish grey and white C horizons.

Water balance diagram Minicoy, Lakshdweep
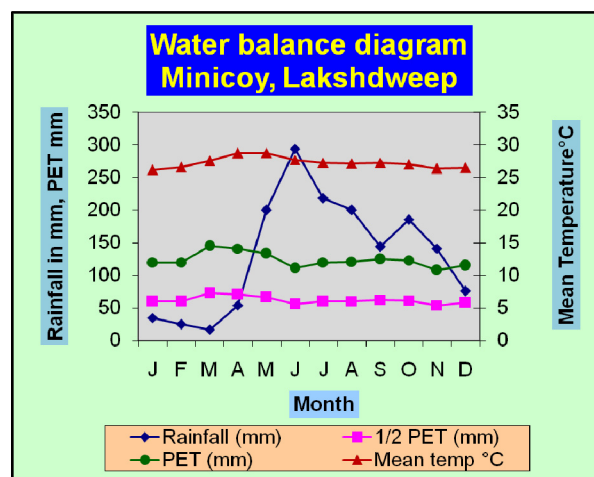
Typifying pedon: Andrott- sandy loam – cultivated

Ap   0-14 cm -- Brown (10 YR 5/3M) sandy loam; weak, medium, subangular blocky structure, friable, slightly sticky and non-plastic; fine to medium common pores; many fine to medium roots; violent effervescence; pH 8.2; clear smooth boundary.

C1   14-26 cm -- Pale brown (10 YR 6/3M) sandy loam; weak, medium, subangular blocky structure, friable, slightly sticky and non-plastic; common, fine to medium pores; common medium roots; violent effervescence; pH 8.4; gradual smooth boundary.

C2   26-44 cm -- Pale brown (10 YR 6/3M) sandy loam; weak, medium, subangular blocky structure, friable, slightly sticky and non-plastic; fine to medium common pores; few medium roots; violent effervescence; pH 8.5; clear wavy boundary.

C3   44-62 cm -- Pale brown (10 YR 6/3M) sandy loam; weak, medium, subangular blocky structure, friable, slightly sticky and non-plastic; fine to medium common pores; few medium roots; violent effervescence; pH 8.4.

62+ cm -- Water table.

Type location: In Plot No. 6A of Andrott Island.

Range in characteristics: Depth of solum ranges from 60 to 100 cm. Depth of the Ap horizon ranges from 11 to 29 cm. Colour of the Ap horizon is in 10 YR hue and value ranges from 3 to 5 and chroma from 2 to 4. Colour of the C horizon is also in 10 YR hue and value ranges from 5 to 8 and chroma from 1 to 3. Texture is sandy loam. Structure is weak, medium, subangular blocky.

Geographic setting: Andrott soils occur in the lowlands of the islands, (Andrott, Agatti, Amini, Kavaratti and Minicoy) and are characterized by the presence of water table between 50 and 75 cm depth. The climate is humid tropical with a mean annual rainfall ranging from 1255 mm (Agatti) to 1934 mm (Andrott) and mean annual temperature of 27.3° to 27.9°C. The temperature regime is isohyperthermic. Considering the position of these soils in the landscape and water saturation for considerable periods of time, the localised moisture regime for these soils is treated as udic. The estimated MAST is 31.1°C, MSST 30.6°C and MWST 29.3°C. The difference between MSST and MWST is 1.3°C.

Geographically associated soils: Principal associated soils are Kavaratti series, which is moderately deep, Typic Ustipsamments.

Drainage and permeability: These soils are imperfectly drained and permeability is rapid.

Land use and vegetation: Cultivated to rice, sugarcane and vegetables.

Distribution and extent: Distributed extensively in the islands of Andrott, Agatti, Kavaratti, Kalpeni and Minicoy.

Series proposed: National Bureau of Soil Survey and Land Use Planning, Regional Centre, Banglore, 1994.

Interpretation: The soils being highly calcareous, growing of cereals should not be encouraged. Vegetable crops like cucurbits, tomato, brinjal and bhindi, banana and legumes can be raised. Green manure crops also raised.

Interpretative groupings:
      i) Land capability subclass   -   IVsw
      ii) Irrigability subclass   -   4sd
      iii) Productivity potential   -   Poor

Soil datasets:

Horizon	Depth (cm)	Sand (2.0-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)	Coarse fragments (Vol. %)	Texture	pH 1:2.5 water	ECe 1:2.5 (dSm^{-1})
Ap	0-14	70.6	19.5	9.9	-	sl	8.2	0.40
C1	14-26	72.7	17.6	9.7	-	sl	8.4	0.24
C2	26-44	64.1	23.8	12.1	-	sl	8.5	0.19
C3	44-62	51.5	32.0	16.5	-	l/sl	8.4	0.18

Depth (cm)	Organic Carbon (%)	CaCO$_3$ Equivalent (%)	Ca	Mg	Na	K	CEC cmol(p+)kg^{-1} soil	Base saturation (%)
			------------cmol(p+)kg^{-1} soil----------					
0-14	1.24	78.0	10.84	0.56	0.15	0.23	3.0	100
14-26	0.87	77.6	10.13	0.24	0.09	0.11	2.2	100
26-44	0.72	78.0	10.51	0.43	0.08	0.03	1.3	100
44-62	0.81	72.5	10.63	0.53	0.07	0.03	1.3	100

Depth (cm)	Organic Carbon (%)	Avail. P$_2$O$_5$ (kg/ha)	Avail. K$_2$O (kg/ha)	Avail. Fe (ppm)	Avail. Mn (ppm)	Avail. Zn (ppm)	Avail. Cu (ppm)
0-14	1.24	125	180	1.47	3.68	0.83	0.04

*Includes N NH$_4$OAc soluble compounds

Source: Krishnan, P., Naidu, L. G. K., Shamsuddin, V. M., Raghu Mohan, N. G., ehgal, J. and Velayutham, M. (1997). Soils of Lakshdweep: Their kinds, distribution, characterization and interpretations for optimum land use. pp 1-65.

3. References:

Anonymus, (2002). Soil Series of Himachal Pradesh . NBSS Publ. No. 91, NBSS&LUP, Nagpur, 177 p.

Challa, O. (2008). Soil Series of Dadra and Nagar Haveli, NBSS Publ. NBSS&LUP, Nagpur, 59p.

Challa, O., Gajbhiye, K. S. and Velayutham, M. (1999). Soil series of Maharashtra, NBSS Publ. No. 79, NBSS&LUP, Nagpur, 428p.

Chamuah, G.S., Walia, C.S., Baruah, U. and Dutta, A.K. (1984). Soil Survey Report of Longding and Wakka Circle under N.E.C. Project, District Tirap, Arunachal Pradesh. NBSS Publ. No.512, NBSS&LUP, Nagpur, i-iiip.

Das, T.H., Sarkar, D. and Gajbhiye, K.S. (2003). Soil Series of Sikkim, NBSS Publ. No.105, NBSS&LUP, Nagpur, 86p.

Deshpande, S. B., Fehrenbacher, J. B. and Beavers, A. H. (1971). Mollisols of tarai region of Uttar Pradesh, Northern India, 1. Morphology and mineralogy, Geoderma 6, 179-193.

Gawande, S. P., Sharma, S. P. and Chanan, R. K. (1979). Soils of the command area of Abichenmethong Canal in Ladakh and their management needs. Journal of the Indian Society of Soil Science 27,427-433.

Giri, J. D., Singh, R. S., Singh, S. K., Jain, B. L. Shyampura, R. L. and Gajbhiye, K. S. (2003). Soils of Ajmer district for optimizing land use, NBSS Publ. No.99, NBSS&LUP, Nagpur, 188p.

Krishnan, P., Naidu, L. G. K., Shamsuddin, V. M., Raghu Mohan, N. G., Sehgal, J. and Velayutham, M. (1997). Soils of Lakshdweep: Their kinds, distribution, characterization and interpretations for optimum land use. NBSS&LUP, pp 1-65.

Mahapatra, S. K., Sharma, J. P. And Sarkar, Dipak, (2010). Soil resource mapping of Mathura district of Uttar Pradesh for perspective land use planning. NBSS Publ. NBSS&LUP, Nagpur, India, 156pp. (unpublished)

Murthy, R. S., Hirekerur, L. R., Deshpande, S. B., VenKata Rao, B. V. and Shankaranarayana, H. S. (1982). Benchmark soils of India- morphology, characteristics and classification for resource management, National Bureau of soil survey and land use planning, Nagpur, India, 374 p.

Nair, K.M., Niranjana, K.V., Rajendra Hegde, Sujatha, K., Balachandra, P.V., Padmakumar, D., Premachandran, P.N. and Vadivelu, S. (2006). Soils of Kuthannur Panchayat, NBSS Publ. No. 959, National Bureau of Soil Survey and Land Use Planning, Nagpur, India, 56p.

Nair, K. M., Baruah, U. and Chamuah, G. S. (1992). Soil SurveyRreport of East Khashi Hills dstricts of Meghalaya. NBSS Publ. No. 522, NBSS&LUP, 108-111p.

Natarajan, A., Janakiraman, M., Manoharan, S., Balasubramaniyan, V., Murugappan, K., Udayakumar, J., Ramesh, M., Chandramohan, D., Niranjana, K. V., Venkatesh, D. H.,

Krishnasamy, M., Sennimalai, P., Thanikody, M., Krishnan, P., Rajamannar, G., Natarajan, S., Jagadeesan, P., and Vadivelu, S., (2006). Land Resources of Sivagangai Block, Sivagangai District, Tamil Nadu (Executive Summary). NBSS Publ. No.1028, p. 261.

NBSS&LUP Staff (2003). Soils of Danda Watershed, Tehri Garhwal, Uttaranchal for Land Use Planning, NBSS Report No.634. Regional Centre Delhi, NBSS&LUP, Nagpur, p40.

NBSS&LUP Staff (1995). Soil Survey Report of Sibsagar District, Assam. NBSS&LUP Publ. No. 529 (ICAR), Regional Centre Jorhat, NBSS&LUP, Nagpur, 80p.

NBSS&LUP Staff (1984). Soil Survey and land evaluation of Operational Research Project Flood Prone Area, Kandela Village, Kesarganj Tehsil, Bahraich District, Uttar Pradesh, NBSS&LUP Publ. No. 461 (ICAR), Regional Centre Delhi, NBSS&LUP, Nagpur, p15.

Pal, D. K., Bhattacharyya, T., Ray, S. K. and Bhuse, S. R. (2003). Developing a model on the formation and resllience of naturally degraded black soils of the Peninsular India as a decision support system for better land use planning, NRDMS, DST Project Report, NBSSLUP (ICAR), Nagpur, 144p.

Pal, D.K., Sohan Lal, Bhattacharyya, T., Chandran, P., Ray, S.K., Satyavathi, P.L.A., Raja, P., Maurya, U.K., Durge, S.L. and Kamble, G.K. (2010). Pedogenic thresholds in Benchmark soils under rice-wheat cropping system in a climosequence of the Indo-Gangetic Alluvial Plains, Final Project Report, Division of Soil Resource Studies, NBSS&LUP, Nagpur, p.193.

Reddy, R. S., Budihal, S. L., Ramesh Kumar, S. C. and Naidu, L. G. K. (2005). Benchmark Soils of Andhra Pradesh. NBSS Publ. No.128, NBSS&LUP, Nagpur, 143p.

Reddy, R.S., Budihal, S.L., Ramesh Kumar, S.C., Naidu, L.G.K. and Krishnan, P. (2005a). Soil Series of Medak District, Andra Pradesh. NBSS Publ. No.127, NBSS&LUP, Nagpur, 102p.

Reddy, R.S., Naidu, L.G.K., Ramesh Kumar, S.C., Budihal, S.L. and Krishnan, P. (2005b). Land Resources of Medak District, Andra Pradesh for Land Use Planning. NBSS Publ. No.791, NBSS&LUP, Nagpur 401 p.

Sarkar, D., Baruah, U. and Sahoo, A. K. (2005). Soils of Krishnagiri Farm, Longol Hill, ICAR Complex, Manipur, NBSS Publ. No. 851, NBSS&LUP (ICAR), Nagpur 55p.

Sarkar, D., Sah, K.D., Sahoo, A. K. and Gajbhiye, K.S. (2005a). Soil series of Orissa, NBSS Publ. No. 119, NBSS&LUP (ICAR), Nagpur, 254p.

Sarkar, D., Velayutham, M and Bhattacharyya, T. (1999). Soils of Madhubani district for optimizing land use. NBSS Publ. 76, NBSS&LUP (ICAR), Nagpur, 177p.

Sehgal, J.L., Mandal, D.K. and Mandal, C. (1994). India – Agro-Ecological Subregions, 1:4 million, NBSS&LUP, Nagpur.

Sharma, J. P., Giri, J. D., Shyampura R. L. and Gajbhiye, K. S., (2005). Soil Series of Gujarat, NBSS&LUP Publ. no. 120, NBSS&LUP, Nagpur-440010

Singh, R.S., Jain, B. L., Giri, J. D. and Shyampura, R. L. (2006). Soils of Bhilwara district for land use planning. NBSS Publ. No.135, NBSS&LUP, Nagpur, 239p.

Sohan Lal, Deshpande, S. B. and Sehgal, J. (Eds.) (1994). Soil series of India. Soils Bulletin 40, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.684p.

Tamgadge, D.B., Bhaskar, B.P., Singh, S.R., Bobade, S.V., Gaikwad, M.S. and Gaikwad S.S. (2008). Soil Resource Inventory for Land Use planning of Seoni District, Madhya Pradesh. NBSS Publ., Technical Report No. 1020, NBSS&LUP, Nagpur, 154p.

Tamgadge, D.B., Gajbhiye, K. S. and Pande, G. P. (2002). Soil series of Chattisgarh Sate, NBSS Publ. No. 85, NBSS&LUP, Nagpur, 183p.

Vadivelu, S., Ramesh Kumar, S. C., Thayalan, S. and Sarkar, D. (2008). Perspective land use plan 2015 and 2025 for the Union Territory of Pudducherry. NBSS Publ. No. 142, Nagpur. 196p.

Vadivelu, S., Sen, T. K., Bhaskar, B. P., Baruah, U., Sarkar, D., Maji, A. K. and K. S. Gajbhiye (2004). Soil series of Assam, NBSS Publ. No. 101, NBSS&LUP, Nagpur, 229p.

Velayutham, M., Mandal, D.K., Mandal, C. and Sehgal, J. (1999). Agro-Ecological Subregions of India for development and planning. Publ. 35, NBSS&LUP, Nagpur, India, 452p.

Walia, C.S., Rana, K.P.C. and Tarsem Lal (1998). The Soils of Bilaspur district, Himachal Pradesh for Land Use Planning. NBSS Publ.536, NBSS&LUP, Nagpur, pp.122p.

Data requirements for InfoCrop, RothC and Century C models

For Century Model tmax and tmin are model requirements. This data should be collected from the meterological datasets of IMD.

AESR 1.1

(Eastern aspect of Ladakh Plateau, cold, hyper-arid ecosubregion (ESR) with shallow skeletal soils, very low AWC and LGP <60 days (A13Eh1)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Ladakh II (Jammu & Kashmir)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-10	B	C 10-150
Physical	Sand (%)	87.32	93.52	93.20	78.20		92.29
	Silt (%)	3.86	0.50	0.50	11.00		0.95
	Clay (%)	8.82	5.98	6.30	10.80		6.76
	Saturation Fraction [d]	0.39	0.41	0.41	0.39		0.41
	Field Capacity Fraction [d]	0.09	0.06	0.04	0.12		0.07
	Wilting Point Fraction [d]	0.04	0.02	0.02	0.06		0.03
	Saturated HC (mm/day) [d]	1619.00	2699.00	2699.00	1113.00		2079.00
	Bulk Density (Mg m^{-3}) [d]	1.59	1.55	1.55	1.61		11.57
Chemical	Organic Carbon (%)	0.08	0.07	0.06	0.13		0.06
	Water pH	8.67	8.85	8.80	8.50		8.79
	EC (dS/m)	0.27	0.23	0.29	0.21		0.27
Other (site)	Slope %	5.00			5.00		

Soil Series: Ladakh III (Jammu & Kashmir)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-82		A 0-30	B	C 30-82
Physical	Sand (%)	76.40	70.40		77.50		73.59
	Silt (%)	8.74	8.70		8.70		8.72
	Clay (%)	13.04	11.9		13.8		12.43
	Saturation Fraction [d]	0.39	0.39		0.39		0.39
	Field Capacity Fraction [d]	0.14	0.15		0.14		0.14
	Wilting Point Fraction [d]	0.08	0.07		0.08		0.71
	Saturated HC (mm/day) [d]	902.4	856.6		845.50		932.40
	Bulk Density (Mg m^{-3}) [d]	1.62	1.62		1.62		1.62
Chemical	Organic Carbon (%)	0.11	0.08		0.12		0.09
	Water pH	8.50	8.50		8.50		8.50
	EC (dS/m)	0.31	0.21		0.21		0.28
Other (site)	Slope %	5.00			5.00		

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 82 cm in Ladakh III).

[c]Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B and C) not mentioned the column was left blank. For example in Ladakh II and Ladakh III soil series, since B horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).

Soil and climatic datasets as required for Roth*C* model

Soil Series: Ladakh II (Jammu & Kashmir)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	-14.37	11.8	16.1
February	-5.63	8.6	25.4
March	-3.38	11.9	50.3
April	5	6.5	78.7
May	10.56	6.5	105.7
June	15	4.3	119.2
July	16.67	15.7	123
August	16.67	19.5	106.4
September	14.44	12.2	81.1
October	7.22	7.1	52.1
November	0	2.9	27.4
December	-5.63	8	17.5
Average	4.71	-	-
Total	-	115	802.9

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-10	10.8	1.59	0.13
10-28	10.8	1.59	0.10
28-52	6.3	1.59	0.03
52-75	4.3	1.55	0.08
75-90	8.3	1.55	0.07
90-150	6.3	1.55	0.06

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Ladakh III (Jammu & Kashmir)

1. Climatic data:

	MAT (°C)	MAR (mm)	PET (mm)
January	-14.37	11.8	16.1
February	-5.63	8.6	25.4
March	-3.38	11.9	50.3
April	5	6.5	78.7
May	10.56	6.5	105.7
June	15	4.3	119.2
July	16.67	15.7	123
August	16.67	19.5	106.4
September	14.44	12.2	81.1
October	7.22	7.1	52.1
November	0	2.9	27.4
December	-5.63	8	17.5
Average	4.71	-	-
Total	-	115	802.9

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-10	13.8	1.62	0.12
10-30	13.8	1.62	0.12
30-40	11.9	1.62	0.09
40-82	11.9	1.62	0.08

[1] *Values for 0-50, 50-82 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Ladakh II (Jammu & Kashmir) 1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	11.8	-14.37
February	8.6	-5.63
March	11.9	-3.38
April	6.5	5
May	6.5	10.56
June	4.3	15
July	15.7	16.67
August	19.5	16.67
September	12.2	14.44
October	7.1	7.22
November	2.9	0
December	8	-5.63
Average	-	4.71
Total	115	-

2. Soil data: Required physical and chemical properties of soils.

.Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-10	8.5	0.13	1.59	78.2	11.0	10.8
10-28	8.6	0.10	1.59	85.2	4.0	10.8
28-52	8.8	0.03	1.59	93.2	0.5	6.3
52-75	8.9	0.08	1.55	95.2	0.5	4.3
75-90	8.8	0.07	1.55	91.2	0.5	8.3
90-150	8.8	0.06	1.55	93.2	0.5	6.3

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Ladakh III (Jammu & Kashmir)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	11.8	-14.37
February	8.6	-5.63
March	11.9	-3.38
April	6.5	5
May	6.5	10.56
June	4.3	15
July	15.7	16.67
August	19.5	16.67
September	12.2	14.44
October	7.1	7.22
November	2.9	0
December	8	-5.63
Average	-	4.71
Total	115	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-10	8.5	0.12	1.62	77.4	8.7	13.8
10-30	8.5	0.12	1.62	77.4	8.8	13.8
30-40	8.5	0.09	1.62	79.4	8.7	11.9
40-82	8.5	0.08	1.62	70.4	8.7	11.9

[1] *Values for 0-50, 50-82 estimated by pedotransfer functions*

Soil Resource Information for Crop and Soil Carbon Modelling

AESR 1.2

(Western Aspect of Ladakh Plateau and north Kashmir Himalayas, cold to cool, typic-arid ESR with shallow, loamyskeletalsoils, low AWC and LGP 60-90 days (A13Et2)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Kibber (Himachal Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-120	A 0-15	B 15-53	C 53-120
Physical	Sand (%)	45.67	42.76	42.6	47.50	44.71	42.72
	Silt (%)	32.83	28.09	22.40	34.50	32.29	26.11
	Clay (%)	21.50	29.15	35.00	18.00	23.00	31.17
	Saturation Fraction [d]	0.48	0.45	0.46	0.51	0.47	0.45
	Field Capacity Fraction [d]	0.29	0.31	0.34	0.28	0.29	0.32
	Wilting Point Fraction [d]	0.16	0.19	0.22	0.14	0.16	0.20
	Saturated HC (mm/day) [d]	421.90	161.80	85.68	708.20	343.40	129.10
	Bulk Density (Mg m^{-3}) [d]	1.38	1.45	1.44	1.3	1.41	1.45
Chemical	Organic Carbon (%)	2.15	1.36	1.46	2.76	1.87	1.38
	Water pH	7.77	7.92	7.91	7.60	7.85	7.92
	EC (dS/m)	0.89	0.55	0.48	1.0	0.83	0.52
Other (site)	Slope %	5.00			5.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description(say upto 120 cm in Kibber).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.).*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

v

Soil and climatic datasets as required for Roth*C* model

Soil Series: Kibber (Himachal Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	5.3	64.80	13.40
February	5.8	70.10	14.60
March	10.1	64	37.30
April	14.5	45.70	63.90
May	18.6	59.70	98.40
June	19.7	149.10	106.10
July	18.3	416.10	97.80
August	17.7	419.10	88.90
September	16.9	182.40	75.30
October	14.3	33.30	57.20
November	10.7	10.20	34.60
December	7.2	27.70	20.00
Average	13.3	-	-
Total	-	1542.20	707.00

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-15	18.0	1.38	2.76
15-32	23.0	1.38	2.24
32-53	23.0	1.38	1.57
53-72	21.5	1.45	1.18
72-120	35.0	1.44	1.46

[1] *Values for 0-50, 50-100, 100-120 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Kibber (Himachal Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	64.80	5.3
February	70.10	5.8
March	64	10.1
April	45.70	14.5
May	59.70	18.6
June	149.10	19.7
July	416.10	18.3
August	419.10	17.7
September	182.40	16.9
October	33.30	14.3
November	10.20	10.7
December	27.70	7.2
Average	-	13.3
Total	1542.20	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-15	7.60	2.76	1.38	47.5	34.5	18.0
15-32	7.76	2.24	1.38	47.2	29.8	23.0
32-53	7.92	1.57	1.38	42.7	34.3	23.0
53-72	7.93	1.18	1.45	43.0	35.5	21.5
72-120	7.91	1.46	1.44	42.6	22.4	35.0

[1] *Values for 0-50, 50-100, 100-120 estimated by pedotransfer functions*

AESR 2.1

(Marusthali hot, hyper arid ESR with shallow and deep sandy desert soils very low AWC and LGP < 60 days (M9Eh1)).

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Chirai (Rajasthan)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-36	B 36-90	C 90-170
Physical	Sand (%)	79.44	74.76	71.48	80.70	75.69	70.98
	Silt (%)	9.38	11.68	15.68	8.60	12.64	16.06
	Clay (%)	11.18	13.56	12.84	10.70	11.67	12.96
	Saturation Fraction [d]	0.39	0.39	0.39	0.39	0.31	0.39
	Field Capacity Fraction	0.08	0.09	0.09	0.08	0.09	0.09
	Wilting Point Fraction	0.02	0.03	0.03	0.02	0.03	0.03
	Saturated HC (mm/day) [d]	1153.00	799.40	801.10	1184.00	973.70	789.40
	Bulk Density (Mg m^{-3})	1.48	1.43	1.36	1.48	1.44	1.37
Chemical	Organic Carbon (%)	0.10	0.08	0.06	0.10	0.09	0.06
	Water pH	8.14	8.32	8.40	8.08	8.30	8.40
	EC (dS/m)	0.18	0.42	0.50	0.18	0.40	0.50
Other (site)	Slope %	3.00			3.00		

Soil Series: Pal (Rajasthan)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-35	30-75	75-90	A 0-30	B 30-75	C 75-90
Physical	Sand (%)	75.00	65.00	75.00	75.00	65.00	75.00
	Silt (%)	17.00	24.00	11.00	17.00	24.00	11.00
	Clay (%)	8.00	11.00	10.00	8.00	11.00	10.00
	Saturation Fraction [d]	0.40	0.39	0.39	0.40	0.39	0.39
	Field Capacity Fraction [d]	0.12	0.15	0.13	0.12	0.15	0.13
	Wilting Point Fraction [d]	0.07	0.07	0.06	0.07	0.07	0.06
	Saturated HC (mm/day)[d]	1392.96	848.64	1160.64	1392.96	848.64	1160.64
	Bulk Density (Mg m^{-3}) [d]	1.59	1.61	1.60	1.59	1.61	1.60
Chemical	Organic Carbon (%)	0.22	0.21	0.20	0.22	0.21	0.20
	Water pH	8.40	8.40	8.30	8.40	8.40	8.30
	EC (dS/m)	0.20	0.20	0.20	0.20	0.20	0.20
Other (site)	Slope %	2.00			2.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say A and B) not mentioned the column was left blank. For example in Dune soil series, since A and B horizons was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model

Soil Series: Chirai (Rajasthan)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.22	5.1	84
February	20	6.1	101
March	24.85	2.8	156
April	30	3.3	192
May	34.7	9.7	265
June	34.7	30.7	260
July	30.88	108.2	184
August	28.85	131.3	145
September	28.85	57.4	156
October	27.42	7.6	134
November	22.57	1.8	88
December	18.88	2	77
Average	26.58	-	-
Total	-	366	1842

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-9	9.2	1.49	0.11
9-36	11.2	1.48	0.09
36-76	12.4	1.45	0.10
76-90	9.6	1.40	0.06
90-140	12.7	1.36	0.06
140-170	13.4	1.38	0.06

Soil Series: Pal (Rajasthan)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.22	5.1	84
February	20	6.1	101
March	24.85	2.8	156
April	30	3.3	192
May	34.7	9.7	265
June	34.7	30.7	260
July	30.88	108.2	184
August	28.85	131.3	145
September	28.85	57.4	156
October	27.42	7.6	134
November	22.57	1.8	88
December	18.88	2	77
Average	26.58	-	-
Total	-	366	1842

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-30	8.0	1.59	0.22
30-75	11.0	1.61	0.21
75-90	10.0	1.60	-

[1] *Values for 0-50, 50-90 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Chirai (Rajasthan)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	5.1	17.22
February	6.1	20
March	2.8	24.85
April	3.3	30
May	9.7	34.7
June	30.7	34.7
July	108.2	30.88
August	131.3	28.85
September	57.4	28.85
October	7.6	27.42
November	1.8	22.57
December	2	18.88
Average	-	26.58
Total	366	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-9	8.0	0.11	1.49	82.8	8.0	9.2
9-36	8.1	0.09	1.48	80.0	8.8	11.2
36-76	8.3	0.10	1.45	76.2	11.4	12.4
76-90	8.3	0.06	1.40	74.2	16.2	9.6
90-140	8.4	0.06	1.36	71.8	15.5	12.7
140-170	8.4	0.06	1.38	69.6	17.0	13.4

Soil Series: Pal (Rajasthan)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	5.1	17.22
February	6.1	20
March	2.8	24.85
April	3.3	30
May	9.7	34.7
June	30.7	34.7
July	108.2	30.88
August	131.3	28.85
September	57.4	28.85
October	7.6	27.42
November	1.8	22.57
December	2	18.88
Average	-	26.58
Total	366	-

2. Soil data Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-30	8.5	0.22	1.59	75.0	17.0	8.0
30-75	8.5	0.21	1.61	65.0	24.0	11.0
75-90	8.5	-	1.60	75.0	15.0	10.0

[1] *Values for 0-50, 50-90 estimated by pedotransfer functions*

AESR 2.2

(Kachchh Peninsula (Great Rann of Kutch as inclusion), hot hyper-arid ESR with deep loamy saline and alkali soils, low AWC and LGP <60 days (L12Eh1)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Amiliara (Gujarat)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-105	A 0-17	B 17-94	C 94-105
Physical	Sand (%)	72.53	79.64	84.90	73.70	75.92	84.90
	Silt (%)	7.80	4.25	3.50	12.50	4.79	3.50
	Clay (%)	19.67	16.11	11.60	13.80	19.29	11.60
	Saturation Fraction [d]	0.42	0.43	0.44	0.44	0.43	0.40
	Field Capacity Fraction [d]	0.22	0.18	0.15	0.15	0.18	0.13
	Wilting Point Fraction [d]	0.14	0.12	0.09	0.08	0.12	0.08
	Saturated HC (mm/day) [d]	512.40	838.80	1297.68	913.20	519.64	1196.40
	Bulk Density (Mg m^{-3}) [d]	1.52	1.51	1.49	1.57	1.56	1.51
Chemical	Organic Carbon (%)	0.47	0.41	0.24	0.61	0.424	0.24
	Water pH	8.13	8.37	8.30	8.00	8.30	8.30
	EC (dS/m)	0.20	0.78	5.00	0.20	0.20	5.00
Other (site)	Slope %	1.00			1.00		

Soil Series: Balasar (Gujarat)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-137	A 0-32	B	C 32-137
Physical	Sand (%)	87.52	93.03	94.00	85.50		93.03
	Silt (%)	4.35	3.14	2.90	4.67		3.17
	Clay (%)	8.13	3.83	3.10	9.83		3.80
	Saturation Fraction [d]	0.45	0.47	0.47	0.40		0.42
	Field Capacity Fraction [d]	0.12	0.08	00.08	0.10		0.05
	Wilting Point Fraction [d]	0.06	0.04	0.04	0.06		0.02
	Saturated HC (mm/day) [d]	1939.40	2983.70	3304.80	1445.04		2964.00
	Bulk Density (Mg m^{-3}) [d]	1.50	1.41	1.40	1.59		1.53
Chemical	Organic Carbon (%)	0.05	0.04	0.02	0.07		0.03
	Water pH	9.22	9.30	9.40	9.18		9.34
	EC (dS/m)	0.20	0.37	0.80	0.20		0.49
Other (site)	Slope %	1.00			1.00		

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 105 cm and 137 cm in Amiliara and Balasar respectively).

[c]Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B) not mentioned the column was left blank. For example in Balasar soil series, since B horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).

Soil and climatic datasets as required for Roth*C* model

Soil Series: Amaliara (Gujarat)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	18.1	3	93
February	21	5	110
March	26.1	1	163
April	30.1	1	209
May	32.1	8	266
June	32	22	226
July	29.6	154	258
August	28.5	96	154
September	28.6	38	160
October	28.5	7	158
November	23.9	2	108
December	19.6	2	82
Average	26.51	-	-
Total	-	339	1987

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-17	13.8	1.52	0.61
17-36	23.5	1.52	0.44
36-55	21.6	1.52	0.35
55-94	16.1	1.51	0.45
94-105	11.6	1.51	0.24

[1] *Values for 0-50, 50-100, 100-105 estimated by pedotransfer functions*

Soil Series: Balasar (Gujarat)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	18.1	3	93
February	21	5	110
March	26.1	1	163
April	30.1	1	209
May	32.1	8	266
June	32	22	226
July	29.6	154	258
August	28.5	96	154
September	28.6	38	160
October	28.5	7	158
November	23.9	2	108
December	19.6	2	82
Average	26.51	-	-
Total	-	339	1987

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-10	9.9	1.5	0.21
10-32	9.8	1.5	0.01
32-59	5.1	1.5	0.01
59-99	3.6	1.41	0.05
99-137	3.1	1.41	0.02

[1] *Values for 0-50, 50-100, 100-137 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Amaliara (Gujarat)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	3	18.1
February	5	21
March	1	26.1
April	1	30.1
May	8	32.1
June	22	32
July	154	29.6
August	96	28.5
September	38	28.6
October	7	28.5
November	2	23.9
December	2	19.6
Average	-	26.51
Total	339	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-17	8.0	0.61	1.52	73.7	12.5	13.8
17-36	8.2	0.44	1.52	70.8	5.8	23.5
36-55	8.2	0.35	1.52	73.6	4.8	21.6
55-94	8.4	0.45	1.51	76.6	4.3	16.1
94-105	8.3	0.24	1.51	84.9	3.5	11.6

[1] *Values for 0-50, 50-100, 100-105 estimated by pedotransfer functions*

Soil Series: Balasar (Gujarat)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	3	18.1
February	5	21
March	1	26.1
April	1	30.1
May	8	32.1
June	22	32
July	154	29.6
August	96	28.5
September	38	28.6
October	7	28.5
November	2	23.9
December	2	19.6
Average	-	26.51
Total	339	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-10	8.9	0.21	1.5	85.5	4.6	9.9
10-32	9.3	0.01	1.5	85.5	4.7	9.8
32-59	9.3	0.01	1.5	91.1	3.8	5.1
59-99	9.3	0.05	1.41	93.4	3.0	3.6
99-137	9.4	0.02	1.41	94.0	2.9	3.1

[1] *Values for 0-50, 50-100, 100-137 estimated by pedotransfer functions*

AESR 2.3

(Rajasthan Bagar, North Gujarat Plain and South-Western Punjab Plain, hot typic- arid ESR with deep, loamy desert soils (inclusion of saline phase), low AWC and LGP 60-90 days (M9Et2)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Hisar (Haryana)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-16	B 16-128	C 128-168
Physical	Sand (%)	64.52	46.44	41.92	68.80	50.41	40.80
	Silt (%)	9.88	16.76	18.88	8.00	15.25	20.00
	Clay (%)	25.60	36.80	39.20	23.20	34.34	39.20
	Saturation Fraction [d]	0.39	0.42	0.43	0.39	0.41	0.43
	Field Capacity Fraction [d]	0.24	0.34	0.35	0.21	0.31	0.35
	Wilting Point Fraction [d]	0.16	0.22	0.23	0.14	0.21	0.23
	Saturated HC (mm/day) [d]	193.40	40.32	31.44	288.20	59.52	31.44
	Bulk Density (Mg m^{-3}) [d]	1.61	1.53	1.50	0.14	0.14	0.11
Chemical	Organic Carbon (%)	0.15	0.14	0.11	8.10	7.97	8.20
	Water pH	7.96	8.0	8.09	0.30	0.30	0.30
	EC (dS/m)	0.30	0.30	0.30	0.30	0.30	0.30
Other (site)	Slope %	1.00			1.00		

Soil Series: Jaitaran (Rajasthan)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-20	B 20-120	C 120-150
Physical	Sand (%)	69.90	62.90	76.10	73.50	65.90	79.50
	Silt (%)	20.40	23.50	16.60	15.50	23.25	13.00
	Clay (%)	9.70	13.60	7.30	11.00	10.85	7.50
	Saturation Fraction [d]	0.40	0.39	0.40	0.40	0.39	0.40
	Field Capacity Fraction [d]	0.14	0.18	0.10	0.14	0.15	0.11
	Wilting Point Fraction [d]	0.06	0.09	0.04	0.07	0.07	0.05
	Saturated HC (mm/day) [d]	1050.96	621.60	154.72	1065.36	868.80	1506.00
	Bulk Density (Mg m^{-3}) [d]	1.59	1.61	1.59	1.59	1.61	1.59
Chemical	Organic Carbon (%)	0.31	0.21	0.17	0.40	0.22	0.15
	Water pH	8.31	8.14	8.32	8.50	8.16	8.50
	EC (dS/m)	0.20	0.20	0.20	0.20	0.20	0.20
Other (site)	Slope %	1.00			1.00		

[a] _Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b] _According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 130 cm in Chandawal)._

[c] _Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.)._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model
Soil Series: Hisar (Haryana)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	12.6	17	11.8
February	15.4	13.7	23.2
March	20.7	14.5	78.4
April	26.5	7.6	157.7
May	31.5	12.90	205.3
June	33.3	31.5	211.4
July	30.2	107.7	208.3
August	29.1	121.7	190.1
September	28.2	81	190.1
October	24.4	13.2	164.8
November	18.4	1	126.6
December	14.2	7.1	42.2
Average	23.71	-	-
Total	-	428.4	1609.9

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-16	23.2	1.61	0.14
16-37	25.2	1.61	0.16
37-52	29.2	1.61	0.14
52-77	35.2	1.53	0.14
77-105	39.2	1.53	0.14
105-128	39.2	1.50	0.11
128-168	39.2	1.50	0.11

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Jaitaran (Rajasthan)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	15.78	4.6	81
February	18.94	3.8	101
March	24.21	2.5	160
April	29.73	2.8	207
May	33.07	11.4	259
June	33.84	49	239
July	31.02	175	178
August	28.68	216.9	152
September	29.73	87.9	164
October	26.31	6.6	147
November	21.84	2.3	92
December	17.89	1.5	77
Average	28.51	-	-
Total	-	564.3	1857

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-20	11.0	1.59	0.40
20-45	7.0	1.59	0.27
45-80	18.0	1.61	0.22
80-120	7.0	1.61	0.20
120-150	7.5	1.59	0.15

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Hisar (Haryana)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	17	12.6
February	13.7	15.4
March	14.5	20.7
April	7.6	26.5
May	12.90	31.5
June	31.5	33.3
July	107.7	30.2
August	121.7	29.1
September	81	28.2
October	13.2	24.4
November	1	18.4
December	7.1	14.2
Average	-	23.71
Total	428.4	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-16	8.1	0.14	1.61	68.8	8.0	23.2
16-37	7.9	0.16	1.61	64.8	10.0	25.2
37-52	7.9	0.14	1.61	58.8	12.0	29.2
52-77	8.0	0.14	1.53	48.8	16.0	35.2
77-105	8.0	0.14	1.53	42.8	18.0	39.2
105-128	8.0	0.11	1.50	42.8	18.0	39.2
128-168	8.2	0.11	1.50	40.8	20.0	39.2

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Jaitaran (Rajasthan)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	4.6	15.78
February	3.8	18.94
March	2.5	24.21
April	2.8	29.73
May	11.4	33.07
June	49	33.84
July	175	31.02
August	216.9	28.68
September	87.9	29.73
October	6.6	26.31
November	2.3	21.84
December	1.5	17.89
Average	-	*28.51*
Total	564.3	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3}) [1]	Sand (%)	Silt (%)	Clay (%)
0-20	8.5	0.40	1.59	73.5	15.5	11.0
20-45	8.2	0.27	1.59	69.5	23.5	7.0
45-80	8.1	0.22	1.61	57.5	24.5	18.0
80-120	8.2	0.20	1.61	71.0	22.0	7.0
120-150	8.5	0.15	1.59	79.5	13.0	7.5

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer function*

AESR 2.4

(South Kachchh and North Kathiawar Peninsula, hot arid ESR with deep loamy saline and alkali soils, low AWC and LGP 60-90 days (L12Et2).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Bhola (Gujarat)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-96		A 0-33	B 33-96	C
Physical	Sand (%)	39.35	28.95		45.45	28.42	
	Silt (%)	16.07	27.15		13.06	25.2	
	Clay (%)	44.58	43.90		41.49	46.35	
	Saturation Fraction [d]	0.42	0.41		0.42	0.42	
	Field Capacity Fraction [d]	0.33	0.33		0.32	0.34	
	Wilting Point Fraction [d]	0.17	0.17		0.15	0.17	
	Saturated HC (mm/day) [d]	181.94	110.60		204.23	119.67	
	Bulk Density (Mg m^{-3}) [d]	1.53	1.55		1.55	1.53	
Chemical	Organic Carbon (%)	0.59	0.28		0.66	0.34	
	Water pH	8.47	8.70		8.41	8.66	
	EC (dS/m)	2.24	2.03		1.44	2.68	
Other (site)	Slope %	1.00			1.00		

Soil Series: Semla (Gujarat)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-23	B 23-156	C
Physical	Sand (%)	22.17	19.40	17.44	21.41	19.43	
	Silt (%)	17.86	18.70	23.53	19.93	20.10	
	Clay (%)	59.97	61.90	59.03	58.66	60.47	
	Saturation Fraction [d]	0.47	0.47	0.46	0.47	0.46	
	Field Capacity Fraction [d]	0.35	0.42	0.41	0.32	0.14	
	Wilting Point Fraction [d]	0.17	0.20	0.21	0.15	0.20	
	Saturated HC (mm/day) [d]	55.46	0.24	0.24	93.38	0.24	
	Bulk Density (Mg m^{-3}) [d]	1.41	1.41	1.43	1.42	1.42	
Chemical	Organic Carbon (%)	0.65	0.59	0.48	0.69	0.55	
	Water pH	8.76	9.00	8.93	8.67	8.94	
	EC (dS/m)	0.74	1.10	0.96	0.61	0.99	
Other (site)	Slope %	1.00			1.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 96 cm in Bhola).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Bhola and Semla soil series, since Chorizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.*

Soil and climatic datasets as required for RothC model
Soil Series: Bhola (Gujarat)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	19.4	1	121
February	21.9	0	138
March	26.2	1	206
April	30	3	249
May	32.6	7	302
June	32	99	240
July	28.7	293	170
August	27.8	143	150
September	27.9	93	154
October	28.1	25	169
November	24.8	5	131
December	20.9	4	114
Average	26.69	-	-
Total	-	674	2144

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-16	42.0	1.68	0-16
16-33	41.0	1.86	16-33
33-56	50.6	1.87	33-56
56-73	48.5	1.81	56-73
73-96	40.5	1.72	73-96

Soil Series: Semla (Gujarat)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	19.4	1	121
February	21.9	0	138
March	26.2	1	206
April	30	3	249
May	32.6	7	302
June	32	99	240
July	28.7	293	170
August	27.8	143	150
September	27.9	93	154
October	28.1	25	169
November	24.8	5	131
December	20.9	4	114
Average	26.69	-	-
Total	-	674	2144

2. Soil data: Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-10	56.9	1.80	0.72
10-23	60.0	1.80	0.67
23-45	60.9	1.82	0.62
45-115	61.9	1.89	0.59
115-156	57.8	1.82	0.43

Soil and climatic datasets as required for Century C model

Soil Series: Bhola (Gujarat)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	1	19.4
February	0	21.9
March	1	26.2
April	3	30
May	7	32.6
June	99	32
July	293	28.7
August	143	27.8
September	93	27.9
October	25	28.1
November	5	24.8
December	4	20.9
Average	-	26.69
Total	674	-

2. Soil data: Required Physical and chemical Properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-16	8.1	0-16	1.68	45.4	12.6	42.0
16-33	8.7	16-33	1.86	45.5	13.5	41.0
33-56	8.6	33-56	1.87	27.5	21.9	50.6
56-73	8.7	56-73	1.81	25.5	26.0	48.5
73-96	8.7	73-96	1.72	31.5	28.0	40.5

