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ICAR

ANNUAL REPORT
2019

राष्ट्रीय मृदा सर्वेक्षण एवं भूमि उपयोग नियोजन ब्यूरो
भाकृअनुप
नागपुर

ICAR-National Bureau of Soil Survey & Land Use Planning
Nagpur - 440 033, Maharashtra, India
www.nbsslup.in

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Citation:
ICAR-NBSS&LUP. Annual Report 2019,
ICAR-National Bureau of Soil Survey and Land Use Planning,
Nagpur–440033, India

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ISSN : 0970-9460

December 2019

Published by
The Director, ICAR-National Bureau of Soil Survey and Land Use Planning,
Nagpur 440033

Preface

Rapid strides made in digital soil mapping technologies by developed countries have brought the issues and constraints of traditional soil survey to the fore. This report contains essence of the research endeavors of the National Bureau of Soil Survey and Land Use Planning during 2019, in devising modern and practical ways to prepare land resource inventory on 1:10000 scale combining the benefits of remote sensing technologies to cater to special needs of the country owing to fragmented land holdings, wide variations in eco-systems and prevailing socio-economics. An attempt was made to derive large scale soil maps of Manipur, Nagaland and Sikkim using 1:250K data. Accuracy of these maps needs to be checked but a first step was taken to minimize field visits. Field surveys with modern techniques were carried out to prepare soil maps at 1:10K scale for 122 different blocks across the country. The year marked a change in perception as awareness about land resource inventory and its application for varied purpose was increasingly realized by different state and private agencies. Soil survey data-based watershed development project of Karnataka Government, is no longer the only state funded land resource inventory work as more states are coming forward and joining hands with the Bureau. Governments of Andhra Pradesh, Telangana, Maharashtra, and Arunachal Pradesh inked pacts with the Bureau for drought mitigation, crop colony development, climate resilience, agriculture development, while partnership with states like Goa was continued for mapping of fallow lands. After a year of pilot work, the Bureau has signed consultancy services agreement with two multinational companies, marking the first non- agriculture, commercial application of soil data. Policy making institutions like NITI AAYOG requested the Bureau to prepare land use plans of aspirational districts. Academic and Research institutions approached the bureau for collaboration that includes researchers of forestry, oilseed, coconut, spices, rubber, pomegranate etc.

With increased availability of data on soils and climate it was thought prudent to revise the Agro-ecological regions and sub-regions of the country. The new document will soon be released. The Bureau has played a pivotal role in developing KRISHI Geo-portal. Quinquennial review report of the Bureau was submitted by the Review Team with a note of satisfaction about the performance. The year was also eventful that saw hosting XXVth meeting of Regional committee VII and organizing International training for researchers of African countries, ICAR-Zonal Sports Tournament, celebration of World Soil Day, etc.

At all stages of writing this report, a great deal of sincere efforts and support were made by the scientists, technical, administrative and accounts staff of this Bureau. I express my sincere appreciation and gratitude to them. The Hon. Director General Dr. Trilochan Mohapatra, Deputy Director General, (NRM), Dr. K. Alagusundaram, and Assistant Director General (S&WM), Dr S.K. Chaudhari are thanked for their leadership, untiring support, guidance and motivation to steer the Bureau.

Chandran

P. Chandran

Director (Acting)

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Executive Summary

ICAR-NBSSLUP continued its flagship programme of Land Resource Inventory (LRI) on 1:10000 scale during the year 2019. Soil maps were prepared for different parts of the country on 1:10K scale including the states of Manipur, Nagaland and Sikkim. In addition, soil maps at 1:10K scale were also prepared for 122 different blocks across the country. State-wise distribution is: Andhra Pradesh (1 block), Assam (1 block), Bihar (13 blocks), Haryana (7 blocks), Himachal Pradesh (2 blocks), Jharkhand (10 blocks), Karnataka (55 watersheds/2 blocks), Kerala (1 block), Maharashtra (22 blocks), Mizoram (3 blocks), Odisha (1 block), Punjab (8 blocks) Rajasthan (14 blocks),Tamil Nadu (1 block), Telengana (1 block), Uttarakhand (1 block) and West Bengal (36 blocks).

Landscape ecological unit (LEU) maps for100 blocks across 29 districts in 16 states were prepared/revised which was used as a base for soil survey The regional distribution of blocks is: Northern - 13, Eastern - 52, Western – 14, Central - 9, Southern – 4 and North-Eastern - 8.Land Use Plan of 27 aspirational districts of India was prepared in response to a request from NITI Aayog. Sentinel 2- satellite data (10 m) and ALOS DEM (12.5m) digital terrain database were used to delineate and prepare maps related to land use/ land cover, slope, landform and LEU for aspirational districts. During the year, landform maps were also prepared for 500 villages spread across 15 districts identified by the Government of Maharashtra under the project on climate resilient agriculture (PoCRA).

A methodology was developed to identify and map degraded lands at regional scale through the utilization of coarse resolution MODIS-NDVI time series data. Land degradation maps of 27 aspirational districts have been deployed in BHOOMI Geoportal, and during the year land degradation maps (rasters) for the selected districts of Bihar, Chhattisgarh, Nagaland, Jharkhand, and some parts of West Bengal have been completed. Desertification and land degradation (DLD) vulnerability index mapping for the state of Andhra Pradesh was completed based on data on climate, soil, land use and socio-economic factors. Five DLD vulnerability classes, namely very low, low, medium, high and very high were identified. While 13% of the state is very highly vulnerable to DLD, 15% area is highly vulnerable. This map is expected to serve as a ready reckoner to prioritize areas/districts for drawing up combat plans and measures to arrest DLD. In another study, soil conservation plan was developed for Dhanora block, Seoni district (Madhya Pradesh) after a complete assessment of soil erosion in the block.

Under the Indian Soils Grids Project of the Digital soil mapping initiative, predicted cation exchange capacity (CEC) maps were generated for parts of Koppal and Gadag districts of Karnataka using the Quantile Random Forest Model (QRFM). The predicted CEC map closely matches the observed values with minimum errors, and the model was found to capture maximum variability in the top 30-cm soil depth. Similarly, QRFM could predict the surface soil organic carbon (SOC) stock (R^2 = 31-43%) for a large stretch of the Western Ghats. The predicted total SOC stock in the region ranged from 7.1 to 30.9 kg m^{-2} and the total estimated SOC was 917 Tg.

Hyperspectral library of the soils of Goa was generated, followed by the development of HySIS, an android-based and user-friendly mobile application for visualizing, disseminating, sharing and data mining of the hyperspectral signatures.

Soil organic carbon (SOC) accumulation was found to be five times higher in soils (cultivated and forest) of Nilgiris (Tamil Nadu) with mixed mineralogy as compared to that in the basaltic soils of Bhimashankar Plateau (Maharashtra) with zeolitic and smectitic minerals. Higher CEC of the former soils as compared to the latter indicates the weak role of CEC in OC accumulation. The causal effect of climate, soil and land related predictors on soil pH and SOC was evaluated in coastal soils of South Gujarat using random forest (RF) regression using soil data of two time periods (1990 and 2018). While climate alonesignificantly influenced SOC content upto 20 cm depth during 1990, both climate and land use influenced organic carbon during 2018. During both the time periods, SOC content decreased with depth in the order: humid>semi-arid>arid. Land use and climate interaction significantly controlled the pH, which also increased with depth and was lowest in case of humid as compared to semi-arid climate.

Under the NICRA project, soil data from five different bio-climates for SOC and soil inorganic carbon (SIC) indicated that SOC content reduced upon moving from per-humid to dry semi-arid and arid (Nimone series) climatic conditions. However, the SIC ($CaCO_3$) content is higher in the soils of drier areas with lower rainfall and soils under rainfed agriculture. The results highlight the importance of climate and land use in SOC and SIC formation in the soils.Soil organic carbon (0-23 cm depth)simulation under four representative concentration pathways (RCPs) and three time periods (2020, 2050 and 2080) was carried out using Century carbon model. Datasets from the long term fertilizer experiments (LTFE) conducted at Coimbatore under millet-maize cropping systems showed significant increase in soil organic carbon (SOC) under treatment of 100% NPK plus FYM in all the four RCPs (except RCP 6.0 in 2020) and time periods as compared to the base period. The study recommends that addition of inorganic fertilizer in combination with FYM could be an important strategy for maintaining the SOC and thus, the soil quality under climate change scenarios.

Soil quality assessment was done in areas dominated by cotton and sugarcane-based cropping systems (AESR 6.1) and rice-based cropping system (AESR 18.4). Majority of the districts with cotton based cropping system have relative soil quality index (RSQI) of Class II (80-90) whereas the districts with sugarcane based cropping systems have RSQI of Classes II and III (70-80) in AESR 6.1. In case of AESR 18.4, the RSQI class is III and IV (60-70) in majority of the districts with small patches of classes I (>90) and II. Positive correlation between RSQI and crop yields in both AESRs suggests that the former could serve as a unified criterion for comparing regional soil quality.

Pedotransfer functions (PTF) were developed from easily measurable soil properties such as texture and cation exchange capacity to predict soil hydraulic properties.. With the objective of linking pedological systems with climatic variability, rainfall anomaly index (RAI) and temperature anomaly index (TAI) were computed for Pulivendula tehsil, Kadapa district, Andhra Pradesh, using rainfall and temperature data (1901 to 2002)for trend analysis of biophysical indicators. The findings of this study agree with IPCC prediction in 2007 that the earth could become warmer by 3° C during this century.

Soil erosion was assessed to generate risk maps in Harve 1 micro-watershed in Chamrajnagar district (Karnataka)with the help of Corine model that employs data on soil erodibility, rainfall erosivity, topography and land use - land cover. It shows that 52.1% of micro-watershed is under high erosion risk, whereas 26.9% area is under moderate erosion risk. Digital database of 204 watersheds of Karnataka was created and atlases with different thematic maps (soil fertility, land suitability) were prepared for watershed development planning. About 83,000 LRI cards were generated in *kannada* language by using the digital library software for distribution of cards by the state agricultural department.

During the year, soil characterization/fertility assessments were completed for Palani block of Dindigul district, Dhanpatganj block of Sultanpur district, Baragaon block of Varanasi district, and Kachcch and Junagarh districts. Distribution and characterization of sodic soils in Krishnagiri reservoir project catchment in Kaveripattinam block (Tamil Nadu) were also studied. Further, soil hydrological group (HSG) maps of Arunachal Pradesh, Assam, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Manipur, Meghalaya, Odisha, Punjab, Sikkim, and Uttarakhand were prepared and submitted to the consortium for run-off estimation.

An innovative algorithm was developed and validated to predict soil depth and likelihood of rock layer within 2 m from surface for industrial application. In another industrial application an algorithm to predict engineering properties of soils was developed and validated to assist foundation design of power transmission towers in India and abroad. Angle of repose, bulk density and ultimate bearing capacity of the soils at 500 m interval along the transmission route were derived from the textural composition. The two algorithms are generating regular revenue for the Institute.

Heavy metal contamination was assessed in the area surrounding an iron ore mine located in Bicholim Taluka, Goa. The concentration of Fe and Mn were high whereas Cd and Co were the low in both the surface and sub-surface soils. The Ecological risk (Er) of individual metal varied significantly in the surface soils for all the heavy metals studied. The values of potential Er indicate that it is moderate over the entire study area.

Land management units (LMU)-based land use plans were developed and demonstrated on farmers' fields in Kutali and Gosaba blocks of south 24 Parganas (West Bengal).Land use recommendations were also prepared for Charilam block of Sepahijala district (Tripura), Nagrota Bagwan Block of Kangra District (Himachal Pradesh), and 45 aspirational districts in four Indian states (Bihar, Jharkhand, Odisha and West Bengal) of eastern India. Land capability classification followed by site suitability recommendations for different crops and irrigation were done for Rajpura block of Patiala district (Punjab).

Potential areas for major crops are being delineated at national level by considering soil resource information prepared at 1:1 m scale, soil morphological, physical and chemical properties, and climate data. During the year, potential rice growing areas of the country have been delineated and mapped. In inter-institutional collaborative projects with ICAR-IIOPR, potential areas for oil palm in rainfed and irrigated areas of the country and with ICAR-NRCP, Solapur for pomegranate cultivation in Maharashtra were delineated and mapped.

Under the scheduled tribe components programme, broad landform and 2.5 ha interval grid map of the Ghatshila village (East Singhbhum district, Jharkhand) was prepared and suitable technologies like water harvesting, soil amendments, nutrient management, site-specific crop selection were suggested for enhancing productivity and improving the livelihood. Soil health cards and 1000 horticultural plants consisting of mango, lemon and guava plants were distributed to 66 tribal families. Under the same programme, implemented in Bahphalagaon, Namdeurigaon and Kalbari villages of Jorhat district (Assam), and Ghubadi watershed of Nagpur district (Maharashtra) farmers obtained higher profit by adopting suggested land management practices. Demonstration of integrated farming systems involving Bt cotton and maize under different soils was carried out in selected hamlets of H.D. Kote *taluka* of Mysuru district (Karnataka). The highest seed cotton yield (1.75 t ha^{-1}) and net returns (INR 72,500) were obtained under medium deep, well drained, sandy clay loam soils, whereas maize recorded the highest yield (5 t ha^{-1}) and net returns (INR 51,000) under deep, well drained, sandy clay loam soils.

Socio-economic evaluation of agricultural land use using Automated Land Potential Evaluation System was done for 8400 households of 240 micro watersheds in Yadgiri and Koppal *taluks* belonging to Yadgiri and Koppal districts, respectively. Constraints faced by the farmers were analysed and reported, and alternatives for sustainable agriculture production were suggested. Average monthly rainfall and temperature data of 30 years (1988 to 2018) for 620 observations across the country have been used to develop the revised bio-climatic map of India. The tentative revised 62 agro-ecological sub-regions of India were delineated by integrating physiography, sub-physiography, bioclimate, LGP and selected soils parameters in GIS environment. The areas under arid and semi-arid agro-ecosystems are revised from 53.2 to 45.0 and 116.4 to 145.3 million ha respectively. The draft document on "Revised Agro-ecological regions of India" has been developed.

BHOOMI Geoportal was enriched by deploying various soils based thematic layers as WMS for 27 aspirational districts spread across the country. Various dashboards for visualization and query of spatial and non-spatial databases of socio-economic data, physiography, agro-ecology, soils, soil fertility, land degradation, land use planning and aspirational districts were developed. The MODIS NDVI (250 m) data of India has been processed and deployed for *kharif* season for the year from 2000 to 2018. Metadata format for KRISHI Geoportal was finalized for online metadata generation for the geospatial datasets provided by various ICAR institutes. Further metadata for 8 spatial datasets of soil and allied resources for KRISHI Geoportal were developed. Data received from ICAR-NIVEDI on 13 animal diseases outbreaks for the year 2017 and 2018 have been processed in GIS and thirteen thematic maps have been sent for deployment in KRISHI Geoportal.

सारांश

भाकृअनुप-राष्ट्रीय मृदा सर्वेक्षण एवं भूमि उपयोग नियोजन ब्यूरो ने वर्ष 2019 के दौरान 1:10000 पैमाने पर भूमि संसाधन सूची के मुख्य कार्यक्रम को जारी रखा। मणिपुर, नागालैंड और सिक्किम राज्यों सहित 1:10000 हजार पैमाने पर देश के विभिन्न हिस्सों के लिए मृदा मानचित्र तैयार किए गए। इसके अलावा, देश भर में 122 विभिन्न खण्डों के लिए 1:10000 पैमाने पर मृदा मानचित्र भी तैयार किए गए। जिनका कि राज्य-वार वितरण इस प्रकार हैः आंध्र प्रदेश (1), असम (1), बिहार (13), हरियाणा (7), हिमाचल प्रदेश (2), झारखंड (10), कर्नाटक (2 खण्डों के 55 जलोस्तारण क्षेत्र), केरल (1), महाराष्ट्र (22), मिज़ोरम (3), ओडिशा (1), पंजाब (8) राजस्थान (14), तमिलनाडु (1), तेलंगाना (1), उत्तराखंड (1) और पश्चिम बंगाल (36)।

सोलह राज्यों के 29 जिलों में 100 प्रखंडों के परिदृश्य परिस्थितिक ईकाई मानचित्र तैयार एवं संशोधित किए हैं जो कि मिट्टी सर्वेक्षण के लिए एक आधार के रूप में इस्तेमाल किये गयेः इन ब्लॉकों का क्षेत्रीय वितरण इस प्रकार है - उत्तरी - 13, पूर्वी - 52, पश्चिमी - 14, मध्य - 9, दक्षिणी - 4 और पूर्वोत्तर - 8. भारत सरकार के अनुरोध पर 27 आकांक्षात्मक जिलों की भूमि उपयोग योजना तैयार की गयी। सेंटिनल-2उपग्रह डेटा (10 मीटर) और एएलओएस डेम (12.5 मीटर) डिजिटल इलाके डेटाबेस का उपयोग आकांक्षी जिलों के लिए भूमि उपयोग भूमि कवर, ढलान, लैंडफॉर्म और एलईयू से संबंधित मानचित्रों को तैयार करने के लिए किया गया। इस वर्ष के दौरान, जलवायु परिवर्तनशील कृषि (पोकरा) परियोजना के तहत महाराष्ट्र सरकार द्वारा चिन्हीत 15 जिलों के 500 गाँवों के लिए लैंडफॉर्म मैप तैयार किए गए।

एक पद्धति जिसमें विभेदन मोडिस एवं एनडीवीआई टाइम सीरीज डेटा के उपयोग के माध्यम से क्षेत्रीय स्तर पर अवक्रमितभूमि को चिन्हीत करके मानचित्र विकसित किये गये । भूमि जियोपोर्टल पर 27 आकांक्षात्मक जिलों के अवक्रमित भूमि के मानचित्रों को अपलोड किया और वर्ष के दौरान बिहार, छत्तीसगढ़, नागालैंड, झारखंड के चयनित जिलों और पश्चिम बंगाल के कुछ हिस्सों के लिए भूमि अवक्रमितमानचित्र (रास्टर इमेज) को पूरा करके सूचिबध्द किया गया। जलवायु, मिट्टी, भूमि उपयोग और सामाजिक-आर्थिक कारकों के आंकड़ों पर आधारित आंध्र प्रदेश राज्य के लिए मरुस्थलीकरण और भूमि अवक्रमण संवेदनशील (भेद्यता) सूचकांक मानचित्रण विकसित किये गये। मरुस्थलीकरण और भूमि अवक्रमण भेद्यता पांच वर्गो जैसे् बहुत कम, कम, मध्यम, उच्च और अति उच्च पर चिन्हीत किया गया। राज्य का 13 प्रतिशत क्षेत्रफल मरुस्थलीकरण और भूमि अवक्रमण के लिए अत्यधिक संवेदनशील और 15 प्रतिशत क्षेत्र अत्यधिक असुरक्षित दर्ज किये गये। यह मानचित्र मरुस्थलीकरण और भूमि अवक्रमण को कम करन में क्षेत्रिय स्तर पर या जिलों को प्राथमिकता देने के लिय तैयार रेकनर के रूप में उपयोगकरने हेतु अपेक्षित है। एक अन्य अध्ययन में, खण्डों में मिट्टी के कटाव के पूर्ण मूल्यांकन के बाद धनोरा ब्लॉक, सिवनी जिले (मध्य प्रदेश) के लिए मिट्टी संरक्षण योजना विकसित की गई।

अंकिय मृदा मानचित्रण के उपक्रम माध्यम से भारतीय मृदा ग्रिड परियोजना के तहत, कर्नाटक के कोप्पल और गदग जिलों के कुछ हिस्सों के लिए क्वांटम रैंडम फॉरेस्ट मॉडल (क्यूआरएफएम) का उपयोग करके अनुमानित धनायन विनिमय क्षमता (सीईसी) के मानचित्र तैयार किए गए। अनुमानित धनायन विनिमय क्षमता (सीईसी) मानचित्र दर्ज न्यूनतम त्रुटियों से निकटता से मेल खाता है, और मॉडल शीर्ष 30-सेमी मृदा गहराई में अधिकतम परिवर्तनशीलता को दर्ज करने में सक्षम पाया गया। इसी तरह, क्यूआरएफएम पश्चिमी घाट के एक बड़े हिस्से के लिए सतह की मृदा जैविक कार्बन (एसओसी) स्टॉक (आर 2 = 31-43 प्रतिशत) का अनुमान लगा सकता है। क्षेत्र में अनुमानित कुल एसओसी स्टॉक 7.1 से 30.9 किलोग्राम प्रति वर्गमीटर तक था और कुल अनुमानित एसओसी 917 टेराग्राम पाया गया।

गोवा की मृदा की हाइपरस्पेक्ट्रल लाइब्रेरी विकसित की गई, तत्पश्चात बाद हाइपरस्पेक्ट्रल संकेत के दृश्य, प्रसार, साझा और डेटा खनन के लिए एक एंड्रॉयड-आधारित और उपयोगकर्ता के अनुकूल मोबाइल एप्लिकेशन हायसिस का बनाया गया । मिश्रित खनिज वाली नीलगिरी (तमिलनाडु) की मृदाओं (कृषित खेती और वन) में जैविक कार्बन संचय इसकी तुलना में पांच गुना अधिक पाया गया।

भीमाशंकरपठार (महाराष्ट्र) के बेसाल्टिक मृदा में जिओलाइटिक और स्मेंक्टाईटिक खनिजों के साथ की गई। इन मृदाओं में पाई जाने वाली उच्च सीईसी की भूमिका जैविक कार्बन संचय में कमजोर पड जाती है। मिट्टी के पीएच और एसओसी पर जलवायु, मिट्टी और भूमि से संबंधित आगमकथन के करणीय प्रभाव का मूल्यांकन दक्षिण गुजरात के तटीय मिट्टी में यादृच्छिक वन (आरएफ) दो समय अवधि (1990 और 2018) के मृदा डेटा का उपयोग करके किया गया। वर्ष 1990 के दौरान जबकि जलवायु के कारण 20 सेमी गहराई तक एसओसी का संग्रहण प्रभावित हुआ। वर्ष 2018 के दौरान जलवायु और भूमि उपयोग ने जैविक कार्बन को प्रभावित किया।

दोनों समय अवधि के दौरान, आर्डर क्रमशः आर्द्र > अर्ध- शुष्क > शुष्कक्षेत्रों में गहराई के साथ एसओसी संग्रहण घट गया। भूमि उपयोग और जलवायु की अंतःक्रिया से पीएच को काफी नियंत्रित किया गया, जो गहराई के साथ भी बढ़ा और अर्ध-शुष्क जलवायु की तुलना में आर्द्र जलवायु के मामले में सबसे कम दर्ज किया गया।

एनआईसीआरए (निक्रा) परियोजना के तहत, पांच अलग-अलग जैव-जलवायु क्षेत्रों में एसओसी और मृदा अकार्बनिक कार्बन (एसआईसी) के आंकड़ों से यह पता चला कि एसओसी संग्रहण आर्द्र के बजाय शुष्क अर्ध-शुष्क और शुष्क (निमोन श्रृंखला) जलवायु परिस्थितियों में कम किया गया। हालांकि, वर्षा पर आधारित कृषि के तहत कम वर्षा और शुष्क मृदा क्षेत्रों के मृदा में एसआईसी (कैलिशयम कार्बोनेट) की मात्रा अधिक है। परिणामस्वरुप, जलवायु और भूमि के उपयोग के महत्व को मृदा में एसओसी और एसआईसी विन्यास में चिन्हांकित करता हैं। सेंचुरी कार्बन मॉडल का उपयोग करके चार कार्बनिक सांद्रता (आरसीपी) पथों और तीन समय अवधि (2020, 2050 और 2080) के तहत जैविक कार्बन (0-23 सेमी गहराई) अनुकरण दर्ज किया गया। कोयम्बटूर के बाजरा-मक्का की फसल प्रणाली में, आधार अवधि की तुलना में दीर्घकालिक उर्वरक प्रयोगों से किए गए डेटासैट ने चार आरसीपी (2020 में एसीपी 6.0 को छोड़कर) में चार आरसीपी प्लस इनफॉर्मल 100 एनपीके प्लस एफवाईएम के उपचार के तहत मृदा जैविक कार्बन (एसओसी) में महत्वपूर्ण वृद्धि दर्ज की गई। इस अध्ययन की सिफारिश की है कि गोबर की खाद के साथ संयोजन में अकार्बनिक उर्वरक एसओसी को बनाए रखने के लिए एक महत्वपूर्ण नीति हो सकती है और साथ ही जलवायु परिवर्तन परिदृश्यों के तहत मिट्टी की गुणवत्ता को बनाये रखने में सक्षम है।

मिट्टी की गुणवत्ता का आकलन कपास और गन्ना आधारित फसल प्रणाली (एईएसआर 6.1) और चावल आधारित फसल प्रणाली (एईएसआर 18.4) में किया गया। कपास आधारित फसल प्रणाली वाले अधिकांश जिलों में कक्षा II (80-90) के सापेक्ष मृदा गुणवत्ता सूचकांक पाया गया जबकि गन्ना आधारित फसल प्रणाली वाले जिलों में एईएसआर6.1 में कक्षा 2 और 3 (70-80) केआरएसक्यूहैं। एईएसआर 18.4 के संदर्भ में, आरएसक्यूआई वर्ग तृतीय और चतुर्थ (60-70) वर्ग 1 (>90) और 2 के छोटे पैच वाले अधिकांश जिलों में है। आरईएसक्यूआई और दोनों एईएसआर में फसल की पैदावार के बीच सकारात्मक संबंध दर्ज किया गया और पूर्व क्षेत्रीय मिट्टी की गुणवत्ता की तुलना के लिए एक एकीकृत मानदंड के रूप में काम कर सकता है।

आसानी से मापने योग्य मिट्टी के गुणों जैसे कि बनावट और धनायनविनिमय क्षमता से मृदा हाइड्रोलिक गुणों का अनुमान लगाने के लिये पेडोट्रांसफर फंक्शंस (पीटीएफ) बनाये गये। जलवायु परिवर्तनशीलता के साथ पेडोलॉजिकल सिस्टम को जोड़ने के उद्देश्य से, वर्षा विसंगति सूचकांक (आरएआई) और तापमान विसंगति सूचकांक (टीएआई) पाये गये। पुलिवेंदुला तहसील, कडप्पा जिले, आंध्र प्रदेश के लिए बायोफिजिकल इंडिकेटर्स के ट्रेंड एनालिसिस के लिए वर्षा और तापमान के आंकड़ों (1901 से 2002) का उपयोग करते हुए गणना की गई। इस शताब्दी में 2007 के आयपीसीसी की संकेतिक अध्ययन से यह निष्कर्ष दर्ज किया गया कि पृथ्वी 3°C से गर्म हो सकती है। मृदा अपरदन का आकलन चामराजनगर जिले (कर्नाटक) में हरवे 1 माइक्रो जलोस्तारण क्षेत्र में जोखिम मानचित्र तैयार करने में किया गया, जिसमें कोरीन मॉडल की मदद से मिट्टी के क्षरण, वर्षा क्षरण, स्थलाकृति और भूमि उपयोग - भूमि आच्छादन पर डेटा का उपयोग किया जाता है तथा यह दर्शाता है कि 52.1 प्रतिशत माइक्रो-जलोस्तारण क्षेत्र उच्च क्षरण आशंकित है, जबकि 26.9प्रतिशत क्षेत्र मध्यम कटाव के अंतर्गत है। कर्नाटक के 204 जलोस्तारण क्षेत्र का डिजिटल डेटाबेस बनाया गया। जलोस्तारण क्षेत्र विकास योजना के लिए नक्शे (मिट्टी की उर्वरता, भूमि उपयुक्तता) तैयार किए गए।

राज्य कृषि विभाग द्वारा सॉयल हेल्थ कार्ड के वितरण के लिए डिजिटल लाइब्रेरी सॉफ्टवेयर का उपयोग करके लगभग 83,000 एलआरआई कार्ड्स को कन्नड़ भाषा में तैयार किया गया। वर्ष के दौरान, डिंडीगुल जिले के पलानी ब्लॉक, सुल्तानपुर जिले के धनपतगंज ब्लॉक, वाराणसी जिले के बड़ागांव ब्लॉक, और कच्छ और जूनागढ़ जिलों के लिए मृदा के लक्षण वर्णनध् उर्वरता का आकलन पूर्ण किया गया। साथ ही कावेरीपट्टिनम ब्लॉक (तमिलनाडु) में कृष्णगिरि जलाशय परियोजना कैचमेंट में सोडिक मिट्टी का वितरण और लक्षण का आंकलन भी किया गया। अरुणाचल प्रदेश, असम, छत्तीसगढ़, गुजरात, हरियाणा, हिमाचल प्रदेश, झारखंड, मणिपुर के मृदा हाइड्रोलॉजिकल समूह मानचित्र विकसित किये गये।। मेघालय, ओडिशा, पंजाब, सिक्किम और उत्तराखंड को रन-ऑफ अनुमान के लिए कंसोर्टियम के लिए तैयार और प्रस्तुत किया गया।

औद्योगिक अनुप्रयोग के लिए सतह से 2 मीटर के भीतर मिट्टी की गहराई और चट्टान की परत की संभावना का अनुमान लगाने के लिए एक अभिनव एल्गोरिथ्म विकसित और मान्य किया गया। भारत और विदेश में, एक अन्य औद्योगिक अनुप्रयोग में मिट्टी के इंजीनियरिंग गुणों की अनुमान लगाने हेतु एक एल्गोरिथ्म विकसित किया गया और जिसमें पावर ट्रांसमिशन टावरों की नींव डिजाइन की सहायता के लिए मान्य किया गया। यह दो एल्गोरिदम से संस्थान को नियमित रुप से राजस्व प्राप्त हो रहा हैं।

गोवा के बिचोलिम तालुका में स्थित एक लौह अयस्क खदान के आसपास के क्षेत्र में भारी धातु संदूषण का आकलन किया गया जहां लोहे और मेंगनिज की सांद्रता अधिक जबकि केडमियम और कोबाल्ट दोनों सतह और उप-सतही मिट्टी में कम दर्ज किये गये। अलग-अलग धातु के पारिस्थितिक आशंका (ईआर) का अध्ययन किया गया और पाया गया कि

मिट्टी की सतह में सभी भारी धातुओं में काफी भिन्नता है। इससे संकेत मिलता है कि यह संपूर्ण अध्ययन क्षेत्र इस बावत् मध्यम जोखम का है।

दक्षिण 24 परगना (पश्चिम बंगाल) के कुटाली और गोसाबा ब्लॉक में किसानों के खेतों पर भूमि प्रबंधन इकाई (एलएमयू) आधारित भूमि उपयोग नियाजनों का विकास और प्रदर्शन किया गया और सिपाहीजाला जिले (त्रिपुरा) के चारीलाम खण्ड, कांगडा जिले के नगरोटा खण्ड के लिए भी सिफारिशें की गईं। कांगड़ा जिला (हिमाचल प्रदेश) के बागवान ब्लॉक, और पूर्वी भारत के चार राज्यों (बिहार, झारखंड, ओडिशा और पश्चिम बंगाल) में 45 आकांक्षी जिले हैं। विभिन्न फसलों और सिंचाई के लिए साइट उपयुक्तता सिफारिशों के बाद भूमि क्षमता वर्गीकरण पटियाला जिले (पंजाब) के राजपुरा ब्लॉक के लिए किया गया।

मृदा संसाधनों की जानकारी पर विचार करके मृदा आकारिकीय, भौतिक और रासायनिक गुणों, और जलवायु डेटा के आधार पर राष्ट्रीय स्तर पर प्रमुख फसलों के लिए सक्षम क्षेत्रों को 1ः 1 मिलियन पैमाने पर तैयार किया गया। वर्ष के दौरान, देश के संभावित चावल उगाने वाले क्षेत्रों का परिसीमन और मानचित्रणकिया गया। वर्षा आधारित और सिंचित क्षेत्रों में कृषि विकास हेतु अंतर-संस्थागत सहयोगी परियोजनाओं के माध्यम से आईसीएआर-आईआईओपीआर के साथ आयलपाम के लिए संभावित क्षेत्र और आईसीएआर-एनआरसीपी, सोलापुर के साथ अनार के लिए महाराष्ट्र में संभावित खेती को सीमांकित और मानचित्रित किया गया।

अनुसूचित जनजाति के घटक कार्यक्रम के तहत, घाटशिला गाँव (पूर्वी सिंहभूम जिला, झारखंड) का विस्तृत भू-भाग और 2.5 हेक्टेयर अंतराल का मानचित्र तैयार किया गया और उत्पादकता और आजीविका में सुधार के लिये जल संचयन, मृदा संशोधन, पोषक तत्व प्रबंधन, साइट-विशिष्टीकरण चयन जैसी उपयुक्त तकनीकों को बढ़ाने के लिए सुझाव दिये गये। आम, नींबू और अमरूद के पौधों से युक्त 1000 बागवानी पौधों को 66 आदिवासी परिवारों को मृदा स्वास्थ्य कार्ड के साथ वितरित किया गया। इसी कार्यक्रम के तहत, जोरहाट जिले (असम) के बहफलगांव, नामदेइरगाँव और कलबारी गाँवों में लागू किया गया, तथा नागपुर जिले (महाराष्ट्र) के घुबाड़ी जलोस्तारण क्षेत्र के किसानों ने सुझाए गए भूमि प्रबंधन प्रथाओं पर आधारित सुझावों को अपनाकर उच्च लाभ प्राप्त किया।बीटी कपास और मक्का को अलग-अलग मिट्टी में समाहित करने के लिए एकीकृत कृषि प्रणालियों के प्रदर्शन को मैसूरु जिले (कर्नाटक) का कोटे तालुका में मध्यम गहरी, अच्छी तरह से सूखा, रेतीली मिट्टी व दोमट मिट्टी के तहत उच्चतम बीज कपास की उपज (1.75 टन प्रति हे.) और शुद्ध रिटर्न (₹ 72,500) प्राप्त हुए, जबकि मक्का ने गहरी, अच्छी तरह से सूखा, रेतीले मिट्टी के दोमट मिट्टी में उच्चतम उपज (5 टन प्रति हे) और शुद्ध रिटर्न (₹ 51,000) दर्ज किया।

स्वचालित भूमि संभावित कृषि मूल्यांकन प्रणाली का उपयोग करते हुए कृषि भूमि के उपयोग का सामाजिक-आर्थिक मूल्यांकन क्रमशः यदगिरि और कोप्पल जिलों में स्थित यदगिरि और कोप्पल तालुकों में 240 माइक्रो जलोस्तारण क्षेत्रके 8400 घरों के लिए किया गया। किसानों द्वारा अवरोधों का सामना करने वाले कारको का विश्लेषण किया गया तथा विकल्पों एवं स्थायी कृषि उत्पादन पर सुझाव दिये गये। देश भर में 620 अवलोकनों के लिए 30 वर्षों (1988 से 2018) के औसत मासिक वर्षा और तापमान के आंकड़ों का उपयोग भारत के संशोधित जैव-जलवायु मानचित्र को विकसित करने के लिए किया गया। भारत के अस्थायी संशोधित 62 कृषि-पारिस्थितिक उप-क्षेत्रों के परिसिमांकन हेतु जीआईएस वातावरण में फिजोग्राफी, सब-फिजियोग्राफी, बायोक्लाईमेट, एलजीपी और चयनित मिट्टी पैरामीटर को एकीकृत किया गया। शुष्क और अर्ध-शुष्क कृषि-पारिस्थितिकी तंत्र के तहत क्षेत्रों को क्रमशः 53.2 से 45.0 और 116.4 से 145.3 मिलियन हेक्टेयर तक संशोधित किया गया है। " भारत के संशोधित कृषि-पारिस्थितिक क्षेत्रों " पर मसौदा दस्तावेज विकसित किया गया।

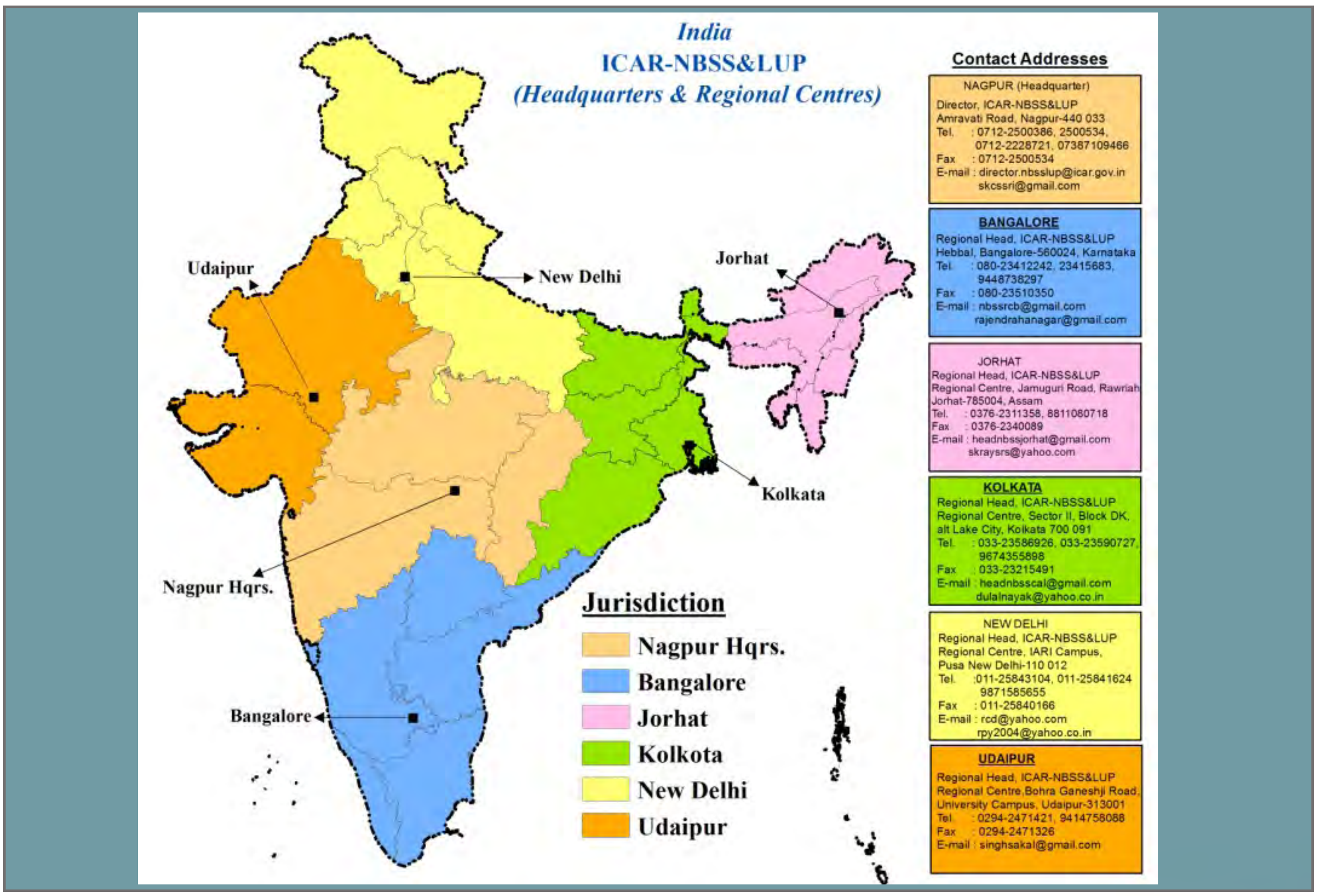
भूमि जियोपार्टल को देश भर में फैले 27 आकांक्षात्मक जिलों के लिए डब्ल्यूएमएस के रूप में विभिन्न मिट्टी आधारित विषयगत परतों को प्रसारित करके और अधिक सक्षम बनाया गया। सामाजिक-आर्थिक डेटा, फिजियोग्राफी, कृषि-पारिस्थितिकी, मिट्टी के स्थानिक और गैर-स्थानिक डेटाबेस के विजुअलाइजेशन और क्वेरी के लिए विभिन्न डैशबोर्ड, उर्वरता, भूमि क्षरण, भूमि उपयोग नियोजन और आकांक्षात्मक जिले विकसित किए गए। भारत के मोडिस एनडीवीआई (250 मीटर) डेटा को वर्ष 2000 से 2018 के लिए खरीफ मौसम के लिए आंककर प्रसारित किया गया। भाकृअनुप संस्थानों द्वारा कृषि जियोपोर्टल के लिए प्रदान किए गए भू-स्थानिक डेटासेट के लिए ऑनलाइन मेटाडेटा प्रारुपों को अंतिम रूप दिया गया। इसके अलावा मिट्टी के 8 स्थानिक डेटासेट और कृषि जियोपोर्टल के लिए संबद्ध संसाधनों का विकास किया गया। वर्ष 2017 और 2018 के लिए 13 पशु रोगों के प्रकोप पर भाकृअनुप व निवेदी से प्राप्त आंकड़ों को जीआईएस में संसाधित किया गयाऔर कृषि जियापोर्टल में प्रसारित हेतु तेरह विषयगत मानचित्र भेजे गए।

1 NBSS&LUP: A Profile

Genesis

After the recognition of Soil Survey as a National Priority, a need was felt for creating a centralized information warehouse to assimilate, verify and disseminate information on nature, extent and distribution of soils in the country. Consequently, the Indian Council of Agricultural Research (ICAR) established National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) (to be hereafter referred to as Bureau) in 1976, with its Hqrs. at Nagpur. The Hqrs. houses 3 Research Divisions, namely, Division of Remote Sensing Applications, Division of Soil Resource Studies and Division of Land Use Planning. Subsequently, five regional centres came into existence that is located at Bangalore, Delhi, Jorhat, Kolkata and Udaipur and address regional specific issues in the mandated areas of work. Besides, there are several units and sections, which provide scientific and technical support to the research divisions and regional centres in accomplishing varied tasks.

The Bureau is the country's only premier national institute mandated for research, development and training (RD&T) in the field of soil survey, land use planning and allied aspects. Over the years, the Bureau has excelled as a centre of RD&T in Soil Survey and Land Use Planning at the national and international level.



Location

The Hqrs. is located on Amravati Road (Kolkata-Mumbai National Highway). It has in its close vicinity the ICAR-affiliated Central Citrus Research Institute (CCRI), Ginning Training Centre (GTC) a regional centre of Central Institute for Research on Cotton Technology (CIRCOT), and Regional Remote Sensing Centre (RRSC, ISRO). The campus of the Bureau is also quite close to Nagpur University. The Hqrs., therefore, has the locational advantage which facilitates multidisciplinary studies, inter-institutional interactions and research linkages, etc. A map showing the location of the Hqrs. and the five regional centres is shown below.

Mandate

- To conduct soil survey and mapping of the soils of the country to promote scientific and optimal land use programmes in collaboration with relevant institutions and agencies.
- To conduct and promote research in the National Agricultural Research System in the areas of Pedology, Soil survey, Remote sensing applications, Land degradation, Land evaluation and Land use planning.
- To impart training and education to create awareness on soil and land resources and their state of health.

The role of the ICAR-National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS&LUP) becomes all the more important due to the serious challenges the country faces in terms of shrinking soil and land resource base, soil/land degradation, depleting nutrient stock, deterioration in soil/land quality, changing climate, land-use conversion and growing crops out of capability domain.

Major Research Themes

- Inventorying natural resources
- Remote sensing and GIS applications
- Basic Pedological Research
- Soil Survey Data Interpretation and Applications
- Land Evaluation and Land Use Planning

Training Areas

- Soil Survey and Land Evaluation for Land Use Planning
- Remote Sensing and GIS Applications in Soil Resources Mapping

Management

A high powered Research Advisory Committee (RAC) comprising eminent professionals, mostly from outside the ICAR system guides the Bureau on formulating its research policies and in planning research thrusts and strategies.

The Institute Management Committee (IMC), constituted and mandated by the ICAR, supervises the functioning of the Bureau. Internal Committees, such as, Institute Research Council, Purchase Committee, Library and Publication Committee, Official Language Committee and a Grievance Cell, to name a few, are operating for decentralization of management. The Institute Joint Staff Council promotes healthy interaction and congenial work environment.

Infrastructural Facilities

- **Laboratories**

The Bureau has various state-of-art laboratories. Some of the modern and sophisticated equipments are listed below.

- X-ray diffractogrameter
- Scanning Electron Microscope
- Inductively coupled Plasma – Atomic emission spectrophotometer
- Atomic Absorption Spectrophotometer
- Spectroradiometer
- Latest Remote Sensing and GIS software
- CN Analyzer

The facilities available in micromorphology and GIS laboratories are the best in the country that match international standards.

- **Data Centre**

A data centre in Bureau is the house for the data generated over the years in the bureau and equipped with server data storage facility and high-end computers for remote sensing data interpretation. A team of dedicated scientists, technical officers and young professionals are working for the cause of developing the area-specific land-use model. Data centre is linked with their replica maintained at their regional centres for exchanging data.

■ **Library**

The Bureau houses a fully computerized library located at the Hqrs. that has a comprehensive collection of books, reports and periodicals. The regional centres also have computerized libraries.

■ **ICAR-NBSS&LUP website**

The Bureau posts all important information about its activities, particularly about research projects, publications, linkages, educational training, staff and infrastructure on its Website (http://www.nbsslup.in).

■ **Bhoomi Geoportal**

NBSSLUP maintains a dedicated portal of soils known as Bhoomi Geoportal which has all kind of information on soil and allied resources in geographical information system (www.bhoomigeoportal-nbsslup.in).

Major Achievements

■ **1976-2019**

The Bureau, through its journey over the last 4 decades, has every reason to feel proud for its tremendous accomplishments in the domains of research and development.

- Soil resource map of the country (1:1 million scale), states (1:250,000 scale) and 82 districts (1:50,000 scale),selected watersheds (267), blocks (60), villages (173) and research farms (106) on 1:10000 scale, Geo-referenced soil information system for black soil region (BSR) and Indo-Gangetic plain (IGP) monitoring soil quality by registering observation through hotspot.
- Agro-Ecological Regions (AER) and Agro-ecological Sub-Region (AESR) maps of the country,
- Land evaluation and land use planning of irrigated, rainfed, coastal, arid, and hill and mountain Agro-ecosystem and showcasing of agro-techniques at 56 operational units**;** Land use planning in the coconut-based farming system of Kerala, strategies for natural resource management in backward districts of India. strategies for arresting other forms of land degradation in India
- Spectral characteristics of benchmark soils of India, mineral composition of dominant soils of India, Organic carbon stock of Indian soils in general, cold arid and hot arid region of India in particular (Product) and Spectral Library (Technology).
- Automated Land Evaluation Software for Linking Socio-economic conditions of the farmers and natural resource information
- Soil erosion map of the country and the states on 1:250000 scale; extent and severity of degradation in the country and land use planning using Remote sensing and GIS.
- Methodology for Land Resource Mapping on 1:10000 scale in the different agro-ecological regions of the country using high-resolution remote sensing data and GIS in conjunction with the cadastral map for site-specific information and situation-specific recommendation
- Soil nutrient maps on 1:50000 scale for the state of West Bengal, Kerala, Goa, Karnataka, Jharkhand, Assam, and Nagaland, Sikkim. Tripura, Andhra Pradesh and Telangana and mining the data for delineating area affected by the low balance of multiple nutrients using GIS and GPS in the Eastern and North-Eastern Region
- Web and Mobile based Farmers' Advisory for Soil Nutrient Management and input based land use planning
- Methodology developed for Soil Health Cards for farmers of different regions using Geo-informatics
- Methodology for the district, block and watershed/ village level land-use planning on 1:10000 scale.
- Decision Support Systems (DSS) for Land Use Planning.
- Development of Bhoomi Geoportal
- Fallow land mapping of Goa
- Land Resource Inventory of Goa
- Two android based mobile GIS application (Apps) developed namely, i) Land Resource Information of Goa (LRIS Goa), and ii) Potential Crop Zone (PCZ) Mapper.
- Sustainable areas for 17 crops.
- Revised Agro-ecological Region (AER) map of the country

Salient achievements (2019)

- Revised Agro-ecological Sub-Region (AESR) of the country

- Land Use Planning of Goa state
- Agriculture land use plan for 27 aspirational districts submitted to NITI Ayog.
- Updation of Bhoomi Geoportal

Special Programmes for the Farming Community

- Institute Village Linkage Programmes (IVLP) undertaken in selected villages of Nagpur district, Maharashtra.
- Developed a farmer's advisory service, hosted on www.wbagrisnet.gov.in of the NIC server and linked to mobile phones that guides farmers on soil fertility management of West Bengal for growing vegetables, rice, pulses and fruits.
- Agro-technologies implemented for livelihood improvement of the farmers in H D Kote block, Mysore district, Karnataka
- 24 Paraganas (South) district, West Bengal and Jorhat, Assam under the Tribal Sub Plan to identify the needs of the farmers of the tribal community, prioritize and address them.
- Prepared 8790+soil health cards for the farmers of the states of Maharashtra, Bihar, Telangana, Haryana, and Rajasthan.
- Mera Gaon Mera Gaurav programme implemented across the country.

New initiatives

- Land use planning for 27 aspirational districts
- Commercial use of soil data for the power transmission company
- Commercial use of soil data for laying optical fibre network
- Assessment and monitoring of the impact of land use planning on soil system and environment
- Updation of information on prime land of different states and the country
- Fallow land mapping of the country
- Updation of National Soil Geoportal.

Linkages

The Bureau maintains linkages with national and international organizations like NRSC, Hyderabad, ICRISAT, Hyderabad, Govt. of Telangana, Goa, Meghalaya and BISAG, Ahmedabad; ICAR-IISS, Bhopal and ICAR-IIFSR, Modipuram, Sterilite India Ltd., KEC international, WDD, Govt. of Maharashtra, Neeranchal Project of DoLR, New Delhi.

Thrust areas for 2017-2020

- Develop concepts and knowledge base on soil formation
- Development of Indian soil taxonomy rationale
- Development of user-friendly classification system for varied conditions
- Explore applicability of remote sensing and GIS techniques and assess their effectiveness and efficiency in soil resource mapping
- Agro-ecological regionalization
- Understand the relevance and importance of soil functions in eco-system services and generate soil quality indicators and quantify soil quality in different regions
- Develop a national soil resource information system
- Develop a prime land map of the country
- Develop soil carbon and other nutrients maps of different states
- Develop indicators of climate change impact (on soils and land use) and soil processes-based mitigation techniques
- **Flagship programme of the Institute**
  - Land Resource Inventory at 1:10000 scale
  - National Network Programme on Agricultural Land Use Planning
- **Emerge as a Centre of Excellence for capacity building in soil survey, remote sensing and GIS applications in soil resource mapping, land evaluation and land use planning**
  - Teaching and training
- **Generate contemporary land use plans at different levels, particularly, at village / farm level**
  - Delineate crop production zones and evaluate

land for land use allocation based on land capability and land suitability classification

- Optimum utilization of vacant (fallow) lands based on their capability and soil suitability
- Prepare blueprints for efficient land use planning for varied purposes and at different levels
- Develop a Decision Support System for sustainable land resource management

- **Adapt RD&T programmes to address contemporary societal challenges**
  - To establish linkage with national and international organizations, stakeholders including farmers
- **Suggest prospective land-use policies for varied situations**
  - To equip the policymakers with policy guidelines on various issues towards suggesting perspective land-use policies.

Institute Budget (including salaries): 2019

- Funds Received : 8369.86 Lakhs
- Funds Utilized : 8346.37 Lakhs

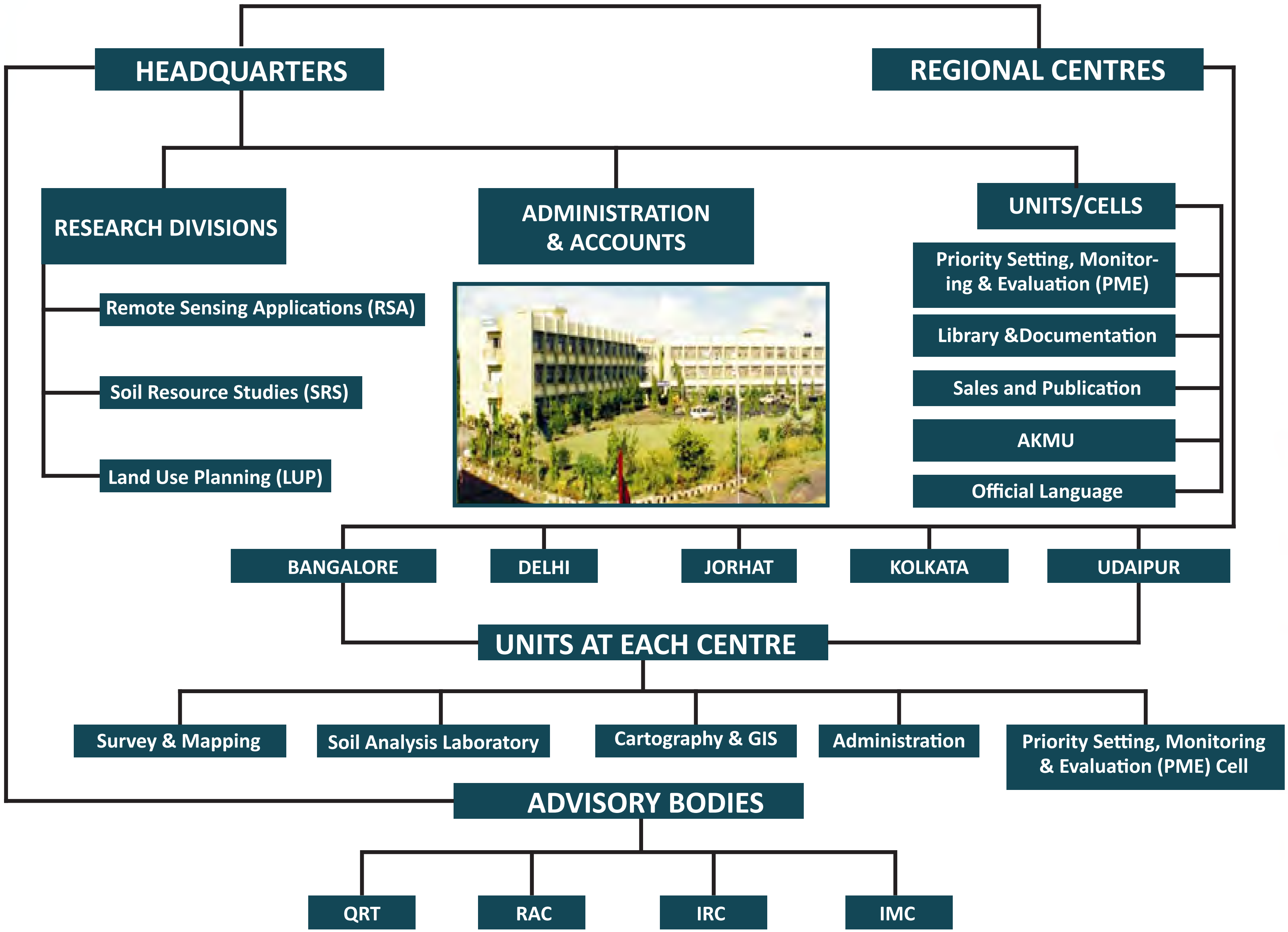
Revenue Generation 2019

- Research Projects : 473.64 lakhs
- Sales of publications : 2.38 lakhs
- Soil analysis/testing : 3.12 lakhs
- **Total : 479.14 lakhs**

Staff Strength (as on 31.12.2019)

Category	Sanctioned	Filled	Vacant	% Vacant
Scientific	97+1 RMP	75	22+1	23
Technical	165	115	50	30
Administrative	67	42	25	37
Supporting	38	27	11	29
Total	**368**	**259**	**109**	**30**

ORGANOGRAM


HEADQUARTERS
REGIONAL CENTRES
RESEARCH DIVISIONS
Remote Sensing Applications (RSA)
Soil Resource Studies (SRS)
Land Use Planning (LUP)
ADMINISTRATION & ACCOUNTS
UNITS/CELLS
Priority Setting, Monitoring & Evaluation (PME)
Library &Documentation
Sales and Publication
AKMU
Official Language
BANGALORE
DELHI
JORHAT
KOLKATA
UDAIPUR
UNITS AT EACH CENTRE
Survey & Mapping
Soil Analysis Laboratory
Cartography & GIS
Administration
Priority Setting, Monitoring & Evaluation (PME) Cell
ADVISORY BODIES
QRT
RAC
IRC
IMC

2 RESEARCH ACHIEVEMENTS

2.1 Remote Sensing and GIS Applications

Base Map Preparations
Eastern Region
Motihari block, East Champaran district, Bihar

Motihari block of East Champaran district, Bihar lies between 26°32′04″and 26°33′33″ N latitudes and 84°52′40″ to 85°03′32.5″ E longitudes, covering an area of 23,577 hectares representing an alluvial plain developed from the runoff-laden alluvium from the Nepal Himalayas and also carried by the Burhi Gandak river, under AESR 13.1 (North Bihar and Avadh Plains, hot dry/moist sub-humid eco-sub region). Based on the landforms (nearly level and very gently sloping young and active alluvial plain) and land use (double-crop, single crop, plantation, brickfield, and fallow land), 17 landscape ecological units (LEUs) were identified (**Table 2.1.1**) and mapped (**Fig.2.1.1**).

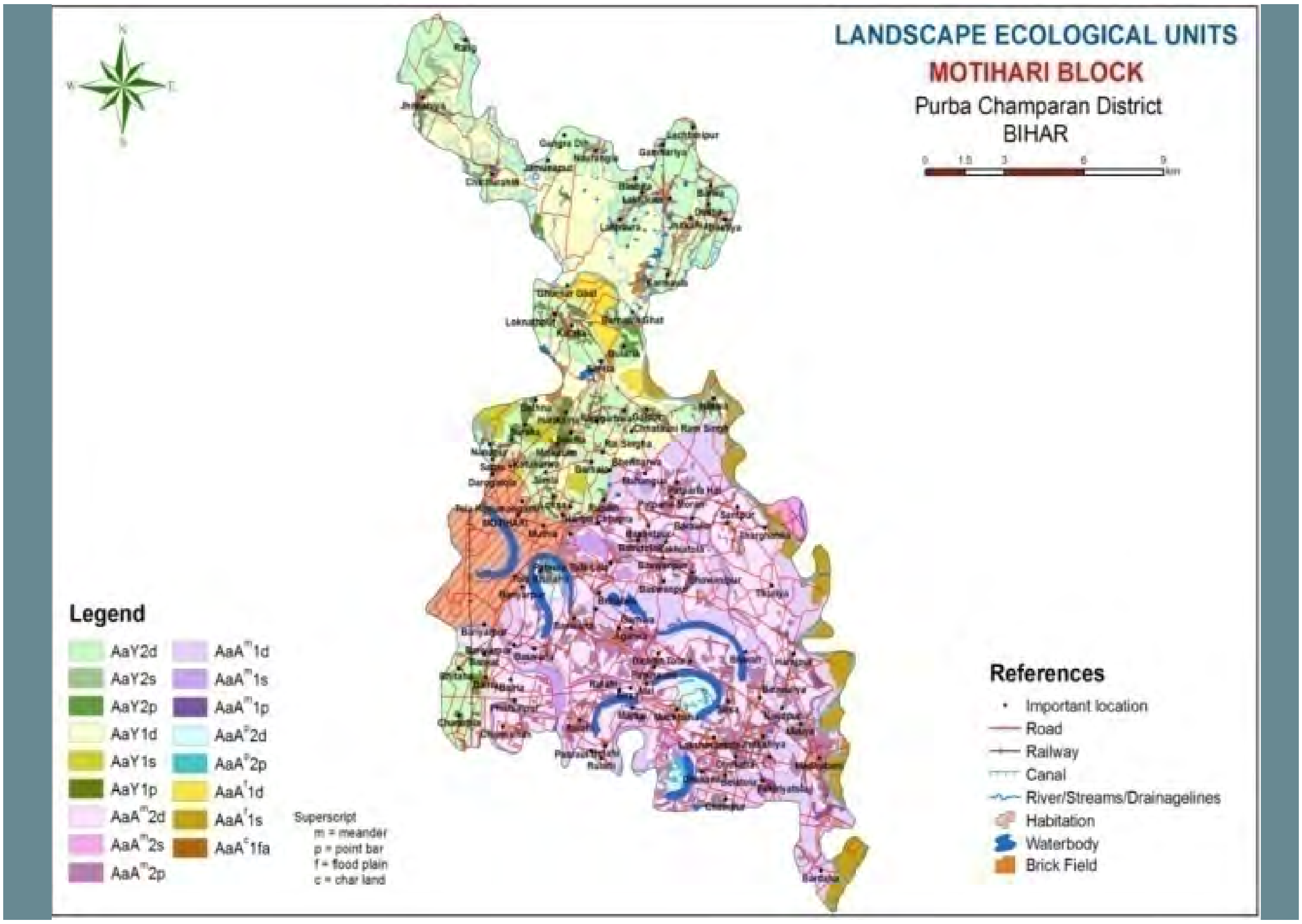


Fig. 2.1.1. LEU map of Motihari block

Table 2.1.1. LEU units of Motihari block, Bihar

Broad landform	LEU	LEU description	Area (ha)	% of TGA
Young alluvial plain	AaY2d	Very gently sloping young alluvial plain (Double crops)	4160	17.65
	AaY2s	Very gently sloping young alluvial plain (Single crop)	149	0.63
	AaY2p	Very gently sloping young alluvial plain (Plantation)	450	1.91
	AaY1d	Nearly level young alluvial plain (Double crops)	2884	12.23
	AaY1s	Nearly level young alluvial plain (Single crop)	221	0.94
	AaY1p	Nearly level young alluvial plain (Plantation)	16	0.07
Active alluvial plain	$AaA^{m}2d$	Very gently sloping active alluvial plain - meander plain (Double crops)	4997	21.19
	$AaA^{m}2s$	Very gently sloping active alluvial plain - meander plain (Single crop)	113	0.48
	$AaA^{m}2p$	Very gently sloping active alluvial plain - meander plain (Plantation)	1476	6.26
	$AaA^{m}1d$	Nearly level active alluvial plain - meander plain (Double crops)	3126	13.26
	$AaA^{m}1s$	Nearly level active alluvial plain - meander plain (Single crop)	665	2.82
	$AaA^{m}1p$	Nearly level active alluvial plain - meander plain (Plantation)	132	0.56
	$AaA^{p}2d$	Very gently sloping Active alluvial plain - point bar (Double crops)	251	1.06
	$AaA^{p}2p$	Very gently sloping active alluvial plain - point bar (Plantation)	83	0.35
	$AaA^{f}1d$	Nearly level active alluvial plain - flood plain (Double crops)	330	1.4
	$AaA^{f}1s$	Nearly level active alluvial plain - flood plain (Single crop)	763	3.24
	$AaA^{c}1fa$	Nearly level active alluvial plain - flood plain (fallow)	77	0.33
Misc.			**3684**	**15.62**
Total			**23577**	**100.00**

Hemtabad Block, North Dinajpur district, West Bengal

Hemtabad block of Uttar Dinajpur district, West Bengal lies between 25°35′15″ and 25°48′53″ N latitudes and 88°11′55″and 88°20′25″ E longitudes under AESR 15.1, occupying an area of 19184 ha. It is bounded by the Thakurgaon district of Bangladesh on the north, Kaliaganj block on the east and south, and Raiganj block on the west. Hemtabad has a flat topography with a gentle slope from north to south. The landscape ecological units (10 LEU) are presented in **table 2.1.2**.

Table 2.1.2. LEU units of Hemtabad block

Broad landform	LEU	LEU description	Area (ha)	% of TGA
Young alluvial plain	AaY1c	Nearly level young alluvial plain (Cultivated land)	9569	49.88
	AaY1p	Nearly level young alluvial plain (Plantation)	18	0.10
	AaY(d)1c	Nearly level young alluvial plain (depressed) (Cultivated land)	430	2.24
	AaY2c	Very gently sloping young alluvial plain (Cultivated land)	47	0.25
	AaY2p	Very gently sloping young alluvial plain (Plantation)	16	0.09
Old alluvial plain	AaO1c	Nearly level old alluvial plain (Cultivated land)	770	4.01
	AaO(d)1c	Nearly level old alluvial plain (depressed) (Cultivated land)	377	1.97
	AaO2c	Very gently sloping old alluvial plain (Cultivated land)	3943	20.55
	AaO2p	Very gently sloping old alluvial plain (Plantation)	214	1.11
	AaO2f	Very gently sloping old alluvial plain (Forest)	200	1.04
Misc.			**3600**	**18.76**
Total			**191.84**	**100.00**

Katihar district, Bihar

Katihar district is a part of the Lower Ganga basin and falls in the Kosi and Mahananda sub-basin. It lies between 25°13′29″ and 25°53′49″N latitudes, and 87°4′17″ and 87°10′12″ E longitudes. The district falls in AESR 13.1 representing hot dry to sub-humid region and occupies an area of 3056 Km^2. Seventeen landform units (**Table 2.1.3**) and 25 LEUs **(Table 2.1.4**) were identified in the district.

Maximum area in the district is occupied by level to nearly level young alluvial plain (19.67% of the total geographical area), followed by the level to nearly level active alluvial plain flood plain (18.33% of TGA) that are mostly found along both sides of the major rivers of the district. Among the landscape ecological units, level to nearly level flood plain of active alluvial plain under cultivation, occupies maximum area (16.0% of TGA). These are mostly associated with river Ganga and its tributaries. Nearly level young alluvial plain under cultivation occupies about 14% of TGA followed by very gently sloping young alluvial plain under cultivation (11.35% of TGA).

Table 2.1.3. Landform units of Indo-Gangetic Alluvial Plains, Katihar district, Bihar

Broad landform	LEU	LEU description	Area (km^2)	% of TGA
Old alluvial plain	AaO2c	Very gently sloping old alluvial plain (Cultivated land)	24.72	0.81
	AaO2p	Very gently sloping old alluvial plain (Plantation)	0.46	0.01
	AaO^d2c	Very gently sloping old alluvial plain depressed (Cultivated land)	1.38	0.05
	AaO1c	Level to nearly level old alluvial plain (Cultivated land)	15.79	0.52
	AaO^d1c	Level to nearly level old alluvial plain depressed (Cultivated land)	7.52	0.25
Young alluvial plain	AaY2c	Very gently sloping young alluvial plain (Cultivated land)	346.96	11.35
	AaY2p	Very gently sloping young alluvial plain (Plantation)	13.12	0.43
	AaY2os	Very gently sloping young alluvial plain (Open scrub)	2.44	0.08
	AaY^d2c	Very gently sloping young alluvial plain depressed (Cultivated land)	3.94	0.13
	AaY1c	Level to nearly level young alluvial plain (Cultivated land)	439.95	14.4
	AaY1p	Level to nearly level young alluvial plain (Plantation)	5.97	0.2
	AaY^d1c	Level to nearly level young alluvial plain depressed (Cultivated land)	1.48	0.05
Active alluvial plain	AaA^m2c	Very gently sloping active alluvial plain meander (Cultivated land)	342.76	11.22
	AaA^m2p	Very gently sloping active alluvial plain meander (Plantation)	5.05	0.16
	$AaA^{md}2c$	Very gently sloping active alluvial plain meander depressed (Cultivated land)	36.78	1.2
	AaA^m1c	Level to nearly level active alluvial plain meander (Cultivated land)	336.46	11.01
	AaA^m1p	Level to nearly level active alluvial plain meander (Plantation)	5.92	0.19
	$AaA^{md}1c$	Level to nearly level active alluvial plain meander depressed (Cultivated land)	39.95	1.31
	AaA^f1c	Level to nearly level active alluvial plain flood plain (Cultivated land)	489.08	16.00
	AaA^f1p	Level to nearly level active alluvial plain flood plain (Plantation)	4.83	0.16
	AaA^f1os	Level to nearly level active alluvial plain flood plain (Open scrub)	0.46	0.02
	$AaA^{fd}1c$	Level to nearly level active alluvial plain flood plain depressed (Cultivated land)	75.54	2.47
	AaA^p1c	Level to nearly level active alluvial plain point bar (Cultivated land)	3.49	0.11
	AaA^c1c	Level to nearly level active alluvial plain char (Cultivated land)	111.71	3.65
	AaA^c1fa	Level to nearly level active alluvial plain char (Fallow land)	22.12	0.72
Misc.			**718.12**	**23.50**
Total			**3056**	**100.00**

Table 2.1.4. Landscape ecological units (LEU) of Katihar district, Bihar

Landform	Description	Area (km²)	% of TGA
AaO2	Very gently sloping old alluvial plain (O2)	34.26	1.12
AaO^d2	Very gently sloping old alluvial plain depressed (O^d2)	1.38	0.05
AaO1	Level to nearly level old alluvial plain (O1)	16.78	0.55
AaO^d1	Level to nearly level old alluvial plain depressed (O^d1)	7.76	0.25
AaY2	Very gently sloping young alluvial plain (Y2)	482.49	15.79
AaY^d2	Very gently sloping young alluvial plain depressed (Y^d2)	3.94	0.13
AaY1	Level to nearly level young alluvial plain (AaY1)	601.24	19.67
AaY^d1	Level to nearly level young alluvial plain depressed (AaY^d1)	1.47	0.05
AaA^m2	Very gently sloping active alluvial plain meander (A^m2)	438.97	14.36
$AaA^{md}2$	Very gently sloping active alluvial plain meander depressed ($A^{md}2$)	38.3	1.25
AaA^m1	Level to nearly level active alluvial plain meander (A^m1)	422.78	13.84
$AaA^{md}1$	Level to nearly level active alluvial plain meander depressed ($A^{md}1$)	42.84	1.4
AaA^f1	Level to nearly level active alluvial plain flood plain (A^f1)	560	18.33
$AaA^{fd}1$	Level to nearly level active alluvial plain flood plain depressed ($A^{fd}1$)	76.93	2.52
AaA^p1	Level to nearly level active alluvial plain point bar (A^p1)	3.77	0.12
AaA^c1	Level to nearly level Active alluvial plain char (AaA^c1)	133.83	4.38
Ox	Ox bow lake (Ox)	1.66	0.05
Misc.		**187.60**	**6.14**
Total		**3056**	**100.00**

Maldah district, West Bengal

Maldah district extends from 24°40"20' to 25°32"08' N latitudes and 87°45"50' to 88°28"10' E longitudes covering an area of 3733 km². This district is situated in AESR 15.1 (Hot moist sub-humid ecological sub-region) with 15 blocks. The physiography of the district is mostly plain barring a few pockets of gentle slopes. The major rivers of the district are the Ganga, Mahananda, Kalindi, Punarbhadra, and Tangon. The river Mahananda divides the district into two regions - the eastern region, consisting mainly of old alluvial soil (commonly known as "Barind") and the western region. The western part is further subdivided by the river Kalindri into two portions, the northern area is known as "Tal" (low lying and vulnerable to inundation during the rainy season), and the southern area is "Diara" (very fertile land). The river Ganges flows along the south-western boundary of the district. Three landform units and 23 LEUs (**Table 2.1.5**) were identified in the district.

Among the landscape ecological units, nearly level active alluvial plain (flood plain, meander plain and point bar) occupies maximum area (35.6% of TGA) followed by nearly level to very gently sloping young alluvial plain (29.2% of TGA) and nearly level to gently sloping old alluvial plain (27.8% of TGA). The district consists mainly of low–lying plains, sloping towards the south with undulating areas on the northeast.