Soil Series: Semla (Gujarat)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	1	19.4
February	0	21.9
March	1	26.2
April	3	30
May	7	32.6
June	99	32
July	293	28.7
August	143	27.8
September	93	27.9
October	25	28.1
November	5	24.8
December	4	20.9
Average	-	26.69
Total	674	-

2. Soil data: Required Physical and chemical Properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-10	8.5	0.72	1.80	22.6	20.5	56.9
10-23	8.8	0.67	1.80	20.5	19.5	60.0
23-45	8.8	0.62	1.82	23.6	15.5	60.9
45-115	9.0	0.59	1.89	19.4	18.7	61.9
115-156	8.9	0.43	1.82	16.6	25.6	57.8

AESR 3.0

(Karnataka Plateau (Rayalseema as inclusion), hot arid ESR with deep loamy and clayey mixed Red and Black soils, low to medium AWC and LGP 60-90 days (K6Et2).) [a]

Soil Master

as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Jamkhandi (Karnataka)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-16	B 16-152	C 152-176
Physical	Sand (%)	64.30	44.44	47.71	73.80	49.61	59.70
	Silt (%)	7.70	12.72	12.30	6.10	11.44	9.80
	Clay (%)	28.00	42.84	39.99	20.10	38.95	30.50
	Saturation Fraction [d]	0.42	0.45	0.44	0.41	0.44	0.42
	Field Capacity Fraction [d]	0.27	0.38	0.36	0.21	0.35	0.31
	Wilting Point Fraction [d]	0.18	0.26	0.24	0.13	0.24	0.19
	Saturated HC (mm/day) [d]	176.88	21.84	28.8	491.28	35.04	80.16
	Bulk Density (Mg m^{-3}) [d]	1.54	1.51	1.53	1.55	1.50	1.53
Chemical	Organic Carbon (%)	1.18	1.13	0.63	1.03	0.97	0.22
	Water pH	8.34	8.34	8.55	8.20	8.44	8.20
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	3.00			3.00		

Soil Series: Sollapuram (Andhra Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-14	B 14-150	C
Physical	Sand (%)	12.15	11.80	6.21	12.30	9.11	
	Silt (%)	23.99	24.30	22.20	23.00	23.44	
	Clay (%)	63.86	63.90	71.59	64.70	67.45	
	Saturation Fraction [e]	0.49	0.49	0.53	0.50	0.51	
	Field Capacity Fraction	0.43	0.43	0.47	0.39	0.45	
	Wilting Point Fraction	0.23	0.25	0.27	0.23	0.25	
	Saturated HC (mm/day) [e]	163.42	108.26	238.18	186.74	158.58	
	Bulk Density (Mg m^{-3}) [e]	1.35	1.36	1.25	1.34	1.31	
Chemical	Organic Carbon (%)	0.53	0.50	0.36	0.60	0.45	
	Water pH	8.44	8.60	8.09	8.40	8.37	
	EC (dS/m)	0.10	0.10	0.19	0.10	0.10	
Other (site)	Slope %	1.00			1.00		

[a] _Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b] _According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 82 cm in Ladakh III)._

[c] _Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Sollapuram soil series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

[e] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur._

Soil and climatic datasets as required for Roth*C* model

Soil Series: Jamakhandi (Karnataka)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	22.33	5.8	109
February	24.66	2.3	123
March	27.33	7.1	165
April	30.33	19.6	180
May	32	29.5	197
June	27.33	76.3	157
July	25.33	58.7	137
August	24.66	65.8	135
September	26	141.5	124
October	25.66	76.7	123
November	23.33	30.7	102
December	21	6.6	97
Average	25.83	-	-
Total	-	520.6	1649

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-16	20.1	1.54	1.03
16-40	29.1	1.58	1.17
40-61	38.0	1.68	1.46
61-89	45.5	1.66	1.15
89-123	40.9	1.37	0.77
123-152	39.2	1.51	0.51
152-176	30.5	1.53	0.22

Soil Series: Sollapuram (Andhra Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	23.9	4.8	131
February	26	6.1	143
March	29.2	3.3	190
April	32.1	15	197
May	32	53.3	199
June	29.7	49.8	179
July	28.1	52.1	161
August	28	84.6	158
September	27.8	149.9	143
October	27	99.3	124
November	24.8	58.2	118
December	23.2	6.6	115
Average	27.65	-	-
Total	-	583	1858

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-14	64.7	1.36	8.4
14-40	63.4	1.4	8.4
40-63	63.9	1.3	8.6
63-102	66.9	1.2	8.6
102-129	71.7	1.4	8.2
129-150	71.9	1.25	7.9

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model
Soil Series: Jamakhandi (Karnataka)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	5.8	22.33
February	2.3	24.66
March	7.1	27.33
April	19.6	30.33
May	29.5	32
June	76.3	27.33
July	58.7	25.33
August	65.8	24.66
September	141.5	26
October	76.7	25.66
November	30.7	23.33
December	6.6	21
Average	-	25.83
Total	520.6	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-16	8.2	1.03	1.54	73.8	6.1	20.1
16-40	8.5	1.17	1.58	65.1	5.8	29.1
40-61	8.2	1.46	1.68	47.2	14.8	38.0
61-89	8.3	1.15	1.66	44.0	10.5	45.5
89-123	8.6	0.77	1.37	42.8	16.3	40.9
123-152	8.5	0.51	1.51	51.9	8.9	39.2
152-176	8.2	0.22	1.53	59.7	9.8	30.5

Soil Series: Sollapuram (Andhra Pradesh)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	4.8	23.9
February	6.1	26
March	3.3	29.2
April	15	32.1
May	53.3	32
June	49.8	29.7
July	52.1	28.1
August	84.6	28
September	149.9	27.8
October	99.3	27
November	58.2	24.8
December	6.6	23.2
Average	-	27.65
Total	583	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-14	8.4	8.4	-	12.3	23.0	64.7
14-40	8.4	8.4	1.4	12.2	24.4	63.4
40-63	8.6	8.6	1.3	11.8	24.3	63.9
63-102	8.6	8.6	1.2	9.2	23.9	66.9
102-129	8.2	8.2	1.4	6.0	22.3	71.7
129-150	7.9	7.9	-	6.2	21.9	71.9

[1]*Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 4.1

(North Punjab Plain, Ganga-Yamuna Doab and Rajasthan Upland, hot semi-arid ESR with deep loamy alluvium-derived soils (occasional saline and sodic phases), medium AWC and LGP 90-120 days (N8Dd3)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Zarifa Viran (Haryana)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-140	A 0-24	B 24-118	C 118-140
Physical	Sand (%)	32.94	28.71	39.69	35.48	30.09	45.00
	Silt (%)	36.58	41.05	35.60	36.98	39.51	32.00
	Clay (%)	30.48	30.24	24.71	27.54	30.40	23.00
	Saturation Fraction	0.34	0.39	0.42	0.38	0.37	0.44
	Field Capacity Fraction [d]	0.32	0.32	0.28	0.31	0.32	0.26
	Wilting Point Fraction [d]	0.18	0.18	0.15	0.17	0.18	0.14
	Saturated HC (mm/day) [d]	74.88	75.84	134.20	102.50	75.84	180.50
	Bulk Density (Mg m^{-3})	1.47	1.56	1.49	1.47	1.52	1.50
Chemical	Organic Carbon (%)	0.25	0.17	0.10	0.30	0.16	0.10
	Water pH	10.04	9.74	9.38	10.30	9.73	9.20
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	1.00			1.00		

Soil Series: Shergarh (Uttar Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-65		C 65-150
Physical	Sand (%)	89.04	94.67	97.51	89.40		97.06
	Silt (%)	7.14	2.55	1.21	6.88		1.15
	Clay (%)	3.82	2.78	1.28	3.72		1.79
	Saturation Fraction [d]	0.42	0.42	0.42	0.41		0.42
	Field Capacity Fraction [d]	0.06	0.04	0.05	0.06		0.05
	Wilting Point Fraction [d]	0.02	0.01	0.004	0.02		0.004
	Saturated HC (mm/day) [d]	2832.00	3811.00	4589.00	2806.00		4520.00
	Bulk Density (Mg m^{-3})	1.55	1.54	1.55	1.56		1.55
Chemical	Organic Carbon (%)	0.09	0.00	0.00	0.07		0.00
	Water pH	8.24	8.67	8.70	8.28		8.74
	EC (dS/m)	0.10	0.10	0.10	0.10		0.10
Other (site)	Slope %	2.00			2.00		

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 140 cm in Zarifa Viran).

[c]Horizons A, B, and C as described in _Soil Survey Staff_ (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Shergarh soil series, since C horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).

Soil and climatic datasets as required for Roth*C* model
Soil Series: Zarifa Viran (Haryana)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	13.4	28.6	14.8
February	16.1	20	26.6
March	21.1	20.3	74.1
April	27.4	7.7	154.4
May	31.3	10.1	202.7
June	32.6	47.6	207.4
July	30	171.1	195.6
August	28.9	253	175.9
September	28.3	110.4	155.4
October	24.8	23.5	102.6
November	19.6	3.7	45.5
December	14.9	9.1	22.3
Average	24.03	-	-
Total	-	705.1	1377.3

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-5	22.0	1.42	0.30
5-24	29.0	1.48	0.30
24-56	33.2	1.48	0.20
56-85	31.4	1.63	0.20
85-118	26.8	1.47	0.10
118-140	23.0	1.50	0.10

Soil Series: Shergarh (Uttar Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.64	12.9	53
February	20.58	15	75
March	24.7	8.1	126
April	31.47	4.8	103
May	35.88	8.6	208
June	38.23	36.6	204
July	31.76	160.3	146
August	33.82	168.9	124
September	33.82	107.2	133
October	26.76	15.5	116
November	20.58	1.5	69
December	16.76	5.1	50
Average	27.67		-
Total	-	544.5	1407.00

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-17	4.5	1.55	0.15
17-40	3.5	1.55	0.09
40-65	3.4	1.54	0.00
65-95	2.6	1.54	0.00
95-126	2.0	1.55	0.00
126-150	0.5	1.55	0.00

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model

Soil Series: Zarifa Viran (Haryana)

1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	28.6	13.4
February	20	16.1
March	20.3	21.1
April	7.7	27.4
May	10.1	31.3
June	47.6	32.6
July	171.1	30
August	253	28.9
September	110.4	28.3
October	23.5	24.8
November	3.7	19.6
December	9.1	14.9
Average	-	24.03
Total	705.1	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-5	10.3	0.30	1.42	43.4	34.6	22.0
5-24	10.3	0.30	1.48	33.4	37.6	29.0
24-56	9.8	0.20	1.48	30.6	36.2	33.2
56-85	9.8	0.20	1.63	26.0	42.6	31.4
85-118	9.6	0.10	1.47	33.2	40.0	26.8
118-140	9.2	0.10	1.50	45.0	32.0	23.0

Soil Series: Shergarh (Uttar Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	12.9	17.64
February	15	20.58
March	8.1	24.7
April	4.8	31.47
May	8.6	35.88
June	36.6	38.23
July	160.3	31.76
August	168.9	33.82
September	107.2	33.82
October	15.5	26.76
November	1.5	20.58
December	5.1	16.76
Average	-	27.67
Total	544.5	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-17	0-17	0.15	1.55	87.5	8.0	4.5
17-40	17-40	0.09	1.55	89.5	7.0	3.5
40-65	40-65	0.00	1.54	90.6	6.0	3.4
65-95	65-95	0.00	1.54	96.4	1.0	2.6
95-126	95-126	0.00	1.55	96.5	1.5	2.0
126-150	126-150	0.00	1.55	98.6	0.9	0.5

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 4.2

(North Gujarat Plain (inclusion of Aravalli range and east Rajasthan Uplands), hot dry semiarid ESR with deep loamy Gray Brown and alluvium-derived soils, medium AWC and LGP 90-120 days (P14Dd3)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Baland (Rajasthan)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-83		A 0-11	B 11-83	C
Physical	Sand (%)	47.56	24.52		59.60	43.71	
	Silt (%)	43.18	23.78		24.30	24.22	
	Clay (%)	27.92	33.04		16.10	32.07	
	Saturation Fraction [d]	0.41	0.42		0.41	0.42	
	Field Capacity Fraction	0.31	0.33		0.26	0.33	
	Wilting Point Fraction	0.12	0.14		0.08	0.14	
	Saturated HC (mm/day) [d]	129.40	67.44		531.40	77.52	
	Bulk Density (Mg m^{-3}) [d]	1.55	1.53		1.57	1.53	
Chemical	Organic Carbon (%)	0.41	0.22		0.58	0.30	
	Water pH	8.24	7.84		8.60	8.00	
	EC (dS/m)	0.46	1.28		0.15	0.88	
Other (site)	Slope %	2.00			2.00		

Soil Series: Kaljodiya (Rajasthan)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-135	A 0-28	B 28-135	C
Physical	Sand (%)	68.43	67.34	68.59	69.00	67.82	
	Silt (%)	12.52	10.47	10.87	13.40	10.82	
	Clay (%)	19.05	22.19	20.54	17.60	21.36	
	Saturation Fraction [d]	0.39	0.39	0.39	0.39	0.39	
	Field Capacity Fraction	0.21	0.24	0.19	0.19	0.22	
	Wilting Point Fraction	0.10	0.15	0.11	.09	0.12	
	Saturated HC (mm/day) [d]	440.60	315.60	365.30	500.60	353.00	
	Bulk Density (Mg m^{-3}) [d]	1.61	1.61	1.62	1.56	1.62	
Chemical	Organic Carbon (%)	0.30	0.21	0.17	0.39	0.12	
	Water pH	8.47	8.27	8.31	8.90	8.46	
	EC (dS/m)	0.31	0.42	0.37	0.21	0.12	
Other (site)	Slope %	4.00			4.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 83 cmand 135 in Baland and Kaljodiya respectively).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Baland and Kaljodiya soil series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Baland (Rajsthan)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.55	5.3	62
February	20.8	2	80
March	26.3	3.6	131
April	31.7	4.1	167
May	36.15	3.6	225
June	34.9	59.5	210
July	29.85	348.2	139
August	28.55	299.2	121
September	28.9	98.5	133
October	27.75	1	122
November	22.8	1.3	75
December	19	9.1	58
Average	27.02	-	-
Total	-	835.4	1523

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-11	16.2	1.55	0.58
11-22	27.7	1.55	0.48
22-36	32.2	1.55	0.35
36-69	33.1	1.53	0.29
69-83	33.1	1.53	0.12

[1] *Values for 0-50, 50-83 estimated by pedotransfer functions*

Soil Series: Kajlodiya (Rajsthan)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.55	5.3	62
February	20.8	2	80
March	26.3	3.6	131
April	31.7	4.1	167
May	36.15	3.6	225
June	34.9	59.5	210
July	29.85	348.2	139
August	28.55	299.2	121
September	28.9	98.5	133
October	27.75	1	122
November	22.8	1.3	75
December	19	9.1	58
Average	27.02	-	-
Total	-	835.4	1523

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-28	17.6	1.61	0.35
28-55	20.9	1.61	0.24
55-85	22.4	1.61	0.21
85-115	22.2	1.62	0.21
115-135	19.3	1.62	0.14

[1] *Values for 0-50, 50-100, 100-135 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model

Soil Series: Baland (Rajsthan)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	5.3	17.55
February	2	20.8
March	3.6	26.3
April	4.1	31.7
May	3.6	36.15
June	59.5	34.9
July	348.2	29.85
August	299.2	28.55
September	98.5	28.9
October	1	27.75
November	1.3	22.8
December	9.1	19
Average	-	27.02
Total	835.4	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-11	8.6	0.58	1.55	59.6	24.3	16.2
11-22	8.5	0.48	1.55	47.5	24.8	27.7
22-36	8.2	0.35	1.55	42.1	25.6	32.2
36-69	7.8	0.29	1.53	43.6	23.4	33.1
69-83	7.9	0.12	1.53	42.6	24.3	33.1

[1] *Values for 0-50, 50-83 estimated by pedotransfer functions*

Soil Series: Kajlodiya (Rajsthan)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	5.3	17.55
February	2	20.8
March	3.6	26.3
April	4.1	31.7
May	3.6	36.15
June	59.5	34.9
July	348.2	29.85
August	299.2	28.55
September	98.5	28.9
October	1	27.75
November	1.3	22.8
December	9.1	19
Average	-	27.02
Total	835.4	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-28	8.6	0.35	1.61	69.0	13.4	17.6
28-55	8.3	0.24	1.61	67.7	11.5	20.9
55-85	8.3	0.21	1.61	67.6	10.0	22.4
85-115	8.2	0.21	1.62	66.7	11.1	22.2
115-135	8.4	0.14	1.62	70.0	10.7	19.3

[1] *Values for 0-50, 50-100, 100-135 estimated by pedotransfer functions*

AESR 4.3

(Ganga Yamuna Doab, Rohilkhand and Avadah Plain, hot moist semi-arid ESR with deep, loamy alluvium-derived soils (sodic phase inclusion), medium to high AWC and LGP 120-150 days (N8Dm4)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Nagaria (Uttar Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-40	B 40-170	C
Physical	Sand (%)	68.03	55.26	67.03	70.00	63.70	
	Silt (%)	25.10	29.62	23.25	23.80	25.79	
	Clay (%)	6.87	15.12	9.72	6.20	10.51	
	Saturation Fraction [d]	0.40	0.39	0.39	0.41	0.39	
	Field Capacity Fraction [d]	0.13	0.20	0.14	0.12	0.16	
	Wilting Point Fraction [d]	0.05	0.09	0.06	0.04	0.07	
	Saturated HC (mm/day) [d]	1321.00	453.40	939.80	1557.00	807.00	
	Bulk Density (Mg m^{-3}) [d]	1.59	1.62	1.62	1.56	1.62	
Chemical	Organic Carbon (%)	0.28	0.12	0.08	0.39	0.12	
	Water pH	8.92	8.50	8.29	8.90	8.46	
	EC (dS/m)	0.18	0.10	0.09	0.21	0.12	
Other (site)	Slope %	4.00			4.00		

Soil Series: Bijaipur (Uttar Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-32	B 32-139	C 139-150
Physical	Sand (%)	21.38	14.64	14.39	24.92	14.13	19.20
	Silt (%)	59.56	55.85	54.91	59.36	55.93	57.40
	Clay (%)	19.06	29.51	30.70	15.72	29.94	23.40
	Saturation Fraction [d]	0.41	0.45	0.45	0.10	0.44	0.42
	Field Capacity Fraction [d]	0.29	0.35	0.35	0.27	0.35	0.31
	Wilting Point Fraction [d]	0.12	0.18	0.19	0.10	0.18	0.14
	Saturated HC (mm/day) [d]	122.90	60.96	54.72	170.20	56.88	83.52
	Bulk Density (Mg m^{-3}) [d]	1.56	1.47	1.47	1.58	1.48	1.55
Chemical	Organic Carbon (%)	0.15	0.15	0.12	0.15	0.14	0.06
	Water pH	6.83	6.72	6.78	6.85	6.75	6.90
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %				4.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.)._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model
Soil Series: Nagaria (Uttar Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	14.6	17.5	47
February	17.4	21.3	71
March	22.8	11.2	121
April	28.9	9.1	168
May	33.8	18.5	192
June	34.2	121.2	182
July	30.8	323.6	128
August	29.4	286	120
September	29	192.8	123
October	26.2	44.5	109
November	20.5	2.5	65
December	16	8.1	44
Average	25.30	-	-
Total	-	1056.3	1370

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-18	6.2	1.59	0.39
18-40	3.5	1.59	0.25
40-66	15.7	1.62	0.15
66-96	15.2	1.62	0.11
96-125	12.2	1.62	0.08
125-145	7.5	1.62	0.08
145-170	6.2	1.62	0.08

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Bijaipur (Uttar Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	15.45	16.7	55
February	18.18	17.9	78
March	24.09	7.8	136
April	30	7	174
May	35	5.6	210
June	34.54	67.4	196
July	30	280.6	136
August	29.09	281.7	117
September	28.63	154.9	123
October	25.9	19.4	116
November	20.45	2.4	72
December	16.81	8.9	51
Average	25.68	-	-
Total	-	870.3	1464

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-17	10.1	1.56	0.18
17-32	22.1	1.56	0.11
32-61	25.0	1.56	0.15
61-84	29.8	1.47	0.15
84-119	32.2	1.47	0.15
119-139	33.3	1.47	0.12
139-172	23.4	1.47	0.06

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model
Soil Series: Nagaria (Uttar Pradesh)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	17.5	14.6
February	21.3	17.4
March	11.2	22.8
April	9.1	28.9
May	18.5	33.8
June	121.2	34.2
July	323.6	30.8
August	286	29.4
September	192.8	29
October	44.5	26.2
November	2.5	20.5
December	8.1	16
Average	-	25.30
Total	1056.3	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-18	8.9	0.39	1.59	70.0	23.8	6.2
18-40	9.1	0.25	1.59	72.8	23.8	3.5
40-66	8.6	0.15	1.62	54.0	30.3	15.7
66-96	8.5	0.11	1.62	54.8	30.0	15.2
96-125	8.1	0.08	1.62	63.8	24.0	12.2
125-145	8.6	0.08	1.62	70.0	22.5	7.5
145-170	8.0	0.08	1.62	71.3	22.5	6.2

[1] *Values for 0-50, 50-100, 100-150estimated by pedotransfer functions*

Soil Series: Bijaipur (Uttar Pradesh)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	16.7	15.45
February	17.9	18.18
March	7.8	24.09
April	7	30
May	5.6	35
June	67.4	34.54
July	280.6	30
August	281.7	29.09
September	154.9	28.63
October	19.4	25.9
November	2.4	20.45
December	8.9	16.81
Average	-	25.68
Total	870.3	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-17	6.8	0.18	1.56	31.2	58.7	10.1
17-32	6.9	0.11	1.56	17.8	60.1	22.1
32-61	6.8	0.15	1.56	15.1	59.9	25.0
61-84	6.7	0.15	1.47	15.0	55.2	29.8
84-119	6.7	0.15	1.47	13.8	54.0	32.2
119-139	6.8	0.12	1.47	12.3	54.4	33.3
139-172	6.9	0.06	1.47	19.2	57.4	23.4

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 4.4

(Madhya Bharat Plateau and Bundelkhand Uplands, hot, moist semi-arid ESR with Deep loamy and clayey mixed Red and Black soils, medium to high AWC and LGP 90-120 days (N6Dm4)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Haripur (Uttar Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-140	A 0-13	B 13-140	C
Physical	Sand (%)	20.01	23.31	26.20	24.00	22.85	
	Silt (%)	44.17	37.05	39.04	48.50	39.61	
	Clay (%)	26.20	40.00	33.80	27.50	37.54	
	Saturation Fraction [d]	0.44	0.40	0.45	0.44	0.46	
	Field Capacity Fraction [d]	0.33	0.38	0.35	0.33	0.37	
	Wilting Point Fraction [d]	0.16	0.24	0.21	0.17	0.23	
	Saturated HC (mm/day) [d]	94.08	39.12	56.64	97.68	44.88	
	Bulk Density (Mg m^{-3}) [d]	1.49	1.42	1.47	1.48	1.43	
Chemical	Organic Carbon (%)	0.38	0.30	0.25	0.46	0.30	
	Water pH	7.85	7.99	8.10	7.00	8.00	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	7.00			7.00		

Soil Series: Singpura (Madhya Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-20	B 25-155	C 155-190
Physical	Sand (%)	51.20	43.65	49.13	59.40	46.41	50.80
	Silt (%)	14.92	17.55	15.85	10.80	16.87	20.50
	Clay (%)	33.88	38.30	35.02	29.80	36.72	28.70
	Saturation Fraction [d]	0.42	0.43	0.42	0.40	0.43	0.40
	Field Capacity Fraction [d]	0.31	0.35	0.32	0.28	0.34	0.28
	Wilting Point Fraction [d]	0.21	0.23	0.21	0.18	0.22	0.17
	Saturated HC (mm/day) [d]	61.92	35.76	51.84	112.08	40.56	107.28
	Bulk Density (Mg m^{-3}) [d]	1.55	1.51	1.55	1.58	1.52	1.58
Chemical	Organic Carbon (%)	0.26	0.21	0.13	0.34	0.18	0.05
	Water pH	7.60	7.68	8.10	7.70	7.82	8.10
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	4.00			4.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 140 cm in Haripur)._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Haripur soil series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for RothC model

Soil Series: Haripur (Uttar Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	6.57	17.3	54
February	9.71	16	78
March	15.42	8.9	130
April	20.85	5.3	167
May	25.14	7.9	210
June	24	73.9	195
July	19.42	310.9	137
August	19.14	312.2	121
September	20	165.3	128
October	16.85	36.3	115
November	10.57	9.7	70
December	7.42	5.8	50
Average	16.26	-	-
Total	-	969.5	1455

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-13	27.5	1.49	0.46
13-35	38.3	1.49	0.39
35-62	39.4	1.49	0.31
62-92	41.3	1.42	0.31
92-140	33.8	1.47	0.25

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Singpura (Madhya Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	15.35	14.5	58.9
February	18.3	8.9	80.5
March	24.45	4.8	134.2
April	30.4	4.8	171.5
May	35.3	6.9	218.5
June	35.5	60.2	219.9
July	30.55	257.8	139.1
August	28.65	259.3	114.5
September	28.4	143.8	126.2
October	25.6	14	115.3
November	19.95	3.3	71.1
December	16	7.6	52.8
Average	25.70	-	-
Total	-	785.9	1502.5

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-20	29.8	1.55	0.34
20-32	35.4	1.55	0.21
32-63	37.4	1.55	0.21
63-96	39.5	1.51	0.21
96-116	37.6	1.51	0.20
116-155	33.8	1.55	0.10
155-190	28.7	1.55	0.05

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model
Soil Series: Haripur (Uttar Pradesh)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	17.3	6.57
February	16	9.71
March	8.9	15.42
April	5.3	20.85
May	7.9	25.14
June	73.9	24
July	310.9	19.42
August	312.2	19.14
September	165.3	20
October	36.3	16.85
November	9.7	10.57
December	5.8	7.42
Average	-	16.26
Total	969.5	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-13	7.7	0.46	1.49	24.0	48.5	27.5
13-35	7.9	0.39	1.49	16.7	45.0	38.3
35-62	7.9	0.31	1.49	21.4	39.2	39.4
62-92	8.0	0.31	1.42	23.3	35.4	41.3
92-140	8.1	0.25	1.47	26.2	40.0	33.8

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Singpura (Madhya Pradesh)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	14.5	15.35
February	8.9	18.3
March	4.8	24.45
April	4.8	30.4
May	6.9	35.3
June	60.2	35.5
July	257.8	30.55
August	259.3	28.65
September	143.8	28.4
October	14	25.6
November	3.3	19.95
December	7.6	16
Average	-	25.70
Total	785.9	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-20	7.7	0.34	1.55	59.4	10.8	29.8
20-32	7.6	0.21	1.55	47.0	17.6	35.4
32-63	7.5	0.21	1.55	44.9	17.7	37.4
63-96	7.7	0.21	1.51	42.9	17.6	39.5
96-116	8.1	0.20	1.51	45.8	16.6	37.6
116-155	8.1	0.10	1.55	50.7	15.5	33.8
155-190	8.1	0.05	1.55	50.8	20.5	28.7

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 5.1

(Central Kathiawar Peninsula, hot, dry semiarid ESR withshallow and medium loamy to clayey black soils (deep black
soils as inclusion) medium AWC and LGP 120-150 days
(L4Dd3)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Gondal (Gujarat)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-27			A 0-27	B	C
Physical	Sand (%)	37.42			37.42		
	Silt (%)	18.74			18.74		
	Clay (%)	43.84			43.84		
	Saturation Fraction [d]	0.45			0.45		
	Field Capacity Fraction	0.26			0.26		
	Wilting Point Fraction	0.13			0.13		
	Saturated HC (mm/day) [d]	485.85			485.85		
	Bulk Density (Mg m^{-3}) [d]	1.45			1.45		
Chemical	Organic Carbon (%)	0.15			0.15		
	Water pH	7.48			7.48		
	EC (dS/m)	0.28			0.28		
Other (site)	Slope %	1.00			1.00		

Soil Series: Kagwad (Gujarat)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-46			A 0-17	B 17-46	C
Physical	Sand (%)	21.62			22.00	21.40	
	Silt (%)	16.73			16.40	16.93	
	Clay (%)	61.65			61.60	61.67	
	Saturation Fraction [d]	0.49			0.49	0.49	
	Field Capacity Fraction	0.31			0.31	0.31	
	Wilting Point Fraction	0.17			0.16	0.17	
	Saturated HC (mm/day) [d]	332.09			331.50	335.27	
	Bulk Density (Mg m^{-3}) [d]	1.34			1.35	1.34	
Chemical	Organic Carbon (%)	0.35			0.39	0.33	
	Water pH	8.14			8.20	8.10	
	EC (dS/m)	0.26			0.30	0.24	
Other (site)	Slope %	2.00			2.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 27 cm and 46 cm in Gondal and Kagwad respectively)._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say B and C) not mentioned the column was left blank. For example in Gondal and Kagwad soil series, sinceB and C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur._

Soil and climatic datasets as required for Roth*C* Model

Soil Series: Gondal (Gujrat)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	19.4	1	121
February	21.9	0	138
March	26.2	1	206
April	30	3	249
May	32.6	7	302
June	32	99	240
July	28.7	293	170
August	27.8	143	150
September	27.9	93	154
October	28.1	25	169
November	24.8	5	131
December	20.9	4	114
Average	26.69	-	-
Total	-	674	2144

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-6	38.0	1.45	0.28
6-27	45.5	1.45	0.11

[1] *Values for 0-27 estimated by pedotransfer functions*

Soil Series: Kagwad (Gujrat)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	19.4	1	121
February	21.9	0	138
March	26.2	1	206
April	30	3	249
May	32.6	7	302
June	32	99	240
July	28.7	293	170
August	27.8	143	150
September	27.9	93	154
October	28.1	25	169
November	24.8	5	131
December	20.9	4	114
Average	26.69	-	-
Total	-	674	2144

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-17	61.6	1.34	0.39
17-35	61.1	1.34	0.35
35-46	62.6	1.34	0.29

[1] *Values for 0-46 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Gondal (Gujrat)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	1	19.4
February	0	21.9
March	1	26.2
April	3	30
May	7	32.6
June	99	32
July	293	28.7
August	143	27.8
September	93	27.9
October	25	28.1
November	5	24.8
December	4	20.9
Average	-	26.69
Total	674	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-6	7.4	0.28	1.45	38.9	23.1	38.0
6-27	7.5	0.11	1.45	37.0	17.5	45.5

[1] *Values for 0-27 estimated by pedotransfer functions*

Soil Series: Kagwad (Gujrat)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	1	19.4
February	0	21.9
March	1	26.2
April	3	30
May	7	32.6
June	99	32
July	293	28.7
August	143	27.8
September	93	27.9
October	25	28.1
November	5	24.8
December	4	20.9
Average	-	26.69
Total	674	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-17	8.2	0.39	1.34	22.0	16.4	61.6
17-35	8.1	0.35	1.34	19.2	19.7	61.1
35-46	8.1	0.29	1.34	25.0	12.4	62.6

[1] *Values for 0-46 estimated by pedotransfer functions*

AESR 5.2
(Madhya Bharat Plateau, Western Malwa Plateau, Eastern Gujarat Plain, Vindhyan and Satpura range and Narmada Valley, hot moist semi-arid ESR with medium and deep, clayey Black soils (shallow black soils as inclusions), medium to high AWC and LGP 120-150 days (I5Dm4).)[a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Haldhar (Gujarat)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-145	A 0-39	B 39-130	C 130-145
Physical	Sand (%)	20.71	27.81	26.82	19.91	26.62	27.40
	Silt (%)	22.42	15.93	19.25	22.54	17.47	22.50
	Clay (%)	56.87	56.26	53.93	57.55	55.91	50.10
	Saturation Fraction [d]	0.49	0.49	0.47	0.50	0.49	0.46
	Field Capacity Fraction [d]	0.37	0.37	0.36	0.38	0.37	0.33
	Wilting Point Fraction [d]	0.20	0.20	0.19	0.20	0.19	0.16
	Saturated HC (mm/day) [d]	432.04	425.35	342.68	460.76	389.93	311.77
	Bulk Density (Mg m^{-3}) [d]	1.34	1.35	1.40	1.33	1.36	1.44
Chemical	Organic Carbon (%)	0.22	0.20	0.23	0.23	0.22	0.17
	Water pH	7.66	7.65	7.95	7.57	7.77	8.10
	EC (dS/m)	0.14	0.09	0.16	0.13	0.12	0.17
Other (site)	Slope %	1.00			1.00		

Soil Series: Jalalpur (Gujarat)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-65	B 65-120	C
Physical	Sand (%)	27.94	26.24	26.82	27.68	30.99	
	Silt (%)	11.29	15.93	19.25	11.52	11.81	
	Clay (%)	60.77	56.26	53.93	60.80	57.20	
	Saturation Fraction [d]	0.51	0.52	0.55	0.50	0.55	
	Field Capacity Fraction [d]	0.39	0.39	0.38	0.40	0.38	
	Wilting Point Fraction [d]	0.22	0.22	0.20	0.22	0.20	
	Saturated HC (mm/day) [d]	1.37	1.40	1.50	1.38	1.46	
	Bulk Density (Mg m^{-3}) [d]	1.31	1.26	1.20	1.33	1.20	
Chemical	Organic Carbon (%)	0.45	0.52	0.29	0.44	0.40	
	Water pH	8.41	8.64	9.26	8.43	9.03	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	1.00			1.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 145 cm in Haldhar).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Jalalpur soil series, since C horizon wasnot reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.*

Soil and climatic datasets as required for RothC Model

Soil Series: Haldhar (Gujrat)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21.02	3.6	82
February	22.56	1.4	98
March	27.43	0.5	145
April	30.51	3.3	181
May	30.51	7.4	227
June	31.02	145.1	185
July	29.74	328.7	120
August	29.48	186	114
September	28.97	166.5	124
October	25.64	32.7	130
November	25.38	8	93
December	22.56	0.7	76
Average	27.07	-	-
Total	-	883.9	1575

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-17	54.5	1.34	0.27
17-39	59.9	1.34	0.20
39-56	54.5	1.34	0.20
56-102	56.5	1.35	0.20
102-130	55.8	1.40	0.27
130-145	50.1	1.40	0.17

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Jalalpur (Gujrat)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	19.14	2	82
February	22.22	2	98
March	27.5	1	145
April	30.81	3	181
May	33.51	4	227
June	31.62	115	185
July	30.81	366	120
August	28.61	264	114
September	28.61	186	124
October	28.05	35	130
November	25.55	9	93
December	21.11	0	76
Average	27.30	-	-
Total	-	987	1575

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-22	60.6	1.20	0.49
22-65	60.9	1.40	0.42
65-110	60.4	1.20	0.56
110-150	53.6	1.20	0.22

Soil and climatic datasets as required for Century C Model

Soil Series: Haldhar (Gujrat)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	3.6	21.02
February	1.4	22.56
March	0.5	27.43
April	3.3	30.51
May	7.4	30.51
June	145.1	31.02
July	328.7	29.74
August	186	29.48
September	166.5	28.97
October	32.7	25.64
November	8	25.38
December	0.7	22.56
Average	-	27.07
Total	883.9	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-17	7.4	0.27	1.34	20.2	25.3	54.5
17-39	7.7	0.20	1.34	19.7	20.4	59.9
39-56	8.0	0.20	1.34	23.5	22.0	54.5
56-102	7.6	0.20	1.35	28.4	15.1	56.5
102-130	7.9	0.27	1.40	25.6	18.6	55.8
130-145	8.1	0.17	1.40	27.4	22.5	50.1

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Jalalpur (Gujrat)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	2	19.14
February	2	22.22
March	1	27.5
April	3	30.81
May	4	33.51
June	115	31.62
July	366	30.81
August	264	28.61
September	186	28.61
October	35	28.05
November	9	25.55
December	0	21.11
Average	-	27.30
Total	987	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-22	8.3	0.49	1.20	29.4	10.0	60.6
22-65	8.5	0.42	1.40	26.8	12.3	60.9
65-110	8.7	0.56	1.20	26.0	13.6	60.4
110-150	9.4	0.22	1.20	36.6	9.8	53.6

AESR 5.3

(Coastal Kathiawar Peninsula, hot moist semi-arid ESR with deep loamy coastal alluvium-derived soils (saline/phases inclusion), low to medium AWC and LGP 120-150 days (L7Dm4)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Khuntwada (Gujarat)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-85		A 0-12	B 12-85	C
Physical	Sand (%)	23.16	22.65		15.20	25.66	
	Silt (%)	33.22	11.88		51.00	20.06	
	Clay (%)	43.62	65.47		33.80	54.28	
	Saturation Fraction [d]	0.41	0.49		0.37	0.45	
	Field Capacity Fraction	0.36	0.41		0.34	0.39	
	Wilting Point Fraction	0.14	0.17		0.13	0.16	
	Saturated HC (mm/day) [d]	316.22	197.73		1752.20	239.71	
	Bulk Density (Mg m^{-3}) [d]	1.56	1.36		1.67	1.46	
Chemical	Organic Carbon (%)	0.66	0.49		0.30	0.64	
	Water pH	8.77	8.70		9.00	8.70	
	EC (dS/m)	0.10	0.02		0.10	0.06	
Other (site)	Slope %	1.00			1.00		

Soil Series: Lilvan (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-75		A 0-15	B 15-75	C
Physical	Sand (%)	14.34	26.59		14.30	19.45	
	Silt (%)	8.58	6.56		7.50	8.01	
	Clay (%)	77.08	66.852		78.20	72.53	
	Saturation Fraction [d]	0.56	0.53		0.56	0.55	
	Field Capacity Fraction	0.46	0.41		0.46	0.44	
	Wilting Point Fraction	0.24	0.18		0.21	0.20	
	Saturated HC (mm/day) [d]	428.13	453.40		355.48	457.82	
	Bulk Density (Mg m^{-3}) [d]	1.14	1.22		1.15	1.17	
Chemical	Organic Carbon (%)	0.49	0.36		0.51	0.43	
	Water pH	7.42	7.36		7.70	7.32	
	EC (dS/m)	0.21	0.17		0.21	0.19	
Other (site)	Slope %	2.00			2.00		

[a] Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b] According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 85 cm in Khuntwada).

[c] Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Khuntwada soil series, since C horizon wasnot reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.

Soil and climatic datasets as required for Roth*C* Model
Soil Series: Khuntwada (Gujarat)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	19.3	3	99
February	22.6	1	120
March	27.1	3	176
April	30.7	13	210
May	32.8	6	245
June	32.3	14	199
July	29.6	243	146
August	28.5	152	134
September	28.7	122	135
October	28.3	38	144
November	24.8	7	112
December	21.4	0	94
Average	27.18	-	-
Total	-	602	1814

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-12	33.8	1.56	0.3
12-27	39.4	1.56	0.9
27-50	51.5	1.56	0.7
50-69	73.4	1.36	0.4
69-85	49.5	1.36	0.6
85-90	-		-

[1] *Values for 0-50, 50-90 estimated by pedotransfer functions*

Soil Series: Lilvan (Gujarat)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	19.3	3	99
February	22.6	1	120
March	27.1	3	176
April	30.7	13	210
May	32.8	6	245
June	32.3	14	199
July	29.6	243	146
August	28.5	152	134
September	28.7	122	135
October	28.3	38	144
November	24.8	7	112
December	21.4	0	94
Average	27.18	-	-
Total	-	602	1814

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-15	78.2	1.14	1.67
15-37	77.9	1.14	5.17
37-58	74.4	1.14	8.77
58-75	63.3	1.22	8.92

Soil and climatic datasets as required for Century C Model
Soil Series: Khuntwada (Gujarat)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	3	19.3
February	1	22.6
March	3	27.1
April	13	30.7
May	6	32.8
June	14	32.3
July	243	29.6
August	152	28.5
September	122	28.7
October	38	28.3
November	7	24.8
December	0	21.4
Average	-	27.18
Total	602	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	9.0	0.3	1.56	15.3	51.0	33.8
12-27	8.7	0.9	1.56	20.1	40.5	39.4
27-50	8.7	0.7	1.56	29.3	19.2	51.5
50-69	8.7	0.4	1.36	16.0	10.6	73.4
69-85	8.7	0.6	1.36	37.1	13.4	49.5
85-90	-	-		-	-	-

[1] *Values for 0-50, 50-90 estimated by pedotransfer functions*

Soil Series: Lilvan (Gujarat)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	3	19.3
February	1	22.6
March	3	27.1
April	13	30.7
May	6	32.8
June	14	32.3
July	243	29.6
August	152	28.5
September	122	28.7
October	38	28.3
November	7	24.8
December	0	21.4
Average	-	27.18
Total	602	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-12	0-15	1.67	1.14	1.67	7.5	78.2
12-27	15-37	5.17	1.14	5.17	7.3	77.9
27-50	37-58	8.77	1.14	8.77	12.0	74.4
50-69	58-75	8.92	1.22	8.92	4.0	63.3

AESR 6.1

(South Western Maharashtra and North Karnataka Plateau, hot dry semi-arid ESR with shallow and medium loamy Black soils (deep clayey Black soils as inclusion), medium to high AWC and LGP 90-120 days (K4Dd3).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Talegaon (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-55		A 0-20	B 20-55	C
Physical	Sand (%)	22.14	22.30		21.90	22.30	
	Silt (%)	31.26	29.30		34.20	29.30	
	Clay (%)	46.60	48.40		43.90	48.40	
	Saturation Fraction [d]	0.46	0.46		0.45	0.46	
	Field Capacity Fraction [d]	0.33	0.34		0.32	0.34	
	Wilting Point Fraction [d]	0.17	0.18		0.15	0.17	
	Saturated HC (mm/day) [d]	418.73	382.92		476.45	382.92	
	Bulk Density (Mg m^{-3}) [d]	1.44	1.43		1.46	1.43	
Chemical	Organic Carbon (%)	0.34	0.26		0.45	0.26	
	Water pH	7.72	7.80		7.60	7.80	
	EC (dS/m)	0.20	0.20		0.10	0.10	
Other (site)	Slope %	3.00			3.00		

Soil Series: Sirasgaon (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-88		A 0-14	B 14-88	C
Physical	Sand (%)	39.28	40.57		42.30	39.37	
	Silt (%)	19.01	14.45		21.10	16.27	
	Clay (%)	41.71	44.98		36.60	44.36	
	Saturation Fraction [d]	0.43	0.44		0.42	0.44	
	Field Capacity Fraction [d]	0.28	0.29		0.26	0.29	
	Wilting Point Fraction [d]	0.14	0.15		0.11	0.14	
	Saturated HC (mm/day) [d]	499.71	479.02		496.83	484.30	
	Bulk Density (Mg m^{-3}) [d]	1.50	1.48		1.55	1.48	
Chemical	Organic Carbon (%)	0.41	0.32		0.42	0.36	
	Water pH	7.90	7.99		7.90	7.94	
	EC (dS/m)	0.26	0.20		0.30	0.22	
Other (site)	Slope %	3.00			3.00		

[a] _Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b] _According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 55 cm and 88 cm in Talegaon and Sirasgaon respectively)._

[c] _Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Talegaon and Sirasgaon soil series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur._

Soil and climatic datasets as required for RothC Model

Soil Series: Talegaon (Maharashtra)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21	3	99
February	23	0	115
March	26.8	5	160
April	29.9	11	184
May	31.1	26	208
June	28.1	131	154
July	25.6	102	126
August	25.1	98	123
September	25.1	175	116
October	25.1	84	127
November	22.4	33	103
December	20.6	8	90
Average	25.32	-	-
Total	-	676	1605

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-20	43.9	1.50	0.45
20-55	48.4	1.50	0.26

[1] *Values for 0-50, 50-55 estimated by pedotransfer functions*

Soil Series: Sirasgaon (Maharashtra)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21.38	2.5	92
February	23.05	1.3	108
March	26.38	2	150
April	29.44	14.2	172
May	30	27.4	192
June	27.5	107.4	141
July	25.27	168.9	108
August	24.44	96.5	105
September	25	130.1	108
October	25.83	76.2	118
November	23.05	30.5	96
December	21.38	4.3	86
Average	25.23	-	-
Total	-	661.3	1476

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-14	36.6	1.40	0.42
14-32	41.2	1.45	0.41
32-55	46.2	1.50	0.40
55-88	44.8	1.50	0.31

Soil and climatic datasets as required for Century C Model

Soil Series: Talegaon (Maharashtra)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	3	21
February	0	23
March	5	26.8
April	11	29.9
May	26	31.1
June	131	28.1
July	102	25.6
August	98	25.1
September	175	25.1
October	84	25.1
November	33	22.4
December	8	20.6
Average	-	25.32
Total	676	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-20	7.6	0.45	1.50	21.9	34.2	43.9
20-55	7.8	0.26	1.50	22.3	29.3	48.4

[1] *Values for 0-50, 50-55estimated by pedotransfer functions*

Soil Series: Sirasgaon (Maharashtra)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	2.5	21.38
February	1.3	23.05
March	2	26.38
April	14.2	29.44
May	27.4	30
June	107.4	27.5
July	168.9	25.27
August	96.5	24.44
September	130.1	25
October	76.2	25.83
November	30.5	23.05
December	4.3	21.38
Average	-	25.23
Total	661.3	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-14	7.9	0.42	1.40	42.3	21.1	36.6
14-32	7.9	0.41	1.45	39.8	19.0	41.2
32-55	7.9	0.40	1.50	36.4	17.4	46.2
55-88	8.0	0.31	1.50	41.2	14.0	44.8

AESR 6.2
(Central and Western Maharashtra Plateau and North Karnataka Plateau and North Western Telangana Plateau,
hot moist semi-arid ESR with shallow and medium loamy to clayey Black soils (medium land deep clayey Black soils as
inclusion), medium to high AWC and LGP 120-150 days (K4Dm4)) [a]

Soil Master
as required for _InfoCrop_ Model
NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Annapur (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-120	A 0-18	B 18-65	C 65-120
Physical	Sand (%)	47.33	73.45	81.30	44.70	53.72	78.82
	Silt (%)	20.85	7.50	6.60	26.20	15.28	6.55
	Clay (%)	31.82	19.05	12.10	29.10	31.00	14.63
	Saturation Fraction [d]	0.42	0.41	0.40	0.42	0.41	0.40
	Field Capacity Fraction [d]	0.31	0.27	0.13	0.29	0.29	0.15
	Wilting Point Fraction [d]	0.20	0.12	0.07	0.18	0.19	0.09
	Saturated HC (mm/day) [d]	80.88	480.72	1100.64	107.52	95.76	807.60
	Bulk Density (Mg m^{-3}) [d]	1.60	1.57	1.59	1.55	1.56	1.6
Chemical	Organic Carbon (%)	0.35	0.23	0.28	0.30	0.35	0.23
	Water pH	7.98	8.17	8.20	7.90	8.05	8.20
	EC (dS/m)	0.33	0.48	0.30	0.20	0.45	0.41
Other (site)	Slope %	5.00			5.00		

Soil Series: Torkewadi (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-15			A 0-15	B	C
Physical	Sand (%)	36.30			36.30		
	Silt (%)	26.50			26.50		
	Clay (%)	37.20			37.20		
	Saturation Fraction [e]	0.42			0.42		
	Field Capacity Fraction [e]	0.29			0.29		
	Wilting Point Fraction [e]	0.13			0.13		
	Saturated HC (mm/day)	-			-		
	Bulk Density (Mg m^{-3}) [e]	1.54			1.54		
Chemical	Organic Carbon (%)	0.51			0.51		
	Water pH	7.90			7.90		
	EC (dS/m)	0.60			0.60		
Other (site)	Slope %	1.00			1.00		

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological
Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is
less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 120 cm and 15 cm in Annapur
and Torkewadi).

[c]Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States
Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the
column was left blank. For example in Torkewadi soil series, since C horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested
by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by
texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).

[e] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested
by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper
prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.

Soil and climatic datasets as required for RothC Model

Soil Series: Annapur (Maharashtra)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21	3	99
February	23	0	115
March	26.8	5	160
April	29.9	11	184
May	31.1	26	208
June	28.1	131	154
July	25.6	102	126
August	25.1	98	123
September	25.1	175	116
October	25.1	84	127
November	22.4	33	103
December	20.6	8	90
Average	25.32	-	-
Total	-	676	1605

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-18	29.1	1.60	0.30
18-43	35.4	160	0.40
43-65	26.0	1.60	0.30
65-94	16.9	1.57	0.18
94-120	12.1	1.59	0.28

[1] *Values for 0-50, 50-100, 100-120 estimated by pedotransfer functions*

Soil Series: Torkewadi (Maharashtra)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21	3	99
February	23	0	115
March	26.8	5	160
April	29.9	11	184
May	31.1	26	208
June	28.1	131	154
July	25.6	102	126
August	25.1	98	123
September	25.1	175	116
October	25.1	84	127
November	22.4	33	103
December	20.6	8	90
Average	25.32	-	-
Total	-	676	1605

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-15	37.2	1.54	0.51

[1] *Values for 0-15estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Annapur (Maharashtra)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	3	21
February	0	23
March	5	26.8
April	11	29.9
May	26	31.1
June	131	28.1
July	102	25.6
August	98	25.1
September	175	25.1
October	84	25.1
November	33	22.4
December	8	20.6
Average	-	25.32
Total	676	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-18	7.9	0.30	1.60	44.7	26.2	29.1
18-43	8.0	0.40	160	44.5	20.1	35.4
43-65	8.1	0.30	1.60	64.2	9.8	26.0
65-94	8.2	0.18	1.57	76.6	6.5	16.9
94-120	8.2	0.28	1.59	81.3	6.6	12.1

[1] *Values for 0-50, 50-100, 100-120 estimated by pedotransfer functions*

Soil Series: Torkewadi (Maharashtra)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	3	21
February	0	23
March	5	26.8
April	11	29.9
May	26	31.1
June	131	28.1
July	102	25.6
August	98	25.1
September	175	25.1
October	84	25.1
November	33	22.4
December	8	20.6
Average	-	25.32
Total	676	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-15	7.9	0.51	1.54	36.3	26.5	37.2

[1] *Values for 0-15 estimated by pedotransfer functions*

AESR 6.3
(Eastern Maharashtra Plateau, hot moist semi-arid ESR with medium land deep clayey Black soils (shallow loamy to clayey Black soils as inclusion), medium to high AWC and LGP 120-150 days (K5Dm4).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Jambha (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-65	B 65-145	C 145-240
Physical	Sand (%)	14.36	9.91	9.12	14.09	10.22	7.10
	Silt (%)	19.52	24.56	20.16	20.07	24.70	29.20
	Clay (%)	66.12	65.53	70.72	65.84	65.08	63.70
	Saturation Fraction [d]	0.50	0.50	0.51	0.50	0.49	0.49
	Field Capacity Fraction [d]	0.43	0.41	0.44	0.42	0.42	0.41
	Wilting Point Fraction [d]	0.24	0.23	0.26	0.24	0.24	0.23
	Saturated HC (mm/day) [d]	94.54	201.08	96.21	107.60	118.01	113.73
	Bulk Density (Mg m^{-3}) [d]	1.34	1.32	1.30	1.34	1.35	1.36
Chemical	Organic Carbon (%)	0.46	0.39	0.46	0.45	0.35	0.15
	Water pH	8.53	8.33	8.58	8.50	8.54	0.20
	EC (dS/m)	0.16	0.16	0.20	0.15	0.20	0.23
Other (site)	Slope %	3.00			3.00		

Soil Series: Loni (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-14	B 14-160	C
Physical	Sand (%)	4.36	4.43	3.85	5.90	4.05	
	Silt (%)	27.85	21.34	27.14	30.50	24.94	
	Clay (%)	67.79	74.23	69.01	63.60	71.01	
	Saturation Fraction [d]	0.58	0.59	0.57	0.56	0.58	
	Field Capacity Fraction	0.46	0.42	0.54	0.40	0.47	
	Wilting Point Fraction	0.25	0.24	0.29	0.22	0.26	
	Saturated HC (mm/day) [d]	809.66	734.11	696.05	826.23	734.10	
	Bulk Density (Mg m^{-3}) [d]	1.12	1.08	1.14	1.17	1.11	
Chemical	Organic Carbon (%)	0.74	0.60	0.45	1.10	0.51	
	Water pH	6.23	6.40	6.51	6.30	6.40	
	EC (dS/m)	0.51	0.37	0.62	0.94	0.47	
Other (site)	Slope %	2.00			2.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Loni soil series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur._

Soil and climatic datasets as required for Roth*C* model

Soil Series: Jambha (Maharashtra)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	22.2	15	111
February	24.5	13	129
March	28.7	12	178
April	32.4	13	201
May	35	12	238
June	31.3	149	194
July	26.9	286	131
August	26.4	210	123
September	26.7	186	118
October	26.5	50	135
November	23.8	24	113
December	21.8	6	99
Average	27.18	-	-
Total	-	976	1770

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-20	59.7	1.71	1.71
20-45	71.5	1.88	1.88
45-65	64.9	2.04	2.04
65-105	65.8	1.99	1.99
105-145	73.0	1.97	1.97
145-190	57.4	1.90	1.90
190-240	63.7	1.93	1.93

Soil Series: Loni (Maharashtra)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	22.1	11.9	112
February	25.2	1	133
March	28.9	19.6	182
April	32.2	17.8	206
May	35	14.1	252
June	31.1	196.2	199
July	26.5	302.4	126
August	25.7	284.3	117
September	26	223.9	118
October	25.4	58.3	125
November	22.7	2	106
December	21.7	2	99
Average	26.88	-	-
Total	-	1133.5	1775

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-14	63.6	1.12	1.10
14-36	69.0	1.3	0.60
36-65	69.9	1.4	0.60
65-99	76.3	1.4	0.60
99-144	68.8	1.3	0.50
144-160	70.6	1.08	0.10

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Jambha (Maharashtra)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	15	22.2
February	13	24.5
March	12	28.7
April	13	32.4
May	12	35
June	149	31.3
July	286	26.9
August	210	26.4
September	186	26.7
October	50	26.5
November	24	23.8
December	6	21.8
Average	-	27.18
Total	976	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-20	8.6	1.71	1.71	13.6	26.7	59.7
20-45	8.5	1.88	1.88	15.2	13.3	71.5
45-65	8.4	2.04	2.04	13.2	21.9	64.9
65-105	8.3	1.99	1.99	8.5	25.7	65.8
105-145	8.6	1.97	1.97	8.7	18.3	73.0
145-190	8.7	1.90	1.90	13.1	29.5	57.4
190-240	8.6	1.93	1.93	7.1	29.2	63.7

Soil Series: Loni (Maharashtra)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	11.9	22.1
February	1	25.2
March	19.6	28.9
April	17.8	32.2
May	14.1	35
June	196.2	31.1
July	302.4	26.5
August	284.3	25.7
September	223.9	26
October	58.3	25.4
November	2	22.7
December	2	21.7
Average	-	26.88
Total	1133.5	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-14	6.3	1.10	1.12	5.9	30.5	63.6
14-36	6.3	0.60	1.3	4.0	26.9	69.0
36-65	6.4	0.60	1.4	3.4	26.7	69.9
65-99	6.4	0.60	1.4	4.9	18.8	76.3
99-144	6.5	0.50	1.3	3.8	27.4	68.8
144-160	6.6	0.10	1.08	4.2	25.2	70.6

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 6.4

(North Sahyadris and Western Karnataka Plateau, hot dry subhumid ESR (K4Cd5).) [a]

Soil Master
as required for *InfoCrop* Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Achmati (Karnataka)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-22	B 22-170	C
Physical	Sand (%)	17.30	10.07	9.80	22.52	10.56	
	Silt (%)	19.16	20.39	20.10	19.61	19.90	
	Clay (%)	63.54	69.54	70.10	57.87	69.54	
	Saturation Fraction [d]	0.48	0.50	0.50	0.47	0.50	
	Field Capacity Fraction [d]	0.35	0.36	0.35	0.35	0.36	
	Wilting Point Fraction [d]	0.16	0.17	0.18	0.14	0.17	
	Saturated HC (mm/day) [d]	97.75	0.24	0.24	161.22	12.57	
	Bulk Density (Mg m^{-3}) [d]	1.37	1.33	1.33	1.41	1.33	
Chemical	Organic Carbon (%)	1.25	0.80	0.71	1.22	0.82	
	Water pH	8.63	8.28	8.90	8.55	8.77	
	EC (dS/m)	0.70	0.48	0.50	0.20	0.95	
Other (site)	Slope %	2.00			2.00		

Soil Series: Nimone (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-139	A 0-18	B 18-125	C 125-139
Physical	Sand (%)	31.89	30.12	33.91	31.50	30.23	44.10
	Silt (%)	13.41	12.49	11.95	14.30	12.67	10.60
	Clay (%)	54.78	57.39	54.14	54.20	57.10	45.30
	Saturation Fraction [d]	0.40	0.40	0.40	0.40	0.40	0.40
	Field Capacity Fraction [d]	0.36	0.39	0.37	0.35	0.38	0.33
	Wilting Point Fraction [d]	0.19	0.21	0.20	0.18	0.20	0.16
	Saturated HC (mm/day) [d]	349.22	223.26	145.12	375.78	242.83	147.90
	Bulk Density (Mg m^{-3})	1.60	1.60	1.60	1.60	1.60	1.60
Chemical	Organic Carbon (%)	0.42	0.45	0.40	0.60	0.40	0.40
	Water pH	8.18	8.45	8.54	8.10	8.39	8.60
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	1.00			1.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 139 cm in Nimone).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Achmati soil series, since C horizon was not reported that column was kept blank.*

[d]*These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Achmati (Karnataka)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	23.42	2.8	121
February	26.31	2.5	131
March	28.15	7.1	173
April	29.47	30.7	179
May	28.94	69.1	184
June	26.31	71.1	145
July	25	67.6	130
August	25	92.2	131
September	25.26	129	123
October	25.52	112	123
November	23.94	44.2	113
December	22.89	9.4	112
Average	25.85	--	-
Total	-	637.7	1665

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})^1	Organic carbon (%)
0-4	54.6	1.37	1.25
4-22	58.6	1.37	1.21
22-54	68.0	1.37	1.27
54-87	69.5	1.33	0.78
87-152	70.1	1.33	0.71
152-170	70.3	-	0.48

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Nimone (Maharashtra)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21.38	2.5	92
February	23.05	1.3	108
March	26.38	2	150
April	29.44	14.2	172
May	30	27.4	192
June	27.5	107.4	141
July	25.27	168.9	108
August	24.44	96.5	105
September	25	130.1	108
October	25.83	76.2	118
November	23.05	30.5	96
December	21.38	4.3	86
Average	25.23	-	-
Total	-	661.3	1476

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-18	54.2	1.6	0.6
18-46	55.0	1.6	0.3
46-76	55.8	1.6	0.5
76-125	59.1	1.6	0.4
125-139	45.3	1.6	0.4

Soil and climatic datasets as required for Century C Model

Soil Series: Achmati (Karnataka)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	2.8	23.42
February	2.5	26.31
March	7.1	28.15
April	30.7	29.47
May	69.1	28.94
June	71.1	26.31
July	67.6	25
August	92.2	25
September	129	25.26
October	112	25.52
November	44.2	23.94
December	9.4	22.89
Average	-	25.85
Total	637.7	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-4	8.3	1.25	1.37	23.5	21.9	54.6
4-22	8.6	1.21	1.37	22.3	19.1	58.6
22-54	8.7	1.27	1.37	13.2	18.8	68.0
54-87	8.8	0.78	1.33	9.8	20.7	69.5
87-152	8.9	0.71	1.33	9.8	20.1	70.1
152-170	8.4	0.48	-	10.0	19.7	70.3

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Nimone (Maharashtra)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	2.5	21.38
February	1.3	23.05
March	2	26.38
April	14.2	29.44
May	27.4	30
June	107.4	27.5
July	168.9	25.27
August	96.5	24.44
September	130.1	25
October	76.2	25.83
November	30.5	23.05
December	4.3	21.38
Average	-	25.23
Total	661.3	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-18	8.1	0.6	1.6	31.5	14.3	54.2
18-46	8.2	0.3	1.6	32.0	13.0	55.0
46-76	8.4	0.5	1.6	32.9	12.3	55.8
76-125	8.5	0.4	1.6	28.2	12.7	59.1
125-139	8.6	0.4	1.6	44.1	10.6	45.3

AESR 7.1

(South Telangana Plateau (Rayalseema) and Eastern Ghat, hot dry semi-arid ESR with deep loamy to clayey mixed Red and Black soils, medium AWC and LGP 90-120 days (K6Dd3).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Rayadurg (Andhra Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-64		A 0-12	B 12-64	C
Physical	Sand (%)	33.42	34.20		39.20	32.30	
	Silt (%)	40.29	43.90		39.60	41.42	
	Clay (%)	26.29	21.90		21.20	26.28	
	Saturation Fraction [d]	0.43	0.42		0.42	0.43	
	Field Capacity Fraction [d]	0.30	0.28		0.25	0.30	
	Wilting Point Fraction [d]	0.16	0.14		0.13	0.16	
	Saturated HC (mm/day) [d]	128.64	166.32		213.84	122.40	
	Bulk Density (Mg m^{-3}) [d]	1.51	1.55		1.55	1.52	
Chemical	Organic Carbon (%)	0.47	0.34		0.49	0.43	
	Water pH	8.72	8.60		8.70	8.69	
	EC (dS/m)	0.10	0.10		0.10	0.10	
Other (site)	Slope %	5.00			5.00		

Soil Series: Kurnool (Andhra Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-18	B 18-151	C
Physical	Sand (%)	22.63	13.30	11.71	32.10	13.65	
	Silt (%)	27.35	27.50	26.64	26.20	27.29	
	Clay (%)	50.02	59.20	61.65	41.70	59.06	
	Saturation Fraction [e]	0.41	0.44	0.45	0.39	0.44	
	Field Capacity Fraction [e]	0.40	0.43	0.44	0.35	0.43	
	Wilting Point Fraction [e]	0.21	0.24	0.25	0.18	0.24	
	Saturated HC (mm/day)	-	-	-	-	-	
	Bulk Density (Mg m^{-3}) [e]	1.57	1.49	1.46	1.61	1.49	
Chemical	Organic Carbon (%)	0.52	0.25	0.22	0.78	0.27	
	Water pH	9.56	9.60	9.52	9.10	9.62	
	EC (dS/m)	0.01	0.80	2.15	0.01	1.12	
Other (site)	Slope %	1.00			1.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 64 cm in Rayadurg).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Rayadurg and Kurnool soil series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Rayadurg (Andhra Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	25.05	131	131
February	27.65	156	156
March	30.85	209	209
April	33.6	210	210
May	34.5	205	205
June	31.95	167	167
July	30.05	148	148
August	29.7	144	144
September	29.15	132	132
October	28.2	124	124
November	25.85	106	106
December	24.3	103	103
Average	29.24	-	-
Total	-	1835	1835

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-12	21.2	1.51	0.49
12-35	31.8	1.51	0.55
35-64	21.9	1.51	0.34

[1] *Values for 0-50, 50-64 estimated by pedotransfer functions*

Soil Series: Kurnool (Andhra Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	24.15	4.1	118
February	26.8	8.1	135
March	30	5.3	181
April	32.65	14.2	195
May	33.6	29.7	221
June	30.3	75.9	190
July	28.15	105.9	161
August	27.8	103.1	155
September	27.6	146.1	134
October	27.4	78.5	126
November	25.1	30.2	108
December	23.45	5.8	104
Average	28.08	-	-
Total	-	606.9	1828

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-18	41.7	1.57	0.78
18-50	54.7	1.57	0.37
50-79	58.9	1.49	0.32
79-109	59.6	1.49	0.16
109-151	62.1	1.46	0.23

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Rayadurg (Andhra Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	131	25.05
February	156	27.65
March	209	30.85
April	210	33.6
May	205	34.5
June	167	31.95
July	148	30.05
August	144	29.7
September	132	29.15
October	124	28.2
November	106	25.85
December	103	24.3
Average	-	29.24
Total	1835	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	8.7	0.49	1.51	39.2	39.6	21.2
12-35	8.8	0.55	1.51	29.9	38.3	31.8
35-64	8.6	0.34	1.51	34.2	43.9	21.9

[1] *Values for 0-50, 50-64 estimated by pedotransfer functions*

Soil Series: Kurnool (Andhra Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	4.1	24.15
February	8.1	26.8
March	5.3	30
April	14.2	32.65
May	29.7	33.6
June	75.9	30.3
July	105.9	28.15
August	103.1	27.8
September	146.1	27.6
October	78.5	27.4
November	30.2	25.1
December	5.8	23.45
Average	-	28.08
Total	606.9	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-18	9.1	0.78	1.57	32.1	26.2	41.7
18-50	9.8	0.37	1.57	17.3	28.0	54.7
50-79	9.6	0.32	1.49	14.1	27.0	58.9
79-109	9.6	0.16	1.49	12.2	28.2	59.6
109-151	9.5	0.23	1.46	11.6	26.3	62.1

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 7.2

(North Telangana Plateau, hot moist semi-arid ESR with deep loamy and clayey mixed Red and Black soils, medium to very high AWC and LGP 120-150 days (K6Dm4).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Kasireddipalli (Andhra Paradesh)

Soil Parameters		Format I Soil Depth (cm)[b]			Format II Horizons (Depth in cm)[c]		
		0-50	50-100	100-120	A 0-40	B 40-130	C 130-180
Physical	Sand (%)	21.98	15.94	12.12	22.60	14.89	12.90
	Silt (%)	22.18	22.84	20.76	22.20	22.14	20.40
	Clay (%)	55.84	61.22	67.12	55.20	62.97	66.70
	Saturation Fraction [d]	0.44	0.45	0.47	0.44	0.46	0.47
	Field Capacity Fraction [d]	0.37	0.41	0.45	0.37	0.42	0.46
	Wilting Point Fraction [d]	0.20	0.23	0.26	0.19	0.23	0.25
	Saturated HC (mm/day) [d]	0.24	0.24	0.24	0.24	0.24	0.24
	Bulk Density (Mg m^{-3}) [d]	1.48	1.46	1.40	1.48	1.44	1.41
Chemical	Organic Carbon (%)	0.60	0.26	0.24	0.64	0.36	0.25
	Water pH	9.08	9.40	9.40	9.00	9.40	9.40
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	1.00			1.00		

Soil Series: Chitkul (Andhra Pradesh)

Soil Parameters		Format I Soil Depth (cm)[b]			Format II Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-20	B 20-150	C
Physical	Sand (%)	41.30	40.98	40.78	40.40	41.04	
	Silt (%)	20.82	18.69	19.08	21.90	19.24	
	Clay (%)	37.88	40.33	40.14	37.70	39.72	
	Saturation Fraction [d]	0.43	0.44	0.42	0.43	0.44	
	Field Capacity Fraction [d]	0.29	0.29	0.28	0.29	0.29	
	Wilting Point Fraction [d]	0.13	0.14	0.14	0.13	0.13	
	Saturated HC (mm/day) [d]	-	460.70	359.09	-	420.18	
	Bulk Density (Mg m^{-3}) [d]	1.52	1.50	1.53	1.52	1.51	
Chemical	Organic Carbon (%)	0.60	0.26	0.24	1.05	0.31	
	Water pH	7.68	7.68	8.02	7.70	7.81	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	1.00			1.00		

[a] Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b] According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths.

[c] Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Kasireddipalli soil series, since C horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.

Soil and climatic datasets as required for Roth*C* model

Soil Series: Kasireddipalli (Andhra Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21.2	0.8	110
February	23.9	16.8	130
March	27.3	18	182
April	30.2	30.2	198
May	31.9	24.1	220
June	28.9	166.4	196
July	26.6	254	140
August	25.5	201.7	136
September	25.8	181.1	119
October	24.9	37.9	124
November	22.4	16.3	104
December	20.4	6.1	99
Average	25.75	-	-
Total	-	953.4	1758

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-20	53.7	1.48	0.73
20-40	56.7	1.48	0.54
40-60	58.4	1.46	0.47
60-90	60.1	1.46	0.39
90-130	67.4	1.40	0.28
130-180	66.7	1.40	0.25

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Chitkul (Andhra Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21.2	0.8	110
February	23.9	16.8	130
March	27.3	18	182
April	30.2	30.2	198
May	31.9	24.1	220
June	28.9	166.4	196
July	26.6	254	140
August	25.5	201.7	136
September	25.8	181.1	119
October	24.9	37.9	124
November	22.4	16.3	104
December	20.4	6.1	99
Average	25.75	-	-
Total	-	953.4	1758

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-20	37.7	1.52	1.05
20-40	39.0	1.52	0.31
40-60	36.0	1.50	0.30
60-81	39.9	1.50	0.26
81-113	43.1	1.50	0.24
113-150	39.1	1.53	0.24

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Kasireddipalli (Andhra Pradesh)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	0.8	21.2
February	16.8	23.9
March	18	27.3
April	30.2	30.2
May	24.1	31.9
June	166.4	28.9
July	254	26.6
August	201.7	25.5
September	181.1	25.8
October	37.9	24.9
November	16.3	22.4
December	6.1	20.4
Average	-	25.75
Total	953.4	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-20	8.8	0.73	1.48	23.5	22.8	53.7
20-40	9.2	0.54	1.48	21.7	21.6	56.7
40-60	9.4	0.47	1.46	19.5	22.1	58.4
60-90	9.4	0.39	1.46	16.2	23.7	60.1
90-130	9.4	0.28	1.40	11.6	21.0	67.4
130-180	9.4	0.25	1.40	12.9	20.4	66.7

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Chitkul (Andhra Pradesh)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	0.8	21.2
February	16.8	23.9
March	18	27.3
April	30.2	30.2
May	24.1	31.9
June	166.4	28.9
July	254	26.6
August	201.7	25.5
September	181.1	25.8
October	37.9	24.9
November	16.3	22.4
December	6.1	20.4
Average	-	25.75
Total	953.4	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-20	7.7	1.05	1.52	40.4	21.9	37.7
20-40	7.7	0.31	1.52	41.8	19.2	39.0
40-60	7.6	0.30	1.50	42.1	21.9	36.0
60-81	7.6	0.26	1.50	41.8	18.3	39.9
81-113	7.8	0.24	1.50	39.0	17.9	43.1
113-150	8.1	0.24	1.53	41.4	19.5	39.1

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 7.3

(Eastern Ghat (South), hot moist semi-arid/dry subhumid ESR with medium to deep, loamy to clayey mixed Red and Black soils, medium AWC and LGP 150-180 days (H6Dm/Cd5).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Peddapuram (Andhra Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-21	B 21-150	C
Physical	Sand (%)	67.18	48.50	43.94	80.90	48.05	
	Silt (%)	4.02	1.90	2.01	5.60	2.11	
	Clay (%)	28.80	49.60	54.05	13.50	49.84	
	Saturation Fraction [d]	0.39	0.45	0.47	0.39	0.45	
	Field Capacity Fraction [d]	0.26	0.41	0.47	0.14	0.42	
	Wilting Point Fraction [d]	0.18	0.29	0.32	0.08	0.29	
	Saturated HC (mm/day) [d]	140.16	3.10	1.00	905.52	2.40	
	Bulk Density (Mg m^{-3}) [d]	1.61	1.47	1.42	1.61	1.46	
Chemical	Organic Carbon (%)	0.26	0.26	0.26	0.45	0.45	
	Water pH	5.48	5.60	5.83	5.72	5.62	
	EC (dS/m)	0.08	0.10	0.10	0.05	0.02	
Other (site)	Slope %	2.00			2.00		

Soil Series: Nuzvid (Andhra Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-8	B 8-150	C
Physical	Sand (%)	65.25	52.19	49.90	85.90	54.09	
	Silt (%)	6.00	7.11	7.50	6.80	6.87	
	Clay (%)	28.75	40.70	42.60	7.30	39.04	
	Saturation Fraction [d]	0.39	0.42	0.43	0.27	0.42	
	Field Capacity Fraction [d]	0.26	0.35	0.36	0.19	0.34	
	Wilting Point Fraction [d]	0.17	0.24	0.25	0.05	0.24	
	Saturated HC (mm/day) [d]	136.08	20.16	2.34	649.92	36.96	
	Bulk Density (Mg m^{-3}) [d]	1.47	1.34	1.32	1.73	1.36	
Chemical	Organic Carbon (%)	0.32	0.26	0.26	0.31	0.28	
	Water pH	6.19	5.93	5.90	6.90	5.95	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	5.00			5.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 18 cm in Cudappah).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Nuzvid soil series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Peddapuram (Andhra Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21.6	5.80	112
February	23.9	12.20	123
March	27.4	11.90	168
April	30.3	25.40	176
May	32.4	48.30	194
June	29.1	130.60	169
July	26.0	196.90	136
August	25.8	160.30	137
September	25.6	164.30	125
October	25.0	180.30	125
November	22.3	92.20	116
December	20.6	5.30	108
Average	25.8	-	-
Total	-	1033.50	1689

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-10	10.2	1.61	0.28
10-21	16.5	1.61	0.24
21-49	39.4	1.61	0.26
49-88	49.6	1.47	0.26
88-112	57.4	1.42	0.25
112-150	53.0	1.42	0.26

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Nuzvid (Andhra Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21.6	7.9	125
February	23.9	9.9	136
March	27.4	17.5	181
April	30.3	19.3	197
May	32.4	49	227
June	29.1	115.8	199
July	26.0	223.5	148
August	25.8	182.4	139
September	25.6	170.7	127
October	25.0	138.7	121
November	22.3	67.1	121
December	20.6	4.1	116
Average	25.8	-	-
Total	-	1005.9	1837

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-8	07.3	1.47	0.31
8-30	30.6	1.34	0.39
30-63	35.3	1.32	0.25
63-150	42.6	1.32	0.26

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Peddapuram (Andhra Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	5.80	21.6
February	12.20	23.9
March	11.90	27.4
April	25.40	30.3
May	48.30	32.4
June	130.60	29.1
July	196.90	26.0
August	160.30	25.8
September	164.30	25.6
October	180.30	25.0
November	92.20	22.3
December	5.30	20.6
Average	-	25.8
Total	1033.50	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-10	6.3	0.28	1.61	85.0	4.4	10.2
10-21	5.2	0.24	1.61	76.8	6.7	16.5
21-49	5.3	0.26	1.61	57.7	2.9	39.4
49-88	5.6	0.26	1.47	48.5	1.9	49.6
88-112	5.6	0.25	1.42	41.2	1.4	57.4
112-150	5.9	0.26	1.42	44.8	2.2	53.0

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Nuzvid (Andhra Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	7.9	21.6
February	9.9	23.9
March	17.5	27.4
April	19.3	30.3
May	49	32.4
June	115.8	29.1
July	223.5	26.0
August	182.4	25.8
September	170.7	25.6
October	138.7	25.0
November	67.1	22.3
December	4.1	20.6
Average	-	25.8
Total	1005.9	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-8	6.9	1.47	1.47	85.9	6.8	07.3
8-30	6.1	1.34	1.47	63.7	5.7	30.6
30-63	6.0	1.32	1.47	58.7	6.0	35.3
63-150	5.9	-	1.34	49.9	7.5	42.6

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 8.1

(Tamil Nadu Uplands and Leeward Flanks of South Sahyadris, hot dry semi-arid ESR with moderately deep to deep, loamy to clayey, mixed Red and Black soils, medium AWC and LGP 90-120 days (H6Dd3).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Coimbatore (Tamil Nadu)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-124	A 0-15	B 15-75	C 75-124
Physical	Sand (%)	33.64	23.35	23.10	40.70	27.70	23.10
	Silt (%)	17.11	21.80	21.90	16.30	19.23	21.90
	Clay (%)	49.24	54.85	55.00	43.00	53.07	55.00
	Saturation Fraction [e]	0.43	0.46	0.46	0.41	0.45	0.46
	Field Capacity Fraction [e]	0.34	0.36	0.37	0.30	0.35	0.37
	Wilting Point Fraction [e]	0.17	0.20	0.20	0.14	0.18	0.19
	Saturated HC (mm/day) [e]	172.86	207.58	183.09	195.48	193.73	183.09
	Bulk Density (Mg m^{-3}) [e]	1.50	1.44	1.43	1.56	1.46	1.43
Chemical	Organic Carbon (%)	0.38	0.36	0.31	0.35	0.41	0.31
	Water pH	8.72	8.50	8.50	8.70	8.64	8.50
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	1.00			1.00		

Soil Series: Kovilpatti (Tamil Nadu)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	0-20	20-128	128-150
Physical	Sand (%)	16.87	13.96	12.87	19.16	13.11	22.90
	Silt (%)	19.92	19.72	25.36	20.86	19.24	52.40
	Clay (%)	63.21	66.32	61.77	59.98	67.65	24.70
	Saturation Fraction	0.70	0.75	0.73	0.42	0.50	0.40
	Field Capacity Fraction	0.39	0.45	0.46	0.36	0.45	0.35
	Wilting Point Fraction	0.23	0.26	0.26	0.21	0.25	0.19
	Saturated HC (mm/day)	7752.00	8064.00	7752.00	5064.00	8448.00	11520.00
	Bulk Density (Mg m^{-3})	1.40	1.40	1.40	1.10	1.40	1.40
Chemical	Organic Carbon (%)	0.35	0.32	0.25	0.62	0.55	0.21
	Water pH	8.00	7.95	7.70	8.00	7.90	7.50
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %						

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 124 cm and 68 cm in Coimbatore and Palathurai respectively).

[c]Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.).

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.

Soil and climatic datasets as required for Roth*C* model

Soil Series: Coimbatore (Tamil Nadu)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	24.4	11	93.2
February	26.2	7	113.5
March	28.4	9	152.2
April	29	61	160.1
May	28.5	69	167.8
June	26.5	34	132.2
July	25.5	42	134.7
August	26	34	133.4
September	26.3	37	127.2
October	26.2	149	127.2
November	25.2	125	105.9
December	24.2	34	92.2
Average	26.37	-	-
Total	-	612	1539.6

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-15	43.0	1.50	0.35
15-42	51.1	1.50	0.40
42-75	54.7	1.44	0.41
75-124	55.0	1.43	0.31

[1] *Values for 0-50, 50-100, 100-124 estimated by pedotransfer functions*

Soil Series: Kovilpatti (Tamil Nadu)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	26.5	6.4	107.6
February	27.7	9.2	125.6
March	29.7	23	160.1
April	30.7	71.6	165.3
May	31.8	36.5	178.1
June	31	12.2	173
July	30.4	20.9	175.1
August	30.6	45.5	173.5
September	30.7	86.3	163.7
October	29.5	197.3	152.2
November	27.2	108.8	133.7
December	26.4	42	109.6
Average	29.35	-	-
Total	-	659.7	1817.5

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-12	13.5	1.40	0.66
12-39	20.9	1.40	0.74
39-57	22.9	1.40	0.81
57-68	21.5	1.40	0.73

[1] *Values for 0-50, 50-68 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Coimbatore (Tamil Nadu)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	11	24.4
February	7	26.2
March	9	28.4
April	61	29
May	69	28.5
June	34	26.5
July	42	25.5
August	34	26
September	37	26.3
October	149	26.2
November	125	25.2
December	34	24.2
Average	-	26.37
Total	612	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-15	8.7	0.35	1.50	40.7	16.3	43.0
15-42	8.8	0.40	1.50	32.7	16.2	51.1
42-75	8.5	0.41	1.44	23.6	21.7	54.7
75-124	8.5	0.31	1.43	23.1	21.9	55.0

[1] *Values for 0-50, 50-100, 100-124 estimated by pedotransfer functions*

Soil Series: Kovilpatti (Tamil Nadu)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	6.4	26.5
February	9.2	27.7
March	23	29.7
April	71.6	30.7
May	36.5	31.8
June	12.2	31
July	20.9	30.4
August	45.5	30.6
September	86.3	30.7
October	197.3	29.5
November	108.8	27.2
December	42	26.4
Average	-	29.35
Total	659.7	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	8.4	0.66	1.40	75.9	10.6	13.5
12-39	8.3	0.74	1.40	67.0	12.1	20.9
39-57	8.6	0.81	1.40	64.4	12.7	22.9
57-68	8.8	0.73	1.40	64.4	14.1	21.5

[1] *Values for 0-50, 50-68 estimated by pedotransfer functions*

AESR 8.2
(Central Karnataka Plateau, hot moist semi-arid ESR with medium to deep Red loamy soils, low AWC and LGP 120- 150 days (K1Dm4).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Tymagondalu (Karnataka)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-13	B 13-160	C
Physical	Sand (%)	56.65	44.60	39.24	79.30	43.90	
	Silt (%)	9.32	10.22	11.40	7.90	10.63	
	Clay (%)	34.03	45.18	49.36	12.80	45.47	
	Saturation Fraction [d]	0.41	0.45	0.46	0.40	0.46	
	Field Capacity Fraction [d]	0.31	0.39	0.41	0.21	0.39	
	Wilting Point Fraction	0.10	0.12	0.12	0.04	0.12	
	Saturated HC (mm/day) [d]	64.08	12.72	7.44	548.88	12.00	
	Bulk Density (Mg m^{-3}) [d]	1.50	1.50	1.53	1.50	1.50	
Chemical	Organic Carbon (%)	0.48	0.50	0.39	0.86	0.76	
	Water pH	6.20	6.60	6.50	6.80	6.29	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	1.00			1.00		

Soil Series: Chanasandra (Karnataka)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-17	B 17-150	C
Physical	Sand (%)	53.61	47.92	55.90	78.10	48.93	
	Silt (%)	10.30	11.99	21.38	13.40	14.48	
	Clay (%)	36.09	40.09	22.72	8.50	36.59	
	Saturation Fraction [d]	0.42	0.43	0.40	0.41	0.43	
	Field Capacity Fraction [d]	0.33	0.35	0.24	0.26	0.34	
	Wilting Point Fraction [d]	0.22	0.24	0.14	0.06	0.22	
	Saturated HC (mm/day) [d]	52.32	27.12	227.52	1426.56	43.92	
	Bulk Density (Mg m^{-3}) [d]	1.53	1.51	1.60	1.56	1.52	
Chemical	Organic Carbon (%)	0.76	0.43	0.18	0.53	0.46	
	Water pH	6.56	6.69	6.70	6.70	6.65	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	5.00			5.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 25 cm in Aisandra)*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Chansandra soil series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Tyamagondalu (Karnataka)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	20.9	7.1	117
February	23.1	8.9	130
March	25.6	10.7	166
April	27.3	44.5	158
May	26.9	107.4	157
June	24.3	70.9	127
July	23.2	111.3	116
August	23.2	136.7	114
September	23.2	163.6	109
October	23.2	153.4	105
November	21.7	61.2	98
December	20.5	13.2	103
Average	23.59	-	-
Total	-	888.9	1500

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-13	12.8	-	0.50
13-34	40.1	1.50	0.46
34-80	43.3	-	0.50
80-110	48.0	1.52	0.49
110-160	49.7	1.53	0.36

[1] *Values for 0-25 estimated by pedotransfer functions*

Soil Series: Channasandra (Karnataka)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	20.9	7.1	117
February	23.1	8.9	130
March	25.6	10.7	166
April	27.3	44.5	158
May	26.9	107.4	157
June	24.3	70.9	127
July	23.2	111.3	116
August	23.2	136.7	114
September	23.2	163.6	109
October	23.2	153.4	105
November	21.7	61.2	98
December	20.5	13.2	103
Average	23.59	-	-
Total	-	888.9	1500

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-17	8.5	1.53	0.53
17-52	50.3	1.53	0.88
52-87	39.1	1.51	0.39
87-106	41.2	1.51	0.46
106-146	20.2	1.60	0.14

[1] *Values for 0-50, 50-100, 100-146 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Tyamagondalu (Karnataka)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	7.1	20.9
February	8.9	23.1
March	10.7	25.6
April	44.5	27.3
May	107.4	26.9
June	70.9	24.3
July	111.3	23.2
August	136.7	23.2
September	163.6	23.2
October	153.4	23.2
November	61.2	21.7
December	13.2	20.5
Average	-	23.59
Total	888.9	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-13	6.8	0.50	-	79.3	7.9	12.8
13-34	5.9	0.46	1.50	50.6	9.3	40.1
34-80	6.1	0.50	-	46.2	10.5	43.3
80-110	6.5	0.49	1.52	42.2	9.8	48.0
110-160	6.5	0.36	1.53	38.5	11.8	49.7

Soil Series: Channasandra (Karnataka)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	7.1	20.9
February	8.9	23.1
March	10.7	25.6
April	44.5	27.3
May	107.4	26.9
June	70.9	24.3
July	111.3	23.2
August	136.7	23.2
September	163.6	23.2
October	153.4	23.2
November	61.2	21.7
December	13.2	20.5
Average	-	23.59
Total	888.9	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-17	6.7	0.53	1.53	78.1	13.4	8.5
17-52	6.5	0.88	1.53	41.0	8.7	50.3
52-87	6.7	0.39	1.51	50.8	10.1	39.1
87-106	6.7	0.46	1.51	41.2	17.6	41.2
106-146	6.7	0.14	1.60	57.9	21.9	20.2

[1] *Values for 0-50, 50-100, 100-146 estimated by pedotransfer functions*

AESR 8.3

(Tamil Nadu Uplands and Plains, hot moist semi-arid ESR with deep red loamy soils, low AWC and LGP 120-150 days (H1Dm4). [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Sivagangai (Tamil Nadu)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-10	B 10-164	C
Physical	Sand (%)	57.98	42.15	41.19	73.00	44.80	
	Silt (%)	7.88	11.03	9.45	6.50	9.63	
	Clay (%)	34.14	46.82	49.36	20.50	44.57	
	Saturation Fraction [d]	0.41	0.45	0.46	0.39	0.45	
	Field Capacity Fraction [d]	0.31	0.40	0.41	0.20	0.39	
	Wilting Point Fraction [d]	0.21	0.28	0.29	0.13	0.28	
	Saturated HC (mm/day) [d]	64.80	8.40	6.00	400.32	9.12	
	Bulk Density (Mg m^{-3}) [d]	1.57	1.45	1.44	1.61	1.47	
Chemical	Organic Carbon (%)	0.34	0.09	0.09	0.46	0.15	
	Water pH	6.07	6.48	6.80	5.80	6.52	
	EC (dS/m)	0.01	0.01	0.02	0.01	0.01	
Other (site)	Slope %	1.00			1.00		