Table 2.1.5. LEU units of Maldah district, West Bengal

Broad landform	LEU	LEU description	Area (km²)	% of TGA
Old alluvial plain	AaO3c	Gently sloping old alluvial plain (Cultivated land)	18.89	0.51
	AaO3h/p	Gently sloping old alluvial plain (Habitation with plantation)	9.82	0.26
	AaO2c	Very gently sloping old alluvial plain (Cultivated land)	370.64	9.93
	AaO2f/p	Very gently sloping old alluvial plain (Forest / Plantation)	3.5	0.09
	AaO2h/p	Very gently sloping old alluvial plain (Habitation with plantation)	253.31	6.79
	AaO1c	Nearly level old alluvial plain (Cultivated land)	255.96	6.86

Broad landform	LEU	LEU description	Area (km²)	% of TGA
	AaO1f/p	Nearly level old alluvial plain (Forest / Plantation)	4.26	0.11
	AaO1h/p	Nearly level old alluvial plain (Habitation with plantation)	120.02	3.21
Young alluvial plain	AaY2c	Very gently sloping young alluvial plain (Cultivated land)	32.39	0.87
	AaY2h/p	Very gently sloping young alluvial plain (Habitation with plantation)	0.74	0.02
	AaY1c	Nearly level young alluvial plain (Cultivated land)	832.77	22.31
	AaY1f/p	Nearly level young alluvial plain (Forest / Plantation)	11.51	0.31
	AaY1h/p	Nearly level young alluvial plain (Habitation with plantation)	212.34	5.69
Active alluvial plain	AaA^m1c	Nearly level active alluvial plain - meander plain (Cultivated land)	317.78	8.51
	AaA^m1f/p	Nearly level active alluvial plain - meander plain (Forest / Plantation)	223.59	5.99
	AaA^m1h/p	Nearly level active alluvial plain - meander plain (Habitation with plantation)	285.19	7.64
	AaA^f1c	Nearly level active alluvial plain - flood plain (Cultivated land)	284.24	7.61
	AaA^f1f/p	Nearly level active alluvial plain - flood plain (Forest / Plantation)	27.71	0.74
	AaA^f1h/p	Nearly level active alluvial plain - flood plain (Habitation with plantation)	81.13	2.17
	AaA^p1c	Nearly level active alluvial plain - point bar (Cultivated land)	8.24	0.22
	AaA^p1f/p	Nearly level active alluvial plain - point bar (Forest / Plantation)	3.69	0.10
	AaA^p1h/p	Nearly level active alluvial plain - point bar (Habitation with plantation)	0.95	0.03
	AaA^c1c	Nearly level active alluvial plain - char land (Cultivated land)	96.95	2.60
Misc.			**277.38**	**7.43**
Total			**3733**	**100.00**

Bolangir district, Odisha

The Bolangir district lies between 20°10′10″ and 21°03′25″ N latitude and 82°40′12″ to 83°43′56″ E longitude covering an area of 6575 km²and it is surrounded by Subarnapur district in the east, Nuapada district in the west, Kalahandi district in the south and Bargarh district in the north. Bolangir district has been divided into 3 sub-divisions and 14 blocks. Soil survey work was undertaken in the Titlagarh subdivision of the district. Six distinct landforms were recognized which was further delineated into 58 landscape ecological units (**Table 2.1.6**).

Moderately sloping undulating upland but presently fallow occupies an area of 205.97 km² (10.54% TGA). As most of this region is under rainfed condition, very little area is cultivated during the *rabi* season Moderately sloping undulating upland under cultivation occupies an area of about 166.75 km² (8.53% of TGA) followed by moderately sloping upper pediment occupied by forest with an area of 141.84 km² (7.26% of TGA).

Table 2.1.6. LEU unit of Titlagarh subdivision, Bolangir district

Broad Landform	LEU*	LEU description	Area (km²)	% of TGA
Hill	EmH5F	Moderately steeply sloping residual hills (Forest)	105.68	5.41
(H)	EmH5j	Moderately steeply sloping residual hills (Open scrub/field/wasteland/Misc)	4.44	0.23
	EmHF4F	Moderately sloping foothills (Forest)	47.91	2.45
	EmHF4b	Moderately sloping foothills (Cropland - presently fallow)	0.47	0.02
Pediment (Pe)	EmPeU4F	Moderately sloping upper pediment (Forest)	141.84	7.26
	EmPeU4k	Moderately sloping upper pediment (Degraded forest)	19.97	1.02
	EmPeU4a	Moderately sloping upper pediment (Cropland with trees)	51.56	2.64

Broad Landform	LEU*	LEU description	Area (km²)	% of TGA
	EmPeU4b	Moderately sloping upper pediment (Cropland - presently fallow)	59.63	3.05
	EmPeU4c	Moderately sloping upper pediment (Cropland - moist fallow)	2.29	0.12
	EmPeU4de	Moderately sloping upper pediment (Depressed)	0.61	0.03
	EmPeU4j	Moderately sloping upper pediment (Open scrub/ field/ Wasteland/ Misc)	12.2	0.62
	EmPeU4T/S	Moderately sloping upper pediment (Trees/scrub)	8.32	0.43
	EmPeL4F	Moderately sloping lower pediment (Forest)	112.48	5.75
	EmPeL4k	Moderately sloping lower pediment (Degraded forest)	26.92	1.38
	EmPeL4a	Moderately sloping lower pediment (Cropland with trees)	40.42	2.07
	EmPeL4b	Moderately sloping lower pediment (Cropland - presently fallow)	55.2	2.82
	EmPeL4c	Moderately sloping lower pediment (Cropland - moist fallow)	9.14	0.47
	EmPeL4de	Moderately sloping lower pediment (Depressed)	0.71	0.04
	EmPeL4j	Moderately sloping lower pediment (Open scrub/ field/ Wasteland/ Misc)	12.82	0.66
	EmPeL4T/S	Moderately sloping lower pediment (Trees/scrub)	16.06	0.82
Upland(U)	EmUd4F	Moderately sloping dissected upland (Forest)	0.14	0.01
	EmUd4k	Moderately sloping dissected upland (Degraded forest)	0.62	0.03
	EmUd4a	Moderately sloping dissected upland (Cropland with trees)	1.34	0.07
	EmUd4b	Moderately sloping dissected upland (Cropland - presently fallow)	2.32	0.12
	EmUUn4F	Moderately sloping undulating upland (Forest)	58.97	3.02
	EmUUn4k	Moderately sloping undulating upland (Degraded forest)	32.86	1.68
	EmUUn4a	Moderately sloping undulating upland (Cropland with trees)	166.75	8.53
	EmUUn4b	Moderately sloping undulating upland (Cropland - presently fallow)	205.97	10.54
	EmUUn4b	Moderately sloping undulating upland (Cropland - presently fallow)	0.57	0.03
	EmUUn4c	Moderately sloping undulating upland (Cropland - moist fallow)	29.1	1.49
	EmUUn4de	Moderately sloping undulating upland (Depressed)	1.61	0.08
	EmUUn4j	Moderately sloping undulating upland (Open scrub/ field/ wasteland/ Misc)	56.61	2.90
	EmUUn4P	Moderately sloping undulating upland (Plantation)	6.54	0.33
	EmUUn4T/S	Moderately sloping undulating upland (Trees/scrub)	17.61	0.90
	EmUUn3F	Gently sloping undulating upland (Forest)	8.79	0.45
	EmUUn3k	Gently sloping undulating upland (Degraded forest)	6.14	0.31
	EmUUn3a	Gently sloping undulating upland (Cropland with trees)	81.36	4.16
	EmUUn3b	Gently sloping undulating upland (Cropland - presently fallow)	130.83	6.69
	EmUUn3c	Gently sloping undulating upland (Cropland - moist fallow)	36	1.84
	EmUUn3de	Gently sloping undulating upland (Depressed)	1.25	0.06
	EmUUn3j	Gently sloping undulating upland (Open scrub/ field/ Wasteland/ Misc)	19.13	0.98
	EmUUn3P	Gently sloping undulating upland (Plantation)	2.27	0.12
	EmUUn3T/S	Gently sloping undulating upland (Trees/scrub)	8.22	0.42
Valley(V)	EmV3F	Gently sloping valley (Forest)	0.47	0.02
	EmV3a	Gently sloping valley (Cropland with crops n trees)	4.66	0.24
	EmV3b	Gently sloping valley (Cropland - presently fallow)	12.98	0.66
	EmV3c	Gently sloping valley (Cropland - moist fallow)	116.68	5.97
Plain (P)	EmUp3a	Gently sloping undulating plain (Cropland with trees)	41.01	2.10
	EmUp3b	Gently sloping undulating plain (Cropland - presently fallow)	23.33	1.19
	EmUp3c	Gently sloping undulating plain (Cropland - moist fallow)	17.4	0.89
	EmUp3de	Gently sloping undulating plain (Depressed)	0.89	0.05
	EmUp3j	Gently sloping undulating plain (Open scrub/ field/ wasteland/ Misc.)	11.67	0.60

Broad Landform	LEU*	LEU description	Area (km^2)	% of TGA
	EmUp3T/S	Gently sloping undulating plain (Trees/scrub)	0.56	0.03
Alluvial Plain (Ap)	EmAp3a	Gently sloping undulating alluvial plain (Cropland with trees)	1.48	0.08
	EmAp3b	Gently sloping undulating alluvial plain (Cropland (presently fallow)	0.52	0.03
	EmAp3c	Gently sloping undulating alluvial plain (Cropland (moist fallow))	3.63	0.19
	EmAp3j	Gently sloping undulating alluvial plain (Open scrub/ field/ wasteland/ Misc.)	0.41	0.02
	EmAp3T/S	Gently sloping undulating alluvial plain (Trees/scrub)	0.08	0.01
Misc.			**115.60**	**5.91**
Total			**1955.05**	**100.00**

**Em: E-Eastern Plateau (Physiography), m-Mahanadi basin (sub-physiography)*

Hazaribagh district, Jharkhand

The Hazaribagh district (23°50’ to 24°25’ N latitude and 85°05’ to 85°55’ E longitude) is situated in the northeast part of North Chhotanagpur Division, covering an area of 4313 km^2 under AESR 11.0 (Chhotanagpur plateau region, Hot, dry sub-humid climate with red and lateritic soils with medium AWC and LGP of 180-210 days). Identification of various landforms and subsequently landscape ecological units of 10 blocks *viz*. Keredari, Barkagaon, Dadi, Churchu, Hazaribagh, Katkamdag, Katkamsandhi, Padma, Ichak, and Daru, of Hazaribagh district, has been completed. LEU descriptions are depicted in **table 2.1.7**.Very gently sloping undulating plains under cultivation occupies maximum area (493 km^2 i.e. 20% TGA) in the 10 selected blocks of the district and is mostly concentrated in the lower plateau region. This is followed by moderately steeply sloping dissected hill/ridge under forest (19.3% of TGA) which is present mostly in the upper plateau region and few areas on the plateau top.

Sahibganj district, Jharkhand

Sahibganj district lies between 24°42’ and 25°21’ N latitudes and 87°25’ and 87°54’ E longitudes and occupies an area of 1599 km^2. The district comprises of 9 blocks, namely, Sahibganj, Mandro, Borio, Barhait, Taljhari, Rajmahal, Udhwa, Pathna, and Barharwa. Five blocks were taken up for the initial survey work. Nine broad landforms were identified in five selected blocks of the district. These include hills, sideslopes, foothill, isolated hillocks, pediment, upland, valley, and alluvial plain (old and active). Combining these landforms along with the slope and land use, 59 landscape ecological units were identified and delineated (**Table 2.1.8**).

Table 2.1.7. LEU units of Hazaribagh district (part)

Broad landform	LEU	LEU description	Area (km^2)	% of TGA
Plateau top	PtR6f	Steeply sloping ridge (Forest)	1.27	0.05
	PtEs6f	Steeply sloping escarpments (Forest)	8.28	0.34
	PtD6f	Steeply sloping dissected hill / ridge (Forest)	4.25	0.17
	PtD5c	Moderately steeply sloping dissected hill / ridge (Cultivated land)	1.7	0.07
	PtD5f	Moderately steeply sloping dissected hill/ridge (Forest)	76.18	3.09
	PtU4c	Moderately sloping undulating upland (Cultivated land)	12.57	0.51
	PtU4f	Moderately sloping undulating upland (Forest)	2.95	0.12
	PtU4s	Moderately sloping undulating upland (Scrubland)	0.21	0.01
	PtU3c	Gently sloping undulating upland (Cultivated land)	19.97	0.81
	PtU3f	Gently sloping undulating upland (Forest)	5.72	0.23
	PtVf3c	Gently sloping valley fill (Cultivated land)	0.38	0.02

Broad landform	LEU	LEU description	Area (km^2)	% of TGA
Upper plateau	PuR6f	Steeply sloping ridge (Forest)	5.68	0.23
	PuEs6f	Steeply sloping escarpments (Forest)	16.89	0.68
	PuEs6s	Steeply sloping escarpments (Scrubland)	0.24	0.01
	PuH6c	Steeply sloping isolated hillocks (Cultivated land)	0.33	0.01
	PuH6f	Steeply sloping isolated hillocks (Forest)	2.65	0.11
	PuD6c	Steeply sloping dissected hill / ridge (Cultivated land)	0.22	0.01
	PuD6f	Steeply sloping dissected hill / ridge (Forest)	31.21	1.26
	PuD6r	Steeply sloping dissected hill / ridge (Rock out crop)	0.14	0.01
	PuD5c	Moderately steeply sloping dissected hill / ridge (Cultivated land)	4.15	0.17
	PuD5f	Moderately steeply sloping dissected hill/ridge (Forest)	475.34	19.26
	PuD5s	Moderately steeply sloping dissected hill / ridge (Scrubland)	0.3	0.01
	PuG5c	Moderately steeply sloping gullied land (Cultivated land)	6.72	0.27
	PuG5f	Moderately steeply sloping gullied land (Forest)	0.39	0.02
	PuG5w	Moderately steeply sloping gullied land (Wasteland)	0.64	0.03
	PuU5w	Moderately steeply sloping undulating upland (Wasteland)	0.71	0.03
	PuU4c	Moderately sloping undulating upland (Cultivated land)	134.36	5.44
	PuU4f	Moderately sloping undulating upland (Forest)	134.15	5.44
	PuU4s	Moderately sloping undulating upland (Scrubland)	3.04	0.12
	PuU4r	Moderately sloping undulating upland (Rock outcrop)	2.32	0.09
	PuU3c	Gently sloping undulating upland (Cultivated land)	287.24	11.64
	PuU3f	Gently sloping undulating upland (Forest)	64.02	2.59
	PuU3s	Gently sloping undulating upland (Scrubland)	0.22	0.01
	PuU3r	Gently sloping undulating upland (Rock outcrop)	0.17	0.01
	PuU3w	Gently sloping undulating upland (Wasteland)	1.49	0.06
	PuVf4c	Moderately sloping valley fill (Cultivated land)	0.64	0.03
	PuVf3c	Gently sloping valley fill (Cultivated land)	17.09	0.69
Lower plateau	PlEs6f	Steeply sloping escarpments (Forest)	4.56	0.18
	PlH6f	Steeply sloping isolated hillocks (Forest)	5.5	0.22
	PlH5f	Moderately steeply sloping isolated hillocks (Forest)	0.15	0.01
	PlU4c	Moderately sloping undulating upland (Cultivated land)	1.79	0.07
	PlU4f	Moderately sloping undulating upland (Forest)	76.99	3.12
	PlU4s	Moderately sloping undulating upland (Scrubland)	0.24	0.01
	PlU4r	Moderately sloping undulating upland (Rock outcrop)	1.24	0.05
	PlG2w	Very gently sloping gullied land (Wasteland)	0.4	0.02
	PlPu3c	Gently sloping undulating plains (Cultivated land)	21.37	0.87
	PlPu3f	Gently sloping undulating plains (Forest)	209.33	8.48
	PlPu3s	Gently sloping undulating plains (Scrubland)	0.33	0.01
	PlPu3r	Gently sloping undulating plains (Rock outcrop)	1.91	0.08

Broad landform	LEU	LEU description	Area (km^2)	% of TGA
	PlPu2c	Very gently sloping undulating plains (Cultivated land)	493.6	20.01
	PlPu2f	Very gently sloping undulating plains (Forest)	118.63	4.81
	PlPu2s	Very gently sloping undulating plains (Scrubland)	3.45	0.14
	PlPu2r	Very gently sloping undulating plains (Rock outcrop)	2.77	0.11
	PlPu2w	Very gently sloping undulating plains (Wasteland)	14.35	0.58
	PlVf2c	Very gently sloping valley fill (Cultivated land)	3.64	0.15
	PlV2c	Very gently sloping valley (Cultivated land)	30.62	1.24
	PlV2f	Very gently sloping valley (Forest)	23.25	0.94
	PlV2w	Very gently sloping valley (Wasteland)	0.14	0.01
Misc.			**129.28**	**5.24**
Total			**2467.37**	**100.00**

Table 2.1.8. Soil-LEU relationship of Sahibganj district (part)

Broad Landform	LEU	Description	Area (km^2)	% of TGA
Hills (H)	EcH6F	Steeply sloping hills (Forest)	38.23	3.46
	EcH6f	Steeply sloping hills (Fallow)	9.75	0.88
	EcH6os	Steeply sloping hills (Open scrub)	59.11	5.35
	EcH5f	Moderately steeply sloping hills (Fallow)	11.33	1.03
	EcH5os	Moderately steeply sloping hills (Open scrub)	20.87	1.89
	EcH5q	Moderately steeply sloping hills (Stone quarry)	6.06	0.55
	EcH4f	Moderately sloping Hills ((Fallow)	1.29	0.12
	EcH4os	Moderately sloping Hills ((Open scrub)	3.15	0.29
	EcSs6os	Steeply sloping side slope (Open scrub)	1.54	0.14
Isolated hillock (HI)	EcHI5os	Moderately steeply sloping Isolated hillock (Open scrub)	3.69	0.33
	EcHI5f	Moderately steeply sloping Isolated hillock (Fallow)	0.17	0.02
	EcHI5q	Moderately steeply sloping Isolated hillock (Stone quarry)	0.56	0.05
	EcHI4F	Moderately sloping Isolated hillock (Forest)	1.14	0.10
	EcHI4f	Moderately sloping Isolated hillock (Fallow)	1.23	0.11
	EcHI4os	Moderately sloping Isolated hillock (Open scrub)	3.90	0.35
	EcHI4q	Moderately sloping Isolated hillock (the stone quarry)	1.79	0.16
Foothill (HF)	EcHF4c	Moderately sloping foothill (Cropland)	1.79	0.16
	EcHF4f	Moderately sloping foothill (Fallow)	13.40	1.21
	EcHF4os	Moderately sloping foothill (Open scrub)	7.59	0.69
	EcHF4q	Moderately sloping foothill (Stone quarry)	0.40	0.04
Pediment (P)	EcPe4c	Moderately sloping pediment (Cropland)	18.36	1.66
	EcPe4f	Moderately sloping pediment (Fallow)	22.71	2.06
	EcPe4os	Moderately sloping pediment (Open scrub)	5.45	0.49

Broad Landform	LEU	Description	Area (km²)	% of TGA
	EcPe^{mo}4f	Moderately sloping pediment with mounds (Fallow)	6.14	0.56
	EcPe^{mo}4os	Moderately sloping pediment with mounds (Open scrub)	6.88	0.62
Upland(U)	EcUUn3c	Gently sloping undulating upland (Cropland)	35.50	3.22
	EcUUn3f	Gently sloping undulating upland (Fallow)	65.22	5.91
	EcUUn3os	Gently sloping undulating upland (Open scrub)	6.96	0.63
Valley(V)	EcV3c	Gently sloping valley (Cropland)	51.07	4.62
	EcV3f	Gently sloping valley (Fallow)	15.78	1.43
Old alluvial plain (AaO)	AaO3c	Gently sloping old alluvial plain (Cropland)	35.66	3.23
	AaO3f	Gently sloping old alluvial plain (Fallow)	13.40	1.21
	AaO3os	Gently sloping old alluvial plain (Open scrub)	0.94	0.09
	AaO2f	Very gently sloping old alluvial plain (Fallow)	75.42	6.83
	AaO2c	Very gently sloping old alluvial plain (Cropland)	126.95	11.50
	AaO2m	Very gently sloping old alluvial plain (Marshy)	0.45	0.04
	AaO2mf	Very gently sloping old alluvial plain (Moist fallow)	20.79	1.88
	AaO2os	Very gently sloping old alluvial plain (Open scrub)	1.81	0.16
	AaO2p	Very gently sloping old alluvial plain (Plantation)	3.87	0.35
Young alluvial plain (AaY)	AaY1c	Nearly level young alluvial plain (Cropland)	75.79	6.86
	AaY1f	Nearly level young alluvial plain (Fallow)	31.18	2.82
	AaY1m	Nearly level young alluvial plain (Marshy)	1.28	0.12
	AaY1mf	Nearly level young alluvial plain (Moist fallow)	2.36	0.21
	AaY1os	Nearly level young alluvial plain (Open scrub)	0.06	0.01
	AaY1p	Nearly level young alluvial plain (Plantation)	0.40	0.04
	AaY1wl	Nearly level young alluvial plain (wasteland)	0.54	0.05
	AaY^{d}1c	Nearly level young alluvial plain_depressed (Cropland)	18.75	1.70
	AaY^{d}1mf	Nearly level young alluvial plain_depressed (Moist fallow)	0.09	0.01
Active Alluvial plain (AaA)	AaA^{f}1c	Nearly level active alluvial flood plain (Cropland)	46.29	4.19
	AaA^{f}1f	Nearly level active alluvial flood plain (Fallow)	8.78	0.80
	AaA^{f}1m	Nearly level active alluvial flood plain (Marshy)	1.65	0.15
	AaA^{f}1mf	Nearly level active alluvial flood plain (Moist fallow)	8.74	0.79
	AaA^{f}1os	Nearly level active alluvial flood plain (Open scrub)	4.00	0.36
	AaA^{f}1p	Nearly level active alluvial flood plain (Plantation)	0.18	0.02
	AaA^{c}1c	Nearly level Char (Cropland)	0.22	0.02
	AaA^{c}1f	Nearly level Char (Fallow)	2.23	0.20
	AaA^{c}1os	Nearly level Char (Open scrub)	0.36	0.03
Wetlands	Wt	Wetlands	11.34	1.03
Misc.			**189.61**	**17.17**
Total			**1104.24**	**100.00**

Southern Region

Palani block of Dindigul District, Tamil Nadu

Palani block of Dindigul district, Tamil Nadu extends from 10° 20' 12" to 10° 32' 33" N latitudes and 77° 18' 22" to 77° 38' 6" E longitudes and covers an area of 399.6 km^2 under AESR 8.1. Seven landform units were identified in the block based on image interpretation of Sentinel-2 data and it was further divided into forty-two landscape ecological units based on six landform units, five slope classes and six landuses *viz*., forest, plantation, single crop, double-crop, fallow and open scrub (**Table 2.1.9**).

Table 2.1.9. Description of landscape ecological units (LEUs), Palani block, Dindigul district, Tamil Nadu

Broad landform	LEU*	Description
Foothills(FH)	DsFH3d	Gently sloping foothills (double-crop)
	DsFH3p	Gently sloping foothills (Plantation)
	DsFH3s	Gently sloping foothills (single crop)
	DsFH3os	Gently sloping foothills (open scrub)
Hill ranges(H)	DsH4p	Moderately sloping hilly terrain (plantation)
	DsH5f	Moderately steep sloping hilly terrain (forest)
Isolated hillock (Hi)	DsHi2os	Very gently sloping isolated hillock (open scrub)
	DsHi3os	Gently sloping isolated hillock (open scrub)
Lower Pediplain(LP)	DsLP1d	Nearly level lower pediplain (double-crop)
	DsLP1p	Nearly level lower pediplain (plantation)
	DsLP1s	Nearly level lower pediplain (single crop)
	DsLP1fa	Nearly level lower pediplain (fallow)
	DsLP2d	Very gently sloping lower pediplain (double-crop)
	DsLP2p	Very gently sloping lower pediplain (plantation)
	DsLP2s	Very gently sloping lower pediplain (single crop)
	DsLP2fa	Very gently sloping lower pediplain (fallow)
Upper Pediplain(UP)	DsUP1s	Nearly level upper pediplain (single crop)
	DsUP1fa	Nearly level upper pediplain (fallow)
	DsUP2d	Very gently sloping upper pediplain (double-crop)
	DsUP2p	Very gently sloping upper pediplain (plantation)
	DsUP2s	Very gently sloping upper pediplain (single crop)
	DsUP2fa	Very gently sloping upper pediplain (fallow)
	DsUP2os	Very gently sloping upper pediplain (open scrub)
	DsUP3d	Gently sloping upper pediplain (double-crop)
	DsUP3p	Gently sloping upper pediplain (plantation)
	DsUP3s	Gently sloping upper pediplain (single crop)
Valley floor(Vfl)	DsVfl1d	Nearly level valley floor (double-crop)
	DsVfl1p	Nearly level valley floor (plantation)
	DsVfl1s	Nearly level valley floor (single crop)
	DsVfl1fa	Nearly level valley floor (fallow)
Valley fringe(Vfr)	DsVfr1d	Nearly level valley fringe (double-crop)
	DsVfr1p	Nearly level valley fringe (plantation)

Broad landform	LEU*	Description
	DsVfr1s	Nearly level valley fringe (single crop)
	DsVfr1fa	Nearly level valley fringe (fallow)
	DsVfr2d	Very gently sloping valley fringe (double-crop)
	DsVfr2p	Very gently sloping valley fringe (plantation)
	DsVfr2s	Very gently sloping valley fringe (single crop)
	DsVfr2fa	Very gently sloping valley fringe (fallow)
	DsVfr3d	Gently sloping valley fringe (double-crop)
	DsVfr3p	Gently sloping valley fringe (plantation)
	DsVfr3s	Gently sloping valley fringe (single crop)
	DsVfr3fa	Gently sloping valley fringe (fallow)

**Ds : D Deccan plateau Physiographic region-s-South Deccan Plateau, Physiographic subregion*

Nedamangalam block of Thiruvarur district, Tamil Nadu

Needamangalam block of Thiruvarur district, Tamil Nadu lies between 10°34’15” to 10°48’34” N latitudes and 79°17’41” to 79°31’56” E longitudes and covers an area of 240.63 km^2 under AESR 18.2. The block is divided into five landform and twenty-five landscape ecological units based on landform, slope, and landuse (**Table 2.1.10**). The major land use is paddy, which is cultivated mostly on nearly level to very gently sloping lands.

Table 2.1.10.Description of Landscape Ecological Units, Needamangalam block of Thiruvarur district, Tamil Nadu

S.No.	LEU	Description
1	HwSsAP1s	Nearly level alluvial plain (single crop)
2	HwSsAP1d	Nearly level alluvial plain (double-crop)
3	HwSsAP1t	Nearly level alluvial plain (> 2 crops)
4	HwSsAP1p	Nearly level alluvial plain (plantation)
5	HwSsAP1f	Nearly level alluvial plain (fallow/ barren/ scrublands)
6	HwSsAP2s	Very gently sloping alluvial plain (single crop)
7	HwSsLD1s	Nearly level lower deltaic plain (single crop)
8	HwSsLD1d	Nearly level lower deltaic plain (double-crop)
9	HwSsLD1t	Nearly level lower deltaic plain (> 2 crops)
10	HwSsLD1f	Nearly level lower deltaic plain (fallow /barren/ scrublands)
11	HwSsNL2s	Very gently sloping natural levee lower deltaic plain (single crop)
12	HwSsNL2d	Very gently sloping natural levee lower deltaic plain (double-crop)
13	HwSsNL2t	Very gently sloping natural levee lower deltaic plain (> 2 crops)
14	HwSsNL2p	Very gently sloping natural levee lower deltaic plain (plantation)
15	HwSsNL2f	Very gently sloping natural levee lower deltaic plain (fallow/barren/scrublands)
16	HwSsPP2s	Very gently sloping pediplain canal command (single crop)
17	HwSsPP2d	Very gently sloping pediplain canal command (double-crop)
18	HwSsPP2t	Very gently sloping pediplain canal command (> 2 crops)
19	HwSsPP2p	Very gently sloping pediplain canal command (plantation)
20	HwSsPP2f	Very gently sloping pediplain canal command (fallow/barren/scrublands)
21	HwSsUP2s	Very gently sloping pediplain upland (single crop)
22	HwSsUP2d	Very gently sloping pediplain upland (double-crop)

S.No.	LEU	Description
23	HwSsUP2p	Very gently sloping pediplain upland (plantation)
24	HwSsUP2t	Very gently sloping pediplain upland (> 2 crops)
25	HwSsUP2f	Very gently sloping pediplain upland (fallow/barren/scrublands)

Rayachoty mandal, YSR Kadapa district, Andhra Pradesh

Six landforms were delineated in Rayachoty mandal (23,240.7 ha) based on the interpretation of Sentinel-2 data. Broadly, uplands cover 15167.14 ha (65.27 %), whereas, lowland/valleys cover 1601.4 ha (6.89 %). Land use/land cover study indicates that the 18.76 percent area is under double crops whereas single crop land occupies about 9803.51 ha (42.18 %) and plantations cover an area of 1613.8 ha (6.94 %).

Kaveripattinam block

Kaveripattinam block in Krishnagiri district of Tamil Nadu covers 30,553 ha.The area represents South Eastern Ghat, Semi arid hot (AESR 8.2) with length of growing period of 90-150 days. Based on the interpretation of satellite image seven distinct landforms *viz*. hills, foothills, upper pediplains, lower pediplains, valley fringes, and valley floors have been identified.

North Eastern Region

Changlang District, Arunachal Pradesh

The first phase of the LRI Arunachal Pradesh project was initiated from the Changlang district of Arunachal Pradesh. This district is located in the eastern-most part of the state and lies between 26°40’ and 27°40’N latitudes, and 95°11’ and 97°11’E longitudes. About 9.08% of the total geographic area (TGA) of Changlang district is under agricultural land, which includes the area under crops, shifting cultivation, and plantation crops (**Table 2.1.11**). Forest cover occupies the major share of the TGA (83.94%) of the district. The land use land cover statistics indicate the potential of agroforestry-based land-use systems and warrants the development of such systems in the district. Landform analysis indicates that 83.8 and 12% of the TGA of the district comes under hill and alluvial plain, respectively (**Table 2.1.12**). In total, 157 landscape ecological units have been identified in the districts (**Table 2.1.13**).

Table 2.1.11. Land use land cover statistics of Changlang district of Arunachal Pradesh

LULC Class	Area(ha)	% of TGA
Agriculture Cropland	23694.83	4.66
Agriculture, Plantation	12702.03	2.50
Barren/Unculturable/Wasteland, Scrubland	9691.46	1.91
Built up	2490.95	0.49
Char Land	918.74	0.18
Fallow land	3326.05	0.65
Forest	201586.15	39.68
Forest, Deciduous	21725.49	4.28
Homestead plantation	5656.94	1.11
Mixed Forest	5812.79	1.14
Reserve forest	197286.10	38.84
Sandbar	4051.88	0.80
Shifting cultivation (Abandoned Jhum)	1064.71	0.21
Shifting cultivation (Jhum)	3824.92	0.75
Snow Cover, Glacial	2954.10	0.58
Tea garden	4860.75	0.96
Terrace cultivation	108.65	0.02

LULC Class	Area(ha)	% of TGA
Water Bodies	6219.67	1.22
Total Area	507976.22	100.00

Table 2.1.12.Landform statistics of Changlang district of Arunachal Pradesh

Landform Class	Area(ha)	% of TGA
Active Flood Plain	2911.95	0.57
Older Flood Plain	20865.92	4.11
Younger Alluvial Plain	22163.38	4.36
Piedmont Alluvial Plain	15046.04	2.96
Piedmont	2323.24	0.46
Low altitudinal hills	64405.02	12.68
Moderate altitudinal hills	14277.47	2.81
Low hills	254724.95	50.15
Moderate hills	61544.25	12.12
High Hills	30921.94	6.09
Narrow Valleys	6206.24	1.22
Snow Cover,Glacial	2954.10	0.58
Sandbar	3412.05	0.67
Waterbodies	6219.67	1.22
Total Area	**507976.22**	**100.00**

Table 2.1.13. Description of LEUs of Changlang district, Arunachal Pradesh

LEU Class	Description
NaAaA1ag	Level to nearly level,Active Flood Plain of Brahmaputra Valleys (Agriculture Cropland)
NaAaA1fa	Level to nearly level,Active Flood Plain of Brahmaputra Valleys (Fallow land)
NaAaO1ag	Level to nearly level,Older Flood Plain of Brahmaputra Valleys (Agriculture Cropland)
NaAaO1fa	Level to nearly level,Older Flood Plain of Brahmaputra Valleys (Fallow land)
NaAaO1hp	Level to nearly level,Older Flood Plain of Brahmaputra Valleys (Homestead plantation)
NaAaO1p	Level to nearly level ,Older Flood Plain of Brahmaputra Valleys (Agriculture, Plantation)
NaAaO2mf	Very gently sloping ,Older Flood Plain of Brahmaputra Valleys (Mixed Forest)
NaAaO2T	Very gently sloping ,Older Flood Plain of Brahmaputra Valleys (Tea garden)
NaAaO3mf	Gently sloping ,Older Flood Plain of Brahmaputra Valleys (Mixed Forest)
NaAaO3T	Gently sloping ,Older Flood Plain of Brahmaputra Valleys (Tea garden)
NaAaP1fa	Level to nearly level ,Piedmont Alluvial Plain of Brahmaputra Valleys (Fallow land)
NaAaP2ag	Very gently sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Agriculture Crop land)
NaAaP2hp	Very gently sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Homestead plantation)
NaAaP2p	Very gently sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Agriculture, Plantation)
NaAaP3fa	Gently sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Fallow land)
NaAaP3mf	Gently sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Mixed Forest)
NaAaP3p	Gently sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Agriculture, Plantation)
NaAaP4fd	Moderately sloping,Piedmont Alluvial Plain of Brahmaputra Valleys (Forest,Deciduous)

LEU Class	Description
NaAaP4j	Moderately sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Shifting cultivation, Jhum)
NaAaP4mf	Moderately sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Mixed Forest)
NaAaP4p	Moderately sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Agriculture, Plantation)
NaAaP5fd	Moderately steeply sloping,Piedmont Alluvial Plain of Brahmaputra Valleys (Forest, Deciduous)
NaAaP5j	Moderately steeply sloping,Piedmont Alluvial Plain of Brahmaputra Valleys (Shifting cultivation, Jhum)
NaAaP5mf	Moderately steeply sloping,Piedmont Alluvial Plain of Brahmaputra Valleys (Mixed Forest)
NaAaP5p	Moderately steeply sloping,Piedmont Alluvial Plain of Brahmaputra Valleys (Agriculture, Plantation)
NaAaP6fd	Steeply sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Forest,Deciduous)
NaAaP6j	Steeply sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Shifting cultivation, Jhum)
NaAaP6mf	Steeply sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Mixed Forest)
NaAaP6p	Steeply sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Agriculture, Plantation)
NaAaP7fd	Very steeply sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Forest,Deciduous)
NaAaP7j	Very steeply sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Shifting cultivation, Jhum)
NaAaP8j	Strongly sloping ,Piedmont Alluvial Plain of Brahmaputra Valleys (Shifting cultivation, Jhum)
NaAaY1ag	Level to nearly level ,Younger Alluvial Plain of Brahmaputra Valleys (Agriculture Crop land)
NaAaY1f	Level to nearly level ,Younger Alluvial Plain of Brahmaputra Valleys (Forest)
NaAaY1fa	Level to nearly level ,Younger Alluvial Plain of Brahmaputra Valleys (Fallow land)
NaAaY2f	Very gently sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Forest)
NaAaY2hp	Very gently sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Homestead plantation)
NaAaY2mf	Very gently sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Mixed Forest)
NaAaY2p	Very gently sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Agriculture, Plantation)
NaAaY2T	Very gently sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Tea garden)
NaAaY3j	Gently sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Shifting cultivation, Jhum)
NaAaY3mf	Gently sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Mixed Forest)
NaAaY3p	Gently sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Agriculture, Plantation)
NaAaY3T	Gently sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Tea garden)
NaAaY4f	Moderately sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Forest)
NaAaY4j	Moderately sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Shifting cultivation, Jhum)
NaAaY4mf	Moderately sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Mixed Forest)
NaAaY4p	Moderately sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Agriculture, Plantation)
NaAaY4T	Moderately sloping ,Younger Alluvial Plain of Brahmaputra Valleys (Tea garden)
NaAaY5f	Moderately steeply sloping,Younger Alluvial Plain of Brahmaputra Valleys (Forest)
NaAaY5j	Moderately steeply sloping,Younger Alluvial Plain of Brahmaputra Valleys (Shifting cultivation, Jhum)
NaAaY5mf	Moderately steeply sloping, Younger Alluvial Plain of Brahmaputra Valleys (Mixed Forest)
NaAaY6j	Steeply sloping,Younger Alluvial Plain of Brahmaputra Valleys (Shifting cultivation, Jhum)
NcHl2hp	Very gently sloping, Low altitudinal hills of Purvanchal hill ranges (Homestead plantation)
NcHl3j	Gently sloping, Low altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHl3p	Gently sloping, Low altitudinal hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHl4j	Moderately sloping, Low altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)

LEU Class	Description
NcHl4p	Moderately sloping, Low altitudinal hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHl5f	Moderately steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Forest)
NcHl5j	Moderately steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHl5p	Moderately steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHl6f	Steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Forest)
NcHl6j	Steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHl6mf	Steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Mixed Forest)
NcHl6p	Steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHl6T	Steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Tea garden)
NcHl7f	Very steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Forest)
NcHl7j	Very steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHl7p	Very steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHl7T	Very steeply sloping, Low altitudinal hills of Purvanchal hill ranges (Tea garden)
NcHl8f	Strongly sloping, Low altitudinal hills of Purvanchal hill ranges (Forest)
NcHl8fd	Strongly sloping, Low altitudinal hills of Purvanchal hill ranges (Forest, Deciduous)
NcHl8j	Strongly sloping, Low altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHl8p	Strongly sloping, Low altitudinal hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHl9f	Very strongly sloping, Low altitudinal hills of Purvanchal hill ranges (Forest)
NcHl9j	Very strongly sloping, Low altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHl9p	Very strongly sloping, Low altitudinal hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHLh4j	Moderately sloping, Low hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHLh5j	Moderately steeply sloping, Low hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHLh5tc	Moderately steeply sloping, Low hills of Purvanchal hill ranges (Terrace cultivation)
NcHLh6f	Steeply sloping, Low hills of Purvanchal hill ranges (Forest)
NcHLh6j	Steeply sloping, Low hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHLh6p	Steeply sloping, Low hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHLh6tc	Steeply sloping, Low hills of Purvanchal hill ranges (Terrace cultivation)
NcHLh7f	Very steeply sloping, Low hills of Purvanchal hill ranges (Forest)
NcHLh7j	Very steeply sloping, Low hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHLh7p	Very steeply sloping, Low hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHLh7tc	Very steeply sloping, Low hills of Purvanchal hill ranges (Terrace cultivation)
NcHLh8f	Strongly sloping, Low hills of Purvanchal hill ranges (Forest)
NcHLh8j	Strongly sloping, Low hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHLh8p	Strongly sloping, Low hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHLh8tc	Strongly sloping, Low hills of Purvanchal hill ranges (Terrace cultivation)
NcHLh9f	Very strongly sloping, Low hills of Purvanchal hill ranges (Forest)
NcHLh9fd	Very strongly sloping, Low hills of Purvanchal hill ranges (Forest, Deciduous)
NcHLh9j	Very strongly sloping, Low hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHm6j	Steeply sloping, Moderate altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)

LEU Class	Description
NcHm6p	Steeply sloping, Moderate altitudinal hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHm6T	Steeply sloping, Moderate altitudinal hills of Purvanchal hill ranges (Tea garden)
NcHm6tc	Steeply sloping, Moderate altitudinal hills of Purvanchal hill ranges (Terrace cultivation)
NcHm7j	Very steeply sloping, Moderate altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHm7p	Very steeply sloping, Moderate altitudinal hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHm8f	Strongly sloping, Moderate altitudinal hills of Purvanchal hill ranges (Forest)
NcHm8j	Strongly sloping, Moderate altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHm8p	Strongly sloping, Moderate altitudinal hills of Purvanchal hill ranges (Agriculture, Plantation)
NcHm9j	Very strongly sloping, Moderate altitudinal hills of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHNv1ag	Level to nearly level,Narrow Valleys of Purvanchal hill ranges (Agriculture Cropland)
NcHNv1ag	Level to nearly level,Narrow Valleys of Purvanchal hill ranges (Agriculture Cropland)
NcHNv1f	Level to nearly level,Narrow Valleys of Purvanchal hill ranges (Forest)
NcHNv1f	Level to nearly level,Narrow Valleys of Purvanchal hill ranges (Forest)
NcHNv1j	Level to nearly level,Narrow Valleys of Purvanchal hill ranges (Shifting cultivation, Jhum)
NcHNv1mf	Level to nearly level,Narrow Valleys of Purvanchal hill ranges (Mixed Forest)
NcHNv1p	Level to nearly level,Narrow Valleys of Purvanchal hill ranges (Agriculture, Plantation)
NcHPi2ag	Very gently sloping,Piedmont of Purvanchal hill ranges (Agriculture Cropland)
NcHPi6p	Steeply sloping,Piedmont of Purvanchal hill ranges (Agriculture, Plantation)
NcHPi7f	Very steeply sloping,Piedmont of Purvanchal hill ranges (Forest)
NcHPi7w1	Very steeply sloping,Piedmont of Purvanchal hill ranges (Barren/Unculturable/Wasteland, Scrubland)
NdSrH9f	Very strongly sloping,High Hills of Eastern Himalayas ranges (Forest)
NdSrH9w1	Very strongly sloping,High Hills of Eastern Himalayas ranges (Barren/Unculturable/Wasteland, Scrubland)
NdSrl5j	Moderately steeply sloping, Low altitudinal hills of Eastern Himalayas ranges (Shifting cultivation, Jhum)
NdSrl5p	Moderately steeply sloping, Low altitudinal hills of Eastern Himalayas ranges (Agriculture, Plantation)
NdSrl6fd	Steeply sloping, Low altitudinal hills of Eastern Himalayas ranges (Forest, Deciduous)
NdSrl6j	Steeply sloping, Low altitudinal hills of Eastern Himalayas ranges (Shifting cultivation, Jhum)
NdSrl6p	Steeply sloping, Low altitudinal hills of Eastern Himalayas ranges (Agriculture, Plantation)
NdSrl7fd	Very steeply sloping, Low altitudinal hills of Eastern Himalayas ranges (Forest, Deciduous)
NdSrl7j	Very steeply sloping, Low altitudinal hills of Eastern Himalayas ranges (Shifting cultivation, Jhum)
NdSrl7p	Very steeply sloping, Low altitudinal hills of Eastern Himalayas ranges (Agriculture, Plantation)
NdSrl8fd	Strongly sloping, Low altitudinal hills of Eastern Himalayas ranges (Forest, Deciduous)
NdSrl8j	Strongly sloping, Low altitudinal hills of Eastern Himalayas ranges (Shifting cultivation, Jhum)
NdSrl8p	Strongly sloping, Low altitudinal hills of Eastern Himalayas ranges (Agriculture, Plantation)
NdSrl9j	Very strongly sloping, Low altitudinal hills of Eastern Himalayas ranges (Shifting cultivation, Jhum)
NdSrLh5p	Moderately steeply sloping, Low hills of Eastern Himalayas ranges (Agriculture, Plantation)
NdSrLh6j	Steeply sloping, Low hills of Eastern Himalayas ranges (Shifting cultivation, Jhum)
NdSrLh7f	Very steeply sloping, Low hills of Eastern Himalayas ranges (Forest)
NdSrLh7fd	Very steeply sloping, Low hills of Eastern Himalayas ranges (Forest, Deciduous)

LEU Class	Description
NdSrLh7j	Very steeply sloping, Low hills of Eastern Himalayas ranges (Shifting cultivation, Jhum)
NdSrLh7p	Very steeply sloping, Low hills of Eastern Himalayas ranges (Agriculture, Plantation)
NdSrLh8f	Strongly sloping, Low hills of Eastern Himalayas ranges (Forest)
NdSrLh8fd	Strongly sloping, Low hills of Eastern Himalayas ranges (Forest, Deciduous)
NdSrLh8j	Strongly sloping, Low hills of Eastern Himalayas ranges (Shifting cultivation, Jhum)
NdSrLh8p	Strongly sloping, Low hills of Eastern Himalayas ranges (Agriculture, Plantation)
NdSrLh9f	Very strongly sloping, Low hills of Eastern Himalayas ranges (Forest)
NdSrLh9w1	Very strongly sloping, Low hills of Eastern Himalayas ranges (Barren/Unculturable/Wasteland, Scrubland)
NdSrMh8f	Strongly sloping, Moderate hills of Eastern Himalayas ranges (Forest)
NdSrMh9f	Very strongly sloping, Moderate hills of Eastern Himalayas ranges (Forest)
NdSrMh9w1	Very strongly sloping, Moderate hills of Eastern Himalayas ranges (Barren/Unculturable/Wasteland, Scrubland)
NdSrNv1ag	Level to nearly level,Narrow Valleys of Eastern Himalayas ranges (Agriculture Cropland)
NdSrNv1f	Level to nearly level,Narrow Valleys of Eastern Himalayas ranges (Forest)
NdSrNv1hp	Level to nearly level,Narrow Valleys of Eastern Himalayas ranges (Homestead plantation)
NdSrNv1mf	Level to nearly level,Narrow Valleys of Eastern Himalayas ranges (Mixed Forest)
NdSrPi2ag	Very gently sloping,Piedmont of Eastern Himalayas ranges (Agriculture Cropland)
NdSrPi2hp	Very gently sloping,Piedmont of Eastern Himalayas ranges (Homestead plantation)
NdSrPi5p	Moderately steeply sloping, Piedmont of Eastern Himalayas ranges (Agriculture, Plantation)
NdSrPi6fd	Steeply sloping,Piedmont of Eastern Himalayas ranges (Forest,Deciduous)
NdSrPi6p	Steeply sloping,Piedmont of Eastern Himalayas ranges (Agriculture, Plantation)
NdSrPi7p	Very steeply sloping,Piedmont of Eastern Himalayas ranges (Agriculture, Plantation)

Kakodonga block of Golaghatdistrict, Assam

Kakodonga block is located at the northernmost part of the Golaghat district of Assam and is under the 15.4 agro-ecological sub-region (Upper Brahmaputra plain, warm to hot per humid eco sub-region). The block occupies an area of 11,800 hectares and is one of the traditional mulberry growing belts in the Golaghat district of Assam. Land resource inventory of the block at 1:10,000 scale has been undertaken to develop soil-site suitability criteria for mulberry cultivation. Appropriate delineation of suitable areas for mulberry cultivation would help in identifying priority areas, where, appropriate management to be taken for better production of the mulberry leaf to promote sericulture in the block and the district as well.

Ten land use land cover classes have been identified, in which, agricultural land occupies a major share (46.1%) of the total geographic area (TGA) of the block (**Table 2.1.14**). The area under homestead plantation and mulberry accounts for 21.3% share and tea gardens occupy a 14.9% share of the TGA of the block.

Table 2.1.14. Land use land cover statistics of Kakodonga block of Golaghat district, Assam

LULC Class	Area (ha)	% of TGA
Agricultural land	5435	46.1
Homestead plantation and mulberry	2515	21.3
Fallow land	1026	8.70

LULC Class	Area (ha)	% of TGA
Tea garden	1760	14.9
Other natural vegetation	74.0	0.60
Settlement	736	6.20
Grazing land	85.0	0.70
River	47.0	0.40
Water bodies	78.0	0.70
Point bars	44.0	0.40
Total area	**11800**	**100**

The agricultural land in the block is mostly mono-cropped and therefore appropriate land use planning is required for increasing the cropping intensity. Since mulberry is an agroforestry crop, agroforestry intervention may be useful in achieving higher cropping intensity. The data also indicates that 8.7% of the TGA of the block comes under fallow land which also requires a proper land-use plan.

Two distinct landform units, active and old flood plains occupying 31.0 and 69.0% of the TGA, respectively, have been delineated in the block).The major share of the study area comes under nearly level (0-1% slope) to very gently sloping (1-3% slope) topography. Landscape ecological unit (LEU) map depicts 13 units (**Table 2.1.15**).

The alluvial deposits of Brahmaputra river and its tributaries consists mainly of highly weathered material from adjoining hill regions of Arunachal Pradesh, Nagaland, and Assam. However, an admixture of unweathered rocks and partially weathered sediment composite are also part of the alluvium. Soils of the Kakodonga block in Golaghat district exhibit a considerable amount of shrink-swell activity (COLE values range from 0.12 – 0.14). The soil reaction is extremely to strongly acid (pH values range from 4.1 – 5.5). It is intriguing that shrink-swells activity is still a major factor in managing the soil properties considering the highly acidic reaction of these soils, and is a topic of investigation. It is also interesting that this region (Golaghat district of Assam) is known as the rice bowl of Assam, even though the presence of a considerable amount of smectitic minerals in these soils may have resulted in conditions favorable for higher productivity of rice in adjoining areas.

Table 2.1.15. Landscape ecological units of Kakodonga block of Golaghat district of Assam

Sl. No.	LEUs	Descriptions
1	NaAFP1ag	Nearly level active flood plains (agricultural crop)
2	NaAFP1fl	Nearly level active flood plains (fallow land)
3	NaAFP2p	Very gently sloping active flood plains (homestead plantation)
4	NaAFP3T	Gently sloping active flood plains (tea garden)
5	NaOFP1ag	Nearly level old alluvial plains (agricultural crop)
6	NaOFP1fl	Nearly level old alluvial plains (fallow land)
7	NaOFP1vg	Nearly level old alluvial plains (natural vegetation)
8	NaOFP2fl	Very gently sloping old alluvial plains (fallow land)
9	NaOFP2GL	Very gently sloping old alluvial plains (grazing land)
10	NaOFP2p	Very gently sloping old alluvial plains (homestead plantation)
11	NaOFP2vg	Very gently sloping old alluvial plains (natural vegetation)
12	NaOFP3T	Gently sloping old alluvial plains (tea garden)
13	NaOFP3vg	Gently sloping old alluvial plains (natural vegetation)

Machi block, Chandel district, Manipur

Machi block of Chandel district, Manipur lies between 24°37'58.72" and 24°25'22.27" N latitudes, and 94°00'42.59'' to 94°22'22.90'' E longitudes covering an area of 487.24 km^2. The study area comes under the Agro-ecological sub-region 17.2. The geology of the study area is sandstone and shale. The average annual rainfall is 2200 mm. The digital elevation model shows that the elevation of the block varies from 250 to 1750 m above MSL.

Twelve land use/ land cover classes were identified in the block. About 61.1% of the TGA is under forest, of which evergreen forest occupies 32.84 % followed by deciduous forest (16.92%) and scrub forest (11.37%). Scrubland occupies 28.06 percent of the study area, whereas agricultural land occupies 2.19 percent (**Table 2.1.16**).

Table 2.1.16. Land use/ land covers of Machi block, Chandel district, Manipur

Land use/ land covers	Area (ha)	% TGA
Agriculture, Cropland	1069	2.19
Barren land/ Scrubland	13671	28.06
Barren rocky	282	0.58
Forest, deciduous	8245	16.92
Forest, evergreen forest	16000	32.84
Forest, scrub forest	5542	11.37
Plantation	109	0.22
Shifting cultivation	3225	6.62
Terrace cultivation	108	0.22
Build up	295	0.60
Sand bar	69	0.15
Water bodies	110	0.23
Total	**48724**	**100.00**

Five distinct landform units were identified *viz.*, steeply sloping structural medium hills with the maximum area i.e. 34.2% of TGA, followed by very steeply sloping structural high hills (31.3% TGA), whereas, very strongly sloping ridge, moderately sloping structural low hills and gently sloping valley accounted for 17.7%, 11.9% and 4.7% of TGA, respectively (**Table 2.1.17**).

Table 2.1.17.Landforms of Machi block, Chandel district, Manipur

Landforms	Area (ha)	% TGA
Gently sloping valley	2271	4.7
Very strongly sloping ridge	8647	17.7
Very steeply sloping structural high hills	15237	31.3
Moderately sloping structural low hills	5786	11.9
Steeply sloping structural medium hills	16682	34.2
Water bodies	100	0.2
Total	**48724**	**100.0**

The study area comprises of 49 LEUs based on GIS overlay of land use/ land covers and slope classes on landforms (**Table 2.1.18**). The majority of LEUs are occupied by scrubland (11.77%) and evergreen forest (11.21%) in high altitude hills. This indicates that in the absence of sufficient vegetative cover, the soils could be more prone to erosion. Hence, appropriate interventions must be introduced to convert the scrublands to evergreen vegetation. Moreover, shifting cultivation has to be practiced more scientifically to fetch better results.

Table 2.1.18.Landscape Ecological Units of Machi block, Chandel district, Manipur

S. No	LEUs	Descriptions	Area (ha)	% of TGA
1	NcHhRg5f1	Steeply sloping ridges (Evergreen forest)	1593	3.27
2	NcHhRg5f2	Steeply sloping ridges (Deciduous forest)	1187	2.44
3	NcHhRg5f3	Steeply sloping ridges (Scrub forest)	529	1.09
4	NcHhRg5sc	Steeply sloping ridges (Shifting cultivation)	367	0.75
5	NcHhRg5w1	Steeply sloping ridges (Scrubland)	841	1.73
6	NcHhRg6f2	Very steeply sloping ridges (Deciduous forest)	956	1.96
7	NcHhRg6f3	Very steeply sloping ridges (Scrub forest)	786	1.61
8	NcHhRg6sc	Very steeply sloping ridges (Shifting cultivation)	430	0.88
9	NcHhRg6w1	Very steeply sloping ridges (Scrubland)	1759	3.61
10	NcHhRg6w2	Very steeply sloping ridges (Barren rocky)	106	0.22
11	NcHhShH4sc	Moderately steep sloping structural high hills (Shifting cultivation)	17	0.04
12	NcHhShH5f1	Steeply sloping structural high hills (Evergreen forest)	3048	6.26
13	NcHhShH5f2	Steeply sloping structural high hills (Deciduous forest)	2587	5.31
14	NcHhShH5f3	Steeply sloping structural high hills (Scrub forest)	1652	3.39
15	NcHhShH5P	Steeply sloping structural high hills (Plantation)	34	0.07
16	NcHhShH5sc	Steeply sloping structural high hills (Shifting cultivation)	910	1.87
17	NcHhShH5w1	Steeply sloping structural high hills (Scrubland)	3540	7.27
18	NcHhShH5w2	Steeply sloping structural high hills (Barren rocky)	94	0.19
19	NcHhShH6f2	Very steeply sloping structural high hills (Deciduous forest)	1138	2.33
20	NcHhShH6f3	Very steeply sloping structural high hills (Scrub forest)	636	1.31
21	NcHhShH6P	Very steeply sloping structural high hills (Plantation)	13	0.03
22	NcHhShH6sc	Very steeply sloping structural high hills (Shifting cultivation)	341	0.70
23	NcHhShH6w1	Very steeply sloping structural high hills (Scrubland)	1071	2.20
24	NcHhShH6w2	Very steeply sloping structural high hills (Barren rocky)	11	0.02
25	NcHhSmH3sc	Moderately slopping structural medium hills (Shifting cultivation)	12	0.02
26	NcHhSmH3tc	Moderately slopping structural medium hills (Terrace cultivation)	94	0.19
27	NcHhSmH3w1	Moderately slopping structural medium hills (Scrubland)	52	0.11
28	NcHhSmH3w2	Moderately slopping structural medium hills (Barren rocky)	29	0.06
29	NcHhSmH4P	Moderately steep slopping structural medium hills (Plantation)	16	0.03
30	NcHhSmH4sc	Moderately steep slopping structural medium hills (Shifting cultivation)	67	0.14
31	NcHhSmH4tc	Moderately steep slopping structural medium hills (Terrace cultivation)	9	0.02
32	NcHhSmH4w1	Moderately steep slopping structural medium hills (Scrubland)	53	0.11
33	NcHhSmH4w2	Moderately steep slopping structural medium hills (Barren rocky)	30	0.06
34	NcHhSmH5f1	Steeply sloping structural medium hills (Evergreen forest)	5461	11.21
35	NcHhSmH5f2	Steeply sloping structural medium hills (Deciduous forest)	1823	3.74

S. No	LEUs	Descriptions	Area (ha)	% of TGA
36	NcHhSmH5f3	Steeply sloping structural medium hills (Scrub forest)	1939	3.98
37	NcHhSmH5P	Steeply sloping structural medium hills (Plantation)	46	0.09
38	NcHhSmH5sc	Steeply sloping structural medium hills (Shifting cultivation)	767	1.57
39	NcHhSmH5tc	Steeply sloping structural medium hills (Terrace cultivation)	5	0.01
40	NcHhSmH5w1	Steeply sloping structural medium hills (Scrubland)	5736	11.77
41	NcHhSmH5w2	Steeply sloping structural medium hills (Barren rocky)	12	0.02
42	NcHhSmH6sc	Very steeply sloping structural medium hills (Shifting cultivation)	49	0.10
43	NcHhSmH6w1	Very steeply sloping structural medium hills (Scrubland)	469	0.96
44	NcHlSlH5f1	Steeply sloping structural low hills (Evergreen forest)	4714	9.68
45	NcHlSlH5f2	Steeply sloping structural low hills (Deciduous forest)	554	1.14
46	NcHlSlH5sc	Steeply sloping structural low hills (Shifting cultivation)	264	0.54
47	NcHlSlH6w1	Very steeply sloping structural low hills (Scrubland)	149	0.31
48	NcVbV1ag	Very gently sloping interhill valley (Agriculture)	1069	2.19
49	NcVbV1f1	Very gently sloping interhill valley (Evergreen forest)	1183	2.43
Miscellaneous area			474	0.97
Total			**48724**	**100.0**

****NcHh-**Northeastern ranges, eastern Himalayas,Purvanchal hills, High altitudinal hills
NcHl- Northeastern ranges, eastern Himalayas,Purvanchal hills, Low altitudinal hills
NcVb- North eastern ranges, eastern Himalayas,Purvanchal hills, Manipur Interhill Basin

Baska block, Baksa district, Assam

Baska block is located at the northern most part of Baksa district (an aspirational district) of Assam and stretches from 26°33'35.7" N to 26°47'20.16" N latitudes and 91°14'0.39" E to 91°25'32.83" E longitudes with an area of 290.47 km^2. The block falls under the AESR15.2 (Brahmaputra plain, hot humid eco sub-region) in the lower Brahmaputra valley zone. Paddy is the main crop and other crops include mustard, jute, potato, maize, lentil, and black gram. Important plantation crops are arecanut, coconut, banana, papaya, guava, mango, lemon and bamboo. The main cropping season for crops is *kharif* and cropping intensity is only 118%.

The base map of the block has been prepared by interpretation of satellite image, and 11 land use/ land cover classes have been identified, in which, agricultural land occupies a major share of the block (53.9% TGA) (**Table 2.1.19**). Homestead plantation (27.6%) and tea gardens (3.3%) also occupy a considerable share of the TGA of the block. Six distinct landform units have been delineated in the block and the majority of area (88.1%) is under younger alluvial plain area **(Table 2.1.20**). Four slope classes have been delineated in which 0-3% slope class occupies 64.1% of TGA followed by the 3-5% slope class (27.5% of TGA).

Table 2.1.19.Land use land cover statistics of Baska block of Baksa district, Assam

LULC Class	Area(ha)	Area % of TGA
Agriculture, Double Cropland	1960	6.7
Agriculture, Single Cropland	13708	47.2
Builtup	1021	3.5
Fallow land	746	2.6
Forest	1636	5.7

LULC Class	Area(ha)	Area % of TGA
Homestead plantation	8013	27.6
Plantation	358	1.2
Sand Bar	56	0.2
Tea garden	962	3.3
Unculturable/Wasteland, Scrubland	247	0.8
Wetlands/Water Bodies, River	341	1.2
Total area	**29047**	**100.0**

Table 2.1.20. Landform statistics of Baska block of Baksa district, Assam

Landform Class	Area(ha)	Area % of TGA
Active Flood Plain	450	1.6
Younger Alluvial Plain	25601	88.1
Undulating Upland	1019	3.5
Piedmont Alluvial Plain	1547	5.3
Highly Dissected Hills and Valleys	89	0.3
Wetlands/Water Bodies, River	341	1.2
Total area	**29047**	**100.0**

Northern Region

Bhimtal Block of Nainital district, Uttarakhand

Bhimtal block of Nainital district, Uttarakhand represents AESR 14.5. It comes under foothills of Kumaun Himalayas (subdued); warm humid/perhumid ESR with medium to deep, loamy tarai soils, covering 110.64 km^2 area of the district. Landform, slope, land use/land cover and land ecological unit maps have been prepared. There are 6 major landforms *viz.* lower-mid hillside slopes, middle hillside slopes, steep to moderately steep hillside slopes, steep to very steep hillside slopes, strongly to very strongly hillside slopes and valley. Four slope classes i.e. moderately, moderately steep, steep, and strongly sloping lands have been identified. The dominant land uses are agriculture (double-cropped), grazing *land*/pastures, degraded land, dense forest, medium forest, and thin forest.

After the intersection of land use/land cover, slope and landforms layers final landscape ecological units (LEU) map has been generated with 46 landscape ecological units (**Table 2.1.21**).

Table. 2.1.21. Landscape Ecological Units (LEU) of Bhimtal Block, Uttarakhand.

S.No.	Units	Description
1.	MIVf8g	Valley Land with Strongly Sloping Pasture/ Grazing Land.
2.	MIVf8ft	Valley Land with Strongly Sloping Thin Forest.
3.	MIVf8fm	Valley Land with Strongly Sloping Medium Forest.
4.	MIVf8d	Valley Land with Strongly Sloping Agriculture for Double-cropped area.
5.	MIVf8DL	Valley Land with Strongly Sloping Degraded Land.
6.	MIVf6ft	Valley Land with Steeply Sloping Thin Forest.
7.	MIVf6fm	Valley Land with Steeply Sloping Medium Forest.
8.	MIVf6d	Valley Land with Steeply Sloping Agriculture for Double-cropped area.

S.No.	Units	Description
9.	MIVf6DL	Valley Land with Steeply Sloping Degraded Land.
10.	MIVf5g	Valley Land with Moderately Steeply Sloping Pasture/ Grazing Land.
11.	MIVf5ft	Valley Land with Moderately Steeply Sloping Thin Forest.
12.	MIVf5fm	Valley Land with Moderately Steeply Sloping Medium forest.
13.	MIVf5d	Valley Land with Moderately Steeply Sloping Agriculture for Double-cropped area
14.	MIVf5DL	Valley Land with Moderately Steeply Sloping Degraded Land.
15.	MIVf4g	Valley Land with Moderately Sloping Pasture/ Grazing Land
16.	MIVf4ft	Valley Land with Moderately Sloping Thin Forest.
17.	MIVf4fm	Valley Land with Moderately Sloping Medium forest.
18.	MIVf4d	Valley Land with Moderately Sloping Agriculture for Double-cropped area.
19.	MIVf4DL	Valley Land with Moderately Sloping Degraded Land.
20.	MIVf6fd	Valley Land with Steeply Sloping Dense Forest.
21.	MIVf5fd	Valley Land with Moderately Steeping Sloping Dense Forest.
22.	MIVf4fd	Valley Land with Moderately Sloping Dense Forest.
23.	MIR8g	Side Slope with Strongly Sloping Pasture/ Grazing Land.
24.	MIR8ft	Side Slope with Strongly Sloping Thin Forest.
25.	MIR8fm	Side Slope with Strongly Sloping Medium forest.
26.	MIR8d	Side Slope with Strongly Sloping Agriculture for Double-cropped area.
27.	MIR8DL	Side Slope with Strongly Sloping Degraded Land.
28.	MIR6g	Side Slope with Steeply Sloping Pasture/ Grazing Land.
29.	MIR6ft	Side Slope with Steeply Sloping Thin Forest.
30.	MIR6fm	Side Slope with Steeply Sloping Medium forest.
31.	MIR6d	Side Slope with Steeply Sloping Agriculture for Double-cropped area.
32.	MIR6DL	Side Slope with Steeply Sloping Degraded Land.
33.	MIR5g	Side Slope with Moderately Steeping Sloping Pasture/ Grazing Land.
34.	MIR5ft	Side Slope with Moderately Steeping Sloping Thin Forest.
35.	MIR5fm	Side Slope with Moderately Steeping Sloping Medium forest.
36.	MIR5d	Side Slope with Moderately Steeping Sloping Agriculture for Double-cropped area.
37.	MIR5DL	Side Slope with Moderately Steeping Sloping Degraded Land.
38.	MIR4g	Side Slope with Moderately Sloping Pasture/ Grazing Land.
39.	MIR4ft	Side Slope with Moderately Sloping Thin Forest.
40.	MIR4fm	Side Slope with Moderately Sloping Medium forest.
41.	MIR4d	Side Slope with Moderately Sloping Agriculture for Double-cropped area.
42.	MIR4DL	Side Slope with Moderately Sloping Degraded Land.
43.	MIR8fd	Side Slope with Moderately Sloping Degraded Land.
44.	MIR6fd	Side Slope with Steeply Sloping Dense Forest.
45.	MIR5fd	Side Slope with Moderately Steeping Sloping Agriculture for Double-cropped area.
46.	MIR4fd	Side Slope with Moderately Sloping Agriculture for Double-cropped area.

Shahid Bhagat Singh Nagar district, Punjab

Shahid Bhagat Singh Nagar lies between 31°5′ and 31°15′ N latitudes and 75°45′ to 76°30′ E longitudes covering an area of 1.27 lakh ha. It is located in the north-eastern part of Punjab State. Some parts of the district are representative of the Himalayan (Shivalik hills and Kandi areas) and part of the district is located in Indo-Gangetic plains. Major area of the district falls in Punjab and Rohilkhand plains, hot, dry-sub-humid agro-ecological sub-region (AESR 9.1). Due to topographical and lithological variations, soil properties and productive capacities vary with landscape position in the district. Currently, the district is facing problems of soil erosion, poor fertility, flooding, drought, lack of irrigation facilities, deforestation, poor groundwater quality, selenium (Se) toxicity, and low farm productivity. The district is divided into five major landform units such as Shivalik Hills, piedmont plain, old alluvial plain, recent alluvial plain, and active flood plain. The landscape ecological units (LEU) map with 27 units has been generated by the integration of landforms, slope, and land use/land cover (**Table 2.1.22**).

Table 2.1.22. Landscape Ecological Units (LEU) of Shahid Bhagat Singh Nagar district, Punjab

Units	LEU code	LEU description
1.1	Ms6ft	Steeply sloping Shivalik Hills (Thin forest)
1.2	Ms4fm	Moderately sloping Shivalik Hills (Medium forest)
1.3	Ms3sb	Gently sloping Shivalik Hills (Shrubs)
1.4	Ms2g	Very gently sloping Ridges Shivalik Hills (Grass land)
2.11	AaPu4g	Moderately sloping Upper Piedmont (agroforestry)
2.12	AaPu3af	Gently sloping Upper Piedmont (agroforestry)
2.13	AaPu2a	Very gently sloping Upper Piedmont (agriculture)
2.14	AaPu1a	Level to nearly level Upper Piedmont (agriculture)
2.21	AaPl4af	Moderately sloping Lower Piedmont (agroforestry)
2.22	AaPl3a	Gently sloping Lower Piedmont (agriculture)
2.23	AaPl2a	Very gently sloping Lower Piedmont (agriculture)
3.11	AaOu3a	Gently sloping Upper old alluvial plain (agriculture)
3.12	AaOu2a	Very gently sloping Upper old alluvial plain (agriculture)
3.13	AaOu1a	Level to nearly level Upper old alluvial plain (agriculture)
3.21	AaOl3a	Gently sloping Lower old alluvial plain (agriculture)
3.22	AaOl2ag	Very gently sloping Lower old alluvial plain high GWT (agriculture)
3.23	AaOl2a	Very gently sloping Lower old alluvial plain (agriculture)
3.24	AaOl1a	Level to nearly level Lower old alluvial plain (agriculture)
4.11	AaYu3a	Gently sloping Upper old alluvial plain (agriculture)
4.12	AaYu2a	Very gently sloping Upper old alluvial plain (agriculture)
4.13	AaYu1a	Level to nearly level Upper old alluvial plain (agriculture)
4.21	AaYl3a	Gently sloping Lower recent flood plain (agriculture)
4.22	AaYl2a	Very gently sloping Lower recent flood plain (agriculture)
4.23	AaYl1a	Level to nearly level Lower recent flood plain (agriculture)
5.1	AaA3a	Gently sloping active flood plain (agriculture)
5.2	AaA2a	Very gently sloping active flood plain (agriculture)
5.3	AaA1a	Level to nearly level active flood plain (agriculture)

Sirsa District, Haryana

It is located between 29°14' to 30°00'N latitudes and 74°29' to 75°18' E longitudes covering an area of 4276 km^2. Sirsa district represents AESR 2.3 (Rajasthan Bagar, North Gujarat plain and South Western Punjab plain) hot typical arid eco sub-region. Four major landforms *viz*. recent alluvial plain susceptible to flooding, old alluvial plain, aeo-fluvial plain with reclaimed dune and aeolian plain with occasional dunes have been delineated. The interpretation of satellite data has been done and landscape ecological units (LEU) map has been prepared with a combination of broad landform, slope, and land use/ land cover maps on 1: 10,000 scale (**Table 2.1.23**). Field survey and soil correlation have been completed and 17 soil series have been identified in the whole district.

Table 2.1.23. Description of landscape ecological units of Sirsa district of Haryana

S.No.	LEU	Soil Series	Description
1.	AaYf1d	Sukhchain, Rattakhera, Rania and Mangla	Level to nearly level recent alluvial plain with susceptible to flooding (double-crop).
2.	AaYf1ah	Parts of some polygons of Sukhchain	Level to nearly level recent alluvial plain with susceptible to flooding (agro-horticulture).
3.	AaYf2d	Kelaniya	Very gently sloping recent alluvial plain with susceptible to flooding (double-crop).
4.	AaYc1d	Rampur Tehari	Level to nearly level recent alluvial plain with low-lying (double - crop).
5.	AaO1d	Khariyan, Mithri, Jalalana, Ganga, Hassu	Level to nearly level old alluvial plain (double-crop).
6.	AaO1ah	Parts of some polygons of Khariyan, Hassu	Level to nearly level l old alluvial plain (agro-horticulture).
7.	AaO2d	Ellanabad	Very gently sloping old alluvial plain (double-crop).
8.	AaOc2d	Kalanwali	Very gently sloping old alluvial plain with low-lying (double-crop).
9.	AaOc2ah	Parts of some polygons of Kalanwali	Very gently sloping old alluvial plain with low-lying (agro-horticulture).
10	AaOc1w/fa	Rori, Surtiya	Level to nearly level old alluvial plain with low-lying (wasteland/fallow land).
11.	AaEf RDS2d	Modiakhera,Roheranwali	Very gently sloping aeofluvial plain with reclaimed dunes (single crop).
12.	AaEf RDS2ah	Parts of some polygons of Modiakhera	Very gently sloping aeofluvial plain with reclaimed dunes (agro-horticulture).
13.	WbEDs2s	Chhatariyan	Very gently sloping Aeolian plain with occasional dunes and (single crop).
14.	WbEDs3fa/w	Umedpura	Gently sloping aeolian plain with occasional dunes (fallow land/ wasteland).

Central Region

Development of Digital Terrain Database and Landform Mapping using Geospatial Techniques

The landform and landscape ecological unit (LEU) maps of nine selected blocks, namely Darwha, Rahuri, and Parbhani in Maharashtra, Bemetara, and Jagdalpur in Chhattisgarh, Dhanora, Raisen, Tikamgarh and Datia in Madhya Pradesh states have been revised and finalized. IRS-P6 P6 LISS-IV (5.8 m) satellite data and SRTM DEM (30 m) digital terrain database have been used for slope analysis, landform delineation, and land use/land cover analysis. Landform analysis and mapping were done based upon the interpretation of high-resolution satellite data in conjunction with ancillary data to classify terrain types/features at the regional scale. Necessary field verifications have been carried out for validation of the delineated landforms in majority of the blocks. LEU's have been derived by superimposing physiography, broad landform, landform unit, slope, and land use/land cover themes in GIS for large scale land resource inventory.

Eleven landforms and 46 LEU's in Jagdalpur block of Jagdalpur district of Chhattisgarh, 9 landforms and 53 LEU's in Tikamgarh block of Tikamgarh district, Madhya Pradesh, 13 landforms and 48 LEU's in Parbhani block of Parbhani district, Maharashtra, 9 landforms and 53 LEU's in Rahuri block of Ahmednagar district, Maharashtra, 10 landforms and 63 LEU's in Raisen block of Raisen district, Madhya Pradesh, 10 landforms and 42 LEU's in Bemetra block of Bemetra district, Chhattisgarh, 9 landforms and 46 LEU's in Datia block of Datia district, Madhya Pradesh, 8 landforms and 80 LEU's in Darwha block of Yavatmal district, Maharashtra and 10 landforms and 63 LEU's in Dhanora block of Seoni district, Madhya Pradesh have been delineated (**Table 2.1.24**).