Soil Series: Salur (Tamil Nadu)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-23	B 23-155	C
Physical	Sand (%)	50.97	51.65	51.67	58.20	50.2	
	Silt (%)	13.57	10.26	8.03	6.50	11.23	
	Clay (%)	35.46	38.09	40.30	35.30	38.57	
	Saturation Fraction [d]	0.42	0.42	0.42	0.41	0.41	
	Field Capacity Fraction [d]	0.33	0.35	0.35	0.31	0.34	
	Wilting Point Fraction [d]	0.21	0.24	0.24	0.21	0.24	
	Saturated HC (mm/day) [d]	57.84	24.72	23.52	57.12	27.12	
	Bulk Density (Mg m^{-3}) [d]	1.53	1.53	1.53	1.55	1.55	
Chemical	Organic Carbon (%)	0.48	0.33	0.14	0.54	0.27	
	Water pH	8.10	8.26	8.40	8.00	8.37	
	EC (dS/m)	0.42	0.63	0.91	0.35	0.72	
Other (site)	Slope %	1.00			1.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Sivagangai and Salur soil series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model

Soil Series: Sivagangai (Tamil Nadu)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	22.99	35.29	56.47
February	25.39	14.12	61.18
March	26.76	16.47	68.24
April	27.45	32.94	68.24
May	30.20	49.41	75.29
June	31.23	28.24	75.29
July	29.85	47.06	75.29
August	29.85	70.59	63.53
September	28.14	91.76	54.12
October	26.76	178.82	35.29
November	24.36	134.12	40.00
December	24.36	84.71	49.41
Average	*27.28*	-	-
Total	-	783.53	722.35

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})^1	Organic carbon (%)
0-10	20.5	1.57	0.46
10-24	35.0	1.57	0.43
24-42	36.0	1.57	0.32
42-70	45.5	1.45	0.09
70-96	47.5	1.45	0.09
96-138	49.0	1.44	0.09
138-164	50.5	1.44	0.09

[1] Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions

Soil Series: Salur (Tamil Nadu)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	22.99	35.29	56.47
February	25.39	14.12	61.18
March	26.76	16.47	68.24
April	27.45	32.94	68.24
May	30.20	49.41	75.29
June	31.23	28.24	75.29
July	29.85	47.06	75.29
August	29.85	70.59	63.53
September	28.14	91.76	54.12
October	26.76	178.82	35.29
November	24.36	134.12	40.00
December	24.36	84.71	49.41
Average	*27.28*	-	-
Total	-	783.53	722.35

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})^1	Organic carbon (%)
0-23	35.3	1.53	0.54
23-59	35.6	1.53	0.42
59-85	38.2	1.53	0.36
85-109	39.4	1.53	0.21
109-155	40.5	1.53	0.12

[1] Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions

Soil and climatic datasets as required for Century C Model
Soil Series: Sivagangai (Tamil Nadu)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	35.29	22.99
February	14.12	25.39
March	16.47	26.76
April	32.94	27.45
May	49.41	30.20
June	28.24	31.23
July	47.06	29.85
August	70.59	29.85
September	91.76	28.14
October	178.82	26.76
November	134.12	24.36
December	84.71	24.36
Average	-	*27.28*
Total	783.53	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-10	5.8	0.46	1.57	73.0	6.5	20.5
10-24	5.9	0.43	1.57	58.4	6.6	35.0
24-42	6.2	0.32	1.57	55.4	8.6	36.0
42-70	6.4	0.09	1.45	44.3	10.2	45.5
70-96	6.5	0.09	1.45	40.6	11.9	47.5
96-138	6.8	0.09	1.44	41.5	9.5	49.0
138-164	6.8	0.09	1.44	40.2	9.3	50.5

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Salur (Tamil Nadu)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	35.29	22.99
February	14.12	25.39
March	16.47	26.76
April	32.94	27.45
May	49.41	30.20
June	28.24	31.23
July	47.06	29.85
August	70.59	29.85
September	91.76	28.14
October	178.82	26.76
November	134.12	24.36
December	84.71	24.36
Average	-	*27.28*
Total	783.53	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-23	8.0	0.54	1.53	58.2	6.5	35.3
23-59	8.2	0.42	1.53	44.8	19.6	35.6
59-85	8.2	0.36	1.53	54.1	7.7	38.2
85-109	8.4	0.21	1.53	51.5	9.1	39.4
109-155	8.4	0.12	1.53	51.7	7.8	40.5

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 9.1
(Punjab and Rohilkhand Plains, hot dry/moist subhumid transitional ESR with deep, loamy to clayey alluvium-derived
(inclusion of saline and sodic phases) soils, medium AWC and LGP 120-150 days (N8Cm/Cd4)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Berpura (Haryana)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-23	B 23-150	C
Physical	Sand (%)	26.44	21.90	29.96	26.36	25.81	
	Silt (%)	45.85	44.41	39.74	47.27	42.23	
	Clay (%)	27.71	33.69	30.80	26.37	31.96	
	Saturation Fraction [d]	0.43	0.45	0.43	0.43	0.44	
	Field Capacity Fraction	0.23	0.24	0.23	0.23	0.24	
	Wilting Point Fraction	0.11	0.13	0.12	.10	0.12	
	Saturated HC (mm/day) [d]	85.44	55.68	72.24	97.44	65.28	
	Bulk Density (Mg m^{-3}) [d]	1.51	1.46	1.50	1.52	1.48	
Chemical	Organic Carbon (%)	0.22	0.22	0.25	0.26	0.23	
	Water pH	8.21	7.86	7.56	8.27	7.77	
	EC (dS/m)	0.20	0.20	0.20	0.20	0.20	
Other (site)	Slope %	2.00			2.00		

Soil Series: Shahzadpur (Uttar Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-18	B 18-133	C 133-150
Physical	Sand (%)	71.62	59.92	67.72	82.20	62.98	73.00
	Silt (%)	12.37	16.18	10.74	7.30	14.28	11.20
	Clay (%)	16.01	23.90	21.54	10.50	22.74	15.80
	Saturation Fraction [d]	0.39	0.39	0.39	0.39	0.39	0.39
	Field Capacity Fraction	0.10	0.12	0.11	0.07	0.11	0.10
	Wilting Point Fraction	0.48	0.68	0.59	0.02	0.06	0.05
	Saturated HC (mm/day) [d]	624.70	222.00	314.90	1242.47	260.6	626.4
	Bulk Density (Mg m^{-3}) [d]	1.62	1.60	1.62	1.60	1.61	1.63
Chemical	Organic Carbon (%)	0.20	0.17	0.12	0.15	0.25	0.08
	Water pH	6.71	6.89	6.57	7.00	6.62	6.50
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	2.00			2.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizon (say C) not mentioned the column was left blank. For example in Berpura soil series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model
Soil Series: Berpura (Haryana)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	13.5	38.5	14
February	16.3	28.4	23
March	21.5	29.5	70
April	27.7	6.1	153
May	31.7	19.3	204
June	33	73.2	210
July	30.3	267.2	199
August	29.2	267.2	183
September	28.8	161.3	159
October	25.4	32.9	109
November	19.6	9.3	41
December	15	13.2	18
Average	24.33	-	-
Total	-	946.1	1383

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-12	26.5	1.51	0.39
12-33	26.3	1.51	0.19
33-60	30.3	1.46	0.19
60-92	35.3	1.46	0.23
92-121	31.5	150	0.23
121-150	30.3	150	0.27

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Shahazadpur (Haryana)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	13.8	39.4	14.2
February	16.2	50.8	22.6
March	21.9	25.7	69.7
April	28	16.3	152.8
May	32.9	21.1	204.4
June	33.9	75.9	209.9
July	30.6	254	199.1
August	29.6	219.5	183.3
September	29.7	158.2	159.3
October	24.8	23.4	109.1
November	19.4	4.6	40.9
December	15.1	16.8	17.5
Average	24.66	-	-
Total	-	905.7	1382.8

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-18	10.5	1.62	0.25
18-43	17.8	1.62	0.17
43-93	23.8	1.60	0.17
93-133	24.5	1.62	0.14
133-150	15.8	1.62	0.08

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Berpura (Haryana)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	38.5	13.5
February	28.4	16.3
March	29.5	21.5
April	6.1	27.7
May	19.3	31.7
June	73.2	33
July	267.2	30.3
August	267.2	29.2
September	161.3	28.8
October	32.9	25.4
November	9.3	19.6
December	13.2	15
Average	-	24.33
Total	946.1	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	8.4	0.39	1.51	23.5	50.0	26.5
12-33	8.2	0.19	1.51	28.0	45.7	26.3
33-60	8.1	0.19	1.46	26.6	43.1	30.3
60-92	7.8	0.23	1.46	20.0	44.7	35.3
92-121	7.8	0.23	150	23.6	44.9	31.5
121-150	7.4	0.27	150	33.7	36.0	30.3

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Shahazadpur (Haryana)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	39.4	13.8
February	50.8	16.2
March	25.7	21.9
April	16.3	28
May	21.1	32.9
June	75.9	33.9
July	254	30.6
August	219.5	29.6
September	158.2	29.7
October	23.4	24.8
November	4.6	19.4
December	16.8	15.1
Average	-	24.66
Total	905.7	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-18	7.0	0.25	1.62	82.2	7.3	10.5
18-43	6.5	0.17	1.62	67.5	14.7	17.8
43-93	6.7	0.17	1.60	59.1	17.1	23.8
93-133	6.6	0.14	1.62	65.0	10.5	24.5
133-150	6.5	0.08	1.62	73.0	11.2	15.8

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 9.2

(Rohilkhand, Avadh and south Bihar Plains, hot dry subhumid ESR with deep loamy alluvium-derived soils, medium to high AWC and LGP 150-180 days (N8Cd5)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Basiaram (Uttar Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-28	B 28-170	C
Physical	Sand (%)	22.14	18.18	12.70	24.36	15.04	
	Silt (%)	60.77	57.96	63.17	62.82	60.49	
	Clay (%)	17.09	23.86	24.13	12.82	24.47	
	Saturation Fraction [d]	0.40	0.42	0.42	0.40	0.42	
	Field Capacity Fraction	0.22	0.24	0.27	0.20	0.26	
	Wilting Point Fraction	0.07	0.09	0.11	0.05	0.11	
	Saturated HC (mm/day) [d]	131.5	77.04	65.52	226.30	74.16	
	Bulk Density (Mg m^{-3}) [d]	1.59	1.54	1.53	1.57	1.52	
Chemical	Organic Carbon (%)	0.26	0.14	0.08	0.36	0.11	
	Water pH	7.33	7.30	7.19	7.31	7.25	
	EC (dS/m)	0.40	0.38	0.39	0.40	0.38	
Other (site)	Slope %	1.00			1.00		

Soil Series: Sarthua (Bihar)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-12	B 12-150	C
Physical	Sand (%)	15.95	9.34	7.70	21.00	10.13	
	Silt (%)	46.91	46.59	40.11	46.80	44.34	
	Clay (%)	37.14	44.07	52.19	32.20	45.53	
	Saturation Fraction [d]	0.47	0.50	0.52	0.46	0.50	
	Field Capacity Fraction [d]	0.37	0.41	0.44	0.35	0.42	
	Wilting Point Fraction [d]	0.22	0.26	0.31	0.20	0.27	
	Saturated HC (mm/day) [d]	49.92	39.60	33.60	77.52	36.72	
	Bulk Density (Mg m^{-3}) [d]	1.41	1.34	1.27	1.44	1.33	
Chemical	Organic Carbon (%)	0.31	0.15	0.10	0.54	0.16	
	Water pH	6.88	7.56	7.95	6.20	7.58	
	EC (dS/m)	0.21	0.26	0.19	0.21	0.25	
Other (site)	Slope %	1.00			1.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Basiaram and Sarthua soil series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model
Soil Series: Basiaram (Uttar Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	16.25	16.3	52
February	19.06	21.3	71
March	24.54	7.1	126
April	30.96	6.9	170
May	33.87	14.5	206
June	32.58	112.3	152
July	28.78	307.9	124
August	29.39	295.7	117
September	27.87	215.4	109
October	25.75	48.8	113
November	20.3	8.4	73
December	16.25	5.8	50
Average	25.47	-	-
Total	-	1060.4	1363

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-13	10.3	1.19	0.48
13-28	15.0	1.23	0.25
28-44	21.5	1.30	0.15
44-82	25.3	1.35	0.15
82-110	21.3	1.30	0.12
110-136	22.6	1.32	0.07
136-170	29.0	1.34	0.07

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Sarthua (Bihar)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.2	20.5	64
February	20.3	6.9	87
March	25.6	9.1	148
April	30.8	11.6	189
May	32.9	24.7	219
June	32.1	139.6	166
July	39.8	253.1	140
August	29.5	248	115
September	29.4	216.3	114
October	27.5	63.4	122
November	22.7	6.8	81
December	18.4	3.4	60
Average	27.18	-	-
Total	-	1003.4	1505

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-12	32.2	1.41	0.54
12-31	38.1	1.41	0.28
31-57	39.3	1.41	0.20
57-76	39.6	1.34	0.16
76-112	49.0	1.34	0.12
112-150	53.2	1.27	0.10

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model
Soil Series: Basiaram (Uttar Pradesh)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	16.3	16.25
February	21.3	19.06
March	7.1	24.54
April	6.9	30.96
May	14.5	33.87
June	112.3	32.58
July	307.9	28.78
August	295.7	29.39
September	215.4	27.87
October	48.8	25.75
November	8.4	20.3
December	5.8	16.25
Average	-	25.47
Total	1060.4	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-13	7.2	0.48	1.19	24.2	65.5	10.3
13-28	7.4	0.25	1.23	24.5	60.5	15.0
28-44	7.4	0.15	1.30	20.5	58.0	21.5
44-82	7.3	0.15	1.35	16.2	58.5	25.3
82-110	7.3	0.12	1.30	21.7	57.0	21.3
110-136	7.2	0.07	1.32	11.6	65.8	22.6
136-170	7.1	0.07	1.34	8.3	62.7	29.0

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Sarthua (Bihar)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	20.5	17.2
February	6.9	20.3
March	9.1	25.6
April	11.6	30.8
May	24.7	32.9
June	139.6	32.1
July	253.1	39.8
August	248	29.5
September	216.3	29.4
October	63.4	27.5
November	6.8	22.7
December	3.4	18.4
Average	-	27.18
Total	1003.4	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	6.2	0.54	1.41	21.0	46.8	32.2
12-31	7.0	0.28	1.41	18.0	43.9	38.1
31-57	7.2	0.20	1.41	10.7	50.0	39.3
57-76	7.4	0.16	1.34	11.3	49.1	39.6
76-112	7.8	0.12	1.34	7.4	43.6	49.0
112-150	8.0	0.10	1.27	7.8	39.0	53.2

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 10.1

(Malwa Plateau, Vindhyan Scarpland and Narmada Valley, hot dry subhumid ESR with medium and deep clayey Black soils (shallow loamy Black soils as inclusion), high AWC and LGP150-180 days (15Cd5).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Kheri (Madhya Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-37	B 37-150	C
Physical	Sand (%)	15.31	16.40	14.51	14.97	15.55	
	Silt (%)	21.83	19.69	20.54	22.54	20.08	
	Clay (%)	62.86	63.91	64.95	62.49	64.37	
	Saturation Fraction [d]	0.45	0.45	0.49	0.42	0.45	
	Field Capacity Fraction [d]	0.38	0.38	0.42	0.38	0.40	
	Wilting Point Fraction [d]	0.21	0.22	0.24	0.21	0.23	
	Saturated HC (mm/day) [d]	610.84	511.57	259.86	610.27	385.74	
	Bulk Density (Mg m^{-3}) [d]	1.91	1.96	1.99	1.89	1.97	
Chemical	Organic Carbon (%)	0.36	0.26	0.25	0.67	0.45	
	Water pH	7.27	7.54	8.04	7.22	7.75	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	1.00			1.00		

Soil Series: Jamra (Madhya Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-140	A 0-45	B 45-140	C
Physical	Sand (%)	25.03	22.70	21.66	25.28	22.26	
	Silt (%)	24.97	19.30	25.10	25.60	21.74	
	Clay (%)	50.00	58.0	53.24	49.12	56.00	
	Saturation Fraction [d]	0.40	0.45	0.42	0.39	0.43	
	Field Capacity Fraction [d]	0.36	0.40	0.38	0.35	0.39	
	Wilting Point Fraction [d]	0.19	0.22	0.20	0.18	0.21	
	Saturated HC (mm/day) [d]	309.94	251.24	171.46	316.23	218.30	
	Bulk Density (Mg m^{-3}) [d]	1.75	1.78	1.79	1.74	1.85	
Chemical	Organic Carbon (%)	0.71	0.65	0.46	0.72	0.57	
	Water pH	8.00	8.10	8.39	7.99	8.22	
	EC (dS/m)	0.23	0.20	0.20	0.24	0.20	
Other (site)	Slope %	1.00			1.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 14 cm and 22 cm in Bamori and Bartuma respectively).*

[c]*Horizons A, B, and C as described in <u>Soil Survey Staff</u> (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B and C) not mentioned the column was left blank. For example in Bamori and Bartuma soil series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Kheri (Madhya Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.9	26.4	69.6
February	20.1	21.5	88.8
March	24.7	14.9	134.9
April	29.5	9.4	165
May	33.9	15	203.2
June	32	170.4	172.6
July	27.1	505	105.8
August	26.5	400.7	99.3
September	26.9	212.4	107.4
October	24.9	50.1	112.7
November	20.3	16.7	78.3
December	17.9	5	63.2
Average	25.14	-	-
Total	-	1447.5	1400.8

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-14	51.1	1.4	0.72
14-32	53.7	1.4	0.56
32-61	46.3	1.4	0.50
61-82	53.6	1.4	0.60
82-112	46.6	1.5	0.40
112-133	44.6	1.5	0.63
133-156	46.7	-	0.36

[1] *Values for 0-14 estimated by pedotransfer functions*

Soil Series: Jamra (Madhya Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	16.57	20.1	81.2
February	20	12.7	100.9
March	25	8.9	154.3
April	30	6.1	186.1
May	33.71	9.9	222.7
June	30.85	127	181.6
July	26.47	416.8	107.5
August	25	372.9	99.1
September	25	195.8	109.9
October	25	27.2	125.2
November	22.05	23.4	95.1
December	18.85	8.6	79.3
Average	24.88	-	-
Total	-	1229.4	1542.9

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-16	44.8	1.67	0.78
16-45	51.5	1.78	0.68
45-102	58.0	1.79	0.65
102-140	53.0	1.94	0.45

Soil and climatic datasets as required for Century C Model

Soil Series: Kheri (Madhya Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	26.4	17.9
February	21.5	20.1
March	14.9	24.7
April	9.4	29.5
May	15	33.9
June	170.4	32
July	505	27.1
August	400.7	26.5
September	212.4	26.9
October	50.1	24.9
November	16.7	20.3
December	5	17.9
Average	-	25.14
Total	1447.5	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-14	7.5	0.72	1.4	18.4	30.5	51.1
14-32	7.6	0.56	1.4	16.6	29.7	53.7
32-61	7.6	0.50	1.4	16.8	36.9	46.3
61-82	7.6	0.60	1.4	6.0	40.4	53.6
82-112	7.8	0.40	1.5	14.8	38.6	46.6
112-133	7.7	0.63	1.5	16.4	39.0	44.6
133-156	8.0	0.36	-	15.9	37.4	46.7

[1] *Values for 0-14 estimated by pedotransfer functions*

Soil Series: Jamra (Madhya Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	20.1	16.57
February	12.7	20
March	8.9	25
April	6.1	30
May	9.9	33.71
June	127	30.85
July	416.8	26.47
August	372.9	25
September	195.8	25
October	27.2	25
November	23.4	22.05
December	8.6	18.85
Average	-	24.88
Total	1229.4	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-16	7.8	0.78	1.67	25.8	29.4	44.8
16-45	8.1	0.68	1.78	25.0	23.5	51.5
45-102	8.1	0.65	1.79	22.7	19.3	58.0
102-140	8.4	0.45	1.94	21.6	25.4	53.0

AESR 10.2
(Satpura and Eastern Maharashtra Plateau, hot dry subhumid ESR with shallow and medium loamy to clayey Black soils
(deep clayey Black soils as inclusion), medium to high AWC and LGP 150-180 days (K4Cd5).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Linga (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-140	A	B	C
Physical	Sand (%)	5.53	9.89	10.19	4.80	8.80	
	Silt (%)	19.98	16.05	17.34	20.60	17.47	
	Clay (%)	74.49	74.06	72.47	74.60	73.65	
	Saturation Fraction [d]	0.54	0.54	0.53	0.53	0.54	
	Field Capacity Fraction [d]	0.45	0.46	0.46	0.46	0.46	
	Wilting Point Fraction [d]	0.27	0.27	0.27	0.27	0.27	
	Saturated HC (mm/day) [d]	229.51	219.45	217.85	167.89	225.13	
	Bulk Density (Mg m^{-3}) [d]	1.23	1.23	1.24	1.24	1.23	
Chemical	Organic Carbon (%)	0.47	0.44	0.36	0.51	0.42	
	Water pH	8.16	8.10	8.10	8.30	8.10	
	EC (dS/m)	0.20	0.20	0.20	0.20	0.20	
Other (site)	Slope %	2.00			2.00		

Soil Series: Sukali (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A	B	C
Physical	Sand (%)	37.74	42.11	36.20	37.50	39.56	38.39
	Silt (%)	27.96	26.47	28.70	27.80	27.60	27.76
	Clay (%)	34.30	31.42	35.10	34.70	32.84	33.85
	Saturation Fraction [d]	0.41	0.40	0.41	0.41	0.40	0.41
	Field Capacity Fraction [d]	0.28	0.26	0.28	0.29	0.28	0.28
	Wilting Point Fraction [d]	0.13	0.11	0.13	0.13	0.12	0.13
	Saturated HC (mm/day)	-	-	-	-	-	-
	Bulk Density (Mg m^{-3}) [d]	1.57	1.58	1.55	1.57	1.58	1.56
Chemical	Organic Carbon (%)	0.25	0.17	0.10	0.38	0.19	0.13
	Water pH	7.88	7.73	7.80	7.90	7.86	7.76
	EC (dS/m)	0.44	0.36	0.50	0.70	0.39	0.42
Other (site)	Slope %	2.00			2.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 82 cm in Ladakh III)._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B and C) not mentioned the column was left blank. For example in Linga and Sukali soil series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur._

Soil and climatic datasets as required for Roth*C* model

Soil Series: Linga (Maharashtra)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21.8	15	81
February	24	22.6	100.2
March	27.4	14.5	144.6
April	30	12.2	170.9
May	32.2	15	201.7
June	29.2	175.3	169.6
July	26	292.6	110.3
August	25.1	216.4	102.1
September	25.7	176.3	107
October	25.7	43.9	112.2
November	23	18.5	86.7
December	21.5	8.4	73.2
Average	25.97	-	-
Total	-	1010.7	1459.5

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})^{1}	Organic carbon (%)
0-16	74.6	1.23	0.51
16-47	74.5	1.23	0.47
47-84	73.8	1.23	0.42
84-117	74.6	1.23	0.49
117-140	70.9	1.24	0.27

[1] *Values for 0-50, 50-100, 100-140 estimated by pedotransfer functions*

Soil Series: Sukali (Maharashtra)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21.8	15	81
February	24	22.6	100.2
March	27.4	14.5	144.6
April	30	12.2	170.9
May	32.2	15	201.7
June	29.2	175.3	169.6
July	26	292.6	110.3
August	25.1	216.4	102.1
September	25.7	176.3	107
October	25.7	43.9	112.2
November	23	18.5	86.7
December	21.5	8.4	73.2
Average	25.97	-	-
Total	-	1010.7	1459.5

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})^{1}	Organic carbon (%)
0-14	34.7	1.57	0.38
14-42	35.5	1.57	0.21
42-63	29.3	1.58	0.17
63-97	31.9	1.58	0.17
97-150	35.1	1.55	0.10

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Linga (Maharashtra)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	15	21.8
February	22.6	24
March	14.5	27.4
April	12.2	30
May	15	32.2
June	175.3	29.2
July	292.6	26
August	216.4	25.1
September	176.3	25.7
October	43.9	25.7
November	18.5	23
December	8.4	21.5
Average	-	25.97
Total	1010.7	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-16	8.3	0.51	1.23	4.8	20.6	74.6
16-47	8.1	0.47	1.23	5.5	20.0	74.5
47-84	8.1	0.42	1.23	9.7	16.5	73.8
84-117	8.1	0.49	1.23	10.3	15.1	74.6
117-140	8.1	0.27	1.24	10.1	19.0	70.9

[1] *Values for 0-50, 50-100, 100-140 estimated by pedotransfer functions*

Soil Series: Sukali (Maharashtra)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	15	21.8
February	22.6	24
March	14.5	27.4
April	12.2	30
May	15	32.2
June	175.3	29.2
July	292.6	26
August	216.4	25.1
September	176.3	25.7
October	43.9	25.7
November	18.5	23
December	8.4	21.5
Average	-	25.97
Total	1010.7	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-14	7.9	0.38	1.57	37.5	27.8	34.7
14-42	7.9	0.21	1.57	36.0	28.5	35.5
42-63	7.8	0.17	1.58	44.3	26.4	29.3
63-97	7.7	0.17	1.58	41.8	26.3	31.9
97-150	7.8	0.10	1.55	36.2	28.7	35.1

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 10.3

(Vindhyan Scarpland and Bundelkhand Plateau, hot dry subhumid ESR with deep loamy to clayey mixed Red and Black soils, medium to high AWC and LGP 150-180 days (I6Cd5).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Sundra (Madhya Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-40	B 40-140	
Physical	Sand (%)	16.14	13.08	14.80	17.55	13.51	
	Silt (%)	26.65	22.88	20.80	26.81	22.36	
	Clay (%)	57.21	64.04	64.40	55.64	64.13	
	Saturation Fraction [d]	0.40	0.42	0.42	0.45	0.50	
	Field Capacity Fraction [d]	0.37	0.40	0.40	0.40	0.44	
	Wilting Point Fraction [d]	0.20	0.23	0.23	0.22	0.25	
	Saturated HC (mm/day)	302.26	201.03	202.98	271.13	155.72	
	Bulk Density (Mg m^{-3})	1.77	1.78	1.79	1.80	1.78	
Chemical	Organic Carbon (%)	0.60	0.20	0.20	1.08	0.50	
	Water pH	8.16	8.30	8.30	8.20	8.35	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	1.00			1.00		

Soil Series: Marha (Madhya Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-70	B 70-180	C
Physical	Sand (%)	9.35	6.40	6.77	8.25	7.91	
	Silt (%)	43.71	44.42	48.94	43.62	47.88	
	Clay (%)	46.94	49.18	44.29	48.13	44.21	
	Saturation Fraction [d]	0.45	0.46	0.44	0.45	0.44	
	Field Capacity Fraction [d]	0.36	0.36	0.34	0.36	0.34	
	Wilting Point Fraction [d]	0.18	0.19	0.17	0.18	0.17	
	Saturated HC (mm/day) [d]	296.97	304.44	299.39	295.88	293.60	
	Bulk Density (Mg m^{-3}) [d]	1.46	1.44	1.49	1.45	1.49	
Chemical	Organic Carbon (%)	0.38	0.26	0.23	0.34	0.23	
	Water pH	8.00	8.00	8.02	8.00	8.04	
	EC (dS/m)	0.20	0.20	0.20	0.20	0.20	
Other (site)	Slope %	3.00			3.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 6 cm in Bishramganj).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Marha soil series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Sundra (Madhya Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	16.57	36	63.46
February	18.85	23	82.69
March	24.54	14	138.46
April	30	10	175
May	34.11	11	213.46
June	33.23	126	188.46
July	24.24	356	123.07
August	27.87	320	109.61
September	27.27	176	117.3
October	25.15	47	113.46
November	20.6	13	71.15
December	17.42	6	55.76
Average	24.99	-	-
Total	-	1138	1451.88

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-12	59.0	1.61	0.7
12-40	54.2	1.88	0.6
40-70	63.5	1.74	0.5
70-140	64.4	1.79	0.2

[1] *Values for 0-6 estimated by pedotransfer functions*

Soil Series: Marha (Madhya Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	16.57	36	63.46
February	18.85	23	82.69
March	24.54	14	138.46
April	30	10	175
May	34.11	11	213.46
June	33.23	126	188.46
July	24.24	356	123.07
August	27.87	320	109.61
September	27.27	176	117.3
October	25.15	47	113.46
November	20.6	13	71.15
December	17.42	6	55.76
Average	24.99	-	-
Total	-	1138	1451.88

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-12	44.2	1.60	0.48
12-44	47.2	1.90	0.36
44-70	51.1	1.92	0.30
70-105	47.9	1.97	0.24
105-137	45.3	1.97	0.24
137-180	40.4	2.01	0.21

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Sundra (Madhya Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	36	16.57
February	23	18.85
March	14	24.54
April	10	30
May	11	34.11
June	126	33.23
July	356	24.24
August	320	27.87
September	176	27.27
October	47	25.15
November	13	20.6
December	6	17.42
Average	-	24.99
Total	1138	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-12	8.9	0.7	1.61	18.6	22.4	59.0
12-40	7.9	0.6	1.88	17.1	28.7	54.2
40-70	8.0	0.5	1.74	10.5	26.0	63.5
70-140	8.5	0.2	1.79	14.8	20.8	64.4

[1] *Values for 0-6 estimated by pedotransfer functions*

Soil Series: Marha (Madhya Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	36	16.57
February	23	18.85
March	14	24.54
April	10	30
May	11	34.11
June	126	33.23
July	356	24.24
August	320	27.87
September	176	27.27
October	47	25.15
November	13	20.6
December	6	17.42
Average	-	24.99
Total	1138	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-12	8.0	0.48	1.60	11.7	44.1	44.2
12-44	8.0	0.36	1.90	9.2	43.6	47.2
44-70	8.0	0.30	1.92	5.5	43.4	51.1
70-105	8.0	0.24	1.97	7.0	45.1	47.9
105-137	8.0	0.24	1.97	5.3	49.4	45.3
137-180	8.1	0.21	2.01	10.6	49.0	40.4

AESR 10.4
(Satpura range and Wainganga Valley, hot moist subhumid ESR with shallow to deep loamy to clayey mixed Red and Black soils, low to medium AWC and LGP 180-210 days (K6Cm6).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Sagar (Madhya Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-60		A 0-12	B 12-60	C
Physical	Sand (%)	18.32	58.80		18.60	29.94	
	Silt (%)	22.01	13.00		25.40	18.53	
	Clay (%)	59.67	28.20		56.00	51.53	
	Saturation Fraction [d]	0.53	0.40		0.53	0.50	
	Field Capacity Fraction	0.29	0.24		0.24	0.29	
	Wilting Point Fraction	0.13	0.11		0.12	0.13	
	Saturated HC (mm/day) [d]	670.65	547.75		782.52	615.20	
	Bulk Density (Mg m^{-3}) [d]	1.24	1.58		1.24	1.34	
Chemical	Organic Carbon (%)	0.72	0.20		1.07	0.50	
	Water pH	6.74	7.40		6.40	6.99	
	EC (dS/m)	0.07	0.07		0.09	0.06	
Other (site)	Slope %	4.00			4.00		

Soil Series: Gondatola (Madhya Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-122	A 0-14	B 14-122	C
Physical	Sand (%)	19.77	32.53	41.10	25.20	29.32	
	Silt (%)	26.73	13.71	10.80	33.80	16.54	
	Clay (%)	53.50	53.76	48.10	41.00	54.14	
	Saturation Fraction [d]	0.56	0.55	0.53	0.53	0.55	
	Field Capacity Fraction	0.23	0.18	0.18	0.21	0.20	
	Wilting Point Fraction	0.11	0.11	0.11	0.11	0.11	
	Saturated HC (mm/day) [d]	1235.17	1084.82	1067.95	1324.10	1120.90	
	Bulk Density (Mg m^{-3}) [d]	1.16	1.19	1.26	1.25	1.18	
Chemical	Organic Carbon (%)	0.93	0.56	0.49	1.11	0.64	
	Water pH	5.10	5.59	5.70	4.90	5.47	
	EC (dS/m)	0.01	0.02	0.01	0.01	0.01	
Other (site)	Slope %	12.00			12.00		

[a] Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b] According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 60 cm and 122 cm in Sagar and Gondatola respectively).

[c] Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Sagar and Gondatola soil series, since C horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.

Soil and climatic datasets as required for Roth*C* model

Soil Series: Sagar (Madhya Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	18.82	19.6	79.6
February	20.88	24.9	99.8
March	25.29	22.3	145.4
April	30.3	16.5	169.5
May	33.33	23.64	195.8
June	30.3	216.4	151.5
July	25.29	419.9	100.6
August	25	355.9	97.6
September	25.29	202.4	104
October	23.82	64.3	116.4
November	20.294	21.6	86.7
December	18.23	10.4	72.2
Average	24.74	-	-
Total	-	1397.84	1419.1

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-12	56.0	1.24	1.07
12-32	63.2	1.24	0.68
32-46	58.2	1.24	0.54
46-60	28.2	1.58	0.20

[1] *Values for 0-50, 50-60 estimated by pedotransfer functions*

Soil Series: Gondatola (Madhya Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	18.82	19.6	79.6
February	20.88	24.9	99.8
March	25.29	22.3	145.4
April	30.3	16.5	169.5
May	33.33	23.64	195.8
June	30.3	216.4	151.5
July	25.29	419.9	100.6
August	25	355.9	97.6
September	25.29	202.4	104
October	23.82	64.3	116.4
November	20.294	21.6	86.7
December	18.23	10.4	72.2
Average	24.74	-	-
Total	-	1397.84	1419.1

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-14	41.0	1.16	1.11
14-43	58.4	1.16	0.91
43-78	58.2	1.19	0.62
78-122	48.1	1.26	0.49

[1] *Values for 0-50, 50-100, 100-122 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model
Soil Series: Sagar (Madhya Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	19.6	18.82
February	24.9	20.88
March	22.3	25.29
April	16.5	30.3
May	23.64	33.33
June	216.4	30.3
July	419.9	25.29
August	355.9	25
September	202.4	25.29
October	64.3	23.82
November	21.6	20.294
December	10.4	18.23
Average	-	24.74
Total	1397.84	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	6.4	1.07	1.24	18.6	25.4	56.0
12-32	6.7	0.68	1.24	16.9	19.9	63.2
32-46	7.0	0.54	1.24	19.7	22.1	58.2
46-60	7.4	0.20	1.58	58.8	13.0	28.2

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Gondatola (Madhya Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	19.6	18.82
February	24.9	20.88
March	22.3	25.29
April	16.5	30.3
May	23.64	33.33
June	216.4	30.3
July	419.9	25.29
August	355.9	25
September	202.4	25.29
October	64.3	23.82
November	21.6	20.294
December	10.4	18.23
Average	-	24.74
Total	1397.84	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-14	4.9	1.11	1.16	25.2	33.8	41.0
14-43	5.1	0.91	1.16	15.7	25.9	58.4
43-78	5.5	0.62	1.19	25.8	16.0	58.2
78-122	5.7	0.49	1.26	41.1	10.8	48.1

[1] *Values for 0-50, 50-100, 100-122 estimated by pedotransfer functions*

AESR 11

(Moderately to gently sloping Chattisgarh/Mahanadi Basin, hot moist/dry subhumid transitional ESR with deep loamy lto clayey Red and Yellow soils, medium AWC and LGP 150-180days (J3Cd/Cm5).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Bichanpur (Chattisgarh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-14	B 14-150	
Physical	Sand (%)	18.10	17.20	17.04	18.20	17.37	
	Silt (%)	30.66	28.40	27.18	31.00	28.51	
	Clay (%)	51.24	54.40	55.78	50.80	54.12	
	Saturation Fraction [d]	0.40	0.42	0.44	0.39	0.41	
	Field Capacity Fraction	0.34	0.36	0.37	0.34	0.36	
	Wilting Point Fraction	0.18	0.20	0.20	0.18	0.19	
	Saturated HC (mm/day) [d]	586.06	499.84	443.80	654.01	496.28	
	Bulk Density (Mg m^{-3})	1.70	1.74	1.79	1.70	1.75	
Chemical	Organic Carbon (%)	0.70	0.60	0.48	1.41	0.98	
	Water pH	7.22	7.45	7.58	7.00	7.46	
	EC (dS/m)	0.20	0.20	0.20	0.20	0.20	
Other (site)	Slope %	5.00			5.00		

Soil Series: Hitekusa (Chattisgarh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-104	A 0-18	B 18-104	C
Physical	Sand (%)	58.86	55.90	54.30	59.20	56.86	
	Silt (%)	15.05	13.50	13.00	16.30	13.79	
	Clay (%)	26.09	30.60	32.70	24.50	29.35	
	Saturation Fraction [d]	0.43	0.43	0.44	0.41	0.42	
	Field Capacity Fraction	0.19	0.19	0.19	0.09	0.06	
	Wilting Point Fraction	0.07	0.08	0.08	0.19	0.19	
	Saturated HC (mm/day) [d]	162.96	125.76	127.20	0.06	0.08	
	Bulk Density (Mg m^{-3})	1.63	1.65	1.66	1.62	1.65	
Chemical	Organic Carbon (%)	0.90	0.85	0.83	0.91	0.87	
	Water pH	5.54	5.65	5.70	5.40	5.64	
	EC (dS/m)	0.20	0.25	0.30	0.20	0.20	
Other (site)	Slope %	5.00			5.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 46 cm and 104 cm in Mohranga and Hitekusa respectively).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Mohranga and Hitekusa soil series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Bichanpur (Chhattisgarh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	20.80	13.70	88.50
February	22.70	26.90	109.90
March	26.70	18.00	160.80
April	30.60	15.50	193.90
May	32.50	21.30	252.30
June	30.10	219.50	178.10
July	27.00	370.80	113.40
August	26.50	389.10	110.00
September	26.20	213.10	111.50
October	25.70	52.30	124.30
November	22.60	14.50	93.20
December	20.80	4.10	80.60
Average	*26.02*	-	-
Total	-	1358.80	1616.50

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-14	50.8	1.70	0.82
14-45	51.0	1.71	0.66
45-75	54.0	1.73	0.70
75-109	54.6	1.75	0.51
109-150+	56.0	1.80	0.47

Soil Series: Hitekusa (Chhattisgarh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	20.6	16	88.5
February	23.2	26.7	109.9
March	27.6	18.8	160.8
April	32.1	19.3	193.9
May	35.5	20.8	252.3
June	32.1	199.6	178.1
July	27.2	339.9	113.4
August	27.1	344.4	110
September	27.5	212.6	111.5
October	26.3	61.5	124.3
November	22.5	13.5	93.2
December	20.2	3	80.6
Average	26.6	-	-
Total	-	1276.1	1616.5

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-18	24.5	1.62	0.91
18-40	26.3	1.63	0.91
40-75	28.5	1.65	0.87
75-104	32.7	1.66	0.83

Soil and climatic datasets as required for Century C Model

Soil Series: Bichanpur (Chhattisgarh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	13.70	20.80
February	26.90	22.70
March	18.00	26.70
April	15.50	30.60
May	21.30	32.50
June	219.50	30.10
July	370.80	27.00
August	389.10	26.50
September	213.10	26.20
October	52.30	25.70
November	14.50	22.60
December	4.10	20.80
Average	-	*26.02*
Total	1358.80	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-14	7.0	0.82	1.70	18.2	31.0	50.8
14-45	7.3	0.66	1.71	18.2	30.8	51.0
45-75	7.4	0.70	1.73	17.2	28.8	54.0
75-109	7.5	0.51	1.75	17.2	28.0	54.6
109-150+	7.6	0.47	1.80	17.0	27.0	56.0

Soil Series: Hitekusa (Chhattisgarh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	16	20.6
February	26.7	23.2
March	18.8	27.6
April	19.3	32.1
May	20.8	35.5
June	199.6	32.1
July	339.9	27.2
August	344.4	27.1
September	212.6	27.5
October	61.5	26.3
November	13.5	22.5
December	3	20.2
Average	-	*26.6*
Total	1276.1	-

2. Soil data: Required Physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-18	5.4	0.91	1.62	59.2	16.3	24.5
18-40	5.6	0.91	1.63	59.2	14.5	26.3
40-75	5.7	0.87	1.65	57.5	14.0	28.5
75-104	5.6	0.83	1.66	54.3	13.0	32.7

AESR 12.1
(Garjat Hills, Dandakaranya and Eastern Ghats, hot moist subhumid ESR with deep loamy Red and Lateritic soils, low to medium AWC and LGP 180-210 days (J2Cm6).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Gadchiroli (Maharashtra)

| Soil Parameters | | Format I | | | Format II | | |
| | | Soil Depth (cm)[b] | | | Horizons (Depth in cm)[c] | | |
		0-50	50-10	100-125	A	B	C
Physical	Sand (%)	57.74	57.30	54.04	58.30	56.29	
	Silt (%)	10.25	10.05	32.65	10.70	10.10	
	Clay (%)	32.01	32.65	35.36	31.00	33.61	
	Saturation Fraction [d]	0.35	0.35	0.37	0.33	0.36	
	Field Capacity Fraction	0.17	0.16	0.18	0.17	0.17	
	Wilting Point Fraction	0.09	0.08	0.09	0.08	0.08	
	Saturated HC (mm/day) [d]	1021.58	906.15	862.45	1047.50	948.45	
	Bulk Density (Mg m^{-3})	1.73	1.72	1.68	1.78	1.70	
Chemical	Organic Carbon (%)	1.32	0.82	0.74	1.42	0.94	
	Water pH	5.87	6.25	6.40	5.90	6.17	
	EC (dS/m)	0.07	0.10	0.10	0.08	0.09	
Other (site)	Slope %	5.00			5.00		

Soil Series: Bawanpuri (Chattisgarh)

| Soil Parameters | | Format I | | | Format II | | |
| | | Soil Depth (cm)[b] | | | Horizons (Depth in cm)[c] | | |
		0-50	50-100	100-150	A	B	C
Physical	Sand (%)	23.13	20.42	18.33	26.00	20.30	
	Silt (%)	27.42	26.00	25.53	28.40	26.00	
	Clay (%)	49.45	53.58	56.14	45.60	53.70	
	Saturation Fraction [d]	0.34	0.35	0.32	0.35	0.32	
	Field Capacity Fraction	0.26	0.28	0.30	0.25	0.28	
	Wilting Point Fraction	0.13	0.14	0.14	0.11	0.14	
	Saturated HC (mm/day) [d]	993.63	846.53	782.65	1215.50	872.35	
	Bulk Density (Mg m^{-3})	1.73	1.74	1.79	1.72	1.76	
Chemical	Organic Carbon (%)	0.57	0.35	0.29	0.99	0.35	
	Water pH	5.89	6.28	6.56	5.40	6.32	
	EC (dS/m)	0.20	0.20	0.20	0.20	0.20	
Other (site)	Slope %	5.00			5.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 122 cm in Gadchiroli)._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Gadchiroli and Bawanpuri soil series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur._