Table 2.1.24. List of completed blocks of central India

S.No.	AESR	Block	District	State	LEU's	Area (ha.)
1	Hot moist semi-arid (6.3)	Darwha	Yavatmal	Maharashtra	80	87221.0
2	Hot dry semi-arid (6.1)	Rahuri	Ahmednagar	Maharashtra	53	98783.8
3	Hot moist semi-arid (6.2)	Parbhani	Parbhani	Maharashtra	48	110993.6
4	Hot moist sub-humid (10.4)	Dhanora	Seoni	Madhya Pradesh	63	55473.6
5	Hot dry sub-humid (10.1)	Raisen	Raisen	Madhya Pradesh	63	130904.2
6	Hot dry sub-humid (10.3)	Tikamgarh	Tikamgarh	Madhya Pradesh	53	87458.9
7	Hot, moist semi-arid (4.4)	Datia	Datia	Madhya Pradesh	46	90839.4
8	Hot moist/dry sub-humid (11.0)	Bemetara	Bemetara	Chhattisgarh	42	73345.6
9	Hot moist sub-humid (12.1)	Jagdalpur	Bastar	Chhattisgarh	46	163358.3
Total						**898378.4**

Landform mapping of Aspirational districts of India

As per the directions of *NITI-Aayog,* Govt. of India, preparation of land use plan of 45 Aspirational districts in 4 states (Bihar, Jharkhand, Odisha and West Bengal) of Eastern Region has been undertaken. Landform analysis, soil database incorporation, land suitability evaluation for crops, and alternate Land use plan (LUP) with geo database have been completed. This includes 4 districts of West Bengal (Nadia, Murshidabad, Maldah, and Dakshin Dinajpur), 5 from Bihar (Araria, Begusarai, Katihar, Sitamarhi, and Sheikhpura), 2 from Odisha (Kalahandi and Rayagada) and 2 from Jharkhand (Pakur and Sahibganj). Additionally, landform analysis has been accomplished for 24 aspirational districts of eastern states (**Table 2.1.25**). Training on using LUP was imparted to state officials belonging to line departments of aspirational districts of Assam and Bihar.

Table 2.1.25. Accomplished landform analysis of Aspirational districts

S. No.	District	State	Total No. of Blocks	District Area (sq km)
1	Nadia	West Bengal	17	3927
2	Murshidabad	West Bengal	26	5324
3	Malda	West Bengal	15	3733
4	Dakshin Dinajpur	West Bengal	10	2178
5	Birbhum	West Bengal	20	4545
6	Pakur	Jharkhand	6	1811

S. No.	District	State	Total No. of Blocks	District Area (sq km)
7	Sahibgunj	Jharkhand	10	2063
8	Araria	Bihar	10	2830
9	Begusarai	Bihar	18	1918
10	Katihar	Bihar	16	3056
11	Sheikhpura	Bihar	6	689
12	Sitamarhi	Bihar	18	2294
13	Aurangabad	Bihar	12	3305
14	Gaya	Bihar	25	4976
15	Nawada	Bihar	14	2494
16	Jamui	Bihar	10	3098
17	Banka	Bihar	13	3020
18	Muzaffarpur	Bihar	17	3172
19	Purnia	Bihar	15	3229
20	Kalahandi	Odisha	14	7920
21	Rayagada	Odisha	15	7073
22	Koraput	Odisha	21	8807
23	Bolangir	Odisha	14	6575
24	Malkangiri	Odisha	11	4325
Total blocks			**353**	**92362**

Ahmednagar District, Maharashtra

Landform map of Ahmednagar block was generated using Sentinal-2A data and 11 landforms were delineated *viz*. table top, upper plateau, middle plateau, lower plateau, escarpment, upper pediments, lower pediments, upper valley, narrow valley, valley and mesa. Soil resource inventory was completed in Ahmadnagar, Akola, Sangamner, Kopargaon, Rahata, and Shrirampur, talukas of Ahmadnagar district, and a total of 38 tentative soil series were identified based on field correlation.

Wardha district, Maharashtra

Landform map of Wardha district consisting of 13 landforms *viz*., Dissected plateau, lower pediment, upper pediment, uplands, middle land, low land, valley, middle plateau, middle pediment, escarpment, lower pediment, lower plateau, and ravine was completed.

Gadchiroli district, Maharashtra

Gadchiroli district of Maharashtra state covers an area of 14042.98 km^2 and is characterized by diverse landforms namely valley, upland, plain, pediment, isolated hills, dissected hills, elongated ridges, degraded plateau, degraded pediment, hillocks, sand bar, and escarpment. About 31.3% of the TGA of the district is occupied by a valley, followed by a pediment, upland, dissected hill, degraded plateau and degraded pediment, plain and elongated ridges (**Table 2.1.26**).

Table 2.1.26. Landforms and their coverage in Gadchiroli district.

Class	Area (ha)	Percent of the total area
Degraded Pediment	75477.9	5.37
Degraded Plateau	96953.9	6.90
Dissected Hills	125433.8	8.93

Class	Area (ha)	Percent of the total area
Elongated Ridges	45297.6	3.23
Escarpment	9997.8	0.71
Hillock	8867.3	0.63
Isolated Hills	6205.6	0.44
Pediments	335876.5	23.90
Plain	48340.9	3.44
Sand bar	7420.7	0.53
Upland	179077.2	12.75
Valley	439538.1	31.30
Others	25810.8	1.84
Total	1404298.15	100.00

Land use/ land cover (LULC)

Mainly seven LULC classes (**Table 2.1.27**) were identified in the Gadchiroli district including double-crop, single crop, forest, sand bar, settlement, river, and water bodies. More than half of the TGA of the district is dominated by forest (56.8%), mostly distributed in the central, eastern, northern, and southern parts of the district. About 40.8 % of the district is occupied by single cropland in major part of the western and few patches in the southeastern and northern parts. The forest area is mainly associated with degraded pediment, degraded plateau, dissected hills, elongated ridges, escarpment, hillocks, isolated hills, and pediment.

Six slope classes *viz*. nearly level to level (0-1%), very gently sloping (1-3%), gently sloping (3-5%), moderately sloping (5-10%), moderately steeply sloping (10-15%) and steeply sloping (>15%) lands have been identified in the district. The landform, slope, and land use/land cover maps were integrated and landscape ecological unit maps with 260 LEU was generated.

Table 2.1.27. The extent of area under different land use/land cover classes

LULC classes	Area (ha)	Percent
Double crop	395.8	0.02
Forest	7,97,494.6	56.79
River	23,502.8	1.67
Sand bar	7,420.7	0.52
Settlement	1,719.5	0.12
Single crop	5,73,318.4	40.82
Water bodies	446.3	0.03
Total	14,04,298.2	100

Yavatmal district of Maharashtra

The district covers an area of 13582 km^2 (4.41% of the state). A total of 284 landscape ecological units (LEUs) consisting of very gently sloping alluvial plains, moderately sloping escarpment, hillocks, hills and ridges, intervening valleys, pediments, pediplains and plateaus representing upper Maharashtra basaltic landscape of Deccan plateau have been identified / delineated, an example of the same is given in **Table 2.1.28**.

Table 2.1.28. Description of Land Ecological Units of Yavatmal district, Maharashtra

LEU Code	LEU Symbol	Description
1	DuBaAp2Dc	Very gently sloping Alluvial plains (Double crop)

LEU Code	LEU Symbol	Description
2	DuBaAp2Df	Very gently sloping Alluvial plains (Degraded forest)
3	DuBaAp2Sc	Very gently sloping Alluvial plains (Single crop)
4	DuBaAp3Bl	Gently sloping Alluvial plains (Barren land)
5	DuBaAp3Dc	Gently sloping Alluvial plains (Double crop)
6	DuBaAp3Df	Gently sloping Alluvial plains (Degraded forest)
7	DuBaAp3F	Gently sloping Alluvial plains (Forest)
8	DuBaAp3Sc	Gently sloping Alluvial plains (Single crop)
9	DuBaAp3Sl	Gently sloping Alluvial plains (Scrubland)
10	DuBaAp3Wl	Gently sloping Alluvial plains (Wasteland)
11	DuBaAp4Dc	Moderately sloping Alluvial plains (Double crop)
12	DuBaAp4Df	Moderately sloping Alluvial plains (Degraded forest)
13	DuBaAp4Sc	Moderately sloping Alluvial plains (Single crop)
14	DuBaE3Bl	Gently sloping Escarpments (Barren land)
15	DuBaE3Df	Gently sloping Escarpments (Degraded forest)

Seloo and Samudrapur tehsils of Wardha district, Maharashtra

Seloo Taluka

Seloo taluka, Wardha district, Maharashtra lies between 20°41’22.9’’ to 21°02’10.0’’ N latitudes and 78°31’27’’ to 78°55’38’’E longitudes covering an area of 765.75 km^2. A total of 14 landforms were identified and delineated in the taluka. Land use/land cover analysis has been carried out and a Landscape Ecological Units (LEU) map of Seloo taluka has been generated (**Table 2.1.29**).

Table 2.1.29. Description of Land Ecological Units of Seloo tehsil, Wardha district, Maharashtra

LEU	Description
DsPL32	Gently sloping dissected plateau (Single Crop)
Esc63	Steeply sloping escarpment (Forest)
LoL32	Gently sloping lowlands (Single Crop)
LoL42	Moderately sloping lowlands (Single crop)
LoPL32	Gently sloping lower plateau (Single Crop)
LoPed31	Gently sloping lower pediment (Double Crop)
MidL31	Gently sloping midland (Double crop)
MidL32	Gently sloping midland (Single crop)
MidPL33	Gently sloping middle plateau (Forest)
NVl42	Moderately sloping narrow valley (Single Crop)
UpL32	Gently sloping upland (Sing Forest)
UpPL43	Moderately sloping upper plateau (Forest)
UpPed32	Gently sloping upper pediment (Single crop)
UpPed33	Gently sloping upper pediment (Barren land)
Vl41	Moderately sloping valley (Double crop)
Messa4	Moderately sloping mesa (Forest)

Samudrapur Taluka

Samudrapur taluka, Wardha district, Maharashtra lies between 20°25'38'' and 20°47'45'' N latitudes, and from 78°48'3'' to 79°13'22''E longitudes covering an area of 966.03 km^2. Using Sentinel data and field visits eight landforms were identified and delineated in the taluka. Land use/land cover analysis has been carried out and a Landscape Ecological Units (LEU) map of Samudrapur taluka has been generated. (**Table 2.1.30**).

Table 2.1.30. Description of landscape ecological units, Samudrapur Taluka, Wardha district, Maharashtra

LEU	Description
Esc63	Steeply sloping escarpment (Forest)
LoL22	Very gently sloping lowlands (Single Crop)
LoL32	Gently sloping lowlands (Single crop)
LoPL52	Moderately steep sloping lower plateau (Single Crop)
LoPL53	Moderately steep sloping lower plateau (forest)
Messa43	Moderately sloping mesa (Forest)
MidL22	Very gently sloping midland (Single crop)
MidL31	Gently sloping midland (Double crop)
MidL32	Gently sloping midland (Single crop)
UpL22	Very gently sloping upland (Sing Forest)
UpL32	Moderately sloping upland (Single crop)
UpL51	Moderately steep sloping upland (Double crop)
UpL51	Moderately steep sloping upland (Single crop)
UpL53	Moderately steep sloping upland (Barren land)
UpPed41	Moderately sloping upper pediment (Double crop)
UpPed42	Moderately sloping upper pediment (Single crop)
Vl21	Very gently sloping valley (Double crop)
Vl31	Gently sloping valley (Double crop)
Vl41	Moderately sloping valley (Double crop)
Vl41	Moderately sloping valley (Single crop)

Western Region

Churu district, Rajasthan

Churu in Rajasthan (27° 24' to 29°00' N latitudes and 73° 40' to 75° 41'' E longitudes, Area 13592 km^2) is the most desiccated district of Indian arid zone. Sandplains with varying heights (6 to 50 m) are common and thus the three major landforms, *viz*. partially stabilized high dunes, partially stabilized medium dunes and sandy arid plain, with 16 landscape ecological units were delineated (**Table 2.1.31**).

Table 2.1.31.Description of landscape ecological units, Churu district, Rajasthan

Broad landform	LEU	Description
Partially stabilized high dunes	WaDh2s	Very gently sloping partially stabilized high dunes (single cropped)
	WaDh3d	Gently sloping partially stabilized high dunes (double-cropped)
	WaDh3s	Gently sloping partially stabilized high dunes (single cropped)
	WaDh4o	Moderately sloping partially stabilized high dunes (open scrub)

Broad landform	LEU	Description
Partially stabilized medium dunes	WaDm2d	Very gently sloping partially stabilized medium dunes (double-cropped)
	WaDm2s	Very gently sloping partially stabilized medium dunes (single cropped)
	WaDm3d	Gently sloping partially stabilized medium dunes (double-cropped)
	WaDm3s	Gently sloping partially stabilized medium dunes (single cropped)
	waDm4o	Moderately slopping partially stabilized medium dunes (open scrub)
Sandy arid plain	WaSp2d	Very gently sloping sandy arid plain (double-cropped)
	WaSp2o	Very gently sloping sandy arid plain (open scrub)
	WaSp2s	Very gently sloping sandy arid plain (single cropped)
	WaSp3d	Gently sloping sandy arid plain (double-cropped)
	WaSp3o	Gently sloping sandy arid plain (open scrub)
	WaSp3s	Gently sloping sandy arid plain (single cropped)
	WaSp4o	Moderately sloping sandy arid plain (open scrub)

Bikaner district, Rajasthan

Soil survey was carried out in Bikaner district (27° 07' to 29° 04' N latitude and 71° 55' to 74° 13' E longitude, Area 29,000 km^2). Dunes, interdunes, and sandy arid plain are the major landforms in the district, and 10 LEUs were delineated (**Table 2.1.32**).

Table 2.1.32.Land Ecological Unit (LEU) of Bikaner district, Rajasthan

Physiographic region	Physiographic sub-region	Broad landform	LEU	Description
Western Plains	Sandy arid plain/ Marusthali	Interdune	WaDi1d	Nearly level interdune (double-cropped)
			WaDi2d	Very gently slopping interdune (double-cropped)
			WaDi3d	Gently slopping interdune (double-cropped)
			WaDi3s	Gently slopping interdune (single cropped)
		Dunes	WaDn3o	Gently sloping dunes (open scrub)
			WaDn4o	Moderately sloping dunes (open scrub)
		Sandy arid plain	WaSp2d	Very gently sloping sandy arid plain (double-cropped)
			WaSp2o	Very gently sloping sandy arid plain (open scrub)
			WaSp2s	Very gently sloping sandy arid plain (single cropped)
			WaSp3s	Gently sloping sandy arid plain (single cropped)

Land Degradation

Assessment of land degradation

A quick, robust, quantitative, and consistent method to identify and map degraded lands at a regional scale has been developed which utilizes coarse resolution MODIS NDVI time-series data as a proxy of land degradation based on the assumption that the degraded lands exhibit a consistently low NDVI in the time series. Though the data used are 16 days maximum value composites, it is affected by clouds, particularly in coastal and hill regions and during monsoon seasons. The methodology includes smoothing the time-series MODIS data and removing the cloud effects using Savitszky- Golay filter before the identification of permanently low productive areas. Land degradation maps were developed by this method, for the selected 27 Aspirational districts and uploaded in the BHOOMI Geoportal. Land degradation maps (rasters) for Bihar, Chhattisgarh, Nagaland, Jharkhand, and some parts of West Bengal have been completed.

Desertification and Land Degradation Vulnerability assessment

Desertification and land degradation (DLD), a function of both natural and human factors, are the most serious forms of environmental threat in India. The identification of the most vulnerable areas to DLD is important for devising strategies to arrest land degradation and desertification. A study was carried out to map the most sensitive areas for DLD in Andhra Pradesh using climate, soil, land use, and socio-economic factors. A map of DLD vulnerability index (**Fig.2.1.2**) was prepared and divided into five desertification and land degradation vulnerability classes namely very low, low, medium, high, and very high. The results indicate that 13% of the state is very highly vulnerable to DLD and 15% is highly vulnerable. This map helps to prioritize the lands for taking up combating plans and measures to arrest the DLD.

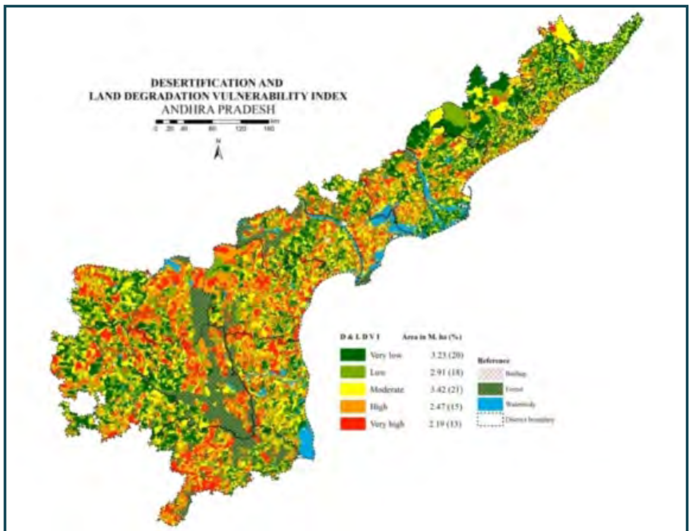


Fig.2.1.2.Desertification and Land Degradation vulnerability index of Andhra Pradesh

Soil erosion assessment and conservation planning in Dhanora block, Seoni district, M.P.

The study was undertaken in Dhanora block of Seoni district of Madhya Pradesh to estimate the potential runoff and soil erosion to identify the critical erosion-prone areas for prioritization using remote sensing and GIS techniques, and to plan and design site-specific suitable soil and water conservation measures. Suitable sites for various conservation measures like contour bund, graded bund, farm pond, vegetative barrier, and contour trench were identified based on landform, land use, slope, soil, and drainage network, and are presented in **figure 2.1.3**.

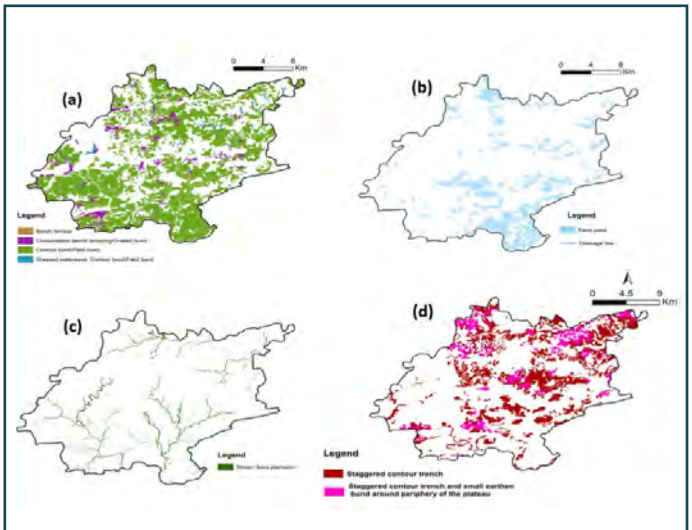


Fig.2.1.3. Suitable sites for various soil conservation measures, (a) grassed waterways, bund and bench terraces, (b) farm ponds, (c) stream bank plantation, and (d) staggered contour trench and small earthen bund around periphery of the plateau

Digital Soil Mapping

IndianSoilGrids project (Digital soil mapping of India)

The study was carried out to map the soil properties in parts of Koppal and Gadag districts of Northern Karnataka Plateau using the Quantile Random Forest Model (QRFM). High-resolution satellite imagery (Sentinal-2- 13 bands, Cartosat-2), terrain attributes such as elevation, slope, aspect, topographic wetness index, topographic position index, plan and profile curvature, multi-resolution index of valley bottom flatness and multi-resolution ridge top flatness, vegetation indexes like NDVI and EVI were used as covariates. The coefficient of determination (R^2), Mean error (ME) and root mean square error (RMSE) were calculated to assess model performance. Prediction interval coverage percentage (PICP) was calculated to evaluate the uncertainty of the prediction. Predicted CEC maps of the area along with uncertainty are shown in **figure 2.1.4**. The predicted soil properties were reliable with observed properties having minimum errors and the QRF model can capture maximum variability in the topsoil (upto 30 cm) as compared to the sub surface soil layers.

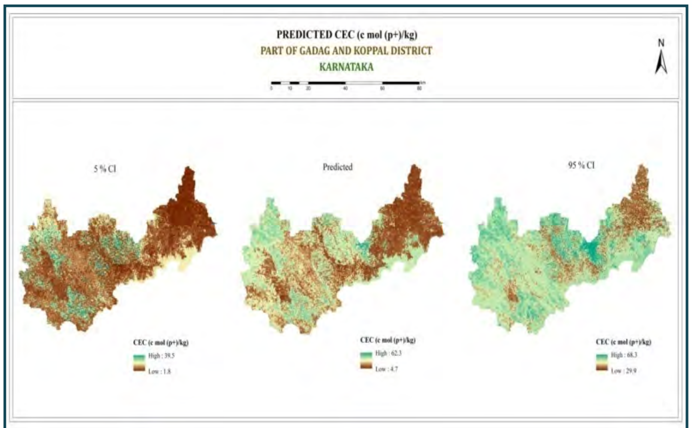


Fig.2.1.4.Predicted CEC (c mol (p+)/kg) in Koppal and Gadag districts

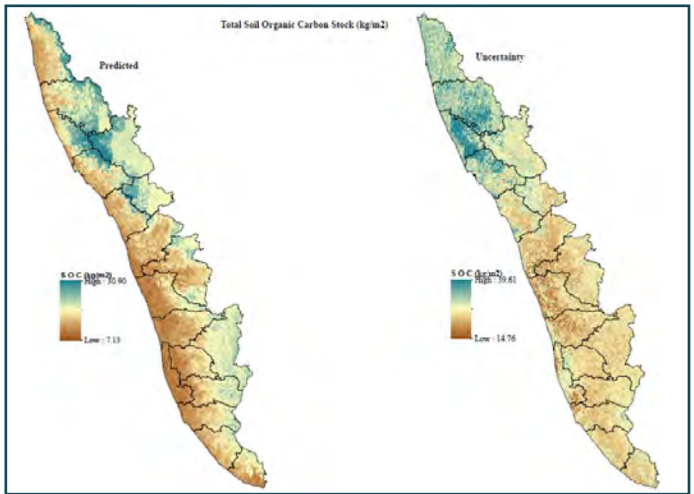


Fig.2.1.5.Predicted total SOC stock and uncertainty estimates (0-200 cm)

Digital mapping of soil organic carbon stocks in the Western Ghats

Spatial information on soil carbon storage at national and global levels is essential for soil quality and environmental management. A study was conducted to map the soil organic carbon (SOC) stock over 56763 km^2 of the Western Ghats of south India using digital soil mapping approach. Landsat data, terrain attributes such as elevation, slope, aspect, topographic wetness index, topographic position index, plan and profile curvature, multi-resolution index of valley bottom flatness, and multi-resolution ridge top flatness and bioclimatic variables were used as covariates. Equal-area quadratic splines were fitted to soil profile datasets to estimate soil organic carbon stock at six standard soil depths (0-5, 5-15, 15-30,30-60, 60-100, and 100-200 cm) and Quantile Regression Forest (QRF) algorithm was used to predict the SOC stocks. The coefficient of determination (R^2), mean error (ME) and root mean square error (RMSE) and prediction interval coverage percentage (PICP) were calculated to assess model performance (**Table 2.1.33**). The QRF model captured maximum variability for the prediction of SOC in different soil depths. Prediction of SOC stock was better for the surface layer (R^2=31-43%) than the sub-surface soil layers (R^2=7-21%). The predicted total soil organic carbon stock in the Western Ghats ranged from 7.1 to 30.9 kg/m^2 and the total estimated SOC was 917 Tg. The present high-resolution SOC map (**Fig.2.1.5**) is expected to help in assessing and monitoring the soil health for proper land use planning.

Table 2.1.33. Performance of Quantile Regression Forest model for prediction of SOC

		Mean error	RMSE	R^2(%)	PICP
SOC	0-5 cm	0.02± 0.01	0.4± 0.01	43± 2	90± 0.9
	5-15 cm	0.04± 0.01	0.8± 0.01	43± 1	90 ±1.1
	15-30 cm	0.04± 0.01	1.0± 0.01	31± 2	90± 0.9
	30-60cm	0.07± 0.02	1.5± 0.02	21± 2	90± 0.8
	60-100 cm	0.20± 0.01	1.4± 0.02	12± 3	88± 1.2
	100-200cm	0.66± 0.03	3.0± 0.03	7± 2	88± 1.0

Application of Hyperspectral remote sensing data in soils

Hyperspectral studies on soils of Katol-Sausar area

Under the DST sponsored project on "Hyperspectral remote sensing for characterization and mapping of red and associated soils of Southern India" two sites *viz*. Sausar (Site No 203) and Katol (Site No, 221) were selected to study the applicability of AVIRIS-NG data in characterization and mapping of soils. Synchronizing with the date of flight, soil sampling and

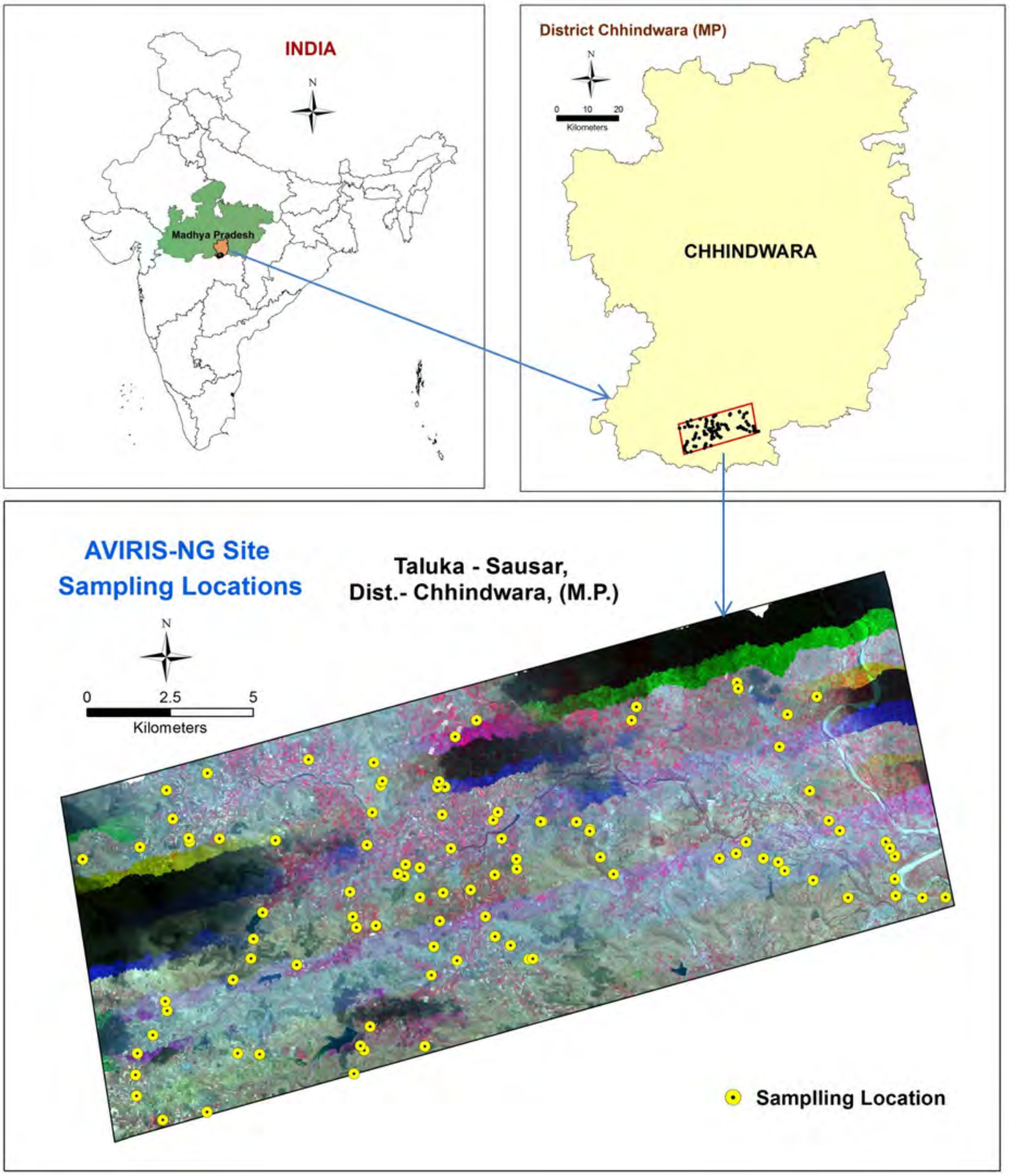


Fig- 2.1.6. AVIRIS-NG of Sausar site

ground spectral data collection were done at these sites jointly by ICAR-NBSS&LUP, Nagpur, and ICAR-IARI, New Delhi. The point locations of the sampling sites and the image of AVIRIS-NG of Sausar site (site no. 203) are depicted in **figure 2.1.6**. A total of 256 surface soil samples were collected of which134 samples were from Sausar and 122 samples, from Katol site, andwere analyzed for pH, EC, organic carbon and other soil properties. The reflectance spectra (350-2500 nm region) of soil samples were also measured in the laboratory. Descriptive statistics of the soil properties of Katol- Sausar site is given in **table 2.1.34**.

Table 2.1.34. Descriptive statistics of soil properties

Parameter	Min.	Max.	Mean	Std. Deviation	CV (%)	10th percentile	50th percentile	75th percentile
pH	5.5	8.5	7.4	0.6	8.7	6.4	7.5	8.0
EC(dS/m)	0.0	1.1	0.2	0.1	59.1	0.1	0.2	0.2
OC(%)	0.1	1.6	0.7	0.3	38.1	0.4	0.7	0.9
P(kg/ha)	1.0	272.0	21.0	23.3	111.2	5.0	15.0	24.0
K(kg/ha)	57.0	1792.0	531.7	358.7	67.5	147.8	438.0	764.0
S(ppm)	1.6	68.3	15.1	10.7	70.9	5.0	11.9	19.2
B(ppm)	0.0	1.3	0.5	0.3	51.4	0.1	0.5	0.7
Cu(ppm)	0.4	15.1	3.7	2.5	67.4	1.5	3.1	4.5
Fe(ppm)	0.4	51.9	8.3	9.0	108.3	1.7	4.4	10.4
Mn(ppm)	0.5	236.7	20.3	27.6	136.3	1.6	10.7	24.0
Zn(ppm)	0.0	2.2	0.5	0.4	69.4	0.1	0.5	0.7
CEC (me/100 g)	10.3	85.0	45.7	12.1	26.5	29.6	46.7	55.4
Exch.Ca (me/100 g)	8.7	77.4	39.1	14.1	36.1	19.7	39.9	50.0
Exch.Mg (me/100 g)	1.5	32.3	9.2	3.7	40.2	4.9	9.0	11.2
Exch.K (me/100 g)	0.1	2.2	0.7	0.4	56.3	0.2	0.6	1.0
Exch.Na (me/100 g)	0.0	1.8	0.3	0.2	92.0	0.1	0.2	0.3
Sum	11.3	87.4	49.2	15.1	30.7	28.8	49.0	60.4
BS (%)	72.0	197.2	109.1	25.9	23.8	81.3	103.9	123.6
ESP	0.0	3.1	0.6	0.5	86.6	0.2	0.4	0.7

Soil spectral data modeling: For spectral data modeling, the dataset of Sausar and Katol sites were pooled together and randomly divided into two sets,*viz*. calibration (2/3 samples) and validation (1/3 samples) datasets. The integrated spectral data were then subjected to Savitzky-Golay 1st derivative using 2nd order polynomial transformations. Soil properties of the calibration datasets were calibrated to 1stderivative soil reflectance data using PLSR (Partial Least Square Regression) technique and validated on the independent validation datasets. The scatter plots of measured and predicted values of studied properties are shown in **figure 2.1.7**. Statistical parameters of the spectral models are given in **table 2.1.35**.

Table 2.1.35. Results of Spectral data modeling for prediction of soil properties using PLSR technique (Sausar-Katol AVIRIS-NG site)

Soil Properties	Calibration set						Validation set					
	No	Mean	Std. Dev.	R-square	RMSEC	PLSR-Factor	No	Mean	Std. Dev.	R-square	RMSEP	RPD
SOC (g/kg)	154	2.61	0.53	0.75	0.27	9	74	2.59	0.56	0.69	0.3	1.9
pH	182	7.42	0.64	0.65	0.37	6	92	7.36	0.65	0.67	0.37	1.8
EC (mS/m)	147	4.45	1.06	0.62	0.66	10	74	4.48	1.12	0.67	0.64	1.8
CEC (meq/100g)	185	46.12	10.78	0.80	4.77	8	93	46.00	13.44	0.80	6	2.2

Note: Square root transformation was applied to SOC and EC

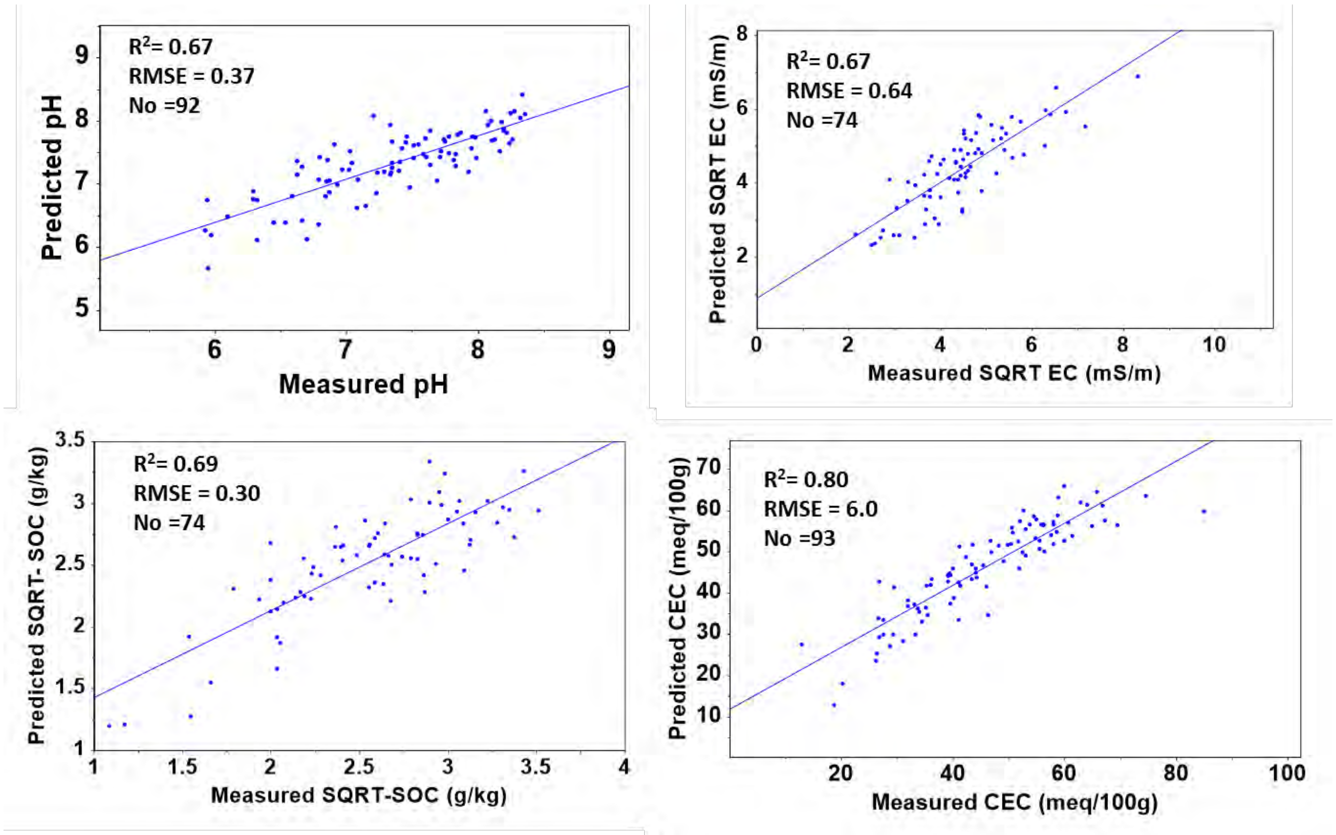


Fig.2.1.7. Scatter plots of measured and predicted values of soil properties in Sausar and Katol soil samples in the validation datasets

Soil Spectral library of Goa state

A total of 1764 soil samples were analyzed and spectral measurements were carried out across VIS-NIR to FTIR range. Hyperspectral library for the soils of Goa (**Fig.2.1.8**) was developed using ENVI software. Android-based mobile app, "Hyoid" was also developed as a novel attempt that will act as a user interactive geo-smart hyperspectral soil information system.