Soil and climatic datasets as required for Roth*C* model

Soil Series: Gadchiroli (Maharashtra)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	14.4	11.7	90
February	18.5	21.3	110
March	23.9	14.7	156
April	28.9	15	178
May	33.3	11.4	214
June	34.1	231.4	177
July	31.9	525.3	119
August	30.3	413.3	116
September	29.1	218.7	111
October	26.8	65.8	119
November	20.6	16.3	91
December	16.0	6.9	79
Average	*25.6*	-	-
Total	-	1551.8	1560

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-18	30.5	1.78	1.42
18-44	33.4	1.71	1.37
44-75	30.5	1.67	0.84
75-105	34.8	1.76	0.81
105-125+	35.5	1.67	0.72

Soil Series: Bawanpuri (Chattisgarh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	20.6	53.10	38.00
February	23.2	60.50	56.00
March	27.6	32.30	97.00
April	32.1	16.00	134.00
May	35.5	31.20	169.00
June	32.1	163.60	162.00
July	27.2	635.00	112.00
August	27.1	706.40	102.00
September	27.5	324.60	104.00
October	26.3	41.10	92.00
November	22.5	6.10	52.00
December	20.2	23.60	35.00
Average	*26.6*	-	-
Total	-	2093.50	1153.00

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-12	45.6	1.72	0.99
12-42	50.2	1.73	0.46
42-79	52.4	1.73	0.37
79-111	55.2	1.76	0.33
111-150+	56.4	1.80	0.28

[1] *Values for 0-50, 50-100, 100-111 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model
Soil Series: Gadchiroli (Maharashtra)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	11.7	14.4
February	21.3	18.5
March	14.7	23.9
April	15	28.9
May	11.4	33.3
June	231.4	34.1
July	525.3	31.9
August	413.3	30.3
September	218.7	29.1
October	65.8	26.8
November	16.3	20.6
December	6.9	16.0
Average	-	*25.6*
Total	1551.8	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-18	5.9	0.13	1.78	58.3	10.7	30.5
18-44	5.8	0.10	1.71	56.4	10.2	33.4
44-75	6.1	0.03	1.67	60.4	9.1	30.5
75-105	6.4	0.08	1.76	54.2	11.0	34.8
105-125+	6.4	0.07	1.67	54.0	10.5	35.5

Soil Series: Bawanpuri (Chattisgarh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	MAR (mm)	20.6
February	53.10	23.2
March	60.50	27.6
April	32.30	32.1
May	16.00	35.5
June	31.20	32.1
July	163.60	27.2
August	635.00	27.1
September	706.40	27.5
October	324.60	26.3
November	41.10	22.5
December	6.10	20.2
Average	23.60	*26.6*
Total	-	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	5.4	0.99	1.72	26.0	28.4	45.6
12-42	6.0	0.46	1.73	22.4	27.4	50.2
42-79	6.2	0.37	1.73	21.6	26.0	52.4
79-111	6.4	0.33	1.76	18.8	26.0	55.2
111-150+	6.6	0.28	1.80	19.1	25.4	56.4

[1] *Values for 0-50, 50-100, 100-111 estimated by pedotransfer functions*

AESR 12.2
(Eastern Ghats, hot moist subhumid ESR with medium to deep loamy Red and Lateritic soils, medium AWC and LGP 180-210 days (H2Cm6)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Bhubaneshwar (Orissa)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-88		A 0-13	B 13-88	C
Physical	Sand (%)	63.35	51.33		77.20	54.86	
	Silt (%)	20.73	29.33		13.70	26.31	
	Clay (%)	15.92	19.34		9.10	18.83	
	Saturation Fraction [d]	0.40	0.41		0.41	0.40	
	Field Capacity Fraction [d]	0.19	0.23		0.13	0.23	
	Wilting Point Fraction [d]	0.10	0.12		0.08	0.12	
	Saturated HC (mm/day)[d]	548.9	320.4		1384.00	479.28	
	Bulk Density (Mg m^{-3})[d]	1.58	1.58		1.55	1.58	
Chemical	Organic Carbon (%)	0.49	0.39		0.59	0.42	
	Water pH	4.82	4.77		4.70	4.82	
	EC (dS/m)	0.10	0.10		0.10	0.10	
Other (site)	Slope %	2.00			2.00		

Soil Series: Motto (Orissa)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-129	A 0-14	B 14-73	C 73-129
Physical	Sand (%)	7.86	7.07	8.80	10.70	4.87	7.91
	Silt (%)	51.48	51.57	65.00	51.50	34.99	60.31
	Clay (%)	40.66	41.50	26.20	37.80	30.37	31.91
	Saturation Fraction [d]	0.50	0.49	0.43	0.49	0.45	0.45
	Field Capacity Fraction [d]	0.40	0.40	0.34	0.38	0.37	0.37
	Wilting Point Fraction [d]	0.24	0.25	0.17	0.23	0.18	0.20
	Saturated HC (mm/day)[d]	57.36	40.80	53.52	84.96	51.12	46.08
	Bulk Density (Mg m^{-3})[d]	1.33	1.35	1.50	1.33	1.44	1.45
Chemical	Organic Carbon (%)	0.50	0.13	0.05	0.96	0.19	0.06
	Water pH	7.19	7.83	8.00	5.60	4.59	7.11
	EC (dS/m)	1.31	2.56	6.13	1.74	1.08	4.06
Other (site)	Slope %	1.00			1.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 88 cm and 12 9cm in Bhubaneshwar and Motto respectively)*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Bhubaneshwar series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth*C* model

Series: Bhubaneswar (Orissa)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	22.4	9	109
February	24.55	20	128
March	27.3	14	170
April	28.65	12	168
May	29.65	63	257
June	29.55	187	143
July	28.65	296	136
August	28.9	256	135
September	29	258	131
October	28.1	242	133
November	25.05	75	116
December	22.45	8	104
Average	27.02	-	-
Total	-	1440	1730

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-13	9.1	1.57	0.59
13-27	15.7	1.60	0.54
27-50	19.9	1.60	0.41
50-78	21.0	1.56	0.39
78-88	14.7	1.57	0.39

Soil Series: Motto (Orissa)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	20.6	17	82
February	23.15	31	102
March	27.6	38	157
April	30.5	48	177
May	31.55	98	219
June	30.45	234	129
July	28.7	318	107
August	28.65	335	101
September	28.55	287	94
October	27.1	230	105
November	23.25	45	88
December	20.5	9	76
Average	26.72	-	-
Total	-	1690	1437

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-14	37.8	1.49	1.45
14-28	39.2	1.48	-
28-54	43.4	1.45	1.60
54-73	46.0	1.40	1.52
73-98	39.0	1.36	1.48
98-129	26.2	1.38	-

Soil and climatic datasets as required for Century C Model

Soil Series: Bhubaneswar (Orissa)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	9	22.4
February	20	24.55
March	14	27.3
April	12	28.65
May	63	29.65
June	187	29.55
July	296	28.65
August	256	28.9
September	258	29
October	242	28.1
November	75	25.05
December	8	22.45
Average	-	27.02
Total	1440	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-13	4.7	0.59	1.57	77.2	13.7	9.1
13-27	4.8	0.54	1.60	56.0	28.3	15.7
27-50	4.9	0.41	1.60	60.0	20.1	19.9
50-78	4.8	0.39	1.56	54.2	24.8	21.0
78-88	4.7	0.39	1.57	43.3	42.0	14.7

Soil Series: Motto (Orissa)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	17	20.6
February	31	23.15
March	38	27.6
April	48	30.5
May	98	31.55
June	234	30.45
July	318	28.7
August	335	28.65
September	287	28.55
October	230	27.1
November	45	23.25
December	9	20.5
Average	-	26.72
Total	1690	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-13	4.7	0.59	1.57	77.2	13.7	9.1
13-27	4.8	0.54	1.60	56.0	28.3	15.7
27-50	4.9	0.41	1.60	60.0	20.1	19.9
50-78	4.8	0.39	1.56	54.2	24.8	21.0
78-88	4.7	0.39	1.57	43.3	42.0	14.7

AESR 12.3

(Chhotanagpur Plateau and Garjat Hills, hot, dry subhumid ESR with moderately deep to deep loamy to clayey Red and Lateritic soils, medium AWC and LGP of 150-180 days(J2Cd5)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Pusaro (Bihar)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-30	B 30-186	C
Physical	Sand (%)	43.75	40.89	37.65	46.07	38.09	
	Silt (%)	28.75	25.93	25.24	29.34	25.93	
	Clay (%)	27.50	33.18	37.11	24.59	35.98	
	Saturation Fraction [d]	0.41	0.422	0.43	0.41	0.43	
	Field Capacity Fraction [d]	0.29	0.32	0.34	0.27	0.34	
	Wilting Point Fraction [d]	0.17	0.19	0.22	0.15	0.21	
	Saturated HC (mm/day) [d]	111.40	63.12	39.60	157.40	44.16	
	Bulk Density (Mg m^{-3}) [d]	1.56	1.53	1.50	1.57	1.51	
Chemical	Organic Carbon (%)	0.19	0.09	0.07	0.24	0.08	
	Water pH	5.16	5.76	5.61	4.79	5.65	
	EC (dS/m)	0.10	0.10		0.10	0.10	
Other (site)	Slope %	4.00			4.00		

Soil Series: Phulkusuma (West Bengal)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-87		A 0-13	B 13-87	
Physical	Sand (%)	57.00	52.00		66.00	52.92	
	Silt (%)	11.28	9.20		14.30	9.76	
	Clay (%)	31.72	38.80		19.70	37.32	
	Saturation Fraction [d]	0.42	0.42		0.40	0.42	
	Field Capacity Fraction [d]	0.31	0.34		0.21	0.33	
	Wilting Point Fraction [d]	0.19	0.24		0.12	0.22	
	Saturated HC (mm/day) [d]	81.36	29.04		398.88	40.56	
	Bulk Density (Mg m^{-3}) [d]	1.55	1.54		1.60	1.54	
Chemical	Organic Carbon (%)	0.30	0.22		0.69	0.43	
	Water pH	6.04	6.20		5.60	6.20	
	EC (dS/m)	0.10	0.10		0.10	0.10	
Other (site)	Slope %	1.00					

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 29 cm in Ranga).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B and C) not mentioned the column was left blank. For example in Ranga and Pusaro series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Pusaro (Bihar)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.63	19.7	65.6
February	20.26	25.5	86.5
March	25	13.7	139.6
April	30	28.9	175.4
May	30	61.5	193.8
June	31.31	205.2	153.1
July	29.21	371.6	127.4
August	28.68	350.1	122.8
September	28.15	279.9	117.3
October	26.57	128.5	114.5
November	21.57	15.4	79.9
December	18.42	2.2	61.4
Average	25.57	-	-
Total	-	1502.2	1437.3

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-9	19.9	1.81	0.26
9-30	26.6	1.65	0.23
30-48	31.8	1.56	0.13
48-73	32.5	1.53	0.10
73-91	33.7	1.62	0.10
91-114	33.9	1.53	0.08
114-141	37.6	1.50	0.07
141-186	40.6	-	0.05

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Phulkusma (West Bengal)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	19.14	17	77
February	22	24	98
March	26.85	17	155
April	31.14	24	188
May	33.14	73	208
June	30.57	192	147
July	28.85	344	112
August	28	335	104
September	28	235	105
October	26.28	113	113
November	22	15	89
December	18.57	3	73
Average	26.21	-	-
Total	-	1392	1469

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-13	19.7	1.55	0.40
13-30	32.7	1.55	0.33
30-87	38.7	1.55	0.22

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Pusaro (Bihar)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	19.7	17.63
February	25.5	20.26
March	13.7	25
April	28.9	30
May	61.5	30
June	205.2	31.31
July	371.6	29.21
August	350.1	28.68
September	279.9	28.15
October	128.5	26.57
November	15.4	21.57
December	2.2	18.42
Average	-	25.57
Total	1502.2	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-9	5.1	0.26	1.81	51.6	28.5	19.9
9-30	5.5	0.23	1.65	43.7	29.7	26.6
30-48	6.3	0.13	1.56	40.2	28.0	31.8
48-73	6.3	0.10	1.53	40.8	26.7	32.5
73-91	6.5	0.10	1.62	40.4	25.9	33.7
91-114	6.5	0.08	1.53	42.1	24.0	33.9
114-141	6.5	0.07	1.50	36.7	25.7	37.6
141-186	6.3	0.05	-	33.6	25.8	40.6

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Phulkusma (West Bangal)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	17	19.14
February	24	22
March	17	26.85
April	24	31.14
May	73	33.14
June	192	30.57
July	344	28.85
August	335	28
September	235	28
October	113	26.28
November	15	22
December	3	18.57
Average	-	26.21
Total	1392	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-13	0-13	0.40	1.55	66.0	14.3	19.7
13-30	13-30	0.33	1.55	56.0	11.3	32.7
30-87	30-87	0.22	1.55	52.0	9.3	38.7

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

ICAR Network Project on Climate Change: NPCC

AESR 13.1
(North Bihar and Avadh Plains, hot dry to moist subhumid transitional ESR with deep, loamy alluvium-derived soils, low to medium AWC and LGP 180-210 days (O8Cd/Cm6)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Baratol (Bihar)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-23	B 23-150	C
Physical	Sand (%)	9.06	12.43	12.00	8.40	11.66	
	Silt (%)	55.44	62.12	64.60	62.10	60.47	
	Clay (%)	35.50	25.45	23.40	29.50	27.87	
	Saturation Fraction [d]	0.48	0.43	0.43	0.47	0.44	
	Field Capacity Fraction [d]	0.38	0.34	0.33	0.36	0.24	
	Wilting Point Fraction [d]	0.22	0.16	0.14	0.19	0.17	
	Saturated HC (mm/day) [d]	61.92	69.36	74.64	86.40	66.00	
	Bulk Density (Mg m^{-3}) [d]	1.38	1.50	1.52	1.40	1.47	
Chemical	Organic Carbon (%)	0.48	0.20	0.18	0.65	0.22	
	Water pH	6.17	6.80	6.80	5.70	6.75	
	EC (dS/m)	0.46	0.37	0.37	0.46	0.37	
Other (site)	Slope %	3.00			3.00		

Soil Series: Hirapatti (Bihar)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-18	B 18-150	C
Physical	Sand (%)	4.37	7.71	29.16	9.20	14.36	
	Silt (%)	74.46	68.40	54.96	70.90	65.27	
	Clay (%)	21.17	23.89	15.88	19.90	20.37	
	Saturation Fraction [d]	0.46	0.45	0.41	0.48	0.43	
	Field Capacity Fraction [d]	0.35	0.34	0.27	0.34	0.32	
	Wilting Point Fraction [d]	0.14	0.15	0.10	0.14	0.13	
	Saturated HC (mm/day) [d]	110.40	82.32	220.80	197.50	114.00	
	Bulk Density (Mg m^{-3}) [d]	1.43	1.47	1.56	1.38	1.51	
Chemical	Organic Carbon (%)	0.70	0.43	0.32	1.14	0.40	
	Water pH	7.96	7.82	7.32	7.90	7.68	
	EC (dS/m)	0.51	0.40	0.29	0.66	0.37	
Other (site)	Slope %	1.00			1.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths.*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Baratol and Hirapatti series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for RothC Model
Soil Series: Baratol (Bihar)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17	19.8	52
February	18.8	14.5	71.1
March	24	10	126.1
April	28.6	20.4	170.2
May	30.4	57.3	205.6
June	30.2	190.4	152.3
July	29.4	329.4	123.9
August	29.2	291.2	116.8
September	29	241.7	108.6
October	27	69.6	112.6
November	22	6.5	73.1
December	18	1.7	50
Average	25.30	-	-
Total	-	1252.5	1362.3

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-23	0.65	1.38	29.5
23-44	0.35	1.38	43.9
44-68	0.25	1.50	29.1
68-150	0.18	1.52	23.4

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Hirapatti (Bihar)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17	19.8	52
February	18.8	14.5	71.1
March	24	10	126.1
April	28.6	20.4	170.2
May	30.4	57.3	205.6
June	30.2	190.4	152.3
July	29.4	329.4	123.9
August	29.2	291.2	116.8
September	29	241.7	108.6
October	27	69.6	112.6
November	22	6.5	73.1
December	18	1.7	50
Average	25.30	-	-
Total	-	1252.5	1362.3

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-18	1.14	1.43	19.9
18-35	0.40	1.43	20.1
35-58	0.51	1.43	23.9
58-71	0.42	1.47	21.4
71-103	0.42	1.47	25.0
103-150	0.32	1.56	15.3

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model
Soil Series: Baratol (Bihar)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	19.8	17
February	14.5	18.8
March	10	24
April	20.4	28.6
May	57.3	30.4
June	190.4	30.2
July	329.4	29.4
August	291.2	29.2
September	241.7	29
October	69.6	27
November	6.5	22
December	1.7	18
Average	-	25.30
Total	1252.5	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-23	5.7	0.65	1.38	8.4	62.1	29.5
23-44	6.5	0.35	1.38	8.6	47.5	43.9
44-68	6.8	0.25	1.50	13.2	57.7	29.1
68-150	6.8	0.18	1.52	12.0	64.6	23.4

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Series: Hirapatti (Bihar)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	19.8	17
February	14.5	18.8
March	10	24
April	20.4	28.6
May	57.3	30.4
June	190.4	30.2
July	329.4	29.4
August	291.2	29.2
September	241.7	29
October	69.6	27
November	6.5	22
December	1.7	18
Average	-	25.30
Total	1252.5	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-18	7.9	1.14	1.43	9.2	70.9	19.9
18-35	8.0	0.40	1.43	2.4	77.5	20.1
35-58	8.0	0.51	1.43	0.8	75.3	23.9
58-71	8.0	0.42	1.47	0.6	78.0	21.4
71-103	7.7	0.42	1.47	12.8	62.2	25.0
103-150	7.3	0.32	1.56	30.2	54.5	15.3

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil Resource Information for Crop and Soil Carbon Modelling

AESR 13.2
(Foothills of Central Himalayas, warm to hot moist subhumid ESR with deep loamy to clayey Tarai soils, high AWC and LGP 180-210 days (B10Cm6)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Bahraich (Uttar Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-142	A 0-39	B	C 39-142
Physical	Sand (%)	25.09	91.10	95.00	14.54		89.63
	Silt (%)	51.4	5.20	2.00	58.39		6.41
	Clay (%)	23.51	3.70	3.00	27.07		3.96
	Saturation Fraction [d]	0.43	0.42	0.42	0.46		0.37
	Field Capacity Fraction	0.32	0.06	0.04	0.36		0.18
	Wilting Point Fraction	0.09	0.01	0.01	0.06		0.01
	Saturated HC (mm/day) [d]	127.90	2910.00	3703.00	99.36		432.00
	Bulk Density (Mg m^{-3}) [d]	1.50	1.55	1.53	1.44		1.67
Chemical	Organic Carbon (%)	0.48	0.06	0.04	0.56		0.06
	Water pH	8.80	9.06	9.10	8.80		9.05
	EC (dS/m)	0.19	0.09	0.08	0.20		0.09
Other (site)	Slope %	1.00			1.00		

Soil Series: Kesarganj (Uttar Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-75	B	C 75-160
Physical	Sand (%)	27.79	60.64	88.34	28.49		89.86
	Silt (%)	55.20	30.46	6.52	55.50		5.43
	Clay (%)	17.01	8.90	5.14	16.01		4.71
	Saturation Fraction [d]	0.42	0.39	0.41	0.42		0.41
	Field Capacity Fraction	0.31	0.15	0.09	0.29		0.07
	Wilting Point Fraction	0.06	0.03	0.01	0.05		0.01
	Saturated HC (mm/day) [d]	224.60	906.50	2426.00	231.10		2517.00
	Bulk Density (Mg m^{-3}) [d]	1.53	1.61	1.56	1.55		1.56
Chemical	Organic Carbon (%)	0.53	0.16	0.11	0.44		0.10
	Water pH	9.08	9.07	8.97	9.05		9.05
	EC (dS/m)	0.24	0.14	0.20	0.21		0.16
Other (site)	Slope %	2.00			2.00		

[a] Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b] According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 142 cm in Bahraich).

[c] Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B) not mentioned the column was left blank. For example in Bahraich and Kesarganj series, since C horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).

Soil and climatic datasets as required for Roth*C* model

Soil Series: Bahraich (Uttar Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	14.34	21.8	51
February	16.38	21.6	73
March	21.48	10.7	129
April	27.81	8.6	176
May	30.42	30	213
June	31.61	155.5	189
July	29.73	318.5	132
August	29.42	313.2	118
September	28.5	226.8	121
October	25.82	56.6	115
November	21.48	5.8	70
December	16.14	7.4	48
Average	24.43	-	-
Total	-	1176.5	1435

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-16	0.71	1.50	32.5
16-39	0.46	1.50	24.3
39-56	0.19	1.50	8.8
56-142	0.04	1.61	3.0

[1] *Values for 0-50, 50-100, 100-142 estimated by pedotransfer functions*

Soil Series: Kesarganj (Uttar Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	14.34	21.8	51
February	16.38	21.6	73
March	21.48	10.7	129
April	27.81	8.6	176
May	30.42	30	213
June	31.61	155.5	189
July	29.73	318.5	132
August	29.42	313.2	118
September	28.5	226.8	121
October	25.82	56.6	115
November	21.48	5.8	70
December	16.14	7.4	48
Average	24.43	-	-
Total	-	1176.5	1435

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-20	0.84	1.53	20.3
20-39	0.37	1.53	15.3
39-75	0.25	1.61	14.0
75-95	0.06	1.61	3.8
95-138	0.12	1.56	5.5
138-160	0.08	1.56	4.0

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model
Soil Series: Bahraich (Uttar Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	21.8	14.34
February	21.6	16.38
March	10.7	21.48
April	8.6	27.81
May	30	30.42
June	155.5	31.61
July	318.5	29.73
August	313.2	29.42
September	226.8	28.5
October	56.6	25.82
November	5.8	21.48
December	7.4	16.14
Average	-	24.43
Total	1176.5	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-16	8.8	0.71	1.50	1.8	65.7	32.5
16-39	8.8	0.46	1.50	23.4	53.3	24.3
39-56	8.8	0.19	1.50	62.5	28.7	8.8
56-142	9.1	0.04	1.61	95.0	2.0	3.0

[1] *Values for 0-50, 50-100, 100-142 estimated by pedotransfer functions*

Soil Series: Kesarganj (Uttar Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	21.8	14.34
February	21.6	16.38
March	10.7	21.48
April	8.6	27.81
May	30	30.42
June	155.5	31.61
July	318.5	29.73
August	313.2	29.42
September	226.8	28.5
October	56.6	25.82
November	5.8	21.48
December	7.4	16.14
Average	-	24.43
Total	1176.5	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-20	9.2	0.84	1.53	17.6	62.1	20.3
20-39	9.0	0.37	1.53	37.3	47.4	15.3
39-75	9.0	0.25	1.61	29.9	56.1	14.0
75-95	9.2	0.06	1.61	93.3	4.0	3.8
95-138	8.9	0.12	1.56	86.4	8.1	5.5
138-160	9.2	0.08	1.56	94.5	1.5	4.0

[1] *Values for 0-50, 50-100, 100-150 estimated by pedotransfer functions*

AESR 14.1
(South Kashmir and Punjab Himalayas, cold and warm by dry semi-arid/dry subhumid ESR with shallow to medium deep loamy Brown Forest and Podzolic soils, low to medium AWC and LGP 90-120 days (A15Dd/Cd3)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Bathal (Himachal Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-66		A 0-24	B 24-66	C
Physical	Sand (%)	64.96	72.40		62.85	69.00	
	Silt (%)	27.52	19.60		30.15	23.00	
	Clay (%)	7.52	8.00		7.00	8.00	
	Saturation Fraction [d]	0.40	0.40		0.39	0.39	
	Field Capacity Fraction [d]	0.14	0.12		0.14	0.13	
	Wilting Point Fraction [d]	0.05	0.05		0.04	0.05	
	Saturated HC (mm/day) [d]	1110.00	1305.0		1160.00	1220.00	
	Bulk Density (Mg m^{-3}) [d]	1.60	1.59		1.60	1.6	
Chemical	Organic Carbon (%)	0.24	0.22		0.25	0.23	
	Water pH	7.95	7.45		7.90	7.79	
	EC (dS/m)	0.10	0.10		0.11	0.10	
Other (site)	Slope %	40.00			40.00		

Soil Series: Kalpa (Himachal Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-110	A 0-33	B 33-91	C 91-110
Physical	Sand (%)	46.61	40.69	33.50	47.59	42.96	33.50
	Silt (%)	31.29	37.29	44.50	30.77	34.73	44.50
	Clay (%)	22.10	22.02	22.00	21.64	22.31	22.00
	Saturation Fraction [d]	0.47	0.48	0.42	0.46	0.43	0.42
	Field Capacity Fraction [d]	0.28	0.29	0.28	0.27	0.27	0.28
	Wilting Point Fraction [d]	0.15	0.15	0.14	0.15	0.41	0.14
	Saturated HC (mm/day) [d]	386.90	376.10	183.60	367.68	254.20	183.60
	Bulk Density (Mg m^{-3}) [d]	1.40	1.38	1.53	1.43	1.51	1.53
Chemical	Organic Carbon (%)	1.93	1.89	0.50	1.95	0.89	0.50
	Water pH	5.75	6.30	6.35	5.75	6.30	6.35
	EC (dS/m)	0.15	0.10	0.10	0.15	0.10	0.10
Other (site)	Slope %	22.00			22.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 66 cm and 110 cm in Bathal and Kalpa respectively.)_

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Bathal series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for RothC model
Soil Series: Bathal (Himachal Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	5.3	64.80	13.40
February	5.8	70.10	14.60
March	10.1	64.00	37.30
April	14.5	45.70	63.90
May	18.6	59.70	98.40
June	19.7	149.10	106.10
July	18.3	416.10	97.80
August	17.7	419.10	88.90
September	16.9	182.40	75.30
October	14.3	33.30	57.20
November	10.7	10.20	34.60
December	7.2	27.70	20.00
Average	13.3	-	-
Total	-	1542.20	707.50

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-12	0.22	1.40	5.5
12-24	0.28	1.40	8.5
24-46	0.24	1.40	8.0
46-66	0.22	1.38	8.0

[1] *Values for 0-50, 50-66 estimated by pedotransfer functions*

Soil Series: Kalpa (Himachal Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	5.3	64.80	13.40
February	5.8	70.10	14.60
March	10.1	64.00	37.30
April	14.5	45.70	63.90
May	18.6	59.70	98.40
June	19.7	149.10	106.10
July	18.3	416.10	97.80
August	17.7	419.10	88.90
September	16.9	182.40	75.30
October	14.3	33.30	57.20
November	10.7	10.20	34.60
December	7.2	27.70	20.00
Average	13.3	-	-
Total	-	1542.20	707.50

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-18	2.5	1.52	20.5
18-33	1.3	1.52	23.0
33-56	0.8	1.52	23.0
56-76	1.0	1.50	22.5
76-91	0.9	1.50	21.0
91-110	0.5	1.61	22.0

[1] *Values for 0-50, 50-100, 100-110 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model
Soil Series: Bathal (Himachal Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	64.80	5.3
February	70.10	5.8
March	64.00	10.1
April	45.70	14.5
May	59.70	18.6
June	149.10	19.7
July	416.10	18.3
August	419.10	17.7
September	182.40	16.9
October	33.30	14.3
November	10.20	10.7
December	27.70	7.2
Average	-	13.3
Total	1542.20	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	7.85	0.22	1.40	64.1	30.4	5.5
12-24	7.94	0.28	1.40	61.6	29.9	8.5
24-46	8.10	0.24	1.40	65.9	26.1	8.0
46-66	7.45	0.22	1.38	72.4	19.6	8.0

[1] *Values for 0-50, 50-66 estimated by pedotransfer functions*

Soil Series: Kalpa (Himachal Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	64.80	5.3
February	70.10	5.8
March	64.00	10.1
April	45.70	14.5
May	59.70	18.6
June	149.10	19.7
July	416.10	18.3
August	419.10	17.7
September	182.40	16.9
October	33.30	14.3
November	10.20	10.7
December	27.70	7.2
Average	-	13.3
Total	1542.20	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-18	5.62	0.84	1.52	48.0	31.5	20.5
18-33	5.90	0.37	1.52	47.1	29.9	23.0
33-56	6.30	0.25	1.52	44.7	32.3	23.0
56-76	6.40	0.06	1.50	40.7	35.6	22.5
76-91	6.15	0.12	1.50	43.3	29.6	21.0
91-110	6.35	0.08	1.61	33.5	44.5	22.0

[1] *Values for 0-50, 50-100, 100-110 estimated by pedotransfer functions*

AESR 14.2
(South Kashmir and Kumaun Himalayas, warm moist to dry subhumid transitional ESR with medium to deep loamy to
clayey Brown Forest and Podzolic soils, medium AWC and LGP 150-210 days (A15Cd/Cm6)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Ropri (Himachal Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-20			A 0-20	B	C
Physical	Sand (%)	65.14			65.14		
	Silt (%)	19.96			19.96		
	Clay (%)	14.90			14.90		
	Saturation Fraction [d]	0.43			0.43		
	Field Capacity Fraction	0.19			0.19		
	Wilting Point Fraction	0.10			0.10		
	Saturated HC (mm/day) [d]	816.00			816.00		
	Bulk Density (Mg m^{-3}) [d]	1.52			1.52		
Chemical	Organic Carbon (%)	1.12			1.12		
	Water pH	7.20			7.20		
	EC (dS/m)	0.20			0.20		
Other (site)	Slope %	35.00			35.00		

Soil Series: Dehra (Himachal Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-130	A 0-12	B 12-108	C 108-130
Physical	Sand (%)	29.56	28.28	57.17	34.80	28.79	64.80
	Silt (%)	44.19	41.18	21.23	46.70	41.62	15.90
	Clay (%)	26.25	30.54	21.60	18.50	25.59	19.30
	Saturation Fraction [d]	0.425	0.43	0.39	0.41	0.43	0.39
	Field Capacity Fraction	0.26	0.27	0.24	0.27	0.27	0.23
	Wilting Point Fraction	0.11	0.13	0.09	0.06	0.12	0.07
	Saturated HC (mm/day) [d]	109.90	68.64	252.00	219.80	77.76	400.30
	Bulk Density (Mg m^{-3}) [d]	1.52	1.50	1.61	1.55	1.51	1.62
Chemical	Organic Carbon (%)	0.29	0.20	0.10	0.41	0.21	0.10
	Water pH	6.39	6.74	6.73	5.70	6.70	6.70
	EC (dS/m)	0.07	0.05	0.05	0.10	0.05	0.05
Other (site)	Slope %	1.00			1.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 20 cm and 130 cm in Ropri and Dehra respectively)._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B and C) not mentioned the column was left blank. For example in Ropri series, since B and C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model

Soil Series: Ropri (Himachal Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	16.47	15.44	48.19
February	17.50	10.29	57.83
March	22.65	5.15	115.66
April	28.31	20.59	154.22
May	29.85	51.47	192.77
June	25.74	190.44	144.58
July	26.76	319.12	115.66
August	26.76	283.09	96.39
September	26.25	241.91	91.57
October	26.76	66.91	96.39
November	22.13	10.29	72.29
December	17.50	5.15	48.19
Average	*23.89*	-	-
Total	-	1219.85	1233.73

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-9	1.10	1.52	11.0
9-20	1.14	1.52	18.1

[1] *Values for 0-20 estimated by pedotransfer functions*

Soil Series: Dehra (Himachal Pradesh)

Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	5.3	59.02	29.51
February	5.8	54.10	73.77
March	10.1	34.43	127.87
April	14.5	49.18	157.38
May	18.6	98.36	216.39
June	19.7	280.33	211.48
July	18.3	265.57	186.89
August	17.7	172.13	152.46
September	16.9	63.93	137.70
October	14.3	34.43	73.77
November	10.7	24.59	44.26
December	7.2	49.18	34.43
Average	13.3	-	-
Total	-	1185.25	1445.90

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-12	0.41	1.52	18.5
12-20	0.29	1.52	23.8
20-43	0.23	1.52	29.3
43-80	0.27	1.50	32.3
80-108	0.10	1.50	27.9
108-130	0.10	1.61	19.3

[1] *Values for 0-50, 50-100, 100-130 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Ropri (Himachal Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	15.44	16.47
February	10.29	17.50
March	5.15	22.65
April	20.59	28.31
May	51.47	29.85
June	190.44	25.74
July	319.12	26.76
August	283.09	26.76
September	241.91	26.25
October	66.91	26.76
November	10.29	22.13
December	5.15	17.50
Average	-	*23.89*
Total	1219.85	-

2. Soil data Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-9	5.62	1.10	1.52	66.1	22.1	11.0
9-20	5.90	1.14	1.52	62.9	18.2	18.1

Soil Series: Dehra (Himachal Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	59.02	5.3
February	54.10	5.8
March	34.43	10.1
April	49.18	14.5
May	98.36	18.6
June	280.33	19.7
July	265.57	18.3
August	172.13	17.7
September	63.93	16.9
October	34.43	14.3
November	24.59	10.7
December	49.18	7.2
Average	*1185.25*	13.3
Total	-	-

2. Soil data: Required physical and chemical properties of soils.

.Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	5.7	0.41	1.52	34.8	46.7	18.5
12-20	6.6	0.29	1.52	31.9	34.3	23.8
20-43	6.6	0.23	1.52	28.0	42.7	29.3
43-80	6.7	0.27	1.50	23.0	44.7	32.3
80-108	6.8	0.10	1.50	36.2	35.9	27.9
108-130	6.7	0.10	1.61	64.8	15.9	19.3

[1] *Values for 0-50, 50-100, 100-130 estimated by pedotransfer functions*

AESR 14.3

(Punjab Himalayas, warm humid to perhumid transitional ESR with shallow to medium deep loamy brown forest and podzolic soils, low to medium AWC and LGP 270-300+ days (A15BA9)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Mataur (Himachal Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
					A	B	C
		0-50	50-90		0-21	21-90	
Physical	Sand (%)	27.02	40.26		16.90	37.78	
	Silt (%)	58.62	38.62		67.40	44.36	
	Clay (%)	14.36	21.12		15.70	17.87	
	Saturation Fraction [d]	0.41	0.40		0.43	0.40	
	Field Capacity Fraction [d]	0.26	0.26		0.29	0.25	
	Wilting Point Fraction [d]	0.9	0.13		0.11	0.11	
	Saturated HC (mm/day) [d]	236.20	184.80		169.90	234.00	
	Bulk Density (Mg m^{-3}) [d]	1.57	1.58		1.52	1.58	
Chemical	Organic Carbon (%)	0.35	0.20		0.51	0.21	
	Water pH	6.75	7.03		6.60	3.70	
	EC (dS/m)	0.20	0.20		0.20	0.10	
Other (site)	Slope %	4.00			4.00		

Soil Series: Rajpura (Himachal Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
					A	B	C
		0-50	50-100	100-150	0-15	15-150	
Physical	Sand (%)	24.35	9.50	8.80	34.50	11.96	
	Silt (%)	48.83	56.01	61.08	44.80	56.48	
	Clay (%)	26.82	34.49	30.12	20.70	31.56	
	Saturation Fraction [d]	0.44	0.46	0.45	0.42	0.46	
	Field Capacity Fraction [d]	0.32	0.37	0.36	0.28	0.36	
	Wilting Point Fraction [d]	0.17	0.20	0.18	0.13	0.19	
	Saturated HC (mm/day) [d]	103.90	53.28	55.44	208.30	60.72	
	Bulk Density (Mg m^{-3}) [d]	1.48	1.42	1.45	1.52	1.44	
Chemical	Organic Carbon (%)	0.47	0.24	0.20	0.60	0.27	
	Water pH	5.80	5.44	5.91	6.30	5.43	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	4.00			4.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 90 cm in Mataur)._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Mataur and Rajpura series, since C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model
Soil Series: Mataur (Himachal Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	10	21.8	51
February	13.12	21.6	73
March	16.56	10.7	129
April	21.25	8.6	176
May	26.25	30	213
June	27.5	155.5	189
July	24.37	318.5	132
August	23.12	313.2	118
September	22.5	226.8	121
October	20.31	56.6	115
November	16.25	5.8	70
December	12.81	7.4	48
Average	19.50	-	-
Total	-	1176.5	1435

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-21	0.51	1.57	15.7
21-38	0.25	1.57	13.1
38-68	0.20	1.58	13.8
68-90	0.20	1.58	27.1

[1] Values for 0-50, 50-90 estimated by pedotransfer functions

Soil Series: Rajpura (Himachal Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	9.44	115.6	17.2
February	11.94	112.3	23.6
March	16.66	103.4	52.3
April	20.58	57.9	90.1
May	25.29	63.5	143.1
June	27.05	190	162.2
July	24.11	809.7	128.8
August	22.64	868.9	114.7
September	22.05	256.8	98.2
October	19.16	35.8	71.8
November	14.72	12.5	41.2
December	11.11	54.9	24.6
Average	18.73	-	-
Total	-	2681.3	967.8

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-15	0.60	1.48	20.7
15-43	0.45	1.48	27.8
43-72	0.30	1.48	36.0
72-107	0.20	1.42	33.3
107-150	0.20	1.45	29.6

[1] Values for 0-50, 50-100, 100-107 estimated by pedotransfer functions

Soil and climatic datasets as required for Century C Model
Soil Series: Mataur (Himachal Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	21.8	10
February	21.6	13.12
March	10.7	16.56
April	8.6	21.25
May	30	26.25
June	155.5	27.5
July	318.5	24.37
August	313.2	23.12
September	226.8	22.5
October	56.6	20.31
November	5.8	16.25
December	7.4	12.81
Average	-	19.50
Total	1176.5	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-21	6.6	0.51	1.57	16.9	67.4	15.7
21-38	6.9	0.25	1.57	26.4	60.5	13.1
38-68	6.8	0.20	1.58	45.6	40.6	13.8
68-90	6.4	0.20	1.58	35.9	37.0	27.1

[1] *Values for 0-50, 50-90 estimated by pedotransfer functions*

Soil Series: Rajpura (Himachal Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	115.6	9.44
February	112.3	11.94
March	103.4	16.66
April	57.9	20.58
May	63.5	25.29
June	190	27.05
July	809.7	24.11
August	868.9	22.64
September	256.8	22.05
October	35.8	19.16
November	12.5	14.72
December	54.9	11.11
Average	-	18.73
Total	2681.3	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-15	6.3	0.60	1.48	34.5	44.8	20.7
15-43	5.6	0.45	1.48	22.4	49.8	27.8
43-72	5.5	0.30	1.48	10.4	53.6	36.0
72-107	5.4	0.20	1.42	8.8	57.9	33.3
107-150	5.3	0.20	1.45	8.8	61.6	29.6

[1] *Values for 0-50, 50-100, 100-107 estimated by pedotransfer functions*

AESR 14.4
(Kumaun Himalayas, warm humid to perhumid transitional ESR with shallow to medium deep loamy Red and Yellow soils, low AWC and LGP 270-300+ days (A3B/A9).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Gajeli (Uttarkhand)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-94		A 0-13	B 13-94	
Physical	Sand (%)	48.65	45.65		51.50	46.57	
	Silt (%)	43.17	45.05		40.50	44.61	
	Clay (%)	8.18	9.30		8.00	8.82	
	Saturation Fraction [d]	0.44	0.40		0.47	0.41	
	Field Capacity Fraction [d]	0.20	0.20		0.21	0.20	
	Wilting Point Fraction [d]	0.06	0.06		0.07	0.07	
	Saturated HC (mm/day) [d]	973.44	671.28		1202.64	700.32	
	Bulk Density (Mg m^{-3}) [d]	1.49	1.58		1.41	1.56	
Chemical	Organic Carbon (%)	1.06	0.46		2.84	1.10	
	Water pH	6.41	6.10		2.84	1.10	
	EC (dS/m)	0.14	3.20		0.25	1.78	
Other (site)	Slope %	35.00			35.00		

Soil Series: Tayari (Uttarkhand)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-28			A 0-28	B	C
Physical	Sand (%)	65.61			65.61		
	Silt (%)	21.89			21.89		
	Clay (%)	12.50			12.50		
	Saturation Fraction [d]	0.44			0.44		
	Field Capacity Fraction [d]	0.19			0.19		
	Wilting Point Fraction [d]	0.09			0.09		
	Saturated HC (mm/day) [d]	932.90			932.90		
	Bulk Density (Mg m^{-3}) [d]	1.47			1.47		
Chemical	Organic Carbon (%)	1.45			1.45		
	Water pH	6.51			6.51		
	EC (dS/m)	0.09			0.09		
Other (site)	Slope %	45.00			45.00		

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 24 cm and 28 cm for Gajeli and Tayari respectively).

[c]Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service,Washington DC). If horizons (say B and C) not mentioned the column was left blank. For example in Gajeli and Tayari series, since B and C horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).