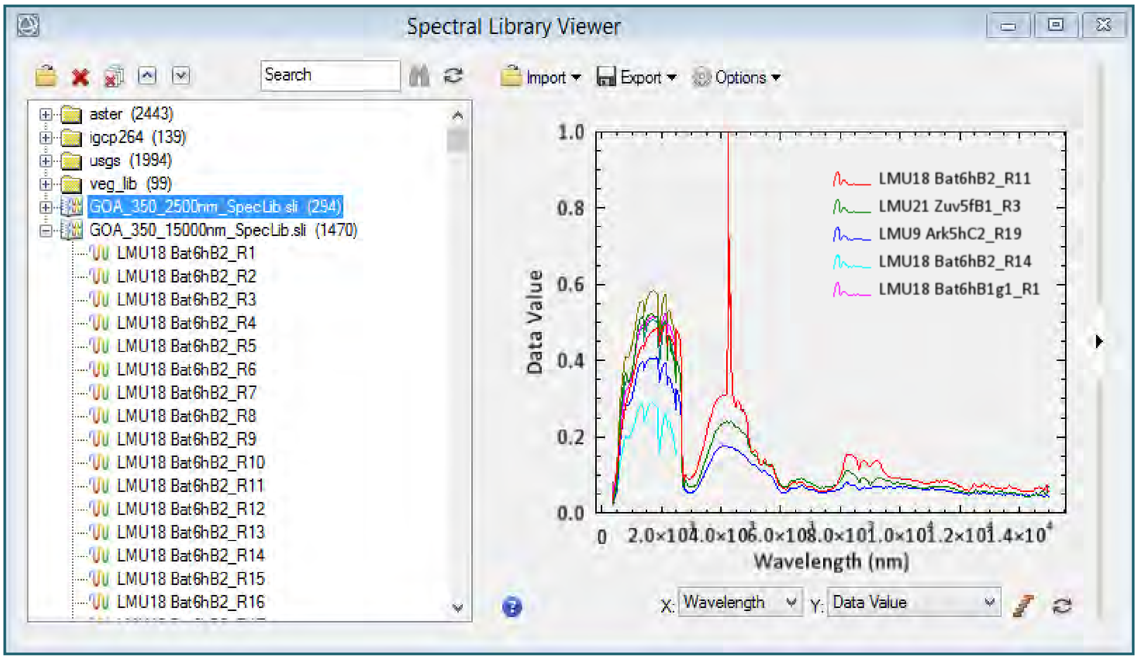


Fig.2.1.8. Hyperspectral library of soils of Goa

2.2 Inventorying Natural Resources

Land Resource Inventory
Eastern Region
Block-level
Motihari block, East Champaran district, Bihar

In Motihari block of East Champaran district, Bihar, eight soil series were tentatively identified and mapped into 10 soil mapping units as phases of series. *Entisols* predominate in the block followed by *Inceptisols* and the soils are calcareous.The descriptive legend of soil series along with LEU is presented in **table 2.2.1**. In the block, 4 land management units were obtained (**Fig.2.2.1; Table 2.2.2**).

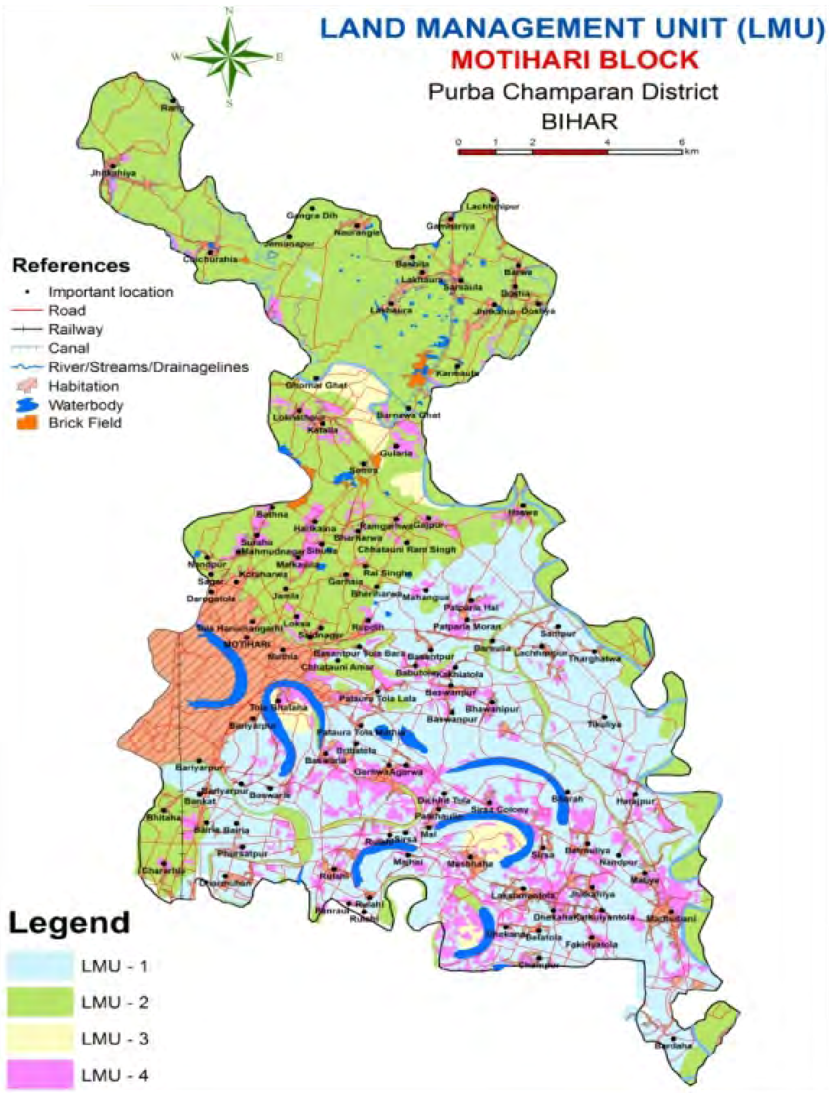


Fig.2.2.1. LMU map of Motihari block, East Champaran district, Bihar

Table 2.2.1. Soil-LEU relationship of Motihari block

LEU	Soil series	Phases	Brief description	Area (ha)	% of TGA
A^{m}2d	Madhubani - 1	Mod-16eB1	Very deep, somewhat poorly drained, coarse-silty soils on very gently sloping meander alluvial plain with silt loam surface texture, calcareous and slight erosion. (*Coarse-silty, mixed, hyperthermic (cal), Aquic Ustifluvents*).	4997	21.2

LEU	Soil series	Phases	Brief description	Area (ha)	% of TGA
$A^{m1}p$ $A^{m2}p$ $A^{p2}p$	Madhubani - 2	Mod-26eB1	Very deep, somewhat poorly drained, coarse-silty soils on very gently sloping meander alluvial plain with silt loam surface texture, calcareous and slight erosion. (*Coarse-silty, mixed, hyperthermic (cal), Typic Haplustalfs*).	1691	7.2
Y2p Y1p	Madhubani - 2	Mod-26gB1	Very deep, somewhat poorly drained, coarse-silty soils on very gently sloping meander alluvial plain with silty clay loam surface texture, calcareous and slight erosion. (*Coarse-silty, mixed, hyperthermic (cal), Typic Haplustalfs*).	466	1.9
$A^{m1}d$	Basmanpur	Bas6eA1	Very deep, somewhat poorly drained, coarse-silty soils on nearly level meander alluvial plain with silt loam surface texture, calcareous and slight erosion. (*Coarse-silty, mixed, hyperthermic (cal), Typic Endoaquents).*	3126	13.3
Y1d	Jhitkahiya	Jhi6eA1	Very deep, somewhat poorly drained, fine-silty soils on a nearly level young alluvial plain with silt loam surface texture, calcareous and slight erosion. (*Fine-silty, mixed, hyperthermic (cal), Fluventic Endoaquepts).*	2884	12.2
Y1s	Jhitkahiya	Jhi6gA1	Very deep, somewhat poorly drained, fine-silty soils on a nearly level young alluvial plain with silty clay loam surface texture, calcareous and slight erosion. (*Fine-silty, mixed, hyperthermic (cal), Fluventic Endoaquepts).*	221	0.9
$A^{f}1d$	Kataha	Kat6eA1	Very deep, moderately well-drained, fine-silty soils on nearly level flood plain with silt loam surface texture, calcareous, and slight erosion. (*Fine-silty (cal), mixed, hyperthermic (cal), Fluventicv Haplustalfs).*	330	1.4
$A^{f}1s$ $A^{m}1s$ $A^{m}2s$ $A^{c}1fa$	Harajpur	Har6eA1	Very deep, somewhat poorly drained, fine-silty soils on nearly level flood plain with silt loam surface texture, calcareous and slight erosion. (*Fine-silty, mixed, hyperthermic (cal), Typic Ustorthents).*	1618	6.9
Y2s Y2d	Barwa	Bar6eB1	Very deep, somewhat poorly drained, fine-silty soils on very gently sloping flood plain with silt loam surface texture, calcareous and slight erosion. *(Coarse-silty, mixed, hyperthermic (cal), Typic Haplustepts).*	4309	18.3
$A^{p}2d$	Sirsamal	Sir6dB1	Very deep, well-drained, coarse-loamy soils on very gently sloping point bar with loam surface texture, calcareous and slight erosion. *(Coarse-loamy, mixed, hyperthermic (cal), Aquic Ustorthents).*	251	1.1
Misc.				**3684**	**15.6**
Study Area				**23577**	**100.0**

Abbreviations: A-Indogangetic plain; Aa-Alluvial plain; Y-Young alluvial plain; A^{m}-Active alluvial plain (Meander); A^{f}- Active alluvial plain (Flood plain); A^{c}-Active alluvial plain (Char land); A^{p}-Active alluvial plain (Point bar); 1-nearly level (0-1%); 2-Very gently sloping (1-3%); p-Plantation, d-Double crop; s-Single crop

Table 2.2.2. Land management units of Motihari block, East Champaran district (Bihar)

LMU	Description	% of TGA
1	Very deep, somewhat poorly drained, silt loam soils on nearly level to very gently sloping meander alluvial plains under paddy-wheat-maize and sugarcane/ vegetables based cropping systems.	34.45
2	Very deep, moderately well to somewhat poorly drained, silt loam soils on nearly level young alluvial plains to flood plain under paddy-wheat and fallow-wheat, maize-lentil based cropping systems.	38.32
3	Very deep, moderately well to well-drained, silt loam to loam soils on nearly level flood plain to very gently sloping point bar under fallow-wheat-maize and sugarcane-based cultivation.	2.46
4	Very deep, well-drained, silt loam soils on very gently sloping meander alluvial plain under plantation of horticultural crops.	9.15
Miscellaneous		**15.62**
Total		**100.00**

Santipur Block, Nadia district, West Bengal

Santipur block of Nadia district of West Bengal extends from 88°19’32’’ to 88°31’52’’ E and 23°11’23’’ to 23°19’54’’ N in the AESR 15.1 (Bengal and Assam plains, hot, moist sub-humid eco-sub region with LGP of 210-240 days), covering a total geographic area of 19,400 hectares.

Seven soil series with 10 phases were mapped from 10 landscape ecological units (LEUs) in the block (**Table 2.2.3)** and 5 land management units (LMU) were carved out (**Fig.2.2.2; Table 2.2.4**).

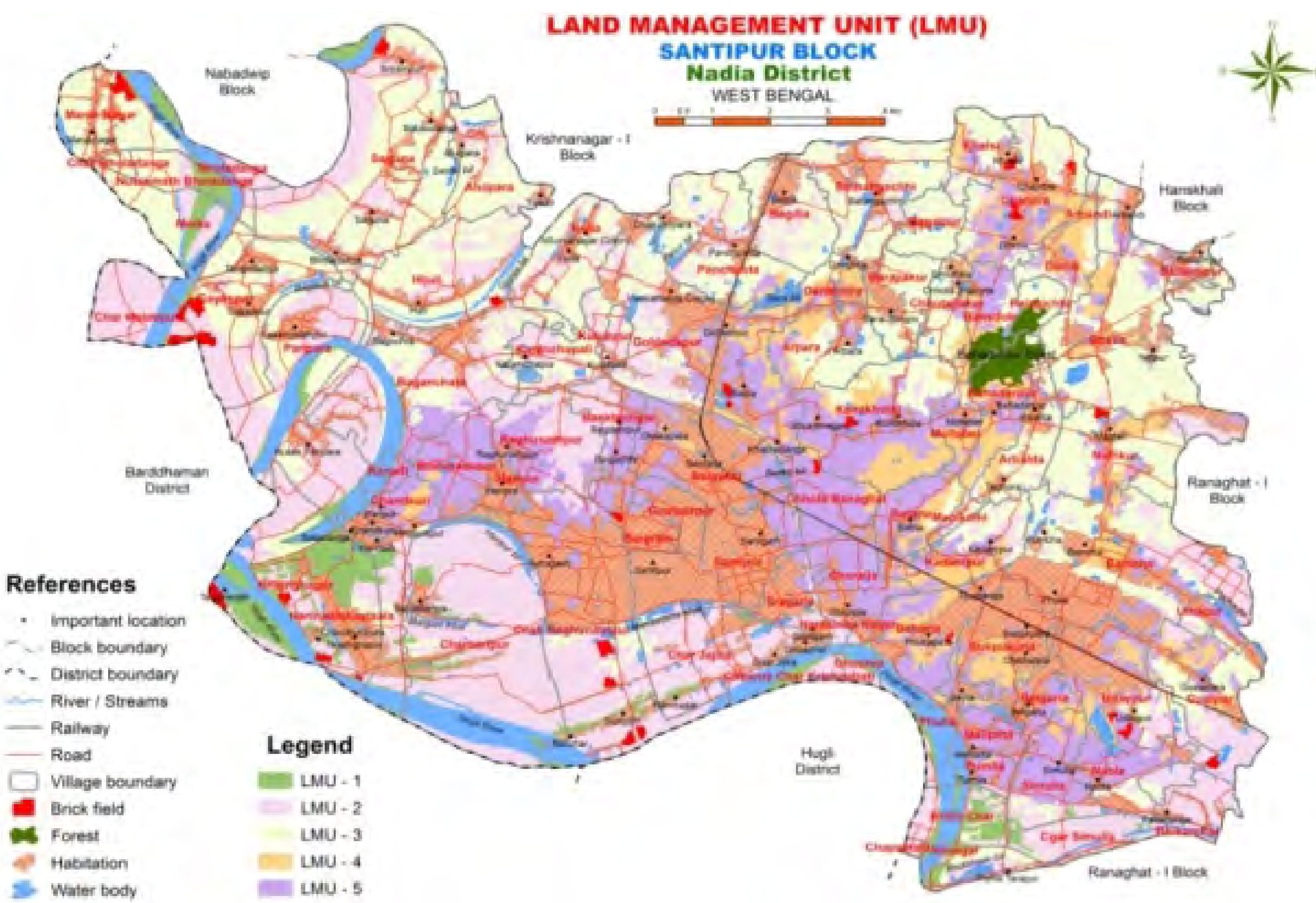


Fig.2.2.2. LMU map of Santipur block, Nadia district, West Bengal

Table 2.2.3. Soil-LEU Relationship in Santipur block

LEU	Soil Series	Phases	Brief descriptions of Soil Series	Area (ha)	% of TGA
AaA^c1fa	Brittirchar	Btc6eA1f3	Very deep, well-drained, neutral to slightly alkaline, calcareous, coarse silty soils with silt loam surface occurring on nearly level active flood plains with slight erosion and severe flooding erosions. *(Coarse silty, mixed, hyperthermic, calcareous, Typic Ustifluvents)*	271	1.4
AaA^f1fa		Btc6gA1f3	Very deep, well-drained, neutral to slightly alkaline, calcareous, coarse silty soils with silty clay loam surface occurring on nearly level active flood plains with slight erosion and severe flooding erosions. *(Coarse silty, mixed, hyperthermic, calcareous, Typic Ustifluvents)*	39	0.2
AaA^f1p		Btc6kA1f3	Very deep, well-drained, neutral to slightly alkaline, calcareous, coarse silty soils with silty clay surface occurring on nearly level active flood plains with severe flooding erosions. *(Coarse silty, mixed, hyperthermic calcareous, Typic Ustifluvents)*	324	1.7
AaA^f1s	Gayeshpur	Gsp6gA1f2	Very deep, imperfectly drained, neutral to slightly alkaline, calcareous, fine silty soils with silty clay loam surface occurring on nearly level active flood plains with slight erosion and moderate flooding erosions. *(Fine silty, mixed, hyperthermic calcareous, Typic Endoaquepts)*	2899	14.8
AaA^f1d	Panchpota	Ppt6gA1f2	Very deep, moderately well-drained, slightly to moderately alkaline, fine loamy soils with silty clay loam surface occurring on nearly level active flood plains with slight erosion and moderate flooding erosions. *(Fine-loamy, mixed, hyperthermic calcareous, Fluventic Haplustepts)*	775	4.0
AaY1d	Saguna	Sgn6gA1	Very deep, imperfectly drained, slightly acidic surface to neutral, fine loamy soils with silty clay loam surface occurring on very gently sloping young alluvial plains with slight erosion. *(Fine loamy, mixed, hyperthermic Aeric Endoaquepts)*	4281	22.1
AaY1p	Bagalpur	Bgp6kA1f1	Very deep, moderately well-drained, neutral to moderately alkaline, calcareous, fine silty soils with silty clay surface occurring on nearly level young alluvial plains with slight erosion and slight flooding erosions. *(Fine-silty, mixed, hyperthermic calcareous, Typic Haplustepts)*	1678	8.7
AaO2d	Ballavpur	Blp6dB1	Very deep, imperfectly drained, neutral to slightly alkaline, fine soils with loamy surface occurring on very gently sloping old alluvial plains with slight erosion. *(Fine, mixed, hyperthermic Typic Endoaqualfs)*	1182	6.1
AaO2os	Arbalda	Arb6hB1	Very deep, imperfectly drained, neutral to slightly alkaline, calcareous, fine loamy soils with sandy clay loam surface occurring on very gently sloping old alluvial plains with slight erosion. *(Fine loamy, mixed, hyperthermic calcareous, Typic Endoaquepts)*	20	0.1
AaO2p		Arb6gB1	Very deep, imperfectly drained, neutral to slightly alkaline, calcareous, fine loamy soils with silty clay loam surface occurring on very gently sloping old alluvial plains with slight erosion. *(Fine loamy, mixed, hyperthermic calcareous, Typic Endoaquepts)*	2598	13.4
Misc.				**5333**	**27.5**
Block Area				**19400**	**100.0**

Abbreviations: A-Indogangetic plain; Aa-Alluvial plain; Y-Young alluvial plain; O^m-Old alluvial plain (Meander); A^m-Active alluvial plain (Meander); A^f- Active alluvial plain (Flood plain); A^c-Active alluvial plain (Char land); A^p-Active alluvial plain (Point bar); 1-nearly level (0-1%); 2-Very gently sloping (1-3%); a-forest, b-h-cultivated lands

Table 2.2.4. Land management units (LMU) of Santipur block, Nadia district (West Bengal)

LMU	Description	Phases	Area in ha (% TGA)
1	Very deep, well-drained, neutral to slightly alkaline, calcareous, coarse silty soils with silt loam to silty clay surface occurring on nearly level active flood plains and char lands (Fallow lands + Orchard plantation)	Btc6eA1f3 Btc6gA1f3 Btc6kA1f3	634 (3.3)
2	Very deep, imperfectly to moderately well-drained, slightly to moderately alkaline, calcareous, fine silty soils with silty clay loam to silty clay surface occurring on nearly level active flood plains and young alluvial plains (Single cropped + Orchard plantation)	Gsp6gA1f2 Bgp6kA1f1	4577 (23.5)
3	Very deep, imperfectly to moderately well-drained, slightly acidic to neutral, fine loamy soils with silty clay loam surface occurring on nearly level active flood plains and young alluvial plains (Double crops)	Ppt6gA1f2 Sgn6gA1	5056 (26.1)
4	Very deep, moderately well-drained, neutral to moderately alkaline, calcareous, fine silty soils with silty clay surface occurring on nearly level young alluvial plains (Orchard plantation)	Blp6dB1	1182 (6.1)
5	Very deep, imperfectly drained, neutral to slightly alkaline, calcareous, fine silty soils with silt loam surface occurring on very gently sloping old alluvial plains (Orchard plantation)	Arb6gB1 Arb6hB1	2618 (13.5)
Misc.		**5333**	**27.5**
Block Area		**19400**	**100.0**

Hemtabad Block, Uttar Dinajpur district, West Bengal

The data generated by soil survey showed that the soils of nearly level young alluvial plains under cultivated lands (AaY1c) occupying the largest area (49.9% of TGA) are very deep, well to moderately well-drained, dark grayish brown to grayish brown and yellowish-brown, light textured varying from sandy clay loam to loam and sandy loam occurring on nearly level young alluvial plain having a loamy surface and slight erosion. The second-largest LEU is very gently sloping old alluvial plains under cultivation (AaO2c) (20.6% of TGA), on which soils are very deep, loamy to sandy clay loam in texture, yellowish-brown to brownish yellow, well-drained with sandy loam surface texture and slight erosion. These LEU's are mainly cultivated under paddy and maize. The soils with LEU developed under forest (AaO2f) and LEU under plantations (AaO2p) are also very deep, well-drained with light texture i.e. sandy loam to loamy sand and sand.

Maynaguri block, Jalpaiguri district, West Bengal

Maynaguri block represents Terai region of West Bengal formed on Teesta alluvial basin. A total of 11 soil series were identified in 22 LEUs and mapped in 12 phases of series as soil mapping units. The soils were very deep, very poor to moderately well-drained, loam to sandy loam texture at surface and silt loam to loamy sand texture in the subsurface, very strongly to moderately acidic in reaction with high organic carbon. The dominant soils are Inceptisols followed by Entisols. Very strongly acidic soils (pH 4.5-5.0) in piedmonts and older alluvial plains and poor drainage situation in soils of old and young alluvial plains are the major problems. Seven land management units (LMUs) were identified in the block. SOC restorative LUP for management of the rice-fallow system in conservation agriculture mode have been recommended. LRI based land use plan revealed an increase in B:C ratio to the tune of 17.4 to 113.8% in arecanut plantation based land use options. On an average, 53.4 % higher B: C ratio was observed by adoption of LRI based land use plan compared to traditional system of cropping.

District Level

Katihar district, Bihar

Katihar district is a part of the Lower Ganga basin and falls in the Kosi and Mahananda sub-basin and occupies an area of 3056 km^2. In the district, 17 landform units and 26 LEUs were identified.

The soil survey of 12 blocks has been done and the physiography-soil relationship in the district indicates that the soils representing old alluvial plain are very deep, moderately well-drained, yellowish-brown to dark gray on very gently sloping old alluvial plain with silt loam surface texture and slight erosion. Soils are mostly under cultivation of paddy in *kharif* and in *rabi* season, mustard, wheat and vegetables are grown with shallow tube-well irrigation. These soils are moderately acidic and medium in fertility status. The soils developed on young alluvial plain are very deep, well-drained, brown to dark yellowish-brown on very gently sloping young alluvial plain with silt loam surface texture, slight erosion and frequent flooding. Soils are mostly under cultivation of paddy in *kharif* and in *rabi* season, potato, mustard, maize, wheat and vegetables are grown with shallow tube-well irrigation. Soils of the area have major problems of light to medium texture, strong acidity, low fertility status and occasional flooding.

The soils developed on very gently sloping active alluvial plain (meander plain) are very deep, well-drained, brown to dark yellowish-brownwith silt loam surface texture, slight erosion and frequent flooding with redoxmorphic features. Soils are mostly under cultivation of paddy in *kharif* and in *rabi*, maize, mustard and vegetables are grown with shallow tube-well irrigation. The soils developed on a nearly level active alluvial plain (flood plain) are very deep, well-drained, light yellowish-brown to brown, loamy sand to silt loam in texture with brown mottles. Soils are mostly under cultivation and in *rabi* season, vegetables and maize are grown. Soils of the area have major problems of light texture and frequent flooding.

Hazaribagh District, Jharkhand

In the district, out of 16 blocks, delineation of landscape ecological units of 10 blocks have been accomplished, out of which, soil survey of 8 blocks *viz.,*Katkamdag, Katkamsandi, Daru, Hazaribagh Sadar, Keredari, Dadi, Churchu and Barkagaon have been completed, covering an area of 227460 hectares (52.7 percent of the total geographic area) of Hazaribagh district. The district is divided into three broad landforms, namely, plateau top, upper plateau, and lower plateau. 22 soil series were tentatively identified across 58 LEUs. The soil-LEU relationship has been depicted as follows (**Table 2.2.5**):

Table 2.2.5. Soil-LEU Relationship of Hazaribagh district, Jharkhand

LEU	Soil Series	Phases	Descriptions
Plateau top (Granite-gneissic landscape)			
EcPtD6f	Chirua	Chr4cF3g3	Moderately deep, somewhat excessively drained, strongly gravelly, fine loamy soils with sandy loam surface occurring on steeply sloping dissected hills and ridges with severe erosion. *(Fine loamy, mixed hyperthermic Typic Haplustalfs)*
EcPtD5f EcPtD5c EcPtD5w	Bendi	Bnd6cE3	Very deep, well-drained, fine loamy soils with sandy clay loam surface occurring on moderately steeply sloping dissected hills with severe erosion. *(Fine loamy, mixed, hyperthermic Rhodic Paleustalfs)*
EcPtU4f	Meyatu	Mtu6dD2	Very deep, well-drained, fine loamy soils with loamy surface occurring on moderately sloping undulating uplands with moderate erosion. *(Fine loamy, mixed, hyperthermic Rhodic Paleustalfs)*

LEU	Soil Series	Phases	Descriptions
EcPtU4c	Dhengura	Dng6eD2	Very deep, moderately well-drained, fine loamy soils with silt loam surface occurring on moderately sloping undulating uplands with moderate erosion. *(Fine loamy, mixed, hyperthermic Oxyaquic Haplustalfs)*
EcPtU3c		Dng6eC2	Very deep, moderately well-drained, fine loamy soils with silt loam surface occurring on gently sloping undulating uplands with moderate erosion. *(Fine loamy, mixed, hyperthermic Oxyaquic Haplustalfs)*
Upper plateau (Granite-gneissic/ Quartzites/ Schist-Phyllites landscape)			
EcPuEs6f EcPuH6f	Rajhar	Rjr3cF3t2g2	Moderately shallow, excessively drained, fine loamy soils with moderate stoniness and moderate gravelliness with sandy loam surface occurring on steeply sloping escarpments and hills with severe erosion. *(Fine loamy, mixed, hyperthermic Typic Haplustalfs)*
EcPuH6w	Banadag	Bng2cF4t3g3	Shallow, excessively drained, loamy-skeletal soils with strong stoniness and strong gravelliness with sandy loam surface occurring on steeply sloping isolated hillocks with very severe erosion. *(Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents)*
EcPuR6f EcPuD6f EcPuD6w	Barikhola	Brk2dF4t3g3	Shallow, excessively drained, loamy-skeletal soils with strong stoniness and strong gravelliness with loamy surface occurring on steeply sloping hills and ridges with very severe erosion. *(Loamy-skeletal, mixed, hyperthermic Lithic Rhodustalfs)*
EcPuD5f	Chharwa	Chw6dE2	Very deep, well-drained, fine soils with loamy surface occurring on moderately steeply sloping dissected hills with moderate erosion. *(Fine, mixed, hyperthermic Rhodic Paleustalfs)*
EcPuD5c EcPuD5w		Chw6hE2	Very deep, well-drained, fine soils with sandy clay loam surface occurring on moderately steeply sloping dissected hills with moderate erosion. *(Fine, mixed, hyperthermic Rhodic Paleustalfs)*
EcPuG5f	Tilayia	Tly5dE3g2	Deep, excessively drained, fine loamy soils with moderate gravelliness with loamy surface occurring on moderately steeply sloping gullied lands with severe erosion. *(Fine loamy, mixed, hyperthermic Typic Rhodustalfs)*
EcPuG5w		Tly5cE3g2	Deep, excessively drained, fine loamy soils with moderate gravelliness with sandy clay loam surface occurring on moderately steeply sloping gullied lands with severe erosion. *(Fine loamy, mixed, hyperthermic Typic Rhodustalfs)*
EcPuU4f	Daru	Dru6dD2	Very deep, well-drained, fine soils with loamy surface occurring on moderately sloping undulating uplands with moderate erosion. *(Fine, mixed, hyperthermic Typic Paleustalfs)*
	Charwa	Chw6hD2	Very deep, well-drained, fine soils with sandy clay loam surface occurring on moderately steeply sloping dissected hills with moderate erosion. *(Fine, mixed, hyperthermic Rhodic Paleustalfs)*

LEU	Soil Series	Phases	Descriptions
EcPuU4c	Daru	Dru6hD2	Very deep, well-drained, fine soils with sandy clay loam surface occurring on moderately sloping undulating uplands with moderate erosion. *(Fine, mixed, hyperthermic Typic Paleustalfs)*
	Meyatu	Mtu6dD2	Very deep, well-drained, fine loamy soils with loamy surface occurring on moderately sloping undulating uplands with moderate erosion. *(Fine loamy, mixed, hyperthermic Rhodic Paleustalfs)*
	Hutpa	Htp6dD2	Very deep, well-drained, fine soils with loamy surface occurring on moderately sloping undulating uplands with moderate erosion. *(Fine, mixed, hyperthermic Typic Paleustalfs)*
EcPuU3f	Hutpa	Htp6dC2	Very deep, well-drained, fine soils with loamy surface occurring on gently sloping undulating uplands with moderate erosion. *(Fine, mixed, hyperthermic Typic Paleustalfs)*
	Daru	Dru6dC2	Very deep, well-drained, fine soils with sandy clay loam surface occurring on gently sloping undulating uplands with moderate erosion. *(Fine, mixed, hyperthermic Typic Paleustalfs)*
EcPuU3c	Meyatu	Mtu6dC2	Very deep, well-drained, fine loamy soils with loamy surface occurring on gently sloping undulating uplands with moderate erosion. *(Fine loamy, mixed, hyperthermic Rhodic Paleustalfs)*
	Bes	Bes6dC2	Very deep, well-drained, fine loamy soils with loamy surface occurring on gently sloping undulating uplands with moderate erosion. *(Fine loamy, mixed, hyperthermic Typic Haplustalfs)*
	Dhengura	Dng6eC2	Very deep, moderately well-drained, fine loamy soils with silt loam surface occurring on gently sloping undulating uplands with moderate erosion. *(Fine loamy, mixed, hyperthermic Oxyaquic Haplustalfs)*
	Marhand	Mrd6gC1	Very deep, somewhat poorly drained, fine soils with silty clay loam surface occurring on gently sloping undulating uplands with slight erosion. *(Fine, smectitic, hyperthermic Vertic Haplustalfs)*
EcPuVf3c	Asdhir	Asd6mC1	Very deep, poorly drained, fine soils with clayey surface occurring on gently sloping valley fills with slight erosion. *(Fine, mixed, hyperthermic Typic Endoaqualfs)*
		Asd6eC1	Very deep, poorly drained, fine soils with silt loam surface occurring on gently sloping valley fills with slight erosion. *(Fine, mixed, hyperthermic Typic Endoaqualfs)*
Lower plateau (Granite-gneissic/ Quartzite landscape)			
EcPlH6f	Barikhola	Brk2dF4t3g3	Shallow, excessively drained, loamy-skeletal soils with strong stoniness and strong gravelliness with loamy surface occurring on steeply sloping isolated hillocks with very severe erosion. *(Loamy-skeletal, mixed, hyperthermic Lithic Rhodustalfs)*

LEU	Soil Series	Phases	Descriptions
EcPlU4c	Pandekuli	Pnk6dD3g1	Very deep, somewhat excessively drained, fine-loamy soils with slight gravelliness with loamy surface occurring on moderately sloping uplands with severe erosion. *(Fine-loamy, mixed, hyperthermic Typic Rhodustalfs)*
EcPlPu3f	Hutpa	Htp6dC2	Very deep, well-drained, fine soils with loamy surface occurring on gently sloping undulating plains with moderate erosion. *(Fine, mixed, hyperthermic Typic Paleustalfs)*
EcPlPu3c	Kharika	Krk6eC2	Very deep, somewhat poorly drained, fine loamy soils with silt loam surface occurring on gently sloping undulating plains with moderate erosion. *(Fine loamy, mixed, hyperthermic Aquic Haplustalfs*)
	Dantokalan	Dnk5fC2	Deep, well-drained, fine loamy soils with clay loam surface occurring on gently sloping undulating plains with moderate erosion. *(Fine loamy, mixed, hyperthermic Typic Haplustepts*)
		Dnk5dC2	Deep, well-drained, fine loamy soils with loamy surface occurring on gently sloping undulating plains with moderate erosion. *(Fine loamy, mixed, hyperthermic Typic Haplustepts)*
	Kathoutia	Kth5dC2	Deep, well-drained, fine loamy soils with loamy surface occurring on gently sloping undulating plains with moderate erosion. *(Fine loamy, mixed, hyperthermic Typic Haplustepts)*
	Kathoutia	Kth5cC2	Deep, well-drained, fine loamy soils with sandy loam surface occurring on gently sloping undulating plains with moderate erosion. *(Fine loamy, mixed, hyperthermic Typic Haplustepts)*
EcPlPu2c	Balsagra	Bls6dB2	Very deep, moderately well-drained, fine loamy soils with loamy surface occurring on very gently sloping undulating plains with slight erosion. *(Fine-loamy, mixed, hyperthermic Typic Haplustalfs)*
	Sarnh	Srn6gB1	Very deep, somewhat poorly drained, very fine soils with silty clay loam surface occurring on very gently sloping undulating plains with slight erosion. *(Very fine, mixed, hyperthermic Vertic Haplustalfs)*
	Jordag	Jrd6eB1	Very deep, somewhat poorly drained, fine loamy soils with silt loam surface occurring on very gently sloping undulating plains with slight erosion. *(Fine-loamy, mixed, hyperthermic Oxyaquic Haplustalfs)*
EcPlVf3c	Asdhir	Asd6dC1	Very deep, poorly drained, fine soils with loamy surface occurring on gently sloping valley fills with slight erosion. *(Fine, mixed, hyperthermic Typic Endoaqualfs)*
		Asd6eC1	Very deep, poorly drained, fine soils with silt loam surface occurring on gently sloping valley fills with slight erosion. *(Fine, mixed, hyperthermic Typic Endoaqualfs)*

Abbreviations: E-Eastern plateau; Ec-Chhotanagpur plateau; Pt-Plateau top; Pu-Upper plateau; Pl-Lower plateau; H-Isolated hillocks; D-Dissected hills; U-Undulating uplands; Pu-Undulating plains; V-Valley fills; 3-Gently sloping (3-5%); 4-Moderately sloping (5-10%); 5-Moderately steeply sloping (10-15%); 6-Steeply sloping (15-25%); f-Forest, c-Cultivated; w-Wasteland.