Soil and climatic datasets as required for Roth*C* model

Soil Series: Gajeli (Uttarankhand)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	11.95	54.8	38
February	14.5	40.4	49
March	19.15	42.5	85
April	24.4	3.7	118
May	28.25	23.9	146
June	29.8	64	128
July	28.15	347.7	79
August	28.1	163.2	68
September	27	182.9	72
October	22.8	33.2	73
November	17.3	11.5	48
December	12.9	38.8	38
Average	22.03	-	-
Total	-	1006.6	942

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-13	1.65	1.49	8.00
13-27	1.21	1.49	8.15
27-44	0.66	1.49	8.25
44-66	0.56	1.49	8.50
66-94	0.40	1.58	9.75

[1] *Values for 0-24 estimated by pedotransfer functions*

Soil Series: Tayari (Uttarankhand)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	11.95	54.8	38
February	14.5	40.4	49
March	19.15	42.5	85
April	24.4	3.7	118
May	28.25	23.9	146
June	29.8	64	128
July	28.15	347.7	79
August	28.1	163.2	68
September	27	182.9	72
October	22.8	33.2	73
November	17.3	11.5	48
December	12.9	38.8	38
Average	22.03	-	-
Total	-	1006.6	942

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Clay (%)
0-8	2.17	1.47	11.75
8-17	1.29	1.47	12.25
17-28	1.05	1.47	13.25

[1] *Values for 0-28 estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Gajeli (Uttarankhand)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	54.8	11.95
February	40.4	14.5
March	42.5	19.15
April	3.7	24.4
May	23.9	28.25
June	64	29.8
July	347.7	28.15
August	163.2	28.1
September	182.9	27
October	33.2	22.8
November	11.5	17.3
December	38.8	12.9
Average	-	22.03
Total	1006.6	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-13	6.64	1.65	1.49	51.50	40.50	8.00
13-27	6.53	1.21	1.49	48.60	43.25	8.15
27-44	6.20	0.66	1.49	47.00	44.75	8.25
44-66	6.23	0.56	1.49	47.25	44.25	8.50
66-94	6.03	0.40	1.58	44.75	45.50	9.75

[1] Values for 0-24 estimated by pedotransfer functions

Soil Series: Tayari (Uttarankhand)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	54.8	11.95
February	40.4	14.5
March	42.5	19.15
April	3.7	24.4
May	23.9	28.25
June	64	29.8
July	347.7	28.15
August	163.2	28.1
September	182.9	27
October	33.2	22.8
November	11.5	17.3
December	38.8	12.9
Average	-	22.03
Total	1006.6	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-8	1.29	2.17	1.47	65.25	23.00	11.75
8-17	6.48	1.05	1.47	71.25	16.50	12.25
17-28	6.51	6.54	1.47	61.25	25.50	13.25

[1] Values for 0-28 estimated by pedotransfer functions

AESR 14.5
(Foothills of Kumaun Himalayas (Subdued), warm moist subhumid ESR with medium to deep, loamy arai soils, medium AWC and LGP 270-300 days (A10A9).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Haldi (Uttarkhand)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
					A	B	C
		0-50	50-100	100-128	0-43	43-106	106-128
Physical	Sand (%)	36.58	35.80	53.53	36.48	35.90	58.53
	Silt (%)	45.54	46.68	33.59	45.77	46.45	29.85
	Clay (%)	17.88	17.52	12.88	17.75	17.65	11.62
	Saturation Fraction [d]	0.42	0.42	0.39	0.42	0.41	0.39
	Field Capacity Fraction	0.22	0.21	0.16	0.23	0.21	0.15
	Wilting Point Fraction	0.08	0.08	0.05	0.07	0.08	0.05
	Saturated HC (mm/day) [d]	272.90	266.40	519.10	274.60	228.20	661.90
	Bulk Density (Mg m^{-3})	1.47	1.54	1.61	1.48	1.50	1.40
Chemical	Organic Carbon (%)	0.59	0.61	0.19	0.63	0.31	0.19
	Water pH	7.05	7.14	7.55	7.06	7.14	7.58
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	4.00			4.00		

Soil Series: Nainital (Uttarkhand)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
					A	B	C
		0-50	50-100	100-135	0-38	38-66	66-135
Physical	Sand (%)	26.37	45.15	49.10	25.19	34.00	49.06
	Silt (%)	45.96	34.36	39.70	46.07	44.49	34.91
	Clay (%)	27.64	14.86	11.10	28.69	21.47	11.91
	Saturation Fraction [d]	0.52	0.43	0.42	0.54	0.47	0.42
	Field Capacity Fraction	0.31	0.24	0.21	0.31	0.28	0.21
	Wilting Point Fraction	0.17	0.06	0.04	0.12	0.09	0.04
	Saturated HC (mm/day) [d]	323.00	478.10	659.50	336.70	326..54	620.60
	Bulk Density (Mg m^{-3})	1.47	1.56	1.55	1.44	1.54	1.56
Chemical	Organic Carbon (%)	2.62	0.95	0.70	2.87	1.52	0.74
	Water pH	7.80	8.37	8.40	7.64	8.30	8.40
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	2.00			2.00		

[a] Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b] According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 128 cm and 135 cm in Haldi and Nainital respectively).

[c] Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.).

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).

Soil and climatic datasets as required for RothC model

Soil Series: Haldi (Uttarakhand)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	5.27	69.9	53
February	8.88	73.1	65
March	12.56	52.6	106
April	16.15	38.1	38
May	20	84.1	181
June	20.81	390.9	147
July	19.23	769.4	92
August	19.23	750.1	80
September	17.69	362.7	82
October	13.58	61	86
November	11.02	12.9	64
December	8.33	25.4	52
Average	14.40	-	-
Total	-	2690.2	1046

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})	Clay (%)
0-20	0.71	1.47	17.8
20-27	0.72	1.56	17.5
27-43	0.48	1.46	17.8
43-67	0.42	1.46	18.7
67-80	0.33	1.51	16.0
80-106	0.20	1.53	17.5
106-119	0.21	1.56	11.7
119-128	0.15	-	11.5

Soil Series: Nainital (Uttarakhand)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	5.27	69.9	53
February	8.88	73.1	65
March	12.56	52.6	106
April	16.15	38.1	38
May	20	84.1	181
June	20.81	390.9	147
July	19.23	769.4	92
August	19.23	750.1	80
September	17.69	362.7	82
October	13.58	61	86
November	11.02	12.9	64
December	8.33	25.4	52
Average	14.40	-	-
Total	-	2690.2	1046

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Organic Carbon (%)	B. D. (Mgm^{-3})	Clay (%)
0-15	3.6	1.39	29.6
15-38	2.4	1.48	28.1
38-53	1.8	1.55	24.3
53-66	1.2	1.52	18.2
66-94	0.8	1.58	13.1
94-135	0.7	1.55	11.1

Soil and climatic datasets as required for Century C Model
Soil Series: Haldi (Uttaranchal)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	69.9	5.27
February	73.1	8.88
March	52.6	12.56
April	38.1	16.15
May	84.1	20
June	390.9	20.81
July	769.4	19.23
August	750.1	19.23
September	362.7	17.69
October	61	13.58
November	12.9	11.02
December	25.4	8.33
Average	-	14.40
Total	2690.2	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-20	7.1	0.71	1.47	36.8	45.4	17.8
20-27	7.1	0.72	1.56	35.3	47.2	17.5
27-43	7.0	0.48	1.46	36.6	45.6	17.8
43-67	7.0	0.42	1.46	37.2	44.1	18.7
67-80	7.1	0.33	1.51	34.9	49.1	16.0
80-106	7.3	0.20	1.53	35.2	47.3	17.5
106-119	7.5	0.21	1.56	59.8	28.5	11.7

Soil Series: Nainital (Uttarakhand)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	69.9	5.27
February	73.1	8.88
March	52.6	12.56
April	38.1	16.15
May	84.1	20
June	390.9	20.81
July	769.4	19.23
August	750.1	19.23
September	362.7	17.69
October	61	13.58
November	12.9	11.02
December	25.4	8.33
Average	-	14.40
Total	2690.2	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic Carbon (%)	B. D. (Mgm^{-3})	Sand %	Silt (%)	Clay (%)
0-15	7.1	3.6	1.39	23.5	26.3	30.1
15-38	8.0	2.4	1.48	38.5	49.0	49.1
38-53	8.3	1.8	1.55	46.8	45.6	45.6
53-66	8.3	1.2	1.52	43.2	27.9	39.7
66-94	8.4	0.8	1.58	29.6	28.1	24.3
94-135	8.4	0.7	1.55	18.2	13.1	11.1

AESR 15.1

(Bengal basin and North Bihar Plain, hot moist subhumid ESR with deep loamy to clayey alluvium-derived soils, medium to high AWC and LGP 210-240 days (08Cm7)) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Amarpur (West Bengal)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-10	B 10-94	C 94-150
Physical	Sand (%)	11.16	18.75	13.12	12.00	15.75	12.65
	Silt (%)	62.74	53.91	68.38	67.70	56.31	68.66
	Clay (%)	26.10	27.34	18.50	20.30	27.94	18.69
	Saturation Fraction [d]	0.45	0.43	0.41	0.44	0.44	0.41
	Field Capacity Fraction [d]	0.34	0.33	0.31	0.32	0.34	0.31
	Wilting Point Fraction [d]	0.16	0.17	0.12	0.13	0.17	0.12
	Saturated HC (mm/day) [d]	79.20	71.76	85.20	112.80	71.28	85.20
	Bulk Density (Mg m^{-3}) [d]	1.47	1.51	1.56	1.5	1.48	1.56
Chemical	Organic Carbon (%)	0.36	0.13	0.12	0.49	0.23	0.11
	Water pH	7.27	7.90	7396	7.00	7.63	7.97
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	3.00			3.00		

Soil Series: Anantpur (West Bengal)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-21	B 21-50	C
Physical	Sand (%)	20.13	13.56	11.60	25.69	13.37	
	Silt (%)	44.63	41.00	45.90	46.81	43.36	
	Clay (%)	35.24	45.44	42.50	27.50	43.27	
	Saturation Fraction [d]	0.45	0.49	0.49	0.44	0.48	
	Field Capacity Fraction [d]	0.36	0.40	0.40	0.32	0.40	
	Wilting Point Fraction [d]	0.21	0.27	0.26	0.17	0.26	
	Saturated HC (mm/day) [d]	52.32	32.16	52.32	96.48	35.28	
	Bulk Density (Mg m^{-3}) [d]	1.45	1.35	1.36	1.49	1.37	
Chemical	Organic Carbon (%)	0.25	0.13	0.09	0.41	0.12	
	Water pH	6.22	6.99	6.40	5.53	6.70	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	1.00			1.00		

[a] _Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b] _According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths._

[c] _Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Anantpur series, since B and C horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model

Soil Series: Amarpur (West Bengal)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	19.3	14	76
February	22	24	96
March	27.1	27	148
April	30.1	43	170
May	30.8	121	171
June	30	259	126
July	28.9	301	109
August	28.9	306	106
September	28.9	290	103
October	27.5	160	112
November	23.3	35	89
December	19.7	3	71
Average	26.38	-	-
Total	-	1583	1377

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-10	20.3	1.47	0.49
10-25	26.3	1.47	0.37
25-62	28.3	1.47	0.31
62-94	28.3	1.51	0.08
94-132	20.3	1.51	0.08
132-150	15.3	1.56	0.18

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Anantapur (West Bengal)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	19.5	11	71.8
February	21.8	25	89.6
March	27.1	25	146.6
April	30.9	46	177.5
May	31.5	115	202.9
June	30.4	196	146.2
July	28.9	314	129.1
August	28.8	301	124.5
September	28.9	237	115.1
October	27.6	107	117.9
November	23.2	23	86.9
December	19.9	4	67.3
Average	26.54	-	-
Total	-	1404	1475.4

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-12	27.5	1.45	0.49
12-21	27.5	1.45	0.30
21-48	40.5	1.45	0.14
48-99	45.5	1.45	0.13
99-150	42.5	1.36	0.09

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model
Soil Series: Amarpur (West Bengal)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	14	19.3
February	24	22
March	27	27.1
April	43	30.1
May	121	30.8
June	259	30
July	301	28.9
August	306	28.9
September	290	28.9
October	160	27.5
November	35	23.3
December	3	19.7
Average	-	26.38
Total	1583	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-10	7.0	0.49	1.47	12.0	67.7	20.3
10-25	6.9	0.37	1.47	11.2	62.5	26.3
25-62	7.6	0.31	1.47	10.8	60.9	28.3
62-94	8.0	0.08	1.51	23.6	48.1	28.3
94-132	8.0	0.08	1.51	8.8	70.9	20.3
132-150	7.9	0.18	1.56	20.8	63.9	15.3

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Anantapur (West Bengal)

1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	11	19.5
February	25	21.8
March	25	27.1
April	46	30.9
May	115	31.5
June	196	30.4
July	314	28.9
August	301	28.8
September	237	28.9
October	107	27.6
November	23	23.2
December	4	19.9
Average	-	26.54
Total	1404	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	5.1	0.49	1.45	29.8	42.7	27.5
12-21	6.1	0.30	1.45	20.2	52.3	27.5
21-48	6.7	0.14	1.45	16.3	43.2	40.5
48-99	7.0	0.13	1.45	13.6	40.9	45.5
99-150	6.4	0.09	1.36	11.6	45.9	42.5

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

AESR 15.2

(Middle Brahmaputra Plain, hot humid ESR with deep, loamy to clayey alluvium-derived soils, medium AWC and LGP 240-270 days (Q8B8).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Morigaon (Assam)

Soil Parameters		Format I			Format II		
		Soil Depth (cm) [b]			Horizons (Depth in cm) [c]		
		0-50	50-100	100-130	A 0-56	B	C 56-130
Physical	Sand (%)	55.56	61.34	28.67	55.98		48.25
	Silt (%)	25.14	21.17	39.08	24.76		28.40
	Clay (%)	19.30	17.49	32.25	19.26		23.35
	Saturation Fraction [d]	0.41	0.39	0.44	0.40		0.40
	Field Capacity Fraction [d]	0.25	0.20	0.33	0.22		0.26
	Wilting Point Fraction [d]	0.12	0.10	0.194	0.12		0.14
	Saturated HC (mm/day) [d]	281.50	454.10	68.15	361.44		197.04
	Bulk Density (Mg m^{-3}) [d]	1.55	1.62	1.49	1.57		1.58
Chemical	Organic Carbon (%)	0.54	0.21	0.28	0.52		0.23
	Water pH	6.17	6.16	6.88	6.19		6.74
	EC (dS/m)	0.10	0.10	0.10	0.10		0.10
Other (site)	Slope %	2.00			2.00		

Soil Series: Barbhagia (Assam)

Soil Parameters		Format I			Format II		
		Soil Depth (cm) [b]			Horizons (Depth in cm) [c]		
		0-50	50-100	100-135	A 0-16	B 16-60	C 60-135
Physical	Sand (%)	29.70	70.72	53.89	30.06	29.82	78.96
	Silt (%)	33.64	16.58	9.56	32.56	35.86	11.87
	Clay (%)	36.66	12.70	6.55	37.38	34.32	9.17
	Saturation Fraction [d]	0.48	0.39	0.39	0.48	0.44	0.38
	Field Capacity Fraction [d]	0.37	0.14	0.16	0.36	0.34	0.22
	Wilting Point Fraction [d]	0.23	0.07	0.04	0.23	0.21	.06
	Saturated HC (mm/day) [d]	85.20	872.16	887.04	80.40	61.68	380.64
	Bulk Density (Mg m^{-3}) [d]	1.38	1.62	1.63	1.39	1.48	1.63
Chemical	Organic Carbon (%)	0.68	0.14	0.12	1.34	0.35	0.13
	Water pH	6.60	6.86	4.71	5.85	6.99	6.77
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	2.00			2.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 130 cm and 135 cm in Morigaon and Barbhagia respectively)._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B) not mentioned the column was left blank. For example in Morigaon series, since B horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model

Soil Series: Morigaon (Assam)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	16.67	12.50	47.00
February	18.75	25.00	66.20
March	20.83	43.75	101.50
April	25.00	87.50	124.70
May	27.08	175.00	120.70
June	28.13	250.00	102.20
July	29.17	412.50	101.40
August	29.17	400.00	102.20
September	29.17	262.50	93.60
October	27.08	212.50	38.20
November	25.00	87.50	66.30
December	20.83	25.00	46.40
Average	*24.74*	-	-
Total	-	1993.75	1010.40

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-10	19.0	1.55	1.0
10-26	25.0	1.55	0.6
25-56	19.0	1.55	0.3
56-80	12.1	1.62	0.2
80-105	23.5	1.62	0.2
105-130	34.0	1.63	0.3

[1]*Values for 0-50, 50-100,100-130 cm estimated by pedotransfer functions*

Soil Series: Barbhagia (Assam)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	16.67	12.50	47.00
February	18.75	25.00	66.20
March	20.83	43.75	101.50
April	25.00	87.50	124.70
May	27.08	175.00	120.70
June	28.13	250.00	102.20
July	29.17	412.50	101.40
August	29.17	400.00	102.20
September	29.17	262.50	93.60
October	27.08	212.50	38.20
November	25.00	87.50	66.30
December	20.83	25.00	46.40
Average	*24.74*	-	-
Total	-	1993.75	1010.40

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-6	30.5	1.38	0.9
6-16	41.5	1.38	1.6
16-40	40.0	1.38	0.4
40-60	27.5	1.38	0.3
60-110	9.0	1.62	0.1
110-135	9.5	1.63	0.2

[1]*Values for 0-50, 50-100,100-130 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model
Soil Series: Morigaon (Assam)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	12.50	16.67
February	25.00	18.75
March	43.75	20.83
April	87.50	25.00
May	175.00	27.08
June	250.00	28.13
July	412.50	29.17
August	400.00	29.17
September	262.50	29.17
October	212.50	27.08
November	87.50	25.00
December	25.00	20.83
Average	-	*24.74*
Total	1993.75	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-10	5.2	1.0	1.55	47.4	33.6	19.0
10-26	6.2	0.6	1.55	51.2	23.8	25.0
25-56	6.3	0.3	1.55	59.4	21.6	19.0
56-80	6.5	0.2	1.62	78.8	8.7	12.1
80-105	6.8	0.2	1.62	40.5	36.0	23.5
105-130	6.9	0.3	1.63	26.3	39.7	34.0

[1]*Values for 0-50, 50-100,100-130 cm estimated by pedotransfer functions*

Soil Series: Barbhagia (Assam)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	12.50	16.67
February	25.00	18.75
March	43.75	20.83
April	87.50	25.00
May	175.00	27.08
June	250.00	28.13
July	412.50	29.17
August	400.00	29.17
September	262.50	29.17
October	212.50	27.08
November	87.50	25.00
December	25.00	20.83
Average	-	24.74
Total	1993.75	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-6	5.6	0.9	1.38	36.0	33.5	30.5
6-16	6.0	1.6	1.38	26.5	32.0	41.5
16-40	6.9	0.4	1.38	29.0	31.0	40.0
40-60	7.1	0.3	1.38	30.8	41.7	27.5
60-110	6.8	0.1	1.62	80.7	10.3	9.0
110-135	6.7	0.2	1.63	75.5	15.0	9.5

[1]*Values for 0-50, 50-100,100-110 cm estimated by pedotransfer functions*

AESR 15.3

(Teesta, lower Brahmaputra Plain and Barak Valley, hot moist humid to perhumid ESR with deep, loamy to clayey alluviumderived soils, medium AWC and LGP 270-300 days (Q8A9).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Bongaigaon (Assam)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-15	B 15-84	C 84-155
Physical	Sand (%)	78.55	82.89	85.50	76.60	80.51	85.50
	Silt (%)	5.95	3.79	2.70	9.10	4.45	2.70
	Clay (%)	15.50	13.32	11.80	14.30	15.04	11.80
	Saturation Fraction [d]	0.41	0.39	0.39	0.42	0.40	0.40
	Field Capacity Fraction [d]	0.17	0.12	0.11	0.16	0.15	0.12
	Wilting Point Fraction [d]	0.11	0.08	0.05	0.09	0.09	0.07
	Saturated HC (mm/day) [d]	777.60	1037.00	1316.00	927.36	852.72	1198.08
	Bulk Density (Mg m^{-3}) [d]	1.56	1.60	1.60	1.54	1.54	1.16
Chemical	Organic Carbon (%)	0.89	0.26	0.17	0.97	0.55	0.16
	Water pH	6.09	6.16	6.73	5.90	6.16	6.10
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	2.00			2.00		

Soil Series: Jogighopa (Assam)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-139	A 0-13	B	C 18-139
Physical	Sand (%)	80.55	86.03	86.75	79.20		85.01
	Silt (%)	7.96	4.13	3.55	8.00		4.95
	Clay (%)	11.49	9.84	9.70	12.80		10.04
	Saturation Fraction [d]	0.41	0.40	0.41	0.43		0.40
	Field Capacity Fraction [d]	0.13	0.10	0.11	0.16		0.10
	Wilting Point Fraction [d]	0.07	0.06	0.06	0.09		0.05
	Saturated HC (mm/day) [d]	1244.00	1439.00	1498.00	1126.32		146.28
	Bulk Density (Mg m^{-3}) [d]	1.56	1.59	1.56	1.56		1.57
Chemical	Organic Carbon (%)	0.57	0.17	0.46	5.80		6.11
	Water pH	5.94	7.06	7.20	0.99		0.31
	EC (dS/m)	0.10	0.10	0.10	0.10		0.10
Other (site)	Slope %	2.00			2.00		

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 132 cm in Jogighopa).

[c]Horizons A, B, and C as described in _Soil Survey Staff_ (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B) not mentioned the column was left blank. For example in Jogighopa n series, since B horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).

Soil and climatic datasets as required for Roth*C* model

Soil Series: Bongaigaon (Assam)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.5	11.40	47.00
February	19.5	18.30	66.20
March	23.3	53.40	101.50
April	25.9	125.90	124.70
May	26.8	273.60	120.70
June	28.1	293.40	102.20
July	28.9	301.50	101.40
August	29.0	263.00	102.20
September	28.6	190.10	93.60
October	26.2	90.10	38.20
November	22.3	11.50	66.30
December	18.7	5.00	46.60
Average	24.6	-	-
Total	-	1637.20	1010.40

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-15	14.3	1.56	0.97
15-34	15.9	1.56	1.04
34-47	16.4	1.56	0.70
47-66	15.1	1.56	0.30
66-84	13.1	1.60	0.20
84-155	11.8	1.60	0.16

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Jogighopa (Assam)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.5	11.40	47.00
February	19.5	18.30	66.20
March	23.3	53.40	101.50
April	25.9	125.90	124.70
May	26.8	273.60	120.70
June	28.1	293.40	102.20
July	28.9	301.50	101.40
August	29.0	263.00	102.20
September	28.6	190.10	93.60
October	26.2	90.10	38.20
November	22.3	11.50	66.30
December	18.7	5.00	46.60
Average	24.6	-	-
Total	-	1637.20	1010.40

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-18	12.80	1.56	0.99
18-43	11.00	1.56	0.39
43-98	9.85	1.56	0.16
98-139	9.70	1.59	0.46

[1]*Values for 0-50, 50-100,100-139 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model

Soil Series: Bongaigaon (Assam)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	11.40	17.5
February	18.30	19.5
March	53.40	23.3
April	125.90	25.9
May	273.60	26.8
June	293.40	28.1
July	301.50	28.9
August	263.00	29.0
September	190.10	28.6
October	90.10	26.2
November	11.50	22.3
December	5.00	18.7
Average	-	24.6
Total	1637.20	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-15	5.9	0.97	1.56	76.6	9.1	14.3
15-34	6.2	1.04	1.56	79.0	5.1	15.9
34-47	6.1	0.70	1.56	80.1	3.5	16.4
47-66	6.3	0.30	1.56	78.7	6.2	15.1
66-84	6.0	0.20	1.60	84.3	2.6	13.1
84-155	6.1	0.16	1.60	85.5	2.7	11.8

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Jogighopa (Assam)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	11.40	17.5
February	18.30	19.5
March	53.40	23.3
April	125.90	25.9
May	273.60	26.8
June	293.40	28.1
July	301.50	28.9
August	263.00	29.0
September	190.10	28.6
October	90.10	26.2
November	11.50	22.3
December	5.00	18.7
Average	-	24.6
Total	1637.20	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-18	5.8	0.99	1.56	79.20	8.00	12.80
18-43	6.0	0.39	1.56	80.00	9.00	11.00
43-98	6.1	0.16	1.56	86.00	4.15	9.85
98-139	6.2	0.46	1.59	86.75	3.55	9.70

[c]*Values for 0-50, 50-100,100-110 cm estimated by pedotransfer functions*

AESR 15.4

(Upper Brahmaputra Plain, warm to hot perhumid ESR with moderately deep to deep loamy, alluvium-derived soils, medium AWC and LGP 300 days (Q8A10).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Sonari (Assam)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A	B	C
Physical	Sand (%)	52.46	49.17	43.00	50.50	47.82	
	Silt (%)	22.48	24.79	2960	25.00	25.65	
	Clay (%)	25.06	26.04	27.40	4.50	26.53	
	Saturation Fraction [d]	0.41	0.41	0.41	0.41	0.41	
	Field Capacity Fraction [d]	0.26	0.27	0.28	0.27	0.27	
	Wilting Point Fraction [d]	0.16	0.16	0.16	0.15	0.16	
	Saturated HC (mm/day) [d]	189.60	151.00	120.50	197.04	134.4	
	Bulk Density (Mg m^{-3}) [d]	1.56	1.57	1.56	1.55	1.57	
Chemical	Organic Carbon (%)	0.47	0.25	0.19	0.60	0.25	
	Water pH	4.9	5.09	5.00	4.90	5.0	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	2.00			2.00		

Soil Series: Amguri (Assam)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-139	A	B	C
Physical	Sand (%)	34.75	46.08	53.50	36.60	34.87	54.50
	Silt (%)	31.88	39.23	36.00	32.40	36.56	36.00
	Clay (%)	33.37	14.69	10.50	31.00	28.57	9.50
	Saturation Fraction [d]	0.46	0.41	0.10	0.47	0.44	0.40
	Field Capacity Fraction [d]	0.34	0.22	018	0.33	0.32	0.18
	Wilting Point Fraction [d]	0.21	0.09	0.07	0.19	0.18	0.06
	Saturated HC (mm/day) [d]	100.80	407.50	687.70	149.52	124.08	757.44
	Bulk Density (Mg m^{-3}) [d]	1.44	1.57	1.59	1.40	1.47	1.59
Chemical	Organic Carbon (%)	1.11	0.49	0.40	1.60	0.79	0.40
	Water pH	5.63	6.30	6.90	5.70	5.60	6.90
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	1.00			1.00		

[a] _Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b] _According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 139 cm in Amguri)._

[c] _Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Amguri series, since B horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for Roth*C* model

Soil Series: Sonari (Assam)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	15.83	29.7	44.1
February	19.16	46.5	70.6
March	21.66	94.6	108.2
April	23.33	218.2	129.5
May	25.83	361.1	135.3
June	27.5	390.8	139.6
July	28.33	476.3	144.3
August	29.16	400.2	137.8
September	27.5	301.8	121.4
October	25.83	135.5	99.7
November	20.83	30.1	72.3
December	18.33	19.5	53.4
Average	23.61	-	-
Total	-	2504.3	1256.2

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-22	24.5	1.56	0.60
22-77	25.5	1.56	0.37
77-100	27.1	1.57	0.11
100-150	27.4	1.56	0.19

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Amguri (Assam)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	15.83	29.7	44.1
February	19.16	46.5	70.6
March	21.66	94.6	108.2
April	23.33	218.2	129.5
May	25.83	361.1	135.3
June	27.5	390.8	139.6
July	28.33	476.3	144.3
August	29.16	400.2	137.8
September	27.5	301.8	121.4
October	25.83	135.5	99.7
November	20.83	30.1	72.3
December	18.33	19.5	53.4
Average	23.61	-	-
Total	-	2504.3	1256.2

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-14	31.0	1.44	1.6
14-37	42.6	1.44	1.1
37-73	19.6	1.44	0.6
73-120	10.5	1.57	0.4

[1]*Values for 0-50, 50-100,100-139cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model

Soil Series: Sonari (Assam)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	29.7	15.83
February	46.5	19.16
March	94.6	21.66
April	218.2	23.33
May	361.1	25.83
June	390.8	27.5
July	476.3	28.33
August	400.2	29.16
September	301.8	27.5
October	135.5	25.83
November	30.1	20.83
December	19.5	18.33
Average	-	23.61
Total	2504.3	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-22	4.9	0.60	1.56	50.5	25.6	24.5
22-77	5.0	0.37	1.56	54.0	20.5	25.5
77-100	5.2	0.11	1.57	43.5	29.4	27.1
100-150	5.0	0.19	1.56	43.0	29.6	27.4

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Amguri (Assam)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	29.7	15.83
February	46.5	19.16
March	94.6	21.66
April	218.2	23.33
May	361.1	25.83
June	390.8	27.5
July	476.3	28.33
August	400.2	29.16
September	301.8	27.5
October	135.5	25.83
November	30.1	20.83
December	19.5	18.33
Average	-	23.61
Total	2504.3	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-14	5.7	1.6	1.44	35.6	32.4	31.0
14-37	5.6	1.1	1.44	32.8	24.6	42.6
37-73	5.6	0.6	1.44	36.2	44.2	19.6
73-120	6.9	0.4	1.57	54.5	36.0	10.5

[1]*Values for 0-50, 50-100,100-139 cm estimated by pedotransfer functions*

AESR 16.1

(Foot-hills of Eastern Himalayas (Bhutan foot-hills), warm to hot perhumid ESR with shallow to medium, loamy-skeletal to loamy Tarai soils, low to medium AWC and LGP 270-300 days (C10A9).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Darrang (Assam)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-108	A 0-28	B 28-46	C 46-108
Physical	Sand (%)	43.62	50.96	56.00	43.00	44.21	56.00
	Silt (%)	27.60	22.68	21.00	29.00	25.42	21.00
	Clay (%)	28.78	26.36	23.00	28.00	30.37	23.00
	Saturation Fraction [d]	0.44	0.41	0.40	0.44	044	0.40
	Field Capacity Fraction [d]	0.31	0.27	0.24	0.30	0.31	0.24
	Wilting Point Fraction [d]	0.18	0.16	0.14	0.18	0.19	0.14
	Saturated HC (mm/day) [d]	139.90	172.10	235.40	157.68	120.72	234.44
	Bulk Density (Mg m^{-3}) [d]	1.44	1.55	1.59	1.48	1.50	1.59
Chemical	Organic Carbon (%)	1.11	0.52	0.29	1.04	087	0.29
	Water pH	5.63	5.87	6.00	5.60	5.70	6.00
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	1.00			1.00		

Soil Series: Dhansiri (Assam)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-110	A 0-22	B	C 22-110
Physical	Sand (%)	78.76	84.30	84.30	73.42		83.42
	Silt (%)	10.35	7.50	7.50	11.63		8.24
	Clay (%)	10.89	8.20	8.20	14.95		8.34
	Saturation Fraction [d]	0.40	0.40	0.40	0.40		0.41
	Field Capacity Fraction [d]	0.26	0.09	0.09	0.17		0.10
	Wilting Point Fraction [d]	0.08	0.04	0.04	0.19		0.10
	Saturated HC (mm/day) [d]	240.70	1683.00	1683.00	732.48		0.05
	Bulk Density (Mg m^{-3}) [d]	1.59	1.59	1.59	1.59		1648.08
Chemical	Organic Carbon (%)	0.27	0.14	0.14	0.44		1.57
	Water pH	6.57	7.80	7.80	6.16		0.15
	EC (dS/m)	0.10	0.10	0.10	0.10		6.80
Other (site)	Slope %	1.00			1.00		

[a]_Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP)._

[b]_According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 108 cm and 110 cm in Darrang and Dhansari)._

[c]_Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B) not mentioned the column was left blank. For example in Dhansiri series, since B horizon was not reported that column was kept blank._

[d] _These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)._

Soil and climatic datasets as required for RothC model

Soil Series: Darrang (Assam)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.5	11.40	47.00
February	19.5	18.30	66.20
March	23.3	53.40	101.50
April	25.9	125.90	124.70
May	26.8	273.60	120.70
June	28.1	293.40	102.20
July	28.9	301.50	101.40
August	29.0	263.00	102.20
September	28.6	190.10	93.60
October	26.2	90.10	38.20
November	22.3	11.50	66.30
December	18.7	5.00	46.60
Average	24.6	-	-
Total	-	1637.20	1010.40

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-28	28.0	1.44	1.04
28-46	29.5	1.44	0.90
46-71	31.0	1.44	0.84
71-108	23.0	1.55	0.29

[1]*Values for 0-50, 50-100, 100-108 cm estimated by pedotransfer functions*

Soil Series: Dhansiri (Assam)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	17.5	11.40	47.00
February	19.5	18.30	66.20
March	23.3	53.40	101.50
April	25.9	125.90	124.70
May	26.8	273.60	120.70
June	28.1	293.40	102.20
July	28.9	301.50	101.40
August	29.0	263.00	102.20
September	28.6	190.10	93.60
October	26.2	90.10	38.20
November	22.3	11.50	66.30
December	18.7	5.00	46.60
Average	24.6	-	-
Total	-	1637.20	1010.40

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-7	16.9	1.59	0.58
7-18	13.7	1.59	0.35
18-40	8.8	1.59	0.20
40-110	8.2	1.59	0.14

[1]*Values for 0-50, 50-100, 100-150 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model

Soil Series: Darrang (Assam)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	11.40	17.5
February	18.30	19.5
March	53.40	23.3
April	125.90	25.9
May	273.60	26.8
June	293.40	28.1
July	301.50	28.9
August	263.00	29.0
September	190.10	28.6
October	90.10	26.2
November	11.50	22.3
December	5.00	18.7
Average	-	24.6
Total	1637.20	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-28	5.6	1.04	1.44	43.0	29.0	28.0
28-46	5.7	0.90	1.44	44.5	26.0	29.5
46-71	5.7	0.84	1.44	44.0	25.0	31.0
71-108	6.0	0.29	1.55	56.0	21.0	23.0

[1]*Values for 0-50, 50-100, 100-108 cm estimated by pedotransfer functions*

Soil Series: Dhansiri (Assam)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	11.40	17.5
February	18.30	19.5
March	53.40	23.3
April	125.90	25.9
May	273.60	26.8
June	293.40	28.1
July	301.50	28.9
August	263.00	29.0
September	190.10	28.6
October	90.10	26.2
November	11.50	22.3
December	5.00	18.7
Average	-	24.6
Total	1637.20	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-7	6.1	0.58	1.59	70.0	13.1	16.9
7-18	6.2	0.35	1.59	75.6	10.7	13.7
18-40	6.8	0.20	1.59	80.6	10.6	8.8
40-110	6.8	0.14	1.59	84.3	7.5	8.2

[1]*Values for 0-50, 50-100, 100-150 cm estimated by pedotransfer functions*

AESR 16.2

(Darjeeling and Sikkim Himalayas, warm perhumid ESR with shallow to medium deep loamy Brown and Red Hill soils, low to medium AWC and LGP 300 days (C11A10).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Reyong (Sikkim)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100		A 0-17	B 17-100	C
Physical	Sand (%)	4.94	4.04		6.00	4.18	
	Silt (%)	66.52	61.38		64.50	63.84	
	Clay (%)	28.54	34.58		29.50	31.98	
	Saturation Fraction [d]	0.60	0.55		0.62	0.57	
	Field Capacity Fraction [d]	0.39	0.39		0.39	0.35	
	Wilting Point Fraction [d]	0.19	0.22		0.20	0.20	
	Saturated HC (mm/day) [d]	563.00	229.90		644.88	326.88	
	Bulk Density (Mg m^{-3}) [d]	1.06	1.20		1.02	1.15	
Chemical	Organic Carbon (%)	3.35	2.17		3.80	2.55	
	Water pH	4.23	4.37		4.30	4.30	
	EC (dS/m)	0.10	0.10		0.10	0.10	
Other (site)	Slope %	9.00			9.00		

Soil Series: Maniram (Sikkim)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-12	B 12-83	C 83-150
Physical	Sand (%)	23.22	30.99	40.40	24.00	24.45	40.40
	Silt (%)	63.32	56.55	46..60	61.80	626.81	46.60
	Clay (%)	13.46	12.46	13.00	14.20	12.74	13.00
	Saturation Fraction [d]	0.54	0.45	0.44	0.57	0.50	0.44
	Field Capacity Fraction [d]	0.32	0.26	0.24	0.33	0.30	0.24
	Wilting Point Fraction [d]	0.11	0.09	0.09	0.12	0.10	0.09
	Saturated HC (mm/day) [d]	810.20	489.8	513.60	974.64	579.12	513.60
	Bulk Density (Mg m^{-3}) [d]	1.21	1.46	1.50	1.13	1.33	1.50
Chemical	Organic Carbon (%)	2.58	1.16	1.00	3.10	1.87	1.00
	Water pH	5.62	6.05	6.00	5.10	5.92	6.00
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	20.00			20.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 100 cm in Rayong).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Rayong series, since B horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Rayong (Sikkim)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	12.75	17.50	51.77
February	13.50	17.50	63.8
March	15.00	35.00	88.66
April	18.00	175.00	115.8
May	21.00	297.00	112.53
June	22.50	332.50	110.1
July	22.50	525.00	98.58
August	23.25	490.00	84.94
September	24.00	490.00	92.38
October	21.75	315.00	81.6
November	19.50	87.50	86.49
December	15.75	35.00	61.8
Average	*19.13*	-	-
Total	-	2817.50	1096.15

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-17	29.5	1.06	3.8
17-27	22.4	1.06	3.4
27-55	30.5	1.06	3.0
55-81	32.5	1.20	2.5
81-100	38.5	1.20	1.5

[1]*Values for 0-50, 50-100 cm estimated by pedotransfer functions*

Soil Series: Maniram (Sikkim)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	12.75	17.50	51.77
February	13.50	17.50	63.8
March	15.00	35.00	88.66
April	18.00	175.00	115.8
May	21.00	297.50	112.53
June	22.50	332.50	110.1
July	22.50	525.00	98.58
August	23.25	490.00	84.94
September	24.00	490.00	92.38
October	21.75	315.00	81.6
November	19.50	87.50	86.49
December	15.75	35.00	61.8
Average	19.13	-	-
Total	-	2817.50	1096.15

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})	Organic carbon (%)
0-12	14.2	1.21	3.1
12-27	15.1	1.21	2.6
27-54	12.0	1.21	2.3
54-83	12.2	1.46	1.1
73-150	13.0	1.46	1.0

[1]*Values for 0-50, 50-100, 100-150 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model

Soil Series: Reyong (Sikkim)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	17.50	12.75
February	17.50	13.50
March	35.00	15.00
April	175.00	18.00
May	297.00	21.00
June	332.50	22.50
July	525.00	22.50
August	490.00	23.25
September	490.00	24.00
October	315.00	21.75
November	87.50	19.50
December	35.00	15.75
Average	-	*19.13*
Total	2817.50	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-17	4.3	3.8	1.06	6.0	64.5	29.5
17-27	4.4	3.4	1.06	4.4	73.2	22.4
27-55	4.1	3.0	1.06	4.4	65.1	30.5
55-81	4.1	2.5	1.20	4.0	63.5	32.5
81-100	4.8	1.5	1.20	4.0	57.5	38.5

[1]*Values for 0-50, 50-100 cm estimated by pedotransfer functions*

Soil Series: Maniram (Sikkim)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	17.50	12.75
February	17.50	13.50
March	35.00	15.00
April	175.00	18.00
May	297.50	21.00
June	332.50	22.50
July	525.00	22.50
August	490.00	23.25
September	490.00	24.00
October	315.00	21.75
November	87.50	19.50
December	35.00	15.75
Average	-	*19.13*
Total	2817.50	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-12	5.1	3.1	1.21	24.0	61.8	14.2
12-27	5.6	2.6	1.21	22.0	62.9	15.1
27-54	5.9	2.3	1.21	23.6	64.4	12.0
54-83	6.1	1.1	1.46	26.5	61.3	12.2
73-150	6.0	1.0	1.46	40.4	46.6	13.0

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

AESR 16.3

(Arunachal Pradesh (Subdued Eastern Himalayas), warm to hot perhumid ESR with deep, loamy to clayey Red Loamy soils, low to medium AWC and LGP 300 days (C1A10).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Longsom (Arunachal Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-68		A 0-15	B 15-68	C
Physical	Sand (%)	26.60	20.1		27.00	24.50	
	Silt (%)	40.66	45.90		46.60	40.50	
	Clay (%)	32.74	34.10		26.40	35.00	
	Saturation Fraction [d]	0.48	0.49		0.48	0.48	
	Field Capacity Fraction [d]	0.35	0.37		0.33	0.36	
	Wilting Point Fraction [d]	0.21	0.21		0.17	0.22	
	Saturated HC (mm/day) [d]	127.2	121.20		216.96	106.32	
	Bulk Density (Mg m^{-3}) [d]	1.38	1.35		1.38	1.37	
Chemical	Organic Carbon (%)	1.44	1.38		1.54	1.39	
	Water pH	5.58	5.80		5.40	5.71	
	EC (dS/m)	0.10	0.10		0.10	0.10	
Other (site)	Slope %	10.00			10.00		

Soil Series: Wakka (Arunachal Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-36			A 0-36	B	C
Physical	Sand (%)	59.17			59.17		
	Silt (%)	27.60			27.60		
	Clay (%)	13.23			13.23		
	Saturation Fraction [d]	0.52			0.52		
	Field Capacity Fraction [d]	0.25			0.25		
	Wilting Point Fraction [d]	0.12			0.12		
	Saturated HC (mm/day) [d]	1237.00			1237.00		
	Bulk Density (Mg m^{-3}) [d]	1.27			1.27		
Chemical	Organic Carbon (%)	3.11			3.11		
	Water pH	5.41			5.41		
	EC (dS/m)	0.10			0.10		
Other (site)	Slope %	42.00			42.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 68 cm and 36 cm in Longsom and Wakka series respectively).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B and C) not mentioned the column was left blank. For example in Longsom series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo-transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Longsom (Arunachal Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	16.84	58.95	43.70
February	16.84	73.68	58.30
March	18.95	176.84	91.40
April	21.05	412.63	104.30
May	23.16	427.37	105.30
June	25.26	368.42	104.40
July	27.37	412.63	105.70
August	29.47	515.79	104.90
September	27.37	486.32	96.20
October	25.26	257.89	80.70
November	21.05	14.74	59.10
December	18.95	14.74	41.60
Average	*22.63*	*-*	*995.60*
Total	-	3220.00	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-15	26.4	1.38	1.54
15-40	36.0	1.38	1.40
40-68	34.1	1.38	1.38
68+	Weathered rocks		

[1]*Values for 0-50, 50--68 cm estimated by pedotransfer functions*

Soil Series: Wakka (Arunachal Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	16.84	58.95	43.70
February	16.84	73.68	58.30
March	18.95	176.84	91.40
April	21.05	412.63	104.30
May	23.16	427.37	105.30
June	25.26	368.42	104.40
July	27.37	412.63	105.70
August	29.47	515.79	104.90
September	27.37	486.32	96.20
October	25.26	257.89	80.70
November	21.05	14.74	59.10
December	18.95	14.74	41.60
Average	*22.63*	*-*	*995.60*
Total	-	3220.00	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-16	15.4	1.27	3.80
16-36	11.5	1.27	2.55
36+	6.2	1.27	0.74

[1]*Values for 0-38 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model

Soil Series: Longsom (Arunachal Pradesh)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	58.95	16.84
February	73.68	16.84
March	176.84	18.95
April	412.63	21.05
May	427.37	23.16
June	368.42	25.26
July	412.63	27.37
August	515.79	29.47
September	486.32	27.37
October	257.89	25.26
November	14.74	21.05
December	14.74	18.95
Average	-	*22.63*
Total	3220.00	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3}) [1]	Sand (%)	Silt (%)	Clay (%)
0-15	5.4	1.54	1.38	27.0	46.6	26.4
15-40	5.6	1.40	1.38	29.0	35.0	36.0
40-68	5.8	1.38	1.38	20.0	45.9	34.1
68+	Weathered rocks					

[1]*Values for 0-50, 50-68 cm estimated by pedotransfer functions*

Soil Series: Wakka (Arunachal Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	58.95	16.84
February	73.68	16.84
March	176.84	18.95
April	412.63	21.05
May	427.37	23.16
June	368.42	25.26
July	412.63	27.37
August	515.79	29.47
September	486.32	27.37
October	257.89	25.26
November	14.74	21.05
December	14.74	18.95
Average	-	*22.63*
Total	3220.00	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3}) [1]	Sand (%)	Silt (%)	Clay (%)
0-16	5.3	3.80	1.27	55.0	29.6	15.4
16-36	5.5	2.55	1.27	62.5	26.0	11.5
36+	5.3	0.74	1.27	71.0	22.8	6.2