Sahibganj district, Jharkhand

Sahibganj district, Jharkhand (latitude: 24°42'49" to 25°21'16" N and Longitude: 87°27'02" to 87°57'54" E) consists of 9 blocks and covers a geographical area of 206300 ha. The district is situated in AESR 13.1 – Eastern plain, Hot Subhumid (moist) Eco-region. The district is characterized by humid to sub-humid climate and the average annual rainfall is 1575 mm. Two broad physiographic divisions *viz*. Hills and Alluvial plains with 7 various landforms have been delineated in this district. Soil survey field works of the two blocks *viz*., Rajmahal and Udhwa have been completed. Tentatively three soil series in Rajmahal block and two series in Udhwa block have been identified.

Saidpur series: The series has been established in Rajmahal block on the young alluvial plain. The soils of this series are black to dark grey, loam to clay loam in texture, and develop deep wide cracks during the dry season. The clay content of these soils ranges from 45 to 55 percent and the CEC ranges from 22.4 to 33.4 cmol(p+)kg^{-1}. The soil is classified as *Fine silty (cal) Typic Haplusterts.*

Tinpahar series: This series has been established in Rajmahal block on a moderately sloping isolated hillock. The soils are brown to dark brown in color, loam to clay loam in texture, gravelly with 10 to15 % gravels with a clay content of 20 to30 %. The soil is classified as *Fine loamy Typic Ustorthents.*

Dharampur series: This series has been established in Rajmahal block on the nearly level young alluvial plain. The soils of this series are very deep well-drained, brown to pale brown in color, clay loam in texture with slight erosion on 0-1% slope. The clay content of these soils ranges from 30 to 35 percent and the CEC ranges from 18.4 to 23.4 cmol(p+)kg^{-1}. The soil is classified as *Fine silty, Typic Haplustalfs.*

Kanakhondi series: This series has been established in Udhwa block on a nearly level active alluvial flood plain. The soils of this series are very deep well-drained, brown to dark brown in color, clay loam in texture with slight erosion. The clay content of these soils ranges from 25 to 30 percent and the CEC ranges from 16.4 to 20.4 cmol(p+)kg^{-1}. The soil is classified as *Fine, silty (cal) VerticHaplustepts.*

Lakhijol series: The series has been established in Udhwa Block on very gently sloping old alluvial plain. The soils of this series are very deep, well-drained, dark brown to very dark brown in colour, clay loam in texture with slight erosion. The clay content of these soils ranges from 32 to 46 percent and the CEC ranges from 20.4 to 24.4 cmol(p+)kg^{-1}. The soil is classified as *Fine silty, UlticHaplustalfs.*

Bolangir district, Odisha

In Saintala Block in Bolangir District in Odisha, forty-one Landscape Ecological units (LEU) were delineated by integrating various land uses, landforms, and slope conditions. A detailed soil survey was carried out and 13 soil series were identified. The soils were classified under loamy- skeletal, coarse-loamy, fine-loamy, and fine textural classes under Ustorthents, Haplustepts, Rhodustalfs, Haplustalfs, and Paleustalfs Great Groups. Strongly to very strongly acidic soils (pH 4.5-5.5) occur in about 29% of TGA and about 86 % of area soils have low organic carbon content (<0.5%). Severe erosion occurs in about 43 % of the area and constraints of shallow depth occur in about 26 % of TGA. The major constraints are soil acidity, low organic matter, along with severe erosion, shallow depth, and undulating topography which adversely affects crop growth and productivity. Soil-LEU relationship for the study area is given in **table 2.2.6**. Based on the potential and constraints of the soils and landscape, eight Land Management Units (LMUs) were delineated in the study area (**Table 2.2.7**).

Table 2.2.6. Soil-LEU relationship of Bolangir district, Odisha

LEU	Soil Series	Brief description of Soil Series
Moderately sloping upper pediments with degraded forest (PeU4k)	Poralmain	Deep, moderately well to well-drained, slightly to moderately acidic, coarse loamy soils, medium to high AWC with slight to severe erosion *(Coarse loamy Typic Haplustepts)*
Moderately sloping lower pediments with degraded forest (PeL4k)	Lathekhend	Very shallow, well-drained, yellowish red, sandy clay loam soils with 45-50% gravels on moderately sloping lower pediments having sandy clay loam surface with severe erosion. (*Loamy skeletal, mixed,hyperthermic, Lithic Ustorthents*)
	Desandh	Moderately shallow, well-drained, yellowish red to dark reddish-brown, clay loam to sandy clay loam soils on moderately sloping upper pediment having sandy loam surface with severe erosion. (*Fine loamy,mixed, hyperthermic, Typic Haplustalfs*).
Gently sloping Upper pediment with crops (PUn3c)	Kandelkelgaon	Deep, moderately well-drained, dark yellowish-brown to yellowish-brown, clay loam to loam to sandy clay loam soils on gently sloping upper pediment having sandy loam surface with slight erosion. (*Coarse loamy,mixed ,hyperthermic, Typic Haplustepts*)
Moderately sloping lower pediments with croplands (PeL4b)	Dabjor	Moderately shallow, well-drained, brown, sandy clay loam to sandy loam soils on moderately sloping lower pediments having a loamy surface with severe erosion. (*Fine loamy,mixed ,hyperthermic, Typic Haplustepts*)
Moderately sloping undulating upland cropland with crops and trees (UUn4a)	Kangarlaga	Moderately deep, well-drained, dark brown to very dark gray to very dark grayish brown, clay loam soils on moderately sloping undulating upland having sandy loam surface and moderate erosion. (*Fine,mixed, hyperthermic, Typic Paleustalfs*)
Moderately sloping undulating uplands with croplands presently fallow (UUn4b)	Dumermunda	Deep, well-drained, dark reddish-brown to dark red, sandy loam to sandy clay loam soils on moderately sloping undulating uplands having sandy loam surface and moderate erosion. (*Fine loamy, mixed,hyperthermic, Typic Rhodustalfs*)
	Patamara	Shallow, well-drained, dark red to dark reddish-brown, clay loam soils on moderately sloping undulating uplands having sandy loam surface with moderate erosion. (*Fine loamy, mixed,hyperthermic, Lithic Rhodustalfs*)
Moderately sloping undulating plain with open scrub (UUn4j)	Dedhel	Deep, well-drained, dark grayish brown to very dark grayish brown to dark brown, clay loam soils on moderately sloping undulating plain having clay loam surface with moderate erosion. (*Fine Loamy, mixed, hyperthermic, Typic Haplustepts*)
Gently sloping undulating upland with croplands presently fallow (UUn3b)	Badmunda	Deep, moderately well-drained, brown to dark yellowish-brown to olive-brown, sandy loam to loam to clay loam soils on gently sloping undulating upland having sandy loam surface with slight erosion. (*Coarse Loamy, mixed,hyperthermic, Typic Haplustepts*)
Gently sloping undulating upland cropland -moist fallow` (UUn3c)	Karcldua	Deep, moderately well-drained, brown to dark yellowish-brown to yellowish-brown, clay loam to sandy clay loam soils on gently sloping undulating upland cropland (moist fallow)`having sandy loam surface with slight erosion. (*Fine loamy, mixed, hyperthermic, Typic Haplustalfs*)
Gently sloping undulating upland open scrub / Wastelandmisc (UUn3j)	Biratkand	Deep, well-drained, light reddish-brown to reddish-brown to yellowish red, sandy clay loam soils on gently sloping undulating upland open scrub /field /Wastelandmisc having sandy loam surface with moderate erosion. (*Fine loamy,mixed ,hyperthermic, Typic Haplustalfs*)

LEU	Soil Series	Brief description of Soil Series
Gently sloping undulating plain with cropland (presently fallow (PUn4b)	Dumermunda	Deep, well-drained, brown, clay loam to sandy clay loam to loam to clay loam soils on gently sloping undulating plain having sandy clay loam surface with slight erosion. (*Fine loamy,mixed ,hyperthermic, Typic Haplustepts*)

Table 2.2.7. Land management units of Sainthala block, Bolangir district, Odisha

LMU	Soil Series	Description
I	Desandth, Dabjor	Moderately shallow, well-drained, slightly acidic, fine loamy soils, medium to high AWC with severe erosion on moderately sloping upper and lower pediments
II	Kandelkelgaon, Poralmain, Badmunda	Deep, moderately well to well-drained, slightly to moderately acidic, coarse loamy soils, medium to high AWC with slight to severe erosion on gently to moderately sloping upper pediment and undulating uplands
III	Lathekhend	Shallow, well-drained, neutral, gravelly loamy soils, low AWC with severe erosion occurring on lower pediments
IV	Kangarlaga	Moderately deep, well-drained, slightly acidic, fine soils, high AWC with moderate erosion occurring in upland and pediments
V	Dumermunda, Biratkan	Moderately deep to deep, moderately well-drained, moderately acidic, fine loamy soils with high AWC and moderate erosion occurring on undulating uplands
VI	Dedhel	Deep, well-drained, neutral fine loamy soils, high AWC with moderate erosion occurring on undulating plains
VII	Kuikeda, Karlidlma	Shallow, moderately well to well-drained, moderately acidic, gravelly loamy soils, low AWC with slight to moderate erosion occurring on undulating upland
VIII	Dumermunda	Deep, well-drained, moderately acidic fine loamy soils, medium AWC with slight erosion occurring on undulating plains

Nadia District, West Bengal

Nadia district of West Bengal is situated between 22°52'30" to 24°05'40" N latitude and 88°19'32" and 88°31'52" E longitude under agro-ecological sub-region of 15.1 (Bengal and Assam plains, a hot, moist sub-humid eco-sub region with LGP of 210-240 days) covering an area of 392700 hectares. In the district, 54 landscape ecological units (LEUs) have been identified. Out of 17 blocks of the district, land resource inventory at 1:10000 scale has been accomplished in 12 blocks, *viz.,*Karimpur-I, Karimpur-II, Tehatta-I, Tehatta-II, Krishnaganj, Nabadwip, Santipur, Hanskhali, Ranaghat-I, Ranaghat-II, Chakdah, and Haringhata, covering an area of 254251 hectares. 22 soil series were identified in these blocks. The LEU wise dominant soil series is given in **table 2.2.8**.

Table 2.2.8. Soil-LEU Relationship of Nadia district, West Bengal

LEU	Dominant Soil Series	Brief Descriptions of Dominant Soil Series
AaY1a AaY1b AaY1c AaY1d	Dakshinpara	Very deep, imperfectly drained, fine loamy soils with silt loam to silty clay loam surface, occurring on nearly level young alluvial plains with slight erosion and slight flooding. *(Fine loamy, mixed, hyperthermic, AericEndoaqualfs)*
AaY1e AaY1f AaY1g AaY1h	Betna	Very deep, imperfectly drained, fine loamy, calcareous soils with silty clay loam to silty clay surface, occurring on nearly level young alluvial plains with slight erosion and slight flooding. *(Fine loamy, mixed, calcareous, hyperthermic, Typic Endoaqualfs)*

LEU	Dominant Soil Series	Brief Descriptions of Dominant Soil Series
AaY2a AaY2b AaY2c	Gobindapur	Very deep, imperfectly drained, fine loamy soils with silt loam to silty clay loam surface, occurring on very gently sloping young alluvial plains with slight erosion and slight flooding. *(Fine loamy, mixed, hyperthermic, AericEndoaqualfs)*
AaY2d AaY2e	Fulbari	Very deep, imperfectly drained, fine loamy, calcareous soils with silty clay loam to silty clay surface, occurring on very gently sloping young alluvial plains with slight erosion and slight flooding. *(Fine loamy, mixed, calcareous, hyperthermic, Typic Endoaqualfs)*
AaY2f AaY2g AaY2h	Mamjoani	Very deep, imperfectly drained, fine loamy soils with loamy to silty clay loam surface, occurring on very gently sloping young alluvial plains with slight erosion and slight flooding. *(Fine loamy, mixed, hyperthermic, Typic Haplustepts)*
AaO^{m}1a AaO^{m}1b	Natidanga	Very deep, imperfectly drained, fine loamy soils with loamy to silty clay loam surface, occurring on nearly level old meander alluvial plains with slight erosion. *(Fine loamy, mixed, hyperthermic, Typic Haplustepts)*
AaO^{m}1c AaO^{m}1d	Mahishbathan	Very deep, poorly drained, fine soils with silty clay loam to silty clay surface, occurring on nearly level old meander alluvial plains with slight erosion and slight flooding. *(Fine, mixed, hyperthermic, Typic Endoaqualfs)*
AaO^{m}1e AaO^{m}1f AaO^{m}1g	Kulgachhi	Very deep, poorly drained, fine soils with shrink-swell nature with silty clay to the clayey surface, occurring on nearly level old meander alluvial plains with slight erosion and slight flooding. *(Fine, mixed, hyperthermic, VerticEndoaqualfs)*
AaA^{m}1a AaA^{m}1b AaA^{m}1c AaA^{m}1d	Chaugachha	Very deep, poorly drained, fine soils with silty clay loam to silty clay surface, occurring on nearly level active meander alluvial plains with slight erosion and moderate flooding. *(Fine, mixed, hyperthermic, Typic Endoaqualfs)*
AaA^{m}1e AaA^{m}1f AaA^{m}1g AaA^{m}1h	Jhikra	Very deep, imperfectly drained, fine silty, calcareous soils with silt loam to silty clay surface, occurring on nearly level active meander alluvial plains with slight erosion and moderate flooding. *(Fine silty, mixed, calcareous, hyperthermic, Fluventic Haplustepts)*
AaA^{m}2a AaA^{m}2b AaA^{m}2c AaA^{m}2d	Ballaldighi	Very deep, imperfectly drained, fine silty soils with silt loam to silty clay surface, occurring on very gently sloping active meander alluvial plains with slight erosion and moderate flooding. *(Fine silty, mixed, hyperthermic, Fluventic Haplustepts)*
AaA^{m}2e AaA^{m}2f AaA^{m}2g AaA^{m}2h	Rudrapara	Very deep, moderately well-drained, coarse silty, calcareous soils with silt loam to silty clay loam surface, occurring on very gently sloping active meander alluvial plains with slight erosion and moderate flooding. *(Coarse silty, mixed, calcareous, hyperthermic, Typic Ustifluvents)*
AaA^{f}1a AaA^{f}1b AaA^{f}1c AaA^{f}1d	Panchpota	Very deep, moderately well-drained, fine loamy soils with silty clay loam surface, occurring on nearly level active flood plains with slight erosion and moderate flooding. *(Fine-loamy, mixed, calcareous, hyperthermic, Fluventic Haplustepts)*
AaA^{f}1e AaA^{f}1f	Fatepur	Very deep, imperfectly drained, fine loamy soils with silt loam to silty clay loam surface, occurring on nearly level active flood plains with slight erosion and severe flooding. *(Fine loamy, mixed, hyperthermic Typic Endoaquepts)*
AaA^{f}1g AaA^{f}1h	Subuddipur	Very deep, moderately well-drained, coarse silty soils with silt loam to sandy loam surface, occurring on nearly level active flood plains with slight erosion and severe flooding. *(Coarse silty, mixed, calcareous, hyperthermic, Typic Ustifluvents)*

LEU	Dominant Soil Series	Brief Descriptions of Dominant Soil Series
AaA^{p}1a AaA^{p}1b AaA^{p}1c AaA^{p}1e	Brahmasasan	Very deep, well-drained, coarse silty soils with silt loam to loamy surface, occurring on nearly level point bars with slight erosion and severe flooding. *(Coarse loamy, mixed, hyperthermic, Typic Ustifluvents)*
AaA^{p}1f AaA^{p}1g AaA^{p}1h	Brittirchar	Very deep, well-drained, coarse silty, calcareous soils with silt loam to sandy loam surface, occurring on nearly level point bars with slight erosion and severe flooding. *(Coarse loamy, mixed, calcareous, hyperthermic, Typic Ustifluvents)*

Abbreviations: A-Indogangetic plain; Aa-Alluvial plain; Y-Young alluvial plain; O^m-Old alluvial plain (Meander); A^m-Active alluvial plain (Meander); A^f- Active alluvial plain (Flood plain); A^p-Active alluvial plain (Char land); A^c-Active alluvial plain (Point bar); 1-nearly level (0-1%); 2-Very gently sloping (1-3%); a-forest, b-h-cultivated lands

Murshidabad district, West Bengal

In the district, soil survey has been conducted in 11 blocks namely, Kandi, Bharatpur-1, Bharatpur-2, Burwan, Khargram, Nabagram, Berhampur, Hariharpara, Nawda, Beldanga-I, and Beldanga –II, covering an area of 261544 hectares (49.1% of TGA). 15 soil series belonging to 3 orders *viz*., Entisols, Alfisols, and Inceptisols were identified. The brief description of the soil series under different LEUs (**Table 2.2.9**) is furnished.

Table 2.2.9. Soil-LEU Relationship of Murshidabad district, West Bengal

LEU	Soil Series	Brief description of soil
AaY1d	Aocha	Very deep, somewhat poorly drained, brown to light brownish gray, silt loam to clay soils on nearly level young alluvial plain having silt loam surface with slight erosion. (*Fine-silty, mixed, hyperthermic, Aeric Endoaquepts)*
	Gopian	Very deep, moderately well-drained, yellowish-brown to light yellowish-brown, silty clay loam to silt loam soils on nearly level young alluvial plain having silty clay loam surface, slight erosion and moderate flood hazard (*Fine- silty (cal), mixed, hyperthermic, Aquic Ustorthents).*
	Gokarna	Very deep, poorly drained, grayish brown to light brownish gray, silt loam to silty clay soils on nearly level young alluvial plain having silt loam surface and slight erosion. (*Fine-silty, mixed, hyperthermic, Aeric Endoaquepts)*
	Harishchandrapur	Very deep, well-drained, yellowish-brown, loamy sand to loam soils on nearly level young alluvial plain having sandy loam surface, slight erosion, and slight flooding. (*Coarse-loamy, mixed, hyperthermic, Fluventic Haplustepts)*
AaY1s	Salinda	Very deep, poorly drained, yellowish-brown to olive-brown, silty clay loam to clay soils on nearly level young alluvial plain having silty clay surface and slight erosion. (*Fine, mixed, hyperthermic, Vertic Haplustepts*)
	Nagar	Very deep, poorly drained, dark brown to black, clay soils on nearly level young alluvial plain having clay surface, slight erosion, and moderate flooding. (*Very fine, mixed, hyperthermic, Vertic Endoaquepts)*
AaO1d	Barwan	Very deep, well-drained, dark grayish brown to brown, silty clay loam to clay soils on nearly level old alluvial plain having clay loam surface and slight erosion.(*Fine-loamy*, *mixed, hyperthermic, Aquic Haplustepts)*
	Hariharpur	Very deep, moderately well-drained, very dark gray to gray, clay loam to loamy sand soils on nearly level old alluvial plain having clay loam surface, slight erosion, and moderate flooding hazards. (*Coarse-loamy (cal), mixed, hyperthermic, Aquic Ustifluvents*)..
	Panchthupi	Very deep, well-drained, yellowish-brown to dark yellowish-brown, loam to sandy soils on nearly level old alluvial plain having sandy loam surface, slight erosion, and slight flooding. (*Coarse-loamy, mixed, hyperthermic, Typic Ustifluvents).*

LEU	Soil Series	Brief description of soil
AaO1s	Singedda	Very deep, somewhat poorly drained, dark brown to dark grayish brown, silty clay to clay soils on nearly level old alluvial plain having silty clay surface and slight erosion. (*Fine, mixed, hyperthermic, Typic Haplustepts)*
AaA1d	Gaurpur	Very deep, poorly drained, very dark gray, silty clay to loam soils on nearly level active alluvial plain having silty clay surface and slight erosion and frequent flood hazard (*Fine-silty, mixed, hyperthermic, Aquic Haplustalfs).*
	Sarbangapur	Very deep, moderately well-drained, dark brown to dark yellowish-brown, silty clay to sandy loam soils on nearly level young alluvial plain having silty clay surface, slight erosion and severe flood hazard (*Fine-silty (cal), mixed, hyperthermic, Typic Endoaquents).*
	Bhapta	Very deep, poorly drained, dark brown to dark gray, silt loam to silty clay loam soils on nearly level active alluvial plain having silt loam surface, slight erosion. (*Coarse-silty (cal), mixed, hyperthermic, Aquic Haplustalfs).*
	Naoda	Very deep, moderately well-drained, very dark gray to light gray, silt loam to loamy sand soils on nearly level active alluvial plain having silt loam surface, slight erosion. (*Fine-silty (cal), mixed, hyperthermic, Aquic Haplustepts).*
	Gopalpur	Very deep, poorly drained, very dark gray to yellowish-brown, silt loam to silty clay soils on nearly level active meander alluvial plain having silt loam surface, slight erosion. (*Fine-silty (cal) Typic Endoaqualfs, mixed, hyperthermic, Typic Ustifluvents).*

Abbreviations: A-Indogangetic plain; Aa-Alluvial plain; Y-Young alluvial plain; O-Old alluvial plain; 1-nearly level (0-1%); 2-Very gently sloping (1-3%); d-Double crop; s-Single crop.

Maldah district, West Bengal

Maldah district of West Bengal situated in lower Indo-Gangetic plain (24°40'20" N to 25°32'08" N latitude and 87°45'50" E to 88°28'10" E longitude, area of 373300 hectares), developed from alluvium under AESR 15.1 (Hot moist sub-humid ecological sub-region) was taken up for land resource inventory at 1:10,000 scale. This district has also been identified as Aspirational District by Niti Ayog (2018). Eleven blocks namely Gazole, Bamangola, Habibpur, Old Maldah, English Bazar, Kaliachak- I, Kaliachak- II, Kaliachak III, Manikchak, Ratua I and Ratua II with an area of 244262 hectares (65.4% of the total geographical area) has been taken into consideration in the first and second phases. Eighteen soil series have been tentatively identified and the soil-LEU relationship has been described in **table 2.2.10**.

Table 2.2.10. Soil-LEU relationship of Maldah district, West Bengal

LEU	Soil Series	Description of Soil Series
AaO1d	Panchgaon	Very deep, somewhat poorly drained, grayish brown to light brownish gray, silt loam to silty clay loam texture, slightly acidic, fine silty alluvial soils on nearly level old alluvial plain having silt loam surface and strong brown mottles in subsoils and slight erosion. *(Fine silty, mixed, hyperthermic,Oxyaquic Haplustalfs)*
AaO2s	Satbaria	Very deep, moderately well-drained, olive-brown to light olive-brown with silt loam to silty clay loam texture, neutral to slightly acidic, fine silty alluvial soils on gently sloping old alluvial having silt loam surface and strong brown mottles and moderate erosion. *(Fine silty,mixed, hyperthermic, Typic Haplustalfs)*
AaY1d	Sakarmma	Very deep, somewhat poorly drained, olive-brown, silt loam to silty clay loam soils on nearly level young alluvial plain having silt loam surface and dark yellowish-brown to red mottles with deep and wide cracks and pressure faces with slight erosion. *(Fine silty, mixed, hyperthermic,Vertic Haplustepts)*

LEU	Soil Series	Description of Soil Series
AaY1d	Sadhail	Very deep, somewhat poorly drained, dark grayish brown to grey soils on nearly level young alluvial plain having clay surface and strong brown mottles and deep cracks with pressure faces in the subsoil and slight erosion. *(Very fine, mixed, hyperthermic,Vertic Endoaquepts)*
AaY1d	Mabarakpur	Very deep, well-drained, light olive-brown to light yellowish-brown with loam to sandy loam texture, neutral to slightly acidic, coarse loamy alluvial soils on nearly level young alluvial plain having loam surface with slight erosion. *(Coarse loamy, mixed, hyperthermic, Typic Haplustepts)*
AaO2d	Chandihar	Very deep, moderately well-drained, light olive-brown to olive-brown with silt loam to silty clay loam texture, neutral to slightly acidic, fine silty alluvial soils on very gently sloping old alluvial plain having silt loam surface with yellowish red mottles and moderate erosion. *(Fine silty, mixed, hyperthermic, Typic Haplustepts)*
AaO1d	Babupur	Very deep, moderately well-drained, light yellowish-brown to light gray with silt loam to silty clay texture, neutral to slightly acidic, fine silty alluvial soils on nearly level old alluvial plain having silt loam surface and brownish yellow mottles slight erosion. *(Fine silty, mixed, hyperthermic,Oxyaquic Haplustepts)*
AaY1d	Adampur	Very deep, somewhat poorly drained, very dark grayish brown to light brownish gray with clay to silty clay loam texture, neutral to slightly acidic, sine silty alluvial soils on nearly level young alluvial plain having clay surface and yellowish-brown mottles slight erosion. *(Fine, mixed, hyperthermic, Typic Epiaquepts)*
AaY2d	Puria	Very deep, somewhat poorly drained, olive-brown to very dark grayish brown with silty clay loam to silty clay texture, moderately to slightly acidic, fine alluvial soils on very gently sloping young alluvial plain having silty clay loam surface, deep cracks with pressure faces and slight erosion. *(Fine, mixed, hyperthermic,Vertic Endoaquepts)*
AaY1d	Khoksan	Very deep, poorly drained, dark olive-brown to grey with clay, moderately to slightly acidic, very fine soils on nearly level young alluvial plain having clay surface, deep cracks with pressure faces and slight erosion. (*Very fine, mixed, hyperthermic,Aeric Endoaquerts)*
AaO2d	Baje Karanja	Very deep, moderately well-drained, grayish brown to grey with silt loam texture, neutral to slightly acidic, coarse silty alluvial soils on very gently sloping old alluvial plain having silt loam surface, dark red to strong brown mottles and slight erosion. *(Coarse silty, mixed, hyperthermic, Aeric Epiaqualfs)*
AaY1d	Rasikpur	Deep, well-drained, grayish brown to light olive-brown with loam to loamy sand texture, neutral to slightly acidic, neutral to slightly acidic soils on nearly level young alluvial plain having loam surface, yellowish-brown mottles, and slight erosion. *(Coarse loamy, mixed, hyperthermic, Typic Ustorthents)*
AaA^m1d	Dakshin Durgapur	Very deep, poorly drained, dark olive-gray to dark grayish brown, silty clay to silty clay loam, neutral to slightly alkaline, fine alluvial soils in nearly level meander plain having silty clay surface with slight erosion. *(Fine, mixed, hyperthermic, Vertic Endoaqualfs)*
AaA^c1s	Hamidpur	Very deep, moderately well-drained, dark grayish brown to light olive-brown with silty loam texture, neutral to slightly alkaline, coarse silty alluvial soils in nearly level char land having silty loam surface with slight erosion. (*Coarse silty, mixed, hyperthermic, Aeric Epiaquents)*
AaA^f 1p	Kamalpur	Very deep, moderately well-drained, light olive-brown to light yellowish-brown with silty loam texture, neutral to slightly alkaline, fine silty, calcareous alluvial soils in active flood plains having silty loam surface with slight erosion. *(Fine silty, mixed, calcareous, hyperthermic Typic Haplustepts)*
AaA^m1d	Mokdompur	Very deep, moderately well-drained, olive-brown to light olive-brown with silty loam to silty clay loam texture, slightly acidic, fine loamy over fine silty alluvial soils in active meander plains having silty loam surface with slight erosion. (*Fine loamy over fine silty, mixed, hyperthermic, Typic Haplustalfs)*

LEU	Soil Series	Description of Soil Series
AaA^f1p	Sultanpur	Very deep, somewhat poorly drained, light olive-brown to light brownish gray with silty loam texture, neutral to slightly alkaline, coarse silty alluvial soils in nearly level flood plain having silty loam surface with slight erosion. *(Coarse silty, mixed, calcareous, hyperthermic, Typic Ustorthents)*
AaA^m1d	Bairgachhi	Very deep, somewhat poorly drained, very dark grayish brown to light olive-brown with clay to sandy loam texture, neutral to slightly alkaline, fine loamy over coarse loamy alluvial soils in nearly level meander plain having clay surface with slight erosion. *(Fine loamy over coarse loamy, mixed, calcareous, hyperthermic, Typic Ustorthents)*

Abbreviations: A-Indogangetic plain; Aa-Alluvial plain; Y-Young alluvial plain; O-Old alluvial plain; A^m – Active alluvial plain ^{meander}; A^c - Active alluvial plain $^{point\ bar}$; A^f- Active alluvial plain $^{flood\ plain}$;1-nearly level (0-1%); 2-Very gently sloping (1-3%); d-Double crop; s-Single crop; p- Plantation crop.

Southern Region

Koppal and Yadgir Districts of Karnataka

Under the Sujala III project, the land resource inventory was completed in 55 micro-watersheds during 2019-20 covering about 32071 ha in Koppal and Yadgir districts in Karnataka. The LRI Data was processed and several thematic maps were generated for soil-site characteristics, soil fertility, land suitability for crops, soil, and water conservation plan and proposed crop plan for each of the micro-watershed. The thematic maps on soil depth, surface soil texture, available potassium, and micronutrients are developed for each micro-watershed. The soil series along with phases of Sidganahalli-3 watershed is presented in **table 2.2.11**. The soil map was prepared with five soil series and 12 phases as soil mapping units. Maps on the land capability of Sidganahalli-3 micro-watershed indicate that 75% of the surveyed area has class II lands and needs trench-cum-bunding to conserve soil and water.

In addition to this, 85,184 Land Resource Inventory cards have been generated and issued to all the farmers owning the land in a given survey number of the micro-watershed. The LRI card contains information on soil fertility status and other soil-site characteristics.

Table 2.2.11.Soil map unit description of Sidganahalli-3 Micro-watershed

Soil map unit No.	Soil Series	Soil Phase Symbol	Mapping Unit Description	Area in ha (%)
Soils of Granite gneiss Landscape				
	LKR	Lakkur soils are moderately shallow (50-75 cm), well-drained, dark reddish-brown to dark red, red gravelly sandy clay soils occurring on very gently to moderately sloping uplands under cultivation		**15 (3.68)**
43		LKRcB2g1	Sandy loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	7 (1.8)
452		LKRhB2g1	Sandy clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	8 (1.88)
	MKH	Mukhadahalli soils are moderately shallow (50-75 cm), well-drained, dark brown to reddish-brown, gravelly red sandy clay soils occurring on very gently to gently sloping uplands under cultivation		**22 (5.28)**
77		MKHcB2g1	Sandy loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	19 (4.53)
85		MKHhB2g1	Sandy clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	3 (0.75)
	TDH	Thammadahalli soils are moderately shallow (50-75cm), well-drained, brown to very dark brown and dark reddish-brown sandy clay to clay soils occurring on nearly level to gently sloping uplands		**5 (1.32)**

Soil map unit No.	Soil Series	Soil Phase Symbol	Mapping Unit Description	Area in ha (%)
55		TDHcB1	Sandy loam surface, slope 1-3%, slight erosion	5 (1.32)
	HDH	Hooradhahalli soils are moderately deep (75-100 cm), well-drained, dark red to dark reddish-brown, red gravelly sandy clay to clay soils occurring on nearly level to moderately sloping uplands under cultivation		**49 (11.8)**
105		HDHbB2g1	Loamy sand surface, slope 1-3%, moderate erosion, gravelly (15-35%)	6 (1.48)
111		HDHcB2g1	Sandy loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	15 (3.74)
112		HDHcB2g2	Sandy loam surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	3 (0.64)
123		HDHhB2g1	Sandy clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	18 (4.32)
128		HDHiB2g1	Sandy clay surface, slope 1-3%, moderate erosion, gravelly (15-35%)	7 (1.62)
	KMH	Kumchahalli soils are deep (100-150cm), well-drained, dark reddish-brown to dark red sandy clay subsoils occurring on nearly level to very gently sloping uplands under cultivation		**4 (0.91)**
197		KMHcB2	Sandy loam surface, slope 1-3%, moderate erosion	0.23(0.06)
201		KMHiB2	Sandy clay loam surface, slope 1-3%, moderate erosion	4 (0.85)

Mahabubnagar Rural Mandal of Mahabubnagar District, Telangana

Soil Survey was carried out in Mahabubnagar Rural mandal covering 14496 ha. The major landforms identified are hills, escarpment, foothills, inter-hill basins, uplands, and lowlands (valley). The major crops are paddy, sorghum, redgram and castor. Mango is a major horticultural crop. A total of 114 profiles were studied and field-level soil correlation was carried out. Soil samples were collected and analyzed in the laboratory for bulk density and soil fertility parameters. Soil bulk density varies from 1.20 to 1.86 Mg $m^{-3}$for surface layer. The soil pH and EC values vary from 5.63 to 9.12 and 0.19 to 1.04 dS m^{-1}, respectively. The organic carbon content in soil varies from 0.19 to 2.89 %, available P from 6 to 121 kg ha^{-1}, K from 67 to 637 kg ha^{-1}, and S from 6.66 to 79.16 mg kg^{-1}. The DTPA extractable Fe varies from 2.20 to 55.00 mg kg^{-1}, Mn from 1.60 to 30.58 mg kg^{-1}, Zn from 0.12 to 2.70 mg kg^{-1}, Cu from 0.30 to 6.94 mg kg^{-1} and Boron from 0.04 to 0.89 mg kg^{-1}.

Elamdesam block, Idukki district, Kerala

High hills of the block have exposed rocks with mixed forest/teak and rubber plantations, whereas, foothills and midlands are covered with rubber, coconut, pineapple, pepper, banana, arecanut, cocoa, nutmeg, and cashew. The plains in valleys or lowlands are occupied with paddy and also used for cultivating tapioca, banana, coconut, arecanut and rubber. Twelve soil series have been identified in the area and mapped into 31 mapping units as phases of soil series. The schematic legend for the soil map of the Elamdesam block is given in **table 2.2.12**.

Table 2.2.12.Schematic legend for soil map of Elamdesam block

Series Name	Mapping unit No.	Mapping unit	Descriptive Legend
Foothills (300-600 m above MSL) and high hills (>600 m above MSL)- Archean Granite- gneiss landform			
Ptk	1	Ptk 5hH2	Foothills of western ghats sandy clay loam texture having a very steep slope of >33 percent
	2	Ptk 5fH2g1	Foothills of western ghats clay loam texture having a very steep slope of >33 percent with surface gravels 15-35 percent

Series Name	Mapping unit No.	Mapping unit	Descriptive Legend
Kbk	3	Kbk2hG2	Foothills of western ghats sandy clay loam texture having a steep slope of 25-33 percent
Foothills (300-600 m above MSL) and high hills (>600 m above MSL)- Archean Charnackite landform			
Acd	4	Acd3 hC2g1	Foothills of western ghats sandy clay loam texture having a gentle slope of 3 -5 percent
Midlands/ Uplands (< 300 m above MSL)- Archean Granite- gneiss landform			
Vnp	5	Vnp5iE2	Midlands/ Uplands of sandy clay texture having a rolling slope of 10-15 percent
	6	Vnp5iB2	Midlands/ Uplands of sandy clay texture hasa very gentle slope of 1-3 percent
	7	Vnp5hB2	Midlands/ Uplands of sandy clay loam texture having a very gentle slope of 1-3 percent
Vlc	8	Vlc5 mC2	Midlands/ Uplands of clay texture having a gentle slope of 3-5 percent
	9	Vlc5hB2	Midlands/ Uplands of sandy clay loam texture having a very gentle slope of 1-3 percent
	10	Vlc5mB2	Midlands/ Uplands of clay texture havinga very gentle slope of 1-3 percent
	11	Vlc5iB2	Midlands/ Uplands of sandy clay texture having a very gentle slope of 1-3 percent
Kmn1	12	Kmn1-4hB2	Midlands/ Uplands of sandy clay loam texture having a very gentle slope of 1-3 percent
	13	Kmn1-4mD2	Midlands/ Uplands having a moderate slope of 5-10 percent
	14	Kmn1-4hD2	Midlands/ Uplands of sandy clay loam texture having a moderate slope of 5-10 percent
	15	Kmn1-4iH2	Midlands/ Uplands of sandy clay texture having a very steep slope of >33 percent
Ckz	16	Ckz2hC2	Midlands/ Uplands of sandy clay loam texture having gentle slope of 3-5 percent
	17	Ckz2iC2	Midlands/ Uplands of sandy clay texture having gentle slope of 3-5 percent
	18	Ckz2hB2g2	Midlands/ Uplands of sandy clay loam texture having very gentle slope of 1-3 percent with surface very gravels of 35-60 percent
Nys	19	Nys1iD2	Midlands/ Uplands of sandy clay texture having moderate slope of 5-10 percent
	20	Nys1hB2	Midlands/ Uplands of sandy clay loam texture having very gentle slope of 1-3 percent
	21	Nys1hB2g1	Midlands/ Uplands of sandy clay loam texture having very gentle slope of 1-3 percent with surface gravels of 15-35 percent
Midlands/ Uplands (< 300 m above MSL)- Archean Charnackite landform			
Kdy	22	Kdy4hB2	Midlands/ Uplands of sandy clay loam texture having very gentle slope of 1-3 percent
	23	Kdy4iD2g1	Midlands/ Uplands of sandy clay texture having moderate slope of 5-10 percent with surface gravels of 15-35 percent
	24	Kdy4 hD2g1	Midlands/ Uplands of sandy clay loam texture having a moderate slope of 5-10 percent with surface gravels of 15-35 percent

Series Name	Mapping unit No.	Mapping unit	Descriptive Legend
Adm	25	Adm3 iD2g1	Midlands/ Uplands of sandy clay texture having a moderate slope of 5-10 percent with surface gravels of 15-35 percent
	26	Adm3hD2	Midlands/ Uplands of sandy clay loam texture having a moderate slope of 5-10 percent
Acr	27	Acr1 1hB2g2	Midlands/ Uplands of sandy clay loam texture having a very gentle slope of 1-3 percent with surface gravels 35-60 percent
	28	Acr11hB2	Midlands/ Uplands of sandy clay loam texture having a very gentle slope of 1-3 percent
Low lands (paddy lands)/ Valley plain			
Kmn2	29	Kmn2-5mA1	Low lands of clay texture having a nearly level slope of 0-1 percent
	30	Kmn2-5iA1	Low lands of sandy clay texture having a nearly level slope of 0-1 percent
	31	Kmn2-5hA1	Low lands of sandy clay loam texture having a nearly level slope of 0-1 percent

Rayachoty mandal, YSR Kadapa district, Andhra Pradesh

Ten soil series were identified and mapped into 53 mapping units (**Fig.2.2.3**). All the soils are formed from granite and gneisses and or its colluvium and alluvium in lowlands. The descriptive legend for the soil map of Rayachoty mandal is given in **table 2.2.13**. Land capability classification showed that 53.57 percent area is moderately good (12450.45 ha), whereas, 3928.29 ha constitute fairly good cultivable lands. Land suitability evaluation for rice indicates that nearly 63 percent area is marginally suitable (S3) and 4.92 percent area is not suitable (N). Major limitations for crop cultivation are climate, topography, soil texture, drainage, rooting condition, gravelliness and soil fertility.

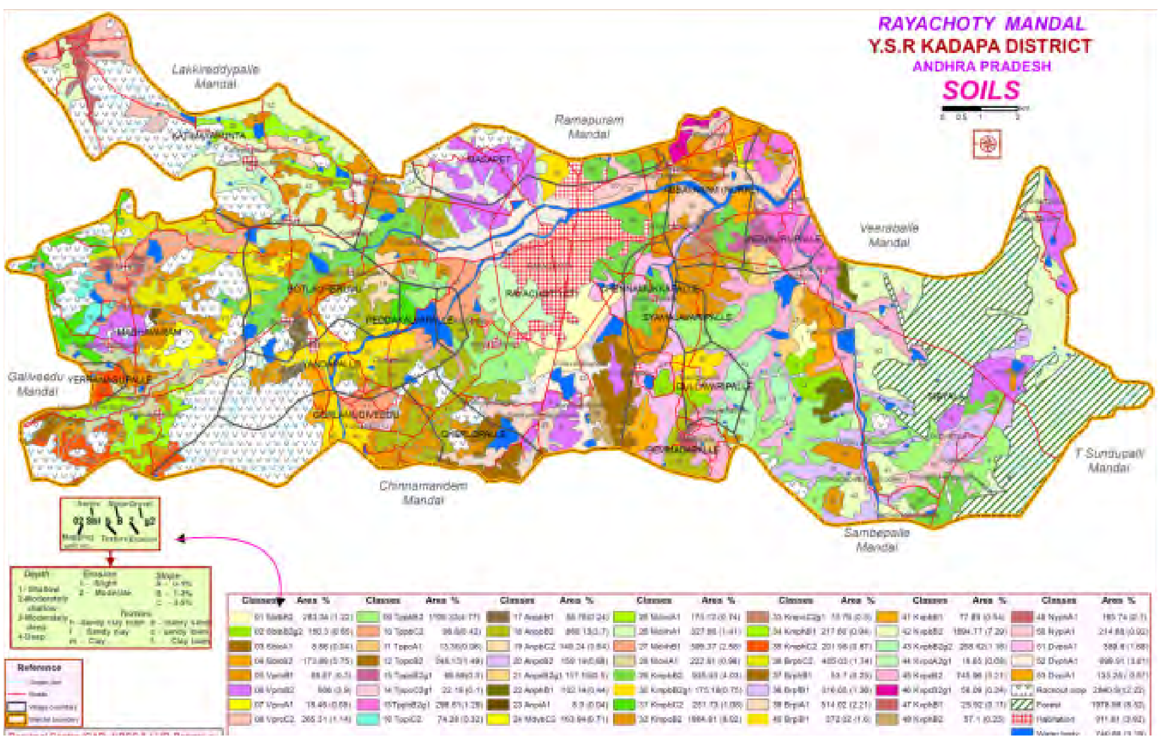


Fig.2.2.3. Soils of Rayachotymandal

Table 2.2.13.Schematic legend for soil map of Rayachotymandal

Series Name	Mapping unit No.	Mapping unit	Descriptive Legend
Sibyala	1	SblbB2	Soils of loamy sand texture having very gentle slope of 1-3 percent
	2	SblbB2g2	Soils of loamy sand texture having very gentle slope of 1-3 percent with surface very gravels of 35-60 percent
	3	SblcA1	Soils of sandy loam texture having nearly level slope of 0-1 percent
	4	SblcB2	Soils of sandy loam texture having very gentle slope of 1-3 percent
Variyapapired-dy-palli	5	VprbB1	Soils of loamy sand texture having very gentle slope of 1-3 percent
	6	VprbB2	Soils of loamy sand texture having very gentle slope of 1-3 percent
	7	VprcA1	Soils of sandy loam texture having nearly level slope of 0-1 percent
	8	VprcC2	Soils of sandy loam texture having gentle slope of 3-5 percent
Turpupalli	9	TppbB2	Soils of loamy sand texture having very gentle slope of 1-3 percent
	10	TppbC2	Soils of loamy sand texture having gentle slope of 3-5 percent
	11	TppcA1	Soils of sandy loam texture having nearly level slope of 0-1 percent
	12	TppcB2	Soils of sandy loam texture having very gentle slope of 1-3 percent
	13	TppcB2g1	Soils of sandy loam texture having very gentle slope of 1-3 percent with surface gravels of 15-35 percent
	14	TppcC2g1	Soils of sandy loam texture having gentle slope of 3-5 percent with surface gravels of 15-35 percent
	15	TpphB2g1	Soils of sandy clay loam texture having very gentle slope of 1-3 percent with surface gravels of 15-35 percent
	16	TppiC2	Soils of sandy clay texture having gentle slope of 3-5 percent
Anumpalli	17	AnpbB1	Soils of loamy sand texture having very gentle slope of 1-3 percent
	18	AnpbB2	Soils of loamy sand texture having very gentle slope of 1-3 percent
	19	AnpbC2	Soils of loamy sand texture having gentle slope of 3-5 percent
	20	AnpcB2	Soils of sandy loam texture having very gentle slope of 1-3 percent
	21	AnpcB2g1	Soils of sandy loam texture having very gentle slope of 1-3 percent with surface gravels of 15-35 percent
	22	AnphB1	Soils of sandy clay loam texture having very gentle slope of 1-3 percent
	23	AnpiA1	Soils of sandy clay texture having nearly level slope of 0-1 percent
Madhavaram	24	MdvbC2	Soils of loamy sand texture having gentle slope of 3-5 percent
	25	MdvcA1	Soils of sandy loam texture having nearly level slope of 0-1 percent
	26	MdvhA1	Soils of sandy clay loam texture having nearly level slope of 0-1 percent
	27	MdvhB1	Soils of sandy clay loam texture having very gentle slope of 1-3 percent
	28	MdviA1	Soils of sandy clay texture having nearly level slope of 0-1 percent
Kumarapalli	29	KmpbB2	Soils of loamy sand texture having very gentle slope of 1-3 percent
	30	KmpbB2g1	Soils of loamy sand texture having very gentle slope of 1-3 percent with surface gravels of 15-35 percent
	31	KmpbC2	Soils of loamy sand texture having gentle slope of 3-5 percent
	32	KmpcB2	Soils of sandy loam texture having very gentle slope of 1-3 percent
	33	KmpcC2g1	Soils of sandy loam texture having gentle slope of 3-5 percent with surface gravels of 15-35 percent
	34	KmphB1	Soils of sandy clay loam texture having very gentle slope of 1-3 percent
	35	KmphC2	Soils of sandy clay loam texture having gentle slope of 3-5 percent

Series Name	Mapping unit No.	Mapping unit	Descriptive Legend
Balreddigari-palli	36	BrpbC2	Soils of loamy sand texture having gentle slope of 3-5 percent
	37	BrphB1	Soils of sandy clay loam texture having very gentle slope of 1-3 percent
	38	BrpfB1	Soils of clay loam texture having very gentle slope of 1-3 percent
	39	BrpiA1	Soils of sandy clay texture having nearly level slope of 0-1 percent
	40	BrpiB1	Soils of sandy clay texture having very gentle slope of 1-3 percent
Kondavand-lapalli	41	KvpbB1	Soils of loamy sand texture having very gentle slope of 1-3 percent
	42	KvpbB2	Soils of loamy sand texture having very gentle slope of 1-3 percent
	43	KvpbB2g2	Soils of loamy sand texture having very gentle slope of 1-3 percent with surface very gravels of 35-60 percent
	44	KvpcA2g1	Soils of sandy loam texture having nearly level slope of 0-1 percent with surface gravels of 15-35 percent
	45	KvpcB2	Soils of sandy loam texture having a very gentle slope of 1-3 percent
	46	KvpcB2g1	Soils of sandy loam texture having a very gentle slope of 1-3 percent with surface gravels of 15-35 percent
	47	KvphB1	Soils of sandy clay loam texture having a very gentle slope of 1-3 percent
	48	KvphB2	Soils of sandy clay loam texture having a very gentle slope of 1-3 percent
Nayanurpalli	49	NyphA1	Soils of sandy clay loam texture having a nearly level slope of 0-1 percent
	50	NypiA1	Soils of sandy clay texture having a nearly level slope of 0-1 percent
Duganvand-lapalli	51	DvpcA1	Soils of sandy loam texture having a nearly level slope of 0-1 percent
	52	DvphA1	Soils of sandy clay loam texture having a nearly level slope of 0-1 percent
	53	DvpiA1	Soils of sandy clay texture having a nearly level slope of 0-1 percent

Adopted villages of Ramanagara district, Karnataka

This project was undertaken in collaboration with IIHR Bengaluru under the farmers first project to enhance the knowledge for holistic village development. The study area covers 1985 ha in kodihali hobli of Ramanagara district, Karnataka. In this village, more than 300 surface samples (0-15cm) were collected at a grid interval of 250×250 using GPS. Soil samples were analyzed for soil pH, organic carbon, available major nutrients (N, P and K), micronutrients (Cu, Mn, Zn, Fe, B), and sulphur. Soil fertility maps were generated using the interpolation technique in GIS. Entire areas of villages adopted under farmers first are low in available soil boron content. Awareness among farmers was created about soil nutrient management and 3000 SHC were issued to farmers of Balepura in the local language (Kannada).

Jalihal hobli, Sindhanur taluk, Raichur district, Karnataka 1:10000 scale

Jalihal hobli of Raichur district, Karnataka extends from 15°38’0” to 15°46’0” N latitudes and 76°35’30” to 76°42’30” E longitude and covers an area of 11080.9 ha in AESR 6.0. Five landform units were identified in the hobli based on elevation and slope. The landscape units identified were summits (11.8%), shoulder slopes (18.7%), side slopes (23.6%), back slopes (26.2%) and foot slopes (17.2%).

Kaveripattinam block, Krishnagiri district, Tamil Nadu

Soils occurring in different landforms (upland, midland, and lowland) were studied in respect of their morphology, physical and chemical characteristics, and 24 soil series have been identified and mapped on 1:10,000 scale with 63 soil mapping units. The brief description of the soil series identified in different landform units along with their taxonomic classification is given **table 2.2.14**. Inceptisols occur in 37% followed by Alfisols (34%) and Entisols (12%) respectively.

Table 2.2.14. Soil series in Kaveripattinam block, Krishnagiri district, Tamil Nadu

Land-Forms	Map unit No.	Soil Series/ taxonomy	Mapping units	Description	Area (ha)	% of TGA
Upland	1	Chaparathi (CPI)- (Sandy, mixed, isohyperthermic, Typic Ustipsamments)	CPIbB2 CPIcB2g2	Very shallow, well-drained, brown colour, loamy texture on very gently sloping upland with gravelly surface and moderate erosion.	247	0.8
	2	Gundalapatti (GDT) (Sandy isohyperthermic, Typic Ustipsamments)	GDTbC2g2 GDTcB2g1 GDThB1	Shallow, well-drained, reddish-brown, loamy sand on gently slopingfoothill with loamy sand surface texture and severe erosion.	166	0.5
	3	Baleguli (BGL) (Sandy-skeletal, isohyperthermic, Typic Ustorthents)	BGLcC3g1	Shallow, well-drained, brown, sandy loam texture on gently sloping (3-5%) foothill with sandy loam surface texture and severe erosion.	541	1.8
	4	Bannihalli (BNH) (Loamy-skeletal, mixed, isohyperthermic, Typic Haplustalfs	BNHbC3g2 BNHhB2g1	Shallow, well-drained, reddish-brown, sandy clay loam texture on gently sloping upland with loamy sand surface texture and severe erosion.	1098	3.6
	5	Dhamodarhalli (DDH) Loamy, mixed, isohyperthermic, Typic Haplustalfs)	DDHcB1 DDHhB2g1 DDHcB2g1	Shallow, well-drained, dark reddish-brown, sandy clay loam texture on very gently slopingupland with sandy loam surface texture and moderate erosion. (	1281	4.2
	6	Thattrahalli (TTH) (Sandy, isohyperthermic, Typic Haplustepts)	TTHcB2 TTHcB2g1	Moderately shallow, well-drained, dark reddish-brown, sandy loam texture on very gently sloping (1-3%) upland with sandy loam surface texture and moderate erosion.	907	3.0
	7	Veeramalai (VML) (Fine loamy, Mixed, isohyperthermic, Typic Haplustalfs)	VMLcB2g1 VMLhB2	Moderately shallow, well-drained, reddish-brown to dark reddish-brown, sandy clay loam texture on very gently sloping upland with sandy loam surface texture and moderate erosion.	705	2.3
	8	Papparapatti (PPT) (Loamy-skeletal, mixed, isohyperthermic, Typic Haplustalfs)	PPTbB2g2 PPTcB2g1	Moderately shallow, well-drained, reddish-brown, sandy clay loamtextureon very gently sloping upland with loamy sand surface texture and moderate erosion.	1323	4.3
	9	Nagojanahalli (NGH) (Fine-loamy, mixed, isohyperthermic, Typic Haplustalfs)	NGHcB2 NGHfB1 NGHcB2g1 NGHhB2	Moderately deep, well-drained, dark reddish-brown to reddish-brown, sandy clay loam texture very gently sloping upland with loamy sand surface texture and moderate erosion.	1768	5.8
	10	Vilangamudi (VLM) (Fine-loamy, mixed, isohyperthermic, Typic Rhodustalfs)	VLMcB2 VLMiB1 VLMbB2g1 VLMhB1g1 VLMcB2g2	Moderately deep, well-drained, dark reddish-brown, sandy clay loam texture very gently sloping upland with sandy loam surface texture and moderate erosion.	2111	6.9
	11	Malayandahalli (MLD) (Fine-loamy, mixed, isohyperthermic, RhodicPaleustalfs)	MLDhB2 MLDbC2 MLDcB2 MLDhA1	Deep, well-drained, dark reddish-brown to dark red, sandy clay to sandy clay loam texture very gently sloping upland with sandy loam surface texture and moderate erosion.	1030	3.4
	12	Karadihalli (KDH) (Fine-loamy, mixed, isohyperthermic, Typic Rhodustalfs)	KDHbB2 KDHhB2 KDHhB1g1	Deep, well-drained, dark reddish-brown to dark red, sandy clay loam to sandy loam on very gently sloping upland with loamy sand surface texture and moderate erosion.	1323	4.3
	13	Erumampatti (EMP) (Sandy, isohyperthermic, Typic Ustifluvents)	EMPbC3 EMPcB2 EMPiB1 EMPhB2	Deep, moderately well-drained, dark brown, sandy loam to the loamy sand texture on very gently sloping upland with sandy loam surface texture and moderate erosion.	1797	5.9
	14	Mittahalli (MTH) (Sandy, isohyperthermic, Typic Ustorthents)	MTHhB2 MTHiA1	Very shallow, well-drained, dark yellowish-brown colour, sandy loam texture on very gently sloping upland with gravelly surface and moderate erosion.)	63	0.2

Land-Forms	Map unit No.	Soil Series/ taxonomy	Mapping units	Description	Area (ha)	% of TGA
Mid Land	15	Paiyur (PYR) (Fine-loamy, mixed, isohyperthermic, Typic Haplustepts)	PYRhA1 PYRcB2 PYRiB2	Moderately shallow, well-drained, dark brown to dark yellowish-brown, sandy clay loam texture on very gently sloping middle land with sandy clay surface texture and moderate erosion.	1211	4.0
	16	Jagatab (JGT) (Fine-loamy, mixed, isohyperthermic(Cal), Typic Haplustepts)	JGThB2 JGTiA1 JGThA1	Moderately deep, moderately well-drained, very dark grayish brown to brown, sandy clay loam texture on nearly level middle land with sandy clay loam surface texture and slight erosion.	1067	3.5
	17	Thallihalli (THL) (Fine-loamy, mixed, isohyperthermic, Typic Haplustepts)	THLhB1 THLiA1	Deep, well-drained, dark brown to dark yellowish-brown, sandy clay loam texture on very gently slopes middle land with sandy clay loam surface texture and slight erosion.	646	2.1
	18	Kalveli (KLV) (Sandy, isohyperthermic (Calcareous), Typic Ustifluvents)	KLViA1 KLVhA1	Deep, moderately well-drained, dark gray to brown, sandy clay loam to sandy loam texture on nearly level slopes middle land with sandy clay loam surface texture and very slight erosion.	885	2.9
Low land	19	Santhapuram (STP) (Fine-loamy, mixed, isohyperthermic (Cal), Typic Haplustepts)	STPhA1 STPiB1	Shallow, moderately well-drained, dark yellowish-brown to brown, sandy clay loam texture on nearly level sloping lowland land with sandy loam surface texture and slight erosion.	1516	5.0
	20	Nedungal (Fine-loamy, mixed, isohyperthermic (Cal), Fluventic Haplustepts) (NDG)	NDGiA1 NDGhA1	Moderately shallow, moderately well-drained, very dark grayish brown to gray, silt loam to clay loam texture on nearly level lowland land with sandy loam surface texture and very slight erosion.	814	2.7
	21	Maruderi (MRD) (Fine-loamy, mixed, isohyperthermic (Cal), Typic Haplustepts)	MRDmA1 MRDhB1	Moderately deep, poorly drained, very dark grayish brown to grayish brown, sandy clay loam texture on nearly level sloping lowland land with sandy clay loam surface texture and slight erosion.	1125	3.7
	22	Pannanthur (PNT) (Fine-loamy, mixed, isohyperthermic (Cal), Typic Haplustepts)	PNThA1 PNTiA1 PNTmA1 PNTmB1	Deep, well-drained, black to grayish brown, sandy clay loam texture on nearly level sloping lowland land with sandy clay loam surface texture and slight erosion.	3213	10.5
	23	Arasampatti (ASP) (Fine, mixed, isohyperthermic (Cal), VerticHaplustepts	ASPmA ASPhA1	Deep, somewhat poorly drained, very dark gray to black, clay texture on nearly level sloping lowland land with clay surface texture and very slight erosion.)	342	1.1
	24	Sundekuppam (SDK) (Fine-loamy, mixed, isohyperthermic, FluventicHaplustepts	SDKcA1N3 SDKhA1N2	Deep, somewhat poorly drained, dark brown to dark grayish brown, sandy clay to sandy clay loam texture on nearly level sloping lowland land with sandy clay surface texture and very slight erosion.	627	2.0
River					493	1.6
Water bodies					991	3.2
Rock outcrops					2734	8.9
Habitation					933	3.0

North-Eastern Region

Chakchaka block, Barpeta district, Assam

Chakchaka block of Barpeta district, Assam lies between 26°27’01.8’’ to 26°30’09.0’’ N latitude and 90°51’52.3’’ to 90°52’01.2’’ E longitude covering an area of 148.16 km^2 and comes under agro-ecological sub-region 15.2 with an average annual rainfall of 1975 mm. The geology of the study area is alluvium.

Six soil series with 20 phases were identified in the Chakchaka block (**Fig.2.2.4; Table 2.2.15**). Two soil series were identified from each landform *viz.,* old alluvial plain, young alluvial plain, and active alluvial plains. These soil series fall under the north bank of Brahmaputra valley, Assam.

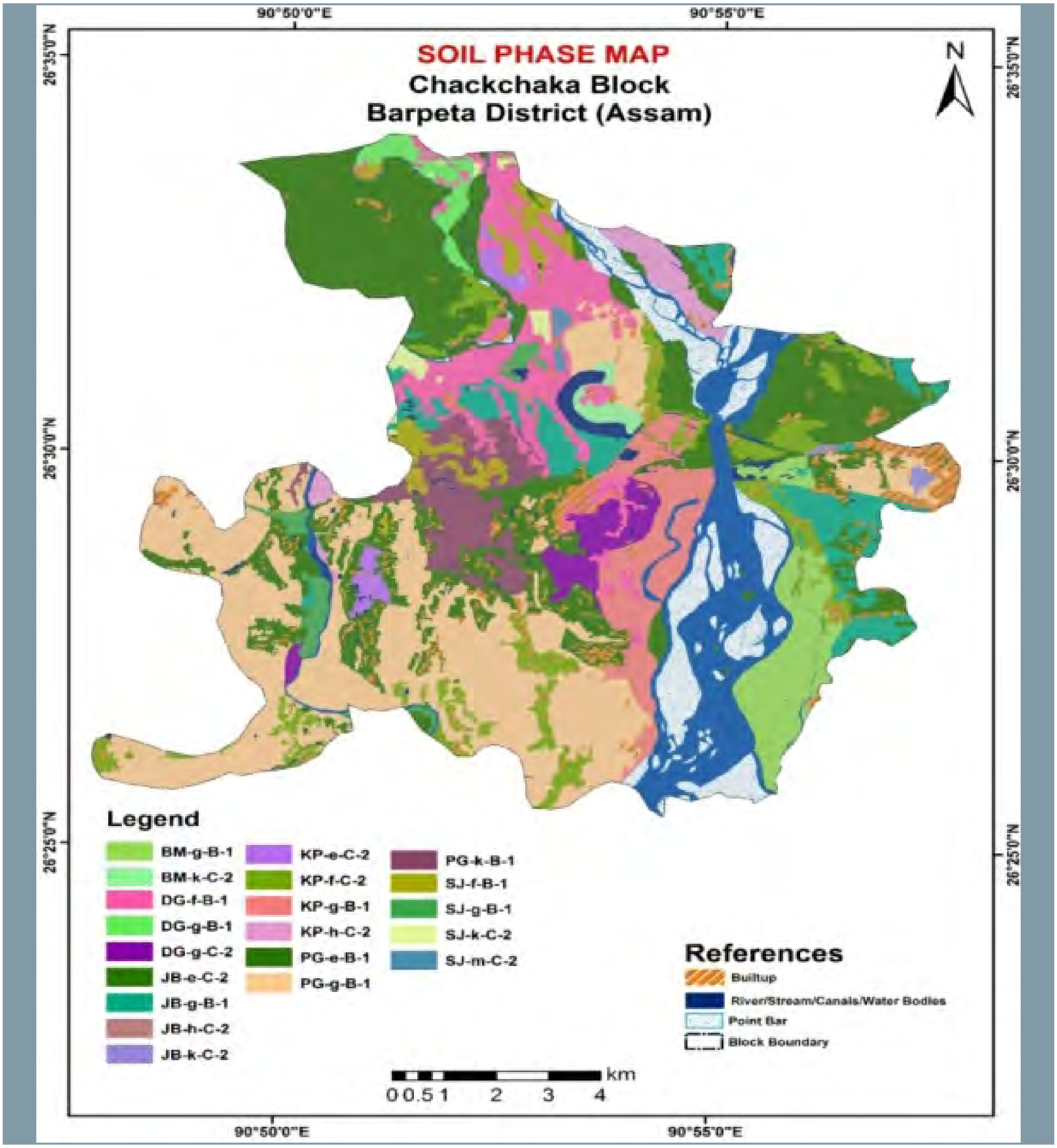


Fig.2.2.4.Soil map of Chakchaka block, Barpeta district, Assam

Soils in old alluvial plain and parts of young alluvial plain are mostly *Alfisols.* The soils of the young alluvial plain are generally *Inceptisols,* whereas, these in the inactive alluvial plain are *Entisols*.

Table 2.2.15.Area under different soil phases of soil series in Chakchaka block, Barpeta district, Assam

S. No	Series Name	Description	Area (ha)	TGA (%)	Soil phases*	Area (ha)	TGA (%)
1	Peragaon (PG)	Deep to very deep, poorly drained, fine, very strongly acidic soils on old alluvial plain (3-5% slope) with slight erosion under rice Cultivation with slight erosion.	5530	37.3	PG-e-B-1	1870	12.62
					PG-g-B-1	3125	21.09
					PG-k-B-1	535	3.61
2	Dakshin Gankgumari (DG)	Deep to very deep, well-drained, fine loamy, very strongly acidic, on young alluvial plain (1-3% slope) under rice cultivation with slight erosion	1363	9.20	DG-f-B-1	937	6.32
					DG-k-B-2	165	1.12
					DG-g-C-2	261	1.76
3	Sukanjani (SJ)	Deep to very deep, moderately drained, fine loamy, very strongly acidic soils on young alluvial plain (1-3% slope) with slight erosion under ramie cultivation.	496	3.35	SJ-f-B-1	244	1.64
					SJ-g-B-1	150	1.01
					SJ-k-C-2	75	0.50
					SJ-m-C-2	28	0.19
4	Begulamari (BM)	Deep to very deep, poorly drained, fine loamy, strongly acidic on young alluvial plain (1-3% slope) under rice cultivation with slight erosion	636	4.30	BM-k-C-2	75	0.51
					BM-g-B-1	561	3.79
5	Jamadar bari (JB)	Deep to very deep, well-drained, sandy, moderately alkali, on an active alluvial plain (0-1% slope) under sun hemp cultivation.	1933	13.0	JB- h-C-2	8	0.05
					JB- g-C-1	698	4.71
					JB- k-C-2	27	0.18
					JB-e-C-2	1200	8.10
6	Khudnabaripathar (KP)	Deep to very deep, moderately drained, coarse moderately alkali, on an active alluvial plain (0-1% slope) under Scrubland.	1620	10.9	KP-e-C-2	121	0.81
					KP-f-C-2	692	4.67
					KP-h-C-2	205	1.39
					KP-g-B-2	601	4.06
	Miscellaneous		3235	21.87	WB	1407	9.50
				ST	959	6.48	
				Sand bar	872	5.89	
	Total area		**14816**	**100.00**	**Total area**	**14816**	**100.00**

*The first two alphabets indicate the name of the soil series, the third alphabet indicates the surface texture, the fourth alphabet indicates the slope class and the digit indicates the erosion class.

Soil series: BM-Begulamari, DG- Dakshin Gankgumari, JB-Jamadar bari, KP-Khudnabaripathar, PG-Peragaon, SJ- Sukanjani ,

Surface texture: d-loam, e-silt loam, f-clay loam, g-silty clay loam, k- silty clay, m-clay, and h- sandy clay loam,

Slope class: A- 0-1%, B – 1-3%, C- 3-5%; Erosion class: 1 – No or slight, 2- Moderate and 3- Severe

The soils on the old alluvial plain are very deep, fine textured, poorly drained with *argillic* (Bt) horizon with app. CEC ≤ 16 cmol (p^+) kg^{-1} having base saturation of more than 35% between the mineral soil surface and a depth of 100 cm and classified as *Endoaqualfs*. Soils on young alluvial plains are classified as *Dystrudepts* and *Eutrudepts* at sub order level, whereas, soils on active alluvial plains are classified as *Psammaquents*.

Kolasib district, Mizoram

The soil resources are described in **table 2.2.16**. The dominant land-use class is forest cover (91.75 % of TGA), which is mainly confined to hills and rolling ridges with varied slope range. In soil inventory of arable lands, 35 phases of 8 soil series have been identified. The dominant soil series in the study area is Chempai series (Loamy, mixed, thermic, *Typic*

Dystrudepts) which occupies 2591.9 ha (1.7 % of TGA). The soils on the high and moderate structural hills are highly weathered, whereas, low activity clays are observed in moderate structural hills (< 16 cmol p^+ kg^{-1} clay CEC). Soils that are confined to valley plains are majorly classified as *Typic Endoaquepts* (Hortoki series) and *Fluventic Endoaquepts* (Bhuchang series).

Table 2.2.16.Soils of arable lands of Kolasib district, Mizoram

Soil Phases (Soil Series)	Description	Area (ha)
Bhg6gA1 (Bhuchang)	Very deep, somewhat poorly drained, clayey soils on nearly level valley plains, silty clay loam surface, and slight erosion.	251.3
Bhg6kA1 (Bhuchang)	Very deep, somewhat poorly drained, clayey soils on nearly level valley plains, silty clay surface, and slight erosion.	27.4
Bhg6mA1 (Bhuchang)	Very deep, somewhat poorly drained, clayey soils on nearly level valley plains, clay surface, and slight erosion.	7.4
Chi5fA1 (Chempai)	Deep, well-drained, loamy soils on nearly level valley plains, clay loam surface, and slight erosion.	130.3
Chi5fB2 (Chempai)	Deep, well-drained, loamy soils on very gently sloping ridge and rolling valleys, clay loam surface, and moderate erosion.	715.7
Chi5fC2 (Chempai)	Deep, well-drained, loamy soils on gently sloping ridge and rolling valleys, clay loam surface and moderate erosion.	16.1
Chi5fD3 (Chempai)	Deep, well-drained, loamy soils on moderately sloping ridge and rolling valleys, clay loam surface and severe erosion.	836.1
Chi5fE4 (Chempai)	Deep, well-drained, loamy soils on moderately steeply sloping ridge and rolling valleys, clay loam surface and very severe erosion.	357.8
Chi5fF4 (Chempai)	Deep, well-drained, loamy soils on steeply sloping ridge and rolling valleys, clay loam surface and very severe erosion.	9.7
Chi5gA1 (Chempai)	Deep, well-drained, loamy soils on nearly level valley plains, silty clay loam surface and slight erosion.	54.4
Chi5hB2 (Chempai)	Deep, well-drained, loamy soils on very gently sloping valley plains, sandy clay loam surface and moderate erosion.	111.1
Chi5mB2 (Chempai)	Deep, well-drained, loamy soils on very gently sloping valley plains as well as rolling and ridges valleys, clay surface and moderate erosion.	92.9
Chi5mC2 (Chempai)	Deep, well-drained, loamy soils on gently sloping rolling and ridges valleys, clay surface and severe erosion.	8.3
Chi5mD3 (Chempai)	Deep, well-drained, loamy soils on moderately sloping rolling and ridges valleys, clay surface and severe erosion.	270.9
Htk5gA1 (Hortoki)	Deep, somewhat poorly drained, fine loamy soils on nearly level valley plains, silty clay loam surface and slight erosion.	1411.0
Htk5mA1 (Hortoki)	Deep, somewhat poorly drained, fine loamy soils on nearly level valley plains, clay surface and slight erosion.	0.6
Lgt6fE4 (Lungmuat)	Very deep, well-drained, fine soils on moderately steeply sloping moderate structural hills, clay loam surface and very severe erosion.	187.1
Lgt6hE4 (Lungmuat)	Very deep, well-drained, fine soils on moderately steeply sloping moderate structural hills, sandy clay loam surface and very severe erosion.	21.4
Lgt6hF4 (Lungmuat)	Very deep, well-drained, fine soils on steeply sloping moderate structural hills, sandy clay loam surface and very severe erosion.	13.0
Lgt6mE4 (Lungmuat)	Very deep, well-drained, fine soils on moderately steeply sloping moderate structural hills, clay surface and very severe erosion.	579.8

Soil Phases (Soil Series)	Description	Area (ha)
Nsp5fE4 (Nisapui)	Deep, well-drained, fine soils on moderately steeply sloping high structural hills, clay loam surface and very severe erosion.	202.1
Nsp5mE4 (Nisapui)	Deep, well-drained, fine soils on moderately steeply sloping high structural hills, clay surface and very severe erosion.	251.1
Nsp5mF4 (Nisapui)	Deep, well-drained, fine soils on steeply sloping high structural hills, clay surface and very severe erosion.	153.9
Shp5hE4 (Saihapui)	Deep, well-drained, fine loamy soils on moderately steeply sloping low structural hills, sandy clay loam surface and very severe erosion.	288.0
Shp5mE4 (Saihapui)	Deep, well-drained, fine loamy soils on moderately steeply sloping low structural hills, clay surface and very severe erosion.	9.3
Vnr5fB2 (Vengthar)	Deep, well-drained, fine soils on very gently valley plains, clay loam surface and moderate erosion.	4.5
Vnr5gA1 (Vengthar)	Deep, well-drained, fine soils on nearly level valley plains, silty clay loam surface and slight erosion.	196.4
Vnr5mB2 (Vengthar)	Deep, well-drained, fine soils on very gently valley plains, clay surface and moderate erosion.	2050.5
Vnr5mD3 (Vengthar)	Deep, well-drained, fine soils on gently sloping rolling and ridges valleys, clay surface and severe erosion.	688.0
Vnr5mE4 (Vengthar)	Deep, well-drained, fine soils on moderately steeply sloping rolling and ridges valleys, clay surface and severe erosion.	72.7
Zwn5fE4 (Zanlawn)	Deep, well-drained, fine soils on moderately steeply sloping high structural hills, clay loam surface and severe erosion.	8.3
Zwn5gE4 (Zanlawn)	Deep, well-drained, fine soils on moderately steeply sloping high structural hills, silty clay loam surface and severe erosion.	130.2
Zwn5gF4 (Zanlawn)	Deep, well-drained, fine soils on steeply sloping high structural hills, silty clay loam surface and severe erosion.	667.1
Zwn5mE4 (Zanlawn)	Deep, well-drained, fine soils on moderately steeply sloping high structural hills, clay surface and severe erosion.	800.9
Zwn5mF4 (Zanlawn)	Deep, well-drained, fine soils on steeply sloping high structural hills, clay surface and severe erosion.	3.3
Habitation		929.4
Waterbodies		2981.1
Forest (Un-surveyed area)		137307.0
Total area		151845.9

Northern Region

Lahul block, Lahul & Spiti district, Himachal Pradesh

Erosion map of the Lahol block indicates that a major (53%) area of the block is affected by very severe erosion followed by moderate and severe erosion. Soil depth is mainly very shallow followed by moderately shallow, deep, moderately deep and shallow. Soil texture is predominantly gravelly sandy loam followed by gravelly sand and gravelly loam, respectively. Major area is occupied by barren and rocky land, followed by strong stoniness and moderate stoniness.

Chamba Block in Tehri Garhwal District of Uttarakhand

Chamba Block of Tehri Garhwal District, Uttarakhand (16,256 ha has been surveyed by random and profile sampling and soil landscape relationship has been developed. Based on correlation of soils 9 soil series with 17 phases have been identified. The brief description of soil series under different landform is presented in **table 2.2.17**.

Table.2.2.17. Soil series description of Chamba block

Sr. No.	Soil series	Mapping Unit	Description
		Soils of Upper Hill Side slopes	
1.	Gunogi		Very shallow, excessively