[1]*Values for 0-38 cm estimated by pedotransfer functions*

AESR 17.1
(Meghalaya Plateau land Nagaland Hill, warm to hot moist humid to perhumid ESR with medium to deep loamy to clayey Red and Lateritic soils, medium AWC and LGP 270-300+ days (D2A9).[a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Mawlyndair (Meghlaya)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-140	A 0-17	B 17-75	C 75-140
Physical	Sand (%)	76.55	76.51	75.50	79.50	75.25	75.50
	Silt (%)	3.53	8.49	11.50	2.50	4.23	11.50
	Clay (%)	19.92	15.00	13.00	18.00	20.52	13.00
	Saturation Fraction [d]	0.46			0.50	0.43	
	Field Capacity Fraction [d]	0.24			0.25	0.25	
	Wilting Point Fraction [d]	0.16			0.16	0.14	
	Saturated HC (mm/day) [d]	613.40			850.80	469.44	
	Bulk Density (Mg m^{-3}) [d]	1.42			1.35	1.52	
Chemical	Organic Carbon (%)	2.84	-	-	3.86	1.53	-
	Water pH	4.75	5.05	5.10	4.50	4.93	5.10
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	30.00			30.00		

Soil Series: Lailad (Meghlaya)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-23	B 23-163	C 163-240
Physical	Sand (%)	47.95	39.57	46.18	42.00	45.45	68.26
	Silt (%)	8.40	1.18	1.52	15.45	1.64	4.00
	Clay (%)	24.47	59.25	52.30	40.50	46.40	27.40
	Saturation Fraction [d]	0.45	0.48	0.46	0.45	0.45	0.41
	Field Capacity Fraction [d]	0.28	0.46	0.42	0.38	0.39	0.28
	Wilting Point Fraction [d]	0.16	0.34	0.31	0.26	0.29	0.17
	Saturated HC (mm/day) [d]	277.20	0.24	1.44	41.52	10.32	130.08
	Bulk Density (Mg m^{-3}) [d]	1.46	1.38	1.44	1.42	1.46	1.56
Chemical	Organic Carbon (%)	146	0.77	0.56	1.78	0.74	0.23
	Water pH	5.66	5.32	5.20	6.00	5.28	5.30
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	20.00			20.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 140 cm in Mawlyndair).*

[c]*Horizons A, B, and C as described in _Soil Survey Staff_ (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.).*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth*C* model
Soil Series: Mawlyndair (Meghalaya)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	18.00	180.00	60.30
February	24.00	405.00	87.20
March	32.00	900.00	129.40
April	36.00	1143.00	159.40
May	38.00	3195.00	161.80
June	38.00	3600.00	92.10
July	38.00	2898.00	131.90
August	38.00	2430.00	88.30
September	36.00	1800.00	86.00
October	32.00	900.00	89.40
November	20.00	135.00	72.40
December	10.00	90.00	61.00
Average	*30.00*	-	-
Total	-	17676.00	1219.20

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-17	18.00	1.42	3.86
17-37	21.50	1.42	3.50
37-75	20.00	1.42	0.49
75-140	10.0	-	T
140+	-----------------------Parent materials-----------------------		

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Lailad (Meghalaya)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	20.41	183.67	60.30
February	24.49	275.51	87.20
March	38.78	964.29	129.40
April	40.82	1836.73	159.40
May	38.78	3168.37	161.80
June	42.86	3462.24	92.10
July	44.90	3214.29	131.90
August	42.86	2525.51	88.30
September	36.73	1882.65	86.00
October	30.61	964.29	89.40
November	20.41	137.76	72.40
December	20.41	91.84	61.00
Average	*33.50*	-	-
Total	-	18707.14	1219.20

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-23	40.5	1.46	1.78
23-47	5.10	1.46	1.22
47-68	56.5	1.46	0.90
68-103	60.8	1.38	0.69
103-130	54,4	1.44	0.62
130-163	48.2	1.44	0.45
163-240	27.4	1.44	0.23
240+	-----------------------Parent materials-----------------------		

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C model
Soil Series: Mawlyndair (Meghalaya)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	180.00	18.00
February	405.00	24.00
March	900.00	32.00
April	1143.00	36.00
May	3195.00	38.00
June	3600.00	38.00
July	2898.00	38.00
August	2430.00	38.00
September	1800.00	36.00
October	900.00	32.00
November	135.00	20.00
December	90.00	10.00
Average	-	*30.00*
Total	17676.00	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-17	4.5	3.86	1.42	79.50	2.00	18.00
17-37	4.8	3.50	1.42	75.35	1.90	21.50
37-75	5.0	0.49	1.42	74.55	5.45	20.00
75-140	5.1	T	-	75.50	11.50	10.0
140+	---Parent materials--------------------------------------					

[1]*Values for 0-50, 50-100,100-110 cm estimated by pedotransfer functions*

Soil Series: Lailad (Meghalaya)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	183.67	20.41
February	275.51	24.49
March	964.29	38.78
April	1836.73	40.82
May	3168.37	38.78
June	3462.24	42.86
July	3214.29	44.90
August	2525.51	42.86
September	1882.65	36.73
October	964.29	30.61
November	137.76	20.41
December	91.84	20.41
Average	-	*33.50*
Total	18707.14	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-23	6.0	1.78	1.46	42.0	15.45	40.5
23-47	5.35	1.22	1.46	54.4	2.5	5.10
47-68	5.45	0.90	1.46	42.0	1.5	56.5
68-103	5.25	0.69	1.38	38.2	1.0	60.8
103-130	5.20	0.62	1.44	44.6	1.0	54,4
130-163	5.20	0.45	1.44	49.5	2.3	48.2
163-240	5.30	0.23	1.44	68.26	4.0	27.4
240+	---Parent materials--------------------------------------					

[1]*Values for 0-50, 50-100,100-110 cm estimated by pedotransfer functions*

AESR 17.2

(Purvachal (Eastern Range), warm to hot perhumid ESR with medium to deep loamy Red and Yellow soils, low to medium AWC and LGP 300 days (D3A10).) [a]

Soil Master
as required for *InfoCrop* Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Longol 5 (Manipur)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-15	B 15-160	C
Physical	Sand (%)	3.10	3.07	2.49	2.50	2.93	
	Silt (%)	48.25	46.11	44.67	48.80	46.07	
	Clay (%)	48.65	50.82	52.84	48.70	51.00	
	Saturation Fraction [d]	0.55	0.54	0.54	0.56	0.54	
	Field Capacity Fraction [d]	0.42	0.43	0.45	0.42	0.43	
	Wilting Point Fraction [d]	0.29	0.30	0.33	0.29	0.30	
	Saturated HC (mm/day) [d]	126.50	86.88	40.56	156.48	81.60	
	Bulk Density (Mg m^{-3}) [d]	1.19	1.21	1.21	1.17	1.21	
Chemical	Organic Carbon (%)	1.86	1.28	0.51	2.34	1.15	
	Water pH	4.64	4.65	4.43	4.90	4.55	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	7.00			7.00		

Soil Series: Longol 6 (Manipur)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-15	B 15-150	C
Physical	Sand (%)	5.95	55.42	6.57	6.10	6.00	
	Silt (%)	36.90	33.11	36.45	39.40	35.19	
	Clay (%)	57.15	61.47	56.98	54.50	58.81	
	Saturation Fraction [d]	0.55	0.55	0.54	0.55	0.55	
	Field Capacity Fraction [d]	0.44	0.45	0.45	0.43	0.46	
	Wilting Point Fraction [d]	0.33	0.33	0.33	0.32	0.34	
	Saturated HC (mm/day) [d]	64.32	50.64	40.56	97.44	45.12	
	Bulk Density (Mg m^{-3}) [d]	1.20	1.20	1.21	1.19	1.19	
Chemical	Organic Carbon (%)	1.38	0.69	0.51	2.21	0.70	
	Water pH	4.38	4.29	4.43	4.35	4.42	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	7.00			7.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths.*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Longsom series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth*C* model

Soil Series: Longol-5 (Manipur)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	3.33	14.3	60.7
February	5.83	34.2	76.9
March	10.83	61.1	117.4
April	15	94.3	126.4
May	23.33	107.3	136.1
June	19.16	316.9	104.1
July	20	225	128.6
August	19.16	209	100.5
September	19.16	112.5	97.5
October	16.66	134.2	100.3
November	9.16	25.2	78
December	5	16.2	58.9
Average	13.89	-	-
Total	-	1350.2	1185.4

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-15	48.7	1.20	2.34
15-40	50.8	1.20	1.64
40-71	43.2	1.20	1.71
71-99	56.6	1.21	0.97
99-127	49.2	1.21	0.93
127-150	57.1	1.21	0.35

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Longol-6 (Manipur)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	3.33	14.3	60.7
February	5.83	34.2	76.9
March	10.83	61.1	117.4
April	15	94.3	126.4
May	23.33	107.3	136.1
June	19.16	316.9	104.1
July	20	225	128.6
August	19.16	209	100.5
September	19.16	112.5	97.5
October	16.66	134.2	100.3
November	9.16	25.2	78
December	5	16.2	58.9
Average	13.89	-	-
Total	-	1350.2	1185.4

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-15	54.5	1.20	2.21
15-40	56.0	1.20	1.10
40-66	64.0	1.20	0.85
66-93	61.0	1.20	0.64
93-124	57.5	1.20	0.55
124-160	56.5	1.21	0.47

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

cl

Soil and climatic datasets as required for Century C model
Soil Series: Longol-5 (Manipur)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	14.3	3.33
February	34.2	5.83
March	61.1	10.83
April	94.3	15
May	107.3	23.33
June	316.9	19.16
July	225	20
August	209	19.16
September	112.5	19.16
October	134.2	16.66
November	25.2	9.16
December	16.2	5
Average	-	13.89
Total	1350.2	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-15	4.9	2.34	1.20	2.5	48.8	48.7
15-40	4.5	1.64	1.20	2.9	46.3	50.8
40-71	4.6	1.71	1.20	4.5	52.3	43.2
71-99	4.7	0.97	1.21	2.0	41.4	56.6
99-127	4.1	0.93	1.21	3.0	47.8	49.2
127-150	4.9	0.35	1.21	1.9	41.0	57.1

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Longol-6 (Manipur)
1. Climatic data:

Months	MAR (mm)	MAT(°C)
January	14.3	3.33
February	34.2	5.83
March	61.1	10.83
April	94.3	15
May	107.3	23.33
June	316.9	19.16
July	225	20
August	209	19.16
September	112.5	19.16
October	134.2	16.66
November	25.2	9.16
December	16.2	5
Average	-	13.89
Total	1350.2	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-15	4.35	2.21	1.20	6.1	39.4	54.5
15-40	4.44	1.10	1.20	6.0	38.0	56.0
40-66	4.20	0.85	1.20	5.6	30.4	64.0
66-93	4.29	0.64	1.20	4.8	34.2	61.0
93-124	4.55	0.55	1.20	7.4	35.1	57.5
124-160	4.55	0.47	1.21	5.8	37.5	56.5

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

AESR 18.2

(North Tamil Nadu Plains (Coastal), hot moist semi-arid ESR with deep, clayey and cracking Coastal land Deltaic alluvium derived soils, high AWC and LGP 120-150 days (S7Dm4).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Kalathur (Tamil Nadu)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-120	A	B	C
Physical	Sand (%)	39.71	25.93	23.80	39.97	25.71	24.10
	Silt (%)	16.75	17.07	17.07	16.76	17.18	17.60
	Clay (%)	43.54	57.00	58.38	43.27	57.11	58.30
	Saturation Fraction [d]	0.39	0.46	0.45	0.39	0.46	0.45
	Field Capacity Fraction [d]	0.36	0.45	0.44	0.36	0.45	0.44
	Wilting Point Fraction [d]	0.18	0.25	0.24	0.17	0.24	0.23
	Saturated HC (mm/day) [d]	0.24	0.24	0.24	0.24	0.24	0.24
	Bulk Density (Mg m^{-3}) [d]	1.62	1.49	1.46	1.63	1.49	1.43
Chemical	Organic Carbon (%)	0.46	0.21	0.13	0.46	0.21	0.11
	Water pH	9.50	9.34	9.20	9.53	9.34	9.20
	EC (dS/m)	0.40	0.82	0.95	0.39	0.83	0.97
Other (site)	Slope %	1.00			1.00		

Soil Series: Tirunallar (Tamil Nadu)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-16	B 16-181	C 181-183
Physical	Sand (%)	16.46	13.13	12.35	16.80	13.35	25.80
	Silt (%)	22.51	29.26	33.91	23.60	30.23	32.20
	Clay (%)	61.03	57.61	53.74	59.60	56.42	42.00
	Saturation Fraction [d]	0.50	0.47	0.46	0.52	0.47	0.42
	Field Capacity Fraction [d]	0.41	0.40	0.38	0.40	0.39	0.33
	Wilting Point Fraction [d]	0.23	0.22	0.20	0.21	0.20	0.16
	Saturated HC (mm/day) [d]	332.81	129.23	157.46	576.10	178.23	191.89
	Bulk Density (Mg m^{-3}) [d]	1.32	1.41	1.44	1.27	1.41	1.54
Chemical	Organic Carbon (%)	0.78	0.35	0.30	1.00	0.40	0.29
	Water pH	7.78	8.46	8.40	7.10	8.36	8.40
	EC (dS/m)	0.13	0.64	1.00	0.14	0.72	0.70
Other (site)	Slope %	1.00			1.00		

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 120 cm in Kalthur).

[c]Horizons A, B, and C as described in _Soil Survey Staff_ (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.).

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.

Soil and climatic datasets as required for RothC Model

Soil Series: Kalathur (Tamil Nadu)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	23.03	42	83.2
February	24.84	15	90.4
March	26.66	27	143.7
April	28.78	38	160.1
May	31.21	71	181.4
June	31.21	35	183.5
July	30	69	181.4
August	29.09	110	173.4
September	28.78	113	158.5
October	28.78	242	150.8
November	26.36	362	115.5
December	24.84	183	98.4
Average	27.80	-	-
Total	-	1307	1720.3

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-14	38.7	1.62	0.90
14-49	45.1	1.62	0.29
49-87	56.4	1.62	0.21
87-104	58.7	1.49	0.21
104-120	58.3	1.49	0.11

[1]*Values for 0-50, 50-100,100-120 cm estimated by pedotransfer functions*

Soil Series: Thirunallar (Puducherry)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	24.8	78.5	96.9
February	26.0	17.2	105.3
March	27.4	25	152.2
April	29.4	24.7	167.0
May	31.4	39.1	181.4
June	31.7	31.1	183.5
July	30.8	43.3	181.4
August	29.9	62.7	173.4
September	29.9	80	165.3
October	27.6	229.2	150.8
November	26.2	398.3	113.4
December	25.2	229.4	95.9
Average	28.3	-	-
Total	-	1258.5	1766.5

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-16	59.6	1.32	1.00
16-53	61.7	1.32	0.67
53-73	61.6	1.41	0.39
73-131	54.2	1.41	0.28
131-181	53.0	1.44	0.33
181-183	42.0	-	0.29

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Kalathur (Tamil Nadu)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	42	23.03
February	15	24.84
March	27	26.66
April	38	28.78
May	71	31.21
June	35	31.21
July	69	30
August	110	29.09
September	113	28.78
October	242	28.78
November	362	26.36
December	183	24.84
Average	-	27.80
Total	1307	-

2. Soil data: Required physical and chemical properties of soils

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-14	9.1	0.90	1.62	43.4	17.9	38.7
14-49	9.7	0.29	1.62	38.6	16.3	45.1
49-87	9.4	0.21	1.62	27.1	16.5	56.4
87-104	9.2	0.21	1.49	22.6	18.7	58.7
104-120	9.2	0.11	1.49	24.1	17.6	58.3

[1]*Values for 0-50, 50-100,100-120 cm estimated by pedotransfer functions*

Soil Series: Thirunallar (Puducherry)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	78.5	24.8
February	17.2	26.0
March	25	27.4
April	24.7	29.4
May	39.1	31.4
June	31.1	31.7
July	43.3	30.8
August	62.7	29.9
September	80	29.9
October	229.2	27.6
November	398.3	26.2
December	229.4	25.2
Average	-	28.3
Total	1258.5	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-16	7.1	1.00	1.32	16.8	23.6	59.6
16-53	8.1	0.67	1.32	16.3	22.0	61.7
53-73	8.6	0.39	1.41	13.5	24.9	61.6
73-131	8.4	0.28	1.41	12.5	33.3	54.2
131-181	8.4	0.33	1.44	12.1	34.9	53.0
181-183	8.4	0.29	-	25.8	32.2	42.0

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

AESR 18.3

(Andhra Plain, hot dry subhumid ESR with deep, clayey Coastal and Deltaic alluvium-derived soils, low to medium AWC and LGP 150-180 days (S7Cd5).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Kovvur (Andhra Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-112	A 0-14	B 14-112	C
Physical	Sand (%)	63.23	42.34	36.70	80.40	46.87	
	Silt (%)	7.26	5.35	52.31	3.70	6.47	
	Clay (%)	29.51	52.31	58.70	15.90	46.66	
	Saturation Fraction [d]	0.43	0.46	0.49	0.41	0.44	
	Field Capacity Fraction [d]	0.31	0.43	0.47	0.17	0.38	
	Wilting Point Fraction [d]	0.18	0.31	0.35	0.11	0.28	
	Saturated HC (mm/day) [d]	99.36	2.4	0.48	787.20	6.24	
	Bulk Density (Mg m⁻³) [d]	1.52	1.42	1.34	1.56	1.47	
Chemical	Organic Carbon (%)	0.45	0.13	0.14	0.85	0.19	
	Water pH	8.05	8.55	8.80	7.60	8.46	
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	
Other (site)	Slope %	2.00			2.00		

Soil Series: Kaveli (Andhra Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50.-100	100-150	A 0-17	B	C 17-150
Physical	Sand (%)	95.13	96.14	94.25	94.20		95.29
	Silt (%)	3.04	2.04	2.11	3.90		2.21
	Clay (%)	1.83	1.82	3.64	1.90		2.5
	Saturation Fraction [d]	0.43	0.43	0.42	0.43		0.42
	Field Capacity Fraction [d]	0.04	0.04	0.05	0.04		0.04
	Wilting Point Fraction [d]	0.01	0.01	0.01	0.01		0.01
	Saturated HC (mm/day) [d]	4640.40	5109.36	3066.96	4334.16		3672.96
	Bulk Density (Mg m⁻³) [d]	1.52	1.54	1.54	1.51		1.53
Chemical	Organic Carbon (%)	0.09	0.03	0.03	0.20		0.03
	Water pH	6.93	7.12	7.23	7.00		7.10
	EC (dS/m)	0.10	0.10	0.10	0.10		0.10
Other (site)	Slope %	4.00			4.00		

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 112 cm in Kovvur).

[c]Horizons A, B, and C as described in _Soil Survey Staff_ (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Kovvur series, since C horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578)

Soil and climatic datasets as required for Roth*C* Model

Soil Series: Kovvur (Andhra Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	24.9	32	111
February	26.55	6.9	126
March	28.8	6.9	173
April	31.4	9.7	184
May	33.7	36.6	197
June	33.2	36.6	170
July	31.15	70.6	152
August	30.8	75.9	153
September	30.35	110.2	142
October	28.6	266.2	122
November	25.95	317.5	99
December	24.55	88.1	99
Average	29.16	-	-
Total	-	1057.2	1728

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})^{1}	Organic carbon (%)
0-14	15.9	1.52	0.85
14-46	33.1	1.52	0.32
46-81	48.4	1.42	0.12
81-112	58.7	1.42	0.14

^{1}*Values for 0-50, 50-100,100-112 cm estimated by pedotransfer functions*

Soil Series: Kaveli series (Andhra Pradesh)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	24.9	32	111
February	26.55	6.9	126
March	28.8	6.9	173
April	31.4	9.7	184
May	33.7	36.6	197
June	33.2	36.6	170
July	31.15	70.6	152
August	30.8	75.9	153
September	30.35	110.2	142
October	28.6	266.2	122
November	25.95	317.5	99
December	24.55	88.1	99
Average	29.16	-	-
Total	-	1057.2	1728

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})^{1}	Organic carbon (%)
0-17	7.0	1.52	0.20
17-53	6.9	1.52	0.03
53-93	7.1	1.54	0.03
93-132	7.3	1.54	0.03
132-150	7.1	1.54	0.03

^{1}*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Kovvur (Andhra Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	32	24.9
February	6.9	26.55
March	6.9	28.8
April	9.7	31.4
May	36.6	33.7
June	36.6	33.2
July	70.6	31.15
August	75.9	30.8
September	110.2	30.35
October	266.2	28.6
November	317.5	25.95
December	88.1	24.55
Average	-	29.16
Total	1057.2	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-14	7.6	0.85	1.52	80.4	3.7	15.9
14-46	8.2	0.32	1.52	57.9	9.0	33.1
46-81	8.4	0.12	1.42	45.8	5.8	48.4
81-112	8.8	0.14	1.42	36.7	4.6	58.7

[1]*Values for 0-50, 50-100,100-112 cm estimated by pedotransfer functions*

Soil Series: Kaveli series (Andhra Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	32	24.9
February	6.9	26.55
March	6.9	28.8
April	9.7	31.4
May	36.6	33.7
June	36.6	33.2
July	70.6	31.15
August	75.9	30.8
September	110.2	30.35
October	266.2	28.6
November	317.5	25.95
December	88.1	24.55
Average	-	29.16
Total	1057.2	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-17	7.0	0.20	1.52	7.0	7.0	7.0
17-53	6.9	0.03	1.52	6.9	6.9	6.9
53-93	7.1	0.03	1.54	7.1	7.1	7.1
93-132	7.3	0.03	1.54	7.3	7.3	7.3
132-150	7.1	0.03	1.54	7.1	7.1	7.1

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

AESR 18.4

(Utkal Plain and East Godavari Delta, hot dry subhumid ESR with deep, loamy to clayey Coastal and deltaic alluvium derived soils, medium AWC and LGP 180-210 days (S7Cd6).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Srikakulam (Andhra Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100-	100-150	A 0-12	B 12-150	C
Physical	Sand (%)	45.17	30.50	27.77	64.50	31.87	
	Silt (%)	19.44	21.25	19.98	17.60	20.45	
	Clay (%)	35.39	48.25	52.25	17.90	47.68	
	Saturation Fraction [d]	0.43	0.47	0.49	0.41	0.47	
	Field Capacity Fraction [d]	0.35	0.41	0.43	0.40	0.41	
	Wilting Point Fraction [d]	0.22	0.29	0.31	0.21	0.29	
	Saturated HC (mm/day) [d]	54.40	14.64	11.28	493.44	14.96	
	Bulk Density (Mg m^{-3}) [d]	1.50	1.39	1.35	1.58	1.40	
Chemical	Organic Carbon (%)	0.58	0.37	0.46	1.65	0.74	
	Water pH	6.07	5.95	6.00	6.20	5.99	
	EC (dS/m)	0.08	0.10	0.10	0.10	0.10	
Other (site)	Slope %	2.00			2.00		

Soil Series: Suryapet (Andhra Pradesh)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-130	A 0-16	B 16-130	C
Physical	Sand (%)	60.14	59.66	55.70	61.90	58.52	
	Silt (%)	13.50	8.16	9.50	15.90	9.77	
	Clay (%)	26.36	32.18	34.80	22.20	31.71	
	Saturation Fraction [d]	0.40	0.40	0.41	0.41	0.40	
	Field Capacity Fraction [d]	0.25	0.29	0.31	0.23	0.29	
	Wilting Point Fraction [d]	0.16	0.19	0.21	0.14	0.19	
	Saturated HC (mm/day) [d]	186.96	83.76	52.32	323.04	82.32	
	Bulk Density (Mg m^{-3}) [d]	1.59	1.59	1.57	1.56	1.58	
Chemical	Organic Carbon (%)	0.35	0.13	0.05	0.78	0.11	
	Water pH	7.90	8.20	8.50	7.90	8.19	
	EC (dS/m)	0.01	0.01	0.01	0.01	0.01	
Other (site)	Slope %	2.00			2.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 50 cm and 130 cm in Srikakulam and Suryapet respectively).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Srikakulam and Kovvur series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth *C* Model

Soil Series: Srikakulam (Andhra Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	24.3	4.1	112
February	26.8	14.5	131
March	29.95	12.5	180
April	32.45	29	191
May	34.7	36.1	211
June	32.4	124.5	169
July	28.7	239.8	129
August	28.4	165.9	123
September	28.5	163.8	115
October	27.7	83.3	116
November	24.85	32.8	102
December	23.4	4.8	98
Average	28.51	-	-
Total	-	911.1	1677

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-12	17.9	1.50	0.95
12-36	37.6	1.50	0.43
36-75	46.6	1.50	0.52
75-108	49.9	1.39	0.41
108-150	52.7	1.35	0.35

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Suryapet (Andhra Pradesh)
1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	21.2	0.8	110
February	23.9	16.8	130
March	27.3	18	182
April	30.2	30.2	198
May	31.9	24.1	220
June	28.9	166.4	196
July	26.6	254	140
August	25.5	201.7	136
September	25.8	181.1	119
October	24.9	37.9	124
November	22.4	16.3	104
December	20.4	6.1	99
Average	25.75	-	-
Total	-	953.4	1758

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-16	22.2	1.59	0.78
16-31	16.3	1.59	0.19
31-52	37.8	1.59	0.12
52-75	35.9	1.59	0.09
75-100	28.3	1.59	0.16
100-130	34.8	1.57	0.05

[1]*Values for 0-50, 50-100,100-130 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Srikakulam (Andhra Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	0.8	24.3
February	16.8	26.8
March	18	29.95
April	30.2	32.45
May	24.1	34.7
June	166.4	32.4
July	254	28.7
August	201.7	28.4
September	181.1	28.5
October	37.9	27.7
November	16.3	24.85
December	6.1	23.4
Average	-	28.51
Total	953.4	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3}) [1]	Sand (%)	Silt (%)	Clay (%)
0-12	6.2	0.95	1.50	64.5	17.6	17.9
12-36	6.1	0.43	1.50	43.3	19.1	37.6
36-75	5.9	0.52	1.50	31.8	21.6	46.6
75-108	6.0	0.41	1.39	29.2	20.9	49.9
108-150	6.0	0.35	1.35	27.5	19.8	52.7

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil Series: Suryapet (Andhra Pradesh)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	0.8	21.2
February	16.8	23.9
March	18	27.3
April	30.2	30.2
May	24.1	31.9
June	166.4	28.9
July	254	26.6
August	201.7	25.5
September	181.1	25.8
October	37.9	24.9
November	16.3	22.4
December	6.1	20.4
Average	-	25.75
Total	953.4	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3}) [1]	Sand (%)	Silt (%)	Clay (%)
0-16	7.9	0.78	1.59	61.9	15.9	22.2
16-31	7.9	0.19	1.59	70.6	13.1	16.3
31-52	7.9	0.12	1.59	50.4	11.8	37.8
52-75	7.8	0.09	1.59	56.2	7.9	35.9
75-100	8.6	0.16	1.59	63.6	8.1	28.3
100-130	8.5	0.05	1.57	55.7	9.5	34.8

[1]*Values for 0-50, 50-100,100-130 cm estimated by pedotransfer functions*

AESR 18.5

(Gangetic Delta, hot moist subhumid to humid ESR with deep, loamy to clayey Coastal and deltaic alluvium-derived soils, medium AWC and LGP 240-270 days (S7Cm7).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Rantrapur (Orissa)

Soil Parameters		Format I			Format II		
		Soil Depth (cm) [b]			Horizons (Depth in cm) [c]		
		0-50	50-100	100-147	A	B	C
Physical	Sand (%)	62.57	58.85	57.60	68.50	59.20	
	Silt (%)	19.83	18.13	16.10	19.20	17.77	
	Clay (%)	17.60	23.02	26.30	12.30	2303	
	Saturation Fraction [d]	0.39	0.39	0.41	0.39	0.39	
	Field Capacity Fraction [d]	0.21	0.23	0.26	0.15	0.23	
	Wilting Point Fraction [d]	0.11	0.14	0.16	0.07	0.14	
	Saturated HC (mm/day) [d]	366.20	237.80	170.20	842.16	237.84	
	Bulk Density (Mg m^{-3}) [d]	1.62	1.61	1.57	1.61	1.60	
Chemical	Organic Carbon (%)	0.13	0.10	0.09	0.20	0.10	
	Water pH	6.65	6.84	7.00	6.40	6.86	
	EC (dS/m)	0.56	0.48	0.42	0.69	0.47	
Other (site)	Slope %	2.00			2.00		

Soil Series: Sagar Island (West Bengal)

Soil Parameters		Format I			Format II		
		Soil Depth (cm) [b]			Horizons (Depth in cm) [c]		
		0-50	50-100	100-150	A	B	C
Physical	Sand (%)	15.66	14.90	14.90	18.90	14.71	
	Silt (%)	40.26	40.40	40.40	41.40	40.21	
	Clay (%)	44.08	44.70	44.70	39.70	45.08	
	Saturation Fraction [d]	0.49	0.49	0.49	0.48	0.49	
	Field Capacity Fraction [d]	0.40	0.41	0.41	0.38	0.41	
	Wilting Point Fraction [d]	0.26	0.27	0.27	0.24	0.27	
	Saturated HC (mm/day) [d]	40.32	33.84	33.84	59.04	33.84	
	Bulk Density (Mg m^{-3}) [d]	1.35	1.35	1.35	1.37	1.35	
Chemical	Organic Carbon (%)	0.45	0.24	0.24	0.79	0.26	
	Water pH	6.81	7.60	7.60	5.10	7.72	
	EC (dS/m)	1.45	1.33	1.33	1.97	1.48	
Other (site)	Slope %	1.00			1.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 147 cm in Rantrapur).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Rantrapur and Sagar series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for RothC Model

Soil Series: Rantrapur (Orissa)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	20.6	17	82
February	23.15	31	102
March	27.6	38	157
April	30.5	48	177
May	31.55	98	219
June	30.45	234	129
July	28.7	318	107
August	28.65	335	101
September	28.55	287	94
October	27.1	230	105
November	23.25	45	88
December	20.5	9	76
Average	26.72	-	-
Total	-	1690	1437

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-11	12.3	1.62	0.20
11-41	18.2	1.62	0.11
41-89	22.1	1.62	0.10
89-147	26.3	1.61	0.09

[1]*Values for 0-50, 50-100,100-147 cm estimated by pedotransfer functions*

Soil Series: Sagar Island (West Bengal)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	20.5	12.8	92
February	23.2	18.3	109
March	27	29.9	163
April	28.9	35	177
May	29.8	87.8	263
June	29.6	240.8	143
July	28.6	344.3	132
August	28.5	396.8	127
September	28.6	367.7	118
October	27.8	203.3	119
November	24.6	41.9	103
December	21.2	4.9	88
Average	26.53	-	-
Total	-	1783.5	1634

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-15	39.7	1.35	0.79
15-37	46.7	1.35	0.35
37-78	44.7	1.35	0.24
78-130+	44.7	1.35	0.23

[1]*Values for 0-50, 50-100,100-110 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Rantrapur (Orissa)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	17	20.6
February	31	23.15
March	38	27.6
April	48	30.5
May	98	31.55
June	234	30.45
July	318	28.7
August	335	28.65
September	287	28.55
October	230	27.1
November	45	23.25
December	9	20.5
Average	-	26.72
Total	1690	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3}) [1]	Sand (%)	Silt (%)	Clay (%)
0-11	6.4	0.20	1.62	68.5	19.2	12.3
11-41	6.7	0.11	1.62	62.3	19.5	18.2
41-89	6.8	0.10	1.62	56.2	18.7	22.1
89-147	7.0	0.09	1.61	57.6	16.1	26.3

[1]*Values for 0-50, 50-100,100-147 cm estimated by pedotransfer functions*

Soil Series: Sagar Island (West Bengal)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	12.8	20.5
February	18.3	23.2
March	29.9	27
April	35	28.9
May	87.8	29.8
June	240.8	29.6
July	344.3	28.6
August	396.8	28.5
September	367.7	28.6
October	203.3	27.8
November	41.9	24.6
December	4.9	21.2
Average	-	26.53
Total	1783.5	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3}) [1]	Sand (%)	Silt (%)	Clay (%)
0-15	5.1	0.79	1.35	18.9	41.4	39.7
15-37	7.5	0.35	1.35	13.9	39.4	46.7
37-78	7.6	0.24	1.35	14.9	40.4	44.7
78-130+	7.9	0.23	1.35	14.9	40.4	44.7

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

AESR 19.1

(North Sahyadris and Konkan Coast, hot humid ESR with medium to deep loamy to clayey mixed Red and Black soils, medium to high AWC and LGP 210-240 days (E6B8).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Pati (Dadra & Nagar Haveli)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-25			A 0-25	B	C
Physical	Sand (%)	28.96			28.96		
	Silt (%)	22.95			22.95		
	Clay (%)	48.09			48.09		
	Saturation Fraction [d]	0.51			0.51		
	Field Capacity Fraction [d]	0.32			0.32		
	Wilting Point Fraction [d]	0.18			0.18		
	Saturated HC (mm/day) [d]	890.32			890.32		
	Bulk Density (Mg m^{-3}) [d]	1.31			1.31		
Chemical	Organic Carbon (%)	1.61			1.61		
	Water pH	6.35			6.35		
	EC (dS/m)	0.20			0.20		
Other (site)	Slope %	12.00			12.00		

Soil Series: Tinoda (Dadra & Nagar Haveli)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-80		A	B	C
Physical	Sand (%)	19.22	16.63		21.60	16.70	16.08
	Silt (%)	25.72	24.47		25.00	29.00	25.27
	Clay (%)	55.06	58.90		53.40	54.30	58.65
	Saturation Fraction [d]	0.55	0.56		0.54	0.55	0.56
	Field Capacity Fraction	0.34	0.37		0.34	0.34	0.36
	Wilting Point Fraction	0.22	0.24		0.19	0.22	0.24
	Saturated HC (mm/day) [d]	1081.74	1063.67		1083.40	1134.90	1100.00
	Bulk Density (Mg m^{-3}) [d]	1.19	1.16		1.21	1.19	1.16
Chemical	Organic Carbon (%)	1.69	0.70		2.40	1.61	0.78
	Water pH	5.66	5.77		5.70	5.60	5.75
	EC (dS/m)	0.20	0.20		0.20	0.20	0.20
Other (site)	Slope %	40.00			40.00		

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 25 cm in Pati).

[c]Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B and C) not mentioned the column was left blank. For example in Pati series, since C horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.

Soil and climatic datasets as required for RothC Model

Soil Series: Pati (Dadra & Nagar Haveli)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	22.44	0.5	110.4
February	22.85	0.4	121.4
March	25.91	0.1	167.2
April	28.16	0.1	181.8
May	29.79	8.5	182.9
June	29.38	597.1	137.4
July	27.55	935.8	113.5
August	26.93	544.4	117.7
September	26.93	426.5	120.7
October	27.34	93.5	137.3
November	25.91	9	122.5
December	23.26	0.1	109.3
Average	26.37	-	-
Total	-	2616	1622.1

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-12	41.9	1.31	2.12
12-25	53.8	1.31	1.13
25-43	-------------------------- Weathered basalt ----------------------		

[1]*Values for 0-25 cm estimated by pedotransfer functions*

Soil Series: Tinoda (Dadra & Nagar Haveli)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	22.44	0.5	110.4
February	22.85	0.4	121.4
March	25.91	0.1	167.2
April	28.16	0.1	181.8
May	29.79	8.5	182.9
June	29.38	597.1	137.4
July	27.55	935.8	113.5
August	26.93	544.4	117.7
September	26.93	426.5	120.7
October	27.34	93.5	137.3
November	25.91	9	122.5
December	23.26	0.1	109.3
Average	26.37	-	-
Total	-	2616	1622.1

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-17	53.4	1.19	2.40
17-36	54.3	1.19	1.61
36-60	58.1	1.19	0.93
60-80	59.3	1.16	0.59

[1]*Values for 0-50, 50-80 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Pati (Dadra & Nagar Haveli)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	0.5	22.44
February	0.4	22.85
March	0.1	25.91
April	0.1	28.16
May	8.5	29.79
June	597.1	29.38
July	935.8	27.55
August	544.4	26.93
September	426.5	26.93
October	93.5	27.34
November	9	25.91
December	0.1	23.26
Average	-	26.37
Total	2616	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-12	6.4	2.12	1.31	34.0	24.1	41.9
12-25	6.3	1.13	1.31	24.3	21.9	53.8
25-43	-- Weathered basalt ------------					

[1]*Values for 0-25 cm estimated by pedotransfer functions*

Soil Series: Tinoda (Dadra & Nagar Haveli)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	0.5	22.44
February	0.4	22.85
March	0.1	25.91
April	0.1	28.16
May	8.5	29.79
June	597.1	29.38
July	935.8	27.55
August	544.4	26.93
September	426.5	26.93
October	93.5	27.34
November	9	25.91
December	0.1	23.26
Average	-	26.37
Total	2616	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-17	5.7	2.40	1.19	25.6	25.0	53.4
17-36	5.6	1.61	1.19	16.7	29.0	54.3
36-60	5.7	0.93	1.19	14.9	27.0	58.1
60-80	5.8	0.59	1.16	17.5	23.2	59.3

[1]*Values for 0-50, 50-80 cm estimated by pedotransfer functions*

AESR 19.2

(Central and South Sahyadris, hot moist subhumid to humidtransitional ESR with deep, loamy to clayey Red and Lateriticsoils, low to medium AWC and LGP 210-270 days (E2Cm/B7(9).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Chimpukkad (Kerala)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-95		A 0-40	B 40-95	C
Physical	Sand (%)	68.56	62.06		69.60	62.29	
	Silt (%)	10.39	7.46		10.91	7.54	
	Clay (%)	21.05	30.48		19.49	30.17	
	Saturation Fraction [d]	0.47	0.49		0.47	0.49	
	Field Capacity Fraction [d]	0.27	0.30		0.27	0.29	
	Wilting Point Fraction [d]	0.11	0.13		0.10	0.12	
	Saturated HC (mm/day) [d]	1467.72	1291.73		1524.30	1324.40	
	Bulk Density (Mg m^{-3}) [d]	1.40	1.36		1.41	1.36	
Chemical	Organic Carbon (%)	0.34	0.29		0.37	0.28	
	Water pH	4.56	5.02		4.48	5.01	
	EC (dS/m)	0.04	0.03		0.05	0.03	
Other (site)	Slope %	5.00			5.00		

Soil Series: Karingathode (Kerala)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-150	A 0-19	B 19-152	C
Physical	Sand (%)	53.32	54.48	51.20	55.50	52.64	
	Silt (%)	11.49	10.10	9.85	11.00	10.38	
	Clay (%)	35.19	35.42	38.95	33.50	36.98	
	Saturation Fraction [d]	0.50	0.51	0.52	0.49	0.51	
	Field Capacity Fraction [d]	0.33	0.34	0.35	0.32	0.34	
	Wilting Point Fraction [d]	0.16	0.16	0.16	0.14	0.16	
	Saturated HC (mm/day) [d]	1277.94	1335.74	1340.00	1234.60	1353.80	
	Bulk Density (Mg m^{-3}) [d]	1.20	1.32	1.30	1.35	1.29	
Chemical	Organic Carbon (%)	0.89	1.01	1.09	0.93	1.00	
	Water pH	5.05	4.85	5.00	5.30	4.92	
	EC (dS/m)	0.03	0.03	0.03	0.03	0.03	
Other (site)	Slope %	5.00			5.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 95 cm in Chimpukkad).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Tinoda and Karingathode series, since C horizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.*

Soil and climatic datasets as required for Roth*C* Model

Soil Series: Chimpukkad (Kerala)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	27.9	10.9	165.7
February	29.3	10.9	162.2
March	30.9	23.1	192
April	30.6	60.2	162.5
May	29.1	132.3	151.3
June	26.3	428.5	108.2
July	25.3	605.3	100.3
August	25.9	333.8	111.7
September	26.7	154.7	123.2
October	27	209.5	114.7
November	27.4	115.8	121.9
December	27.1	30.2	149
Average	27.79	-	-
Total	-	2115.2	1662.7

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-15	20.8	1.40	0.46
15-40	18.7	1.40	0.31
40-68	27.3	1.40	0.24
68-95	32.6	1.36	0.32

[1]*Values for 0-50, 50-95 cm estimated by pedotransfer functions*

Soil Series: Karinganthode (Kerala)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	27.9	10.9	165.7
February	29.3	10.9	162.2
March	30.9	23.1	192
April	30.6	60.2	162.5
May	29.1	132.3	151.3
June	26.3	428.5	108.2
July	25.3	605.3	100.3
August	25.9	333.8	111.7
September	26.7	154.7	123.2
October	27	209.5	114.7
November	27.4	115.8	121.9
December	27.1	30.2	149
Average	27.79	-	-
Total	-	2115.2	1662.7

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-19	33.5	1.20	0.93
19-48	36.4	1.20	0.85
48-76	33.7	1.20	0.98
76-98	37.1	1.32	1.04
98-125	39.3	1.32	1.14
125-152	38.6	1.30	1.03

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Chimpukkad (Kerala)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	10.9	27.9
February	10.9	29.3
March	23.1	30.9
April	60.2	30.6
May	132.3	29.1
June	428.5	26.3
July	605.3	25.3
August	333.8	25.9
September	154.7	26.7
October	209.5	27
November	115.8	27.4
December	30.2	27.1
Average	-	27.79
Total	2115.2	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-15	4.1	0.46	1.40	65.1	14.1	20.8
15-40	4.7	0.31	1.40	72.3	9.0	18.7
40-68	4.9	0.24	1.40	64.4	8.3	27.3
68-95	5.1	0.32	1.36	60.5	6.9	32.6

[1]*Values for 0-50, 50-95 cm estimated by pedotransfer functions*

Soil Series: Karinganthode (Kerala)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	10.9	27.9
February	10.9	29.3
March	23.1	30.9
April	60.2	30.6
May	132.3	29.1
June	428.5	26.3
July	605.3	25.3
August	333.8	25.9
September	154.7	26.7
October	209.5	27
November	115.8	27.4
December	30.2	27.1
Average	-	27.79
Total	2115.2	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-19	5.3	0.93	1.20	55.5	11.0	33.5
19-48	4.9	0.85	1.20	51.7	11.9	36.4
48-76	4.8	0.98	1.20	56.0	10.3	33.7
76-98	4.9	1.04	1.32	53.1	9.8	37.1
98-125	5.0	1.14	1.32	49.9	10.8	39.3
125-152	5.0	1.03	1.30	52.5	8.9	38.6

[1]*Values for 0-50, 50-100,100-150 cm estimated by pedotransfer functions*

AESR 19.3
(Konkan, Karnataka and Kerala Coastal plain, hot humid to per humid transitional ESR with deep, clayey to loamy acidic coastal alluvium-derived soils, low AWC and LGP 240-270days (R7A(B8(7).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Palghar (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50			A 0-15	B 15-50	C
Physical	Sand (%)	11.71			13.90	10.66	
	Silt (%)	29.80			30.70	29.38	
	Clay (%)	58.49			55.40	59.96	
	Saturation Fraction [d]	0.50			0.51	0.50	
	Field Capacity Fraction [d]	0.45			0.43	0.46	
	Wilting Point Fraction [d]	0.25			0.23	0.25	
	Saturated HC (mm/day) [d]	431.50			638.96	375.76	
	Bulk Density (Mg m^{-3}) [d]	1.31			1.29	1.32	
Chemical	Organic Carbon (%)	0.665			0.79	0.59	
	Water pH	7.45			6.90	7.69	
	EC (dS/m)	6.62			6.50	6.82	
Other (site)	Slope %		2.00			2.00	

Soil Series: Virthan (Maharashtra)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100		A 0-43	B 43-100	C
Physical	Sand (%)	15.52	13.50		15.67	14.14	
	Silt (%)	30.28	27.37		60.49	28.59	
	Clay (%)	54.20	59.13		53.84	57.27	
	Saturation Fraction [d]	0.47	0.48		0.47	0.46	
	Field Capacity Fraction [d]	0.36	0.38		0.35	0.37	
	Wilting Point Fraction [d]	0.19	0.21		0.18	0.19	
	Saturated HC (mm/day) [d]	404.02	274.75		424.12	191.68	
	Bulk Density (Mg m^{-3})	1.35	1.70		1.26	1.78	
Chemical	Organic Carbon (%)	1.10	0.57		1.18	0.60	
	Water pH	8.07	8.40		8.02	8.69	
	EC (dS/m)	0.34	0.20		0.36	0.21	
Other (site)	Slope %		5.00			5.00	

[a]Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).

[b]According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 50 cm and 100 cm in Palghar and Virthan respectively).

[c]Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say C) not mentioned the column was left blank. For example in Palghar and Virthan series, since C horizon was not reported that column was kept blank.

[d] These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Tiwary et al. (2010). Estimation of Soil Bulk Density for Shrink Swell soils of India using pedotransfer function. Draft paper prepared for communication to tropical journal, Geosis (NAIP) output, NBSS & LUP, Nagpur.

Soil and climatic datasets as required for Roth*C* Model

Soil Series: Palghar (Maharashtra)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	24.2	2.00	24.30
February	24.9	1.30	24.90
March	26.8	0.00	26.80
April	28.7	2.50	28.70
May	30.1	15.20	30.10
June	29.1	520.70	29.10
July	27.4	711.20	27.40
August	27.1	439.40	27.90
September	27.4	297.20	27.40
October	28.2	88.90	28.30
November	27.5	20.30	27.60
December	25.8	2.00	25.80
Average	27.3	-	-
Total	-	2100.70	328.30

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-15	55.4	1.31	0.79
15-35	58.4	1.31	0.67
35-53	61.7	1.31	0.51
53+	------------------Weathered basalt------------------		

[1]*Values for 0-50cm estimated by pedotransfer functions*

Soil Series: Virthan (Maharashtra)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	24.2	2.00	24.30
February	24.9	1.30	24.90
March	26.8	0.00	26.80
April	28.7	2.50	28.70
May	30.1	15.20	30.10
June	29.1	520.70	29.10
July	27.4	711.20	27.40
August	27.1	439.40	27.90
September	27.4	297.20	27.40
October	28.2	88.90	28.30
November	27.5	20.30	27.60
December	25.8	2.00	25.80
Average	27.3	-	-
Total	-	2100.70	328.30

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3}) [1]	Organic carbon (%)
0-17	51.9	1.35	1.89
17-43	55.1	1.35	0.71
43-61	56.4	1.35	0.64
61-85	56.6	1.70	0.58
85+	56.6	1.70	0.49

[1]*Values for 0-50, 50-100cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Palghar (Maharashtra)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	2.00	24.2
February	1.30	24.9
March	0.00	26.8
April	2.50	28.7
May	15.20	30.1
June	520.70	29.1
July	711.20	27.4
August	439.40	27.1
September	297.20	27.4
October	88.90	28.2
November	20.30	27.5
December	2.00	25.8
Average	-	27.3
Total	2100.70	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-15	6.9	0.79	1.31	13.9	30.7	55.4
15-35	7.6	0.67	1.31	11.8	30.2	58.4
35-53	7.8	0.51	1.31	9.4	28.9	61.7
53+	--Weathered basalt---					

[1]*Values for 0-50 cm estimated by pedotransfer functions*

Soil Series: Virthan (Maharashtra)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	2.00	24.2
February	1.30	24.9
March	0.00	26.8
April	2.50	28.7
May	15.20	30.1
June	520.70	29.1
July	711.20	27.4
August	439.40	27.1
September	297.20	27.4
October	88.90	28.2
November	20.30	27.5
December	2.00	25.8
Average	-	27.3
Total	2100.70	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-17	7.9	1.89	1.35	16.7	31.4	51.9
17-43	8.1	0.71	1.35	15.0	29.9	55.1
43-61	8.4	0.64	1.35	14.6	29.0	56.4
61-85	8.4	0.58	1.70	13.8	27.6	56.6
85+	8.4	0.49	1.70	12.2	25.8	56.6

[1]*Values for 0-50, 50-100cm estimated by pedotransfer functions*

AESR 20.1

(Andaman and Nicobar group of IslandS, hot perhumid ESR with shallow to medium deep, loamy to clayey Red and Yellow and Red Loamy soils, low to medium AWC and LGP 300 days (T3A10).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Basanthipur (Andaman & Nicobar)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100		A 0-7	B 7-75	C 75-100
Physical	Sand (%)	20.28	8.35		25.20	16.17	6.20
	Silt (%)	42.28	52.75		42.50	44.18	58.00
	Clay (%)	37.44	38.90		32.30	39.65	35.80
	Saturation Fraction [d]	0.50	0.49		0.58	0.50	0.48
	Field Capacity Fraction [d]	0.37	0.39		0.38	0.39	0.38
	Wilting Point Fraction [d]	0.24	0.23		0.22	0.24	0.22
	Saturated HC (mm/day) [d]	117.10	63.36		444.96	75.60	59.76
	Bulk Density (Mg m^{-3}) [d]	1.32	1.34		1.12	1.33	1.37
Chemical	Organic Carbon (%)	1.71	0.57		4.10	1.10	0.41
	Water pH	4.87	4.90		5.30	4.84	4.90
	EC (dS/m)	0.10	0.10		0.10	0.10	0.10
Other (site)	Slope %	4.00			4.00		

Soil Series: Govindapur (Andaman & Nicobar)

Soil Parameters		Format I			Format II		
		Soil Depth (cm)[b]			Horizons (Depth in cm)[c]		
		0-50	50-100	100-125	A 0-5	B 5-95	C 95-125
Physical	Sand (%)	32.42	27.70	7.00	35.90	31.02	7.00
	Silt (%)	37.82	37.57	51.80	37.30	36.93	51.80
	Clay (%)	29.76	34.73	41.20	26.80	32.05	41.20
	Saturation Fraction [d]	0.47	0.46	0.50	0.52	0.46	0.50
	Field Capacity Fraction [d]	0.34	0.35	0.40	0.34	0.34	0.40
	Wilting Point Fraction [d]	0.19	0.21	0.24	0.19	0.20	0.24
	Saturated HC (mm/day) [d]	155.30	67.68	55.92	372.96	104.16	55.92
	Bulk Density (Mg m^{-3}) [d]	1.40	1.44	1.33	1.26	1.43	1.3
Chemical	Organic Carbon (%)	1.47	0.64	0.49	3.02	0.98	0.49
	Water pH	5.10	5.07	5.70	4.90	5.06	5.70
	EC (dS/m)	0.10	0.10	0.10	0.10	0.10	0.10
Other (site)	Slope %	4.00			4.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 100 cm and 125 cm in Basanthipur and Govindapur).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.).*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for Roth*C* Model

Soil Series: Basanthipur (Andaman & Nicobar Island)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	25.7	22.73	121.3
February	25.8	31.5	120.7
March	26.9	14.3	145.5
April	28.1	55	136.9
May	27.8	276.3	122.5
June	27	426.4	114.7
July	26.9	442.6	108.9
August	26.6	505.6	104.8
September	26.2	444.3	102.9
October	26.1	301.9	101.1
November	26	265	106.1
December	26	122.8	115.4
Average	26.59	-	-
Total	-	2908.43	1400.8

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-7	32.3	1.32	4.1
7-29	33.1	1.32	0.91
29-50	43.7	1.32	1.74
50-75	42.0	1.32	0.72
75-100	35.8	1.34	0.41

[1]*Values for 0-50, 50-100 cm estimated by pedotransfer functions*

Soil Series: Govindpur (Andaman & Nicobar Island)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	25.7	22.73	121.3
February	25.8	31.5	120.7
March	26.9	14.3	145.5
April	28.1	55	136.9
May	27.8	276.3	122.5
June	27	426.4	114.7
July	26.9	442.6	108.9
August	26.6	505.6	104.8
September	26.2	444.3	102.9
October	26.1	301.9	101.1
November	26	265	106.1
December	26	122.8	115.4
Average	26.59	-	-
Total	-	2908.43	1400.8

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-5	26.8	1.40	3.02
5-21	25.7	1.40	1.86
21-42	31.8	1.40	1.05
42-66	34.4	1.40	0.84
66-95	33.8	1.44	0.56
95-125	41.2	1.44	0.49

[1]*Values for 0-50, 50-100, 100-125 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model
Soil Series: Basanthipur (Andaman & Nicobar Island)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	22.73	25.7
February	31.5	25.8
March	14.3	26.9
April	55	28.1
May	276.3	27.8
June	426.4	27
July	442.6	26.9
August	505.6	26.6
September	444.3	26.2
October	301.9	26.1
November	265	26
December	122.8	26
Average	-	26.59
Total	2908.43	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-7	5.3	4.1	1.32	25.2	42.5	32.3
7-29	4.9	0.91	1.32	26.9	40.0	33.1
29-50	4.7	1.74	1.32	11.7	44.6	43.7
50-75	4.9	0.72	1.32	10.5	47.5	42.0
75-100	4.9	0.41	1.34	6.2	58.0	35.8

[1]*Values for 0-50, 50-100 cm estimated by pedotransfer functions*

Soil Series: Govindpur (Andaman & Nicobar Island)
1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	22.73	25.7
February	31.5	25.8
March	14.3	26.9
April	55	28.1
May	276.3	27.8
June	426.4	27
July	442.6	26.9
August	505.6	26.6
September	444.3	26.2
October	301.9	26.1
November	265	26
December	122.8	26
Average	-	26.59
Total	2908.43	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3}) [1]	Sand (%)	Silt (%)	Clay (%)
0-5	4.9	3.02	1.40	35.9	37.3	26.8
5-21	5.2	1.86	1.40	40.1	34.2	25.7
21-42	5.1	1.05	1.40	27	41.9	31.8
42-66	5.0	0.84	1.40	29.1	36.5	34.4
66-95	5.0	0.56	1.44	30.5	35.7	33.8
95-125	5.7	0.49	1.44	7	51.8	41.2

[1]*Values for 0-50, 50-100, 100-125 cm estimated by pedotransfer functions*

ICAR Network Project on Climate Change: NPCC

AESR 20.2
(Level Lakshadweep and group of Island, hot humid ESR withshallow to medium deep loamy to sandy Black, sandy andLittoral soils, low to medium AWC and LGP 240-270 days(U16B8).) [a]

Soil Master
as required for _InfoCrop_ Model

NOTE: Two formats (Format I & II) for soil parameters are provided. The modellers may decide which one to give the best fit.

Soil Series: Kavaratti (Lakshadweep)

Soil Parameters		Format I				Format II		
		Soil Depth (cm)[b]				Horizons (Depth in cm)[c]		
		0-50	50-100	100-110		A 0-24	B	C 24-110
Physical	Sand (%)	86.90	93.86	92.30		85.70		91.87
	Silt (%)	5.85	2.40	2.70		5.70		3.56
	Clay (%)	7.25	3.74	5.00		8.60		4.57
	Saturation Fraction [d]	0.43	0.43	0.42		0.43		0.42
	Field Capacity Fraction [d]	0.10	0.06	0.07		0.12		0.17
	Wilting Point Fraction [d]	0.05	0.02	0.03		0.07		0.04
	Saturated HC (mm/day) [d]	2150.16	3001.00	2597.00		1681.68		2352.00
	Bulk Density (Mg m^{-3}) [d]	1.51	1.52	1.53		1.51		1.53
Chemical	Organic Carbon (%)	0.82	0.31	0.32		0.97		0.43
	Water pH	8.50	8.90	8.90		8.4		8.81
	EC (dS/m)	0.32	0.16	0.18		0.40		0.19
Other (site)	Slope %	3.00				3.00		

Soil Series: Andrott (Lakshadweep)

Soil Parameters		Format I				Format II		
		Soil Depth (cm)[b]				Horizons (Depth in cm)[c]		
		0-50	50-62			A 0-14	B	C 14-62
Physical	Sand (%)	66.47	51.50			70.60		61.53
	Silt (%)	22.09	32.00			19.50		25.33
	Clay (%)	11.44	16.50			9.90		13.14
	Saturation Fraction [d]	0.40	0.42			0.44		0.42
	Field Capacity Fraction [d]	0.16	0.23			0.16		0.19
	Wilting Point Fraction [d]	0.07	0.11			0.08		0.09
	Saturated HC (mm/day) [d]	889.40	444.00			1252.80		761.28
	Bulk Density (Mg m^{-3}) [d]	1.59	1.53			1.49		1.54
Chemical	Organic Carbon (%)	0.91	0.81			1.24		0.79
	Water pH	8.38	8.40			8.20		8.40
	EC (dS/m)	0.26	0.18			0.10		0.20
Other (site)	Slope %	12.00				12.00		

[a]*Also see Velayutham et. al (1999) (Velayutham M., Mandal D.K., Mandal C., Srinivas C.V.,and Sehgal J. 1999.Agro-Ecological Subregions of India for Planning and Development. NBSS Publ.35. NBSS & LUP).*

[b]*According to format of soil master as shown in InfoCrop model as 0-50, 50-100, 100-150 cm of soil depths. If the soil depth is less than 50, 100 or 150 the depth is shown as it was reported in soil series description (say upto 110 cm and 62 cm in Kavaratti and Andrott respectively).*

[c]*Horizons A, B, and C as described in Soil Survey Staff (2006) (Soil Survey Staff 2006. Keys to Soil Taxonomy. United States Department of Agriculture. National Resource Conservation Service, Washington DC.). If horizons (say B) not mentioned the column was left blank. For example in Kavaratti and Andrott series, since Bhorizon was not reported that column was kept blank.*

[d] *These datasets were not available in the original soil series description. We took the help of pedo- transfer function suggested by Saxton and Rawls (2006) to estimate these values (Saxton, K.E. and Rawls, W.J. 2006 .Soil water characteristic estimates by texture and organic matter for hydraulic solutions. Soil Science Society of America Journal, 70: 1569-1578).*

Soil and climatic datasets as required for RothC Model

Soil Series: Kavaratti (Lakshdweep)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	26.2	35	120
February	26.6	25	120
March	27.6	17	145
April	28.7	54	141
May	28.8	200	133
June	27.7	294	111
July	27.3	218	120
August	27.2	200	121
September	27.3	144	125
October	27.1	185	123
November	26.4	141	108
December	26.5	76	115
Average	27.28	-	-
Total	-	1589	1482

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-24	8.6	1.51	0.97
24-50	6.0	1.51	0.69
50-80	2.9	1.51	0.31
80-110	5.0	1.52	0.32

[1]*Values for 0-50, 50-100,100-110 cm estimated by pedotransfer functions*

Soil Series: Andrott (Lakshdweep)

1. Climatic data:

Months	MAT (°C)	MAR (mm)	PET (mm)
January	26.2	35	120
February	26.6	25	120
March	27.6	17	145
April	28.7	54	141
May	28.8	200	133
June	27.7	294	111
July	27.3	218	120
August	27.2	200	121
September	27.3	144	125
October	27.1	185	123
November	26.4	141	108
December	26.5	76	115
Average	27.28	-	-
Total	-	1589	1482

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	Clay (%)	B. D. (Mgm^{-3})[1]	Organic carbon (%)
0-14	9.9	1.59	1.24
14-26	9.7	1.59	0.87
26-44	12.1	1.59	0.72
44-62	16.5	1.59	0.81

[11]*Values for 0-50, 50-62 cm estimated by pedotransfer functions*

Soil and climatic datasets as required for Century C Model

Soil Series: Kavaratti (Lakshdweep)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	35	26.2
February	25	26.6
March	17	27.6
April	54	28.7
May	200	28.8
June	294	27.7
July	218	27.3
August	200	27.2
September	144	27.3
October	185	27.1
November	141	26.4
December	76	26.5
Average	-	27.28
Total	1589	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})	Sand (%)	Silt (%)	Clay (%)
0-24	8.4	0.97	1.51	85.7	5.7	8.6
24-50	8.6	0.69	1.51	88.0	6.0	6.0
50-80	8.9	0.31	1.51	94.9	2.3	2.9
80-110	8.9	0.32	1.52	92.3	2.7	5.0

Soil Series: Andrott (Lakshdweep)

1. Climatic data:

Months	MAR (mm)	MAT (°C)
January	35	26.2
February	25	26.6
March	17	27.6
April	54	28.7
May	200	28.8
June	294	27.7
July	218	27.3
August	200	27.2
September	144	27.3
October	185	27.1
November	141	26.4
December	76	26.5
Average	-	27.28
Total	1589	-

2. Soil data: Required physical and chemical properties of soils.

Depth (cm)	pH	Organic carbon (%)	B. D. (Mgm^{-3})[1]	Sand (%)	Silt (%)	Clay (%)
0-14	0-15	1.24	1.59	70.6	19.5	9.9
14-26	15-37	0.87	1.59	72.7	17.6	9.7
26-44	37-58	0.72	1.59	64.1	23.8	12.1
44-62	58-75	0.81	1.59	51.5	32.0	16.5

[1]Values for 0-50, 50-62cm estimated by pedo-transfer functions

Annexure II

Landscape, landuse and soil profile

Landscape, landuse and soils (Kasireddipalli TM, Ramchandrapuram, Medak, A.P.)

Benchmark spot at Kasireddipalli, Medak, Andhra Pradesh under agricultural system (Traditional Management) with Kharif fallow-chickpea crop rotation.

Wide and polygonal surface cracks in the Benchmark spot.

Typically Kasireddypalli benchmark soil profile

Closer view of the profile. (*Sodic Haplusterts*)

Landscape, landuse and soils (Kovilpatti, Tamil Nadu)

Agricultural Research Station, a site for benchmark spot No. 9 at Kovilpatti, Tuticorin, Tamil Nadu

Typical land use under agricultural system (Sorghum and Cotton)

Soil-site for Kovilpatti series   Closer view of slickenside in the profile
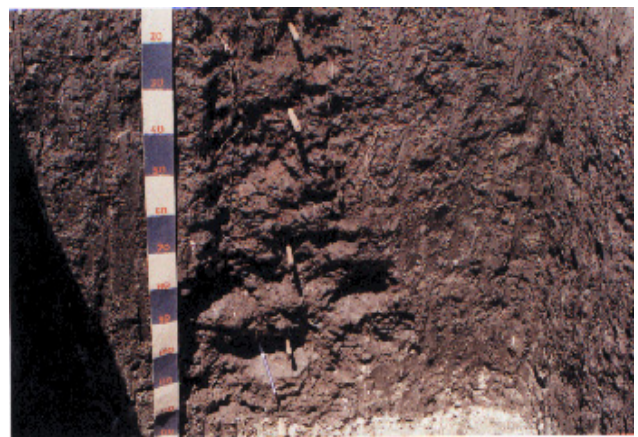
Typical black soil profile of Kovilpatti series showing accumulation of Gypsum in the lowermost horizon.

Landscape, landuse and soils (Semla, Rajkot)

Wide cracks are common in Semla soils

Benchmark spot at Semla, Rajkot Gujarat under Agricultural system with Cototn/Groundnut-Wheat Crop Rotation.

Closer view of the profile

Typical profile of Semla soil.

Landscape, landuse and soils (Linga, Nagpur)

Exact management practice in 10 years old horticulture farm on Linga soils

Horticultural system under high Management with Linga soil

Site selection for profile examination and sample collection
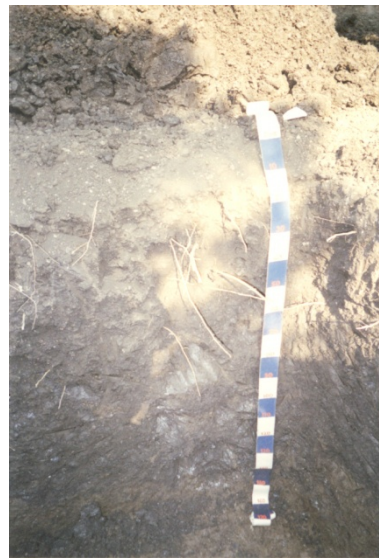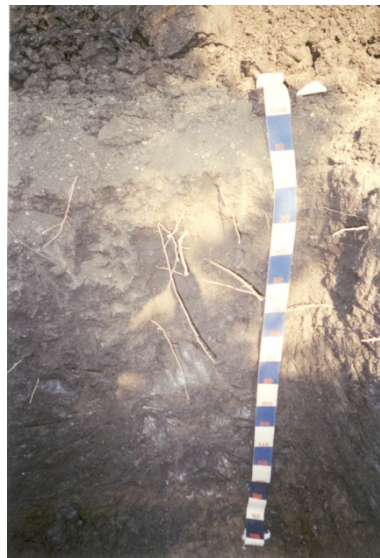
Very deep black soil profile of Linga series (*Typic Haplusterts*)

f

Landscape, landuse and soils (Kheri, Khajri-Kheria, Jabalpur)

Kheri soils under Agriculture (Low Management) with Soybean/Paddy-Wheat Cropping system.

A typical profile of Kheri Soils (*Typic Haplustert*)
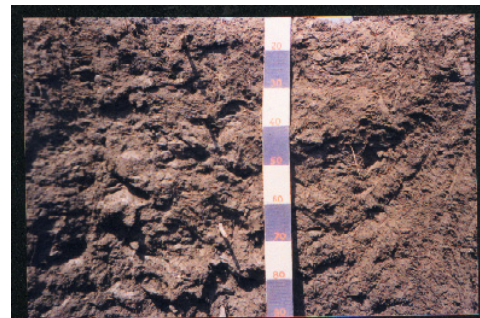
Closer view of the soil profile

Landscape, landuse and soils (Haldi, Nainital, Uttarakhand)

Haldi series

Elevetion: 200 to 250 m above MSL

MAT: 23.2 ºC

MAR: 1700 mm
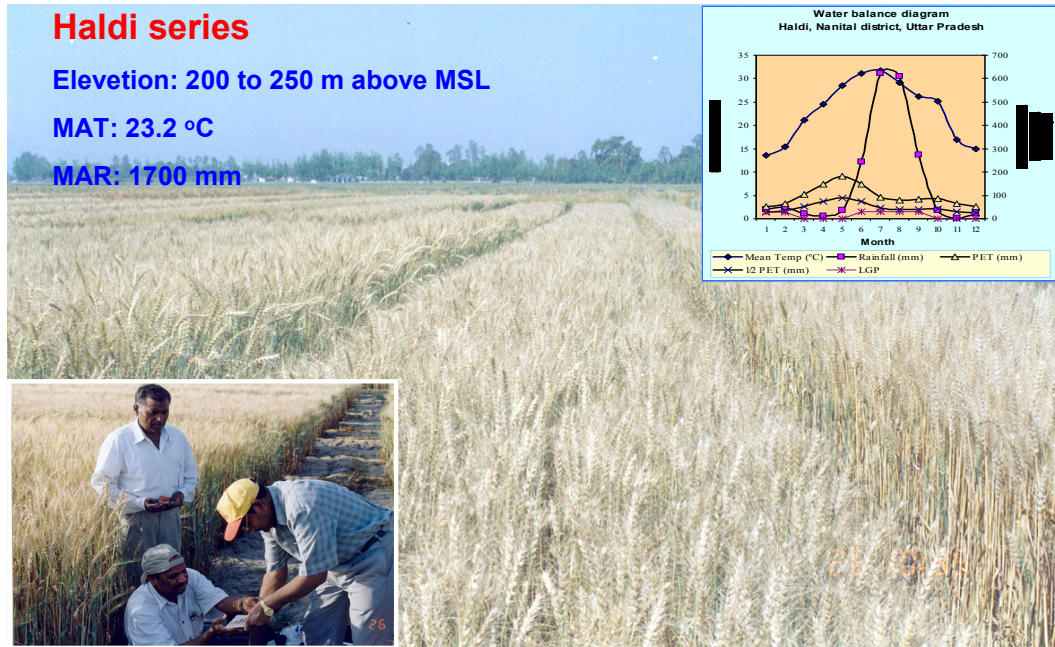
Haldi series

Fine-loamy, mixed, hyperthermic,
Typic Haplustalfs.

Pedon of Haldi soil series

h
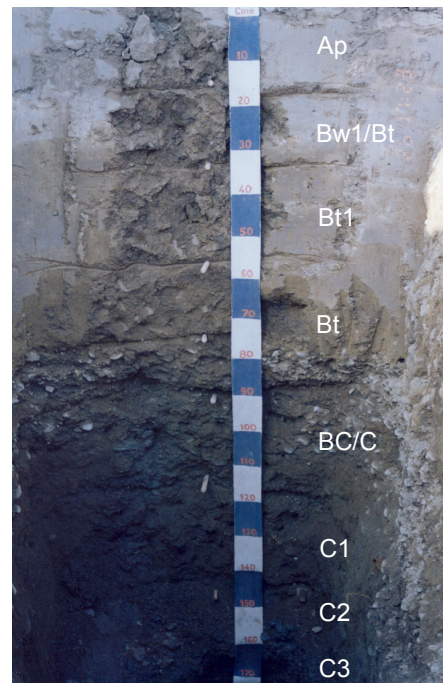
Landscape, landuse and soils (Sagar Island series, 24- Paraganas S, West Bengal)

Sagar Island series

**Fine, mixed, isohyoerthermic,
*Typic Endoaquepts.***

Pedon of Sagar Island soil series
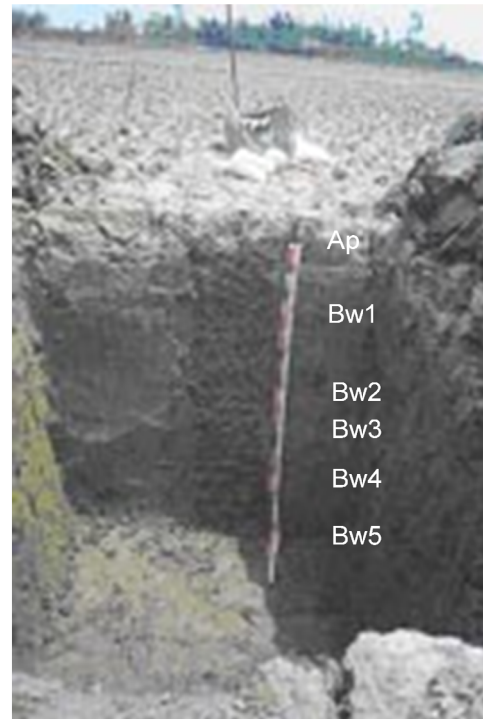
Landscape of Sagar Island series

Sagar Island series

Use

Paddy *(Oryza sativa)*

Betel wine *(Piper betle)*

Potato *(Solanum tuberosum)*

Mustard *(Brassica junca)*

Sunflower *(Helianthus annuus)*

Natural vegetation

Babul *(Acacia arabica)*

Palm (*Borassus flabellifer***)**

Mango (*Mangifera indica***)**

Jhau (*Tamarix dioica)*

NBSS&LUP PUBLICATIONS

SOIL RESOURCE MAPS

- *Soil Map of India, scale 1:7 million, 1985.

- **Soil Resource Maps of**:
  - +West Bengal, Bull.27 (Bull. in Bengali Version)
  - +Pondicherry & Karaikal, Bull.28
  - +Gujarat, Bull.29
  - +Haryana, Bull.44
  - +Punjab, Bull.45
  - +Tamil Nadu, Bull.46
  - +Karnataka, Bull.47
  - +Kerala, Bull.48
  - +Orissa, Bull.49(Bull.in Oriya Version)
  - +Bihar, Bull.50
  - +Rajasthan, Bull.51
  - +Meghalaya, Bull.52
  - +Maharashtra, Bull.54 (Bull. in Marathi Version)
  - +Arunachal Pradesh, Bull.55
  - +Manipur, Bull.56
  - +Himachal Pradesh, Bull.57
  - +Madhya Pradesh, Bull.59 (Bull.in Hindi Version)
  - +Sikkim, Bull.60
  - #Andaman & Nicobar Islands, Bull.61+
  - +Jammu & Kashmir, Bull.62
  - +Tripura, Bull.65
  - +Assam, Bull.66 (Bull. in Assami Version)
  - +Nagaland, Bull.67
  - +Uttar Pradesh, #Bull.68
  - +Andhra Pradesh, Bull.69
  - +Lakshadweep, Bull.70
  - +Delhi, Bull. 72
  - +Goa, Bull. 74
  - +Mizoram, Bull.75

RESEARCH BULLETINS

- *Glossary of Geomorphological Terms, Bull. No.1, 1980.
- *Soils of North Eastern Region, Bull.No.2, 1981.
- *Land Use Plan for Development of Bundelkhand Region based on Land and Soil Resources Survey, Bull.No.3, 1981.
- *Soils and Suggested Land Use of Maharashtra, Bull.No.4, 1980.
- *Soil-Physiographic Relationship in India, Bull. No. 5, 1982.
- *Soil-based Agrotechnology Transfer under Lab-to-Land Programme, Bull.No.6, 1982.
- *Bioclimatic Analysis of India, Bull.No.7, 1982.
- *Soil Survey of ICRISAT Farm and Type Area around Patancheru, Andhra Pradesh, Bull.No.8 (rev.ed.) 1993.
- *Geomorphology, Soils and Land Use of Haryana, Bull.No.9, 1983.
- +Memorandum of Soil Correlation, Bull.No.10, 1984.
- *The Soils of Mondha Village (Nagpur) for Agrotechnology Transfer, Bull.No.11, 1986.
- +The Soils of Hassan District (Karnataka) for Land Use Planning, Bull.No.12, 1987.

- *Field Manual, Rev. ed. Bull.No.13, 1989.
- *Laboratory Methods, Bull.No.14, 1987
- *Benchmark Soils of India: Mondha Series, Bull.No.15, 1987.
- *Benchmark Soils of India: Pali Series, Bull.No.16, 1987.
- +Agroclimatic Environments and Moisture Regimes in North-West India - their application in soils and crop growth, Bull.No.17, 1987.
- +NBSS&LUP Publications: 1976-1988, Bull.No.18, 1988.
- +NBSS&LUP Publications: 1988-1999, Bull.No.18 (Supplement), 2000.
- *Benchmark Swell-Shrink Soils of India-their Morphology, Characteristics and Classification, Bull.No.19, 1988.
- *The Soils of Kolar District (Karnataka) for Land Use Planning, Bull.No.20, 1988.
- +Agro-ecological Zones of India - 5th Approx. (scale 1:6000,000), NBSS Publ.21, 1989.
- *Land Resource Atlas of Nagpur District, Bull.No.22, 1994.
- +Soil Resource Mapping of Different States of India - Why and How?, Bull.No.23, Reprint, 1994.
- *Agro-ecological Regions of India, 2nd ed. Bull.No.24, 1992.
- *Proceedings, 3rd National Workshop on Soil Resource Mapping of Different States of India, Bull.No.25, 1990.
- +The Soils of Anantnag and Part of Pulwama Districts (Jammu & Kashmir) for Land Use Planning, Bull.No.26, 1991.
- *The Suitability of Vertisols and Associated Soils for Improved Cropping Systems in Central India, Bull.No.30, 1991.
- +Soils of Punjab, Bull.No.31, 1992.
- *Soil Resource Mapping of Different States for Sustainable Agricultural Production: Proceedings, 4th National Meet, Nov.1-2, 1991, Bull. No.32, 1991.
- +The Soils of Bankura District (West Bengal) for Land Use Planning, Bull.No.33, 1992.
- *Micromorphology of Soils of India. Bull.No.34, 1992.
- +Agro-Ecological Subregions of India, Bull.No.35.
- +Soil Series - Criteria and Norms, Bull.No.36, 1992.
- *Red and Lateritic Soils of India: Resource appraisal and Management, Bull.No.37, 1993.
- $Soil Degradation in India: Status and impact, Bull.No.38, 1994.
- +Growing Period for Crop Planning, Bull.No.39, 1993.
- *Soil Series of India, Bull.No.40, 1994.
- *Soil Temperature Regimes in India, Bull.No.41, 1994.
- *Land Evaluation for Land Use Planning (Papers of Indo-UK Workshop), Bull.No.42, 1993.
- *Soil Moisture Regimes of India, Bull. No.43, 1994.

- +Soil Climatic Database for Crop Planning in India, Bull.No.53, 1999.
- +Soil Climatic Environments in India, Bull.No.58, 1995.
- +Soil Based Land Use Planning Series: Udaipur dist. Rajasthan, Bull.No.63, 1995.
- +Soil Monoliths: Their Collection, Preparation and Display. Bull.No.64, 1995.
- +Soil Resources of Goa for Perspective Land Use Planning, NBSS Publ. 71, 1997.
- +Land Resource Management: A Decade of Post-Graduate Research, NBSS Publ.73, 1998.
- +Soils of Madhubani district for optimising land use, NBSS Publ. 76, 1999.
- +Soil Resource Atlas of Bhopal District (M.P.), NBSS Publ.77, 1999.

- +Soil Series of Madhya Pradesh, NBSS Publ.78, 1999.
- +Soil Series of Maharashtra, NBSS Publ.79, 1999.
- +Soil Resource Atlas – Guna District (M.P.), NBSS Publ.80, 2000.
- +Agro-ecological Assessment of Soil Resources of Rajasthan for Land Use Planning, NBSS Publ.81, 2000.
- *Soil Erosion in Maharashtra, NBSS Publ.82, 2000.
- +Significance of Minerals in Soil Environment of India, NBSS Review Series-1, 2000.
- +Climate Change and Polygenesis in Vertisols of the Purna Valley (Maharashtra) and Their Management, NBSS Publ.83, 2000.
- +A Decade of GIS Aided Research – Highlights, NBSS Publ.84, 2001.
- +Soil Series of Chhatisgarh State, NBSS Publ.85, 2001.
- +Soil Resource Atlas of Betul District (M.P.), NBSS Publ.86, 2001.
- +Soil Based Agro-Technology Transfer in Sukli (Distt. Nagpur), NBSS Publ.87, 2001.
- +Soils of Hugli District for Optimising Land Use, NBSS Publ.88, 2001.
- +Soil Series of West Bengal, NBSS Publ.89, 2001.
- +Soil Resource Atlas of Dhar Dist. (M.P.), NBSS Publ.90, 2001, 100p, ISBN:81-85460-68X.
- #Soil Series of Himachal Pradesh, NBSS Publ.91, ISBN:81-85460-69-8.
- +Soil Series of Goa, NBSS Publ.92, ISBN:81-85460-70-1.
- *Soil Resource Atlas of Ratlam Distt. (M.P.), NBSS Publ.93.
- +Soils of India, (1:1 M Scale, 11 Sheets Maps) NBSS Publ.94, ISBN:81-85460-72-8.
- +Soil Resource Atlas of Bilaspur Distt. (Chhattisgarh), NBSS Publ.95. ISBN:81-85460-73-6.
- +Soil Series of Rajasthan, NBSS Publ.96. ISBN:81-85460-75-2.
- +Soil Erosion of Tripura: A model for soil conservation and crop performance, NBSS Publ.97. ISBN:81-85460-76-0.
- #Soil Series of Bihar, NBSS Publ.98. ISBN:81-85460-77-9.
- *Soils of Ajmer district for optimising land use. NBSS Publ.99. ISBN:81-85460-78-7.
- +Soil Resource Atlas of Chhindwara Distt. (M.P.), NBSS Publ.100. ISBN:81-85460-79-5.
- +Soil Series of Assam. NBSS Publ.101.
- +Soil Erosion of Rajasthan. NBSS Publ.102. ISBN:81-85460-80-9
- +Soil Erosion of Chhattisgarh. NBSS Publ.103. ISBN:81-85460-81-7
- #Soil Resource Atlas of Jadgalpur (Baster) Distt. (Chhattisgarh). NBSS Publ.104.ISBN:81-85460-82-5
- +Soil Series of Sikkim. NBSS Publ.105.ISBN:81-85460-83-3
- #Soil Erosion: Madhya Pradesh. NBSS Publ.106.ISBN:81-85460-84-1.
- #Soil Resource atlas of Jorhat Distt.(Assam). NBSS Publ.107. ISBN:81-85460-85-X
- +Salt affected soils, Etah Distt. (UP). NBSS Publ.108.ISBN:81-85460-86-8
- +Soil Series of Nagaland. NBSS Publ.109.ISBN:81-85460-87-6.
- #Soil Resource information and land use planning of Chhattisgarh. NBSS Publ.110.ISBN:81-85460-88-4
- +Soil Series of Tripura. NBSS Publ.111.ISBN:81-85460-89-2
- #Soil Series of Delhi. NBSS Publ.112.ISBN:81-85460-91-4
- +Land use planning of Udaipur dist. Soil resource and agro-ecological assessment. NBSS Publ.113.ISBN:81-85460-92-2
- +Potential soil loss in A.P. NBSS Publ. 114.ISBN:81-85460-93-0
- #Economic land evaluation for sustainable land management of Rajanukunte watershed, Karnataka. NBSS Publ.115.ISBN:81-85460-94-9
- #Soil resource atlas Wardha dist. (Maharashtra). NBSS Publ.116..ISBN:81-85460-95-7
- #Soil Erosion of West Bengal. NBSS Publ.117..ISBN:81-85460-96-5
- #Soil Erosion: Assam. NBSS Publ.118.ISBN:81-85460-97-3
- #Soil Series of Orissa. NBSS Publ.119.ISBN:81-85460-98-1
- #Soil Series of Gujarat. NBSS Publ.120.ISBN:81-85460-99-X
- +Soil Series of Meghalaya. NBSS Publ.121.ISBN:81-89043-00-5
- #Soil Resources of Jalna district (Maharashtra) for optimising land use. NBSS Publ.122.ISBN:81-89043-01-3
- #Soil Resource for land use .planning, Meerut district (U.P.) NBSS Publ.123.ISBN:81-89043-02-1

- #Soil resource for land use planning, Etah district (U.P.) NBSS Publ.124.ISBN:81-89043-03-X
- #Soil Erosion of Bihar, NBSS Publ.125. ISBN:81-89043-04-8.
- +Soil Erosion of Orissa, NBSS Publ.126. ISBN:81-89043-05-6.
- +Soil Series of Medak district, Andhra Pradesh, NBSS Publ.127. ISBN:81-89043-06-4.
- +Benchmark soils of Andhra Pradesh, NBSS Publ.128. ISBN:81-89043-07-2.
- +Manual soil-site suitability criteria for major crops. NBSS Publ.129. ISBN:81-89043-08-0.
- +Optimising land use of Birbhum district (West Bengal) soil resource assessment. NBSS Publ.130. ISBN:81-89043-09-9.
- +Land use planning of Cherrapunji, Meghalaya: Soil resource and agro-ecological assessment. NBSS Publ.131. ISBN:81-89043-10-2.
- +Technology assessment and refinement: Institute-village linkage programme (success story). NBSS Publ.133. ISBN:81-89043-12-9.
- +Soil series of Manipur. NBSS Publ.134. ISBN:81-89043-13-7.
- +Soils of Bhilwara district for land use planning. NBSS Publ.135. ISBN:81-89043-14-5.
- +Soil series of Kerala. NBSS Publ.136. ISBN:81-89043-15-3.
- #Assessment of soil loss for prioritisation of watersheds: A remote sensing & GIS approach. NBSS Publ.137. ISBN:81-89043-16-1.
- #Soil erosion of Manipur. NBSS Publ.138. ISBN:81-89043-17- X.
- # Mineralogy of Benchmark soils of West Bengal. NBSS Publ.139. ISBN:81-89043-18-8.
- #Agroecological zones of Kerala. NBSS Publ.140. ISBN:81-89043-19-6.
- +Perspective land use plan: Union Territory of Puducherry. NBSS Publ.142. ISBN:978-81-89043-21-6.
- +Soil taxonomic database of India and the states (1:250,000 scale). NBSS Publ.143. ISBN:978-81-89043-22-3.
- +Soil based agrotechnologies for livelihood improvement. NBSS Publ.144. ISBN:978-81-89043-23-0
- +Soil Survey Manual, NBSS Publ.146. ISBN:978-81-89043-25-4
- + Field Guide for Soil Survey

Salt-Affected Soils of Different States in India

- Andaman Nicobar (3 sheets)
- Andhra Pradesh (9 sheets)
- Bihar (7 sheets)
- Haryana (4 sheets)
- Orissa (3 sheets)
- Punjab (4 sheets)
- West Bengal (3 sheets)
- Maharashtra (9 sheets)
- Kerala (2 sheets)
- Karnataka (5 sheets)
- Uttar Pradesh (17 sheets)
- Rajasthan (16 sheets)

For a copy, contact: National Remote Sensing Agency, Balanagar, Hyderabad-500 007

BOOKS

- *Murthy, R.S., Hirekerur, L.R., Deshpande, S.B. and Venkata Rao, B.V. eds. Benchmark Soils of India: Morphology, Characteristics, and Classification for Resource Management, 1982, 374p.
- *Soil Survey Staff, USDA. Soil Taxonomy, Indian Reprint, 1978.
- +Sehgal, J., Blum, W.E. and Gajbhiye, K.S. Red and Lateritic Soils, 1998. Vol.1, 453p., Vol.11, Oxford & IBH, New Delhi, 113p
- Sehgal, J., Gajbhiye, K.S., Batta, R.K. and Sarma, V.A.K., Eds. Swell-Shrink Soils (Vertisols) of India: Resource Appraisal and Management. Kalyani Publishers, New Delhi, 1999, 202p.
  (For order, contact: M/s Kalyani Publishers, 1/1 Rajindernagar, Ludhiana-141 008.

(#) In Press; (*) Out of stock   (+) Available
($) For copies, contact: M/s Oxford & IBH Publ.Co.,
    66, Janpath, New Delhi-110 001, India.
Note:
For procuring the Bureau's publications please contact:
The Director, NBSS&LUP, Amravati Road, Nagpur-440 033, India.
E-mail: director@nbsslup.ernet.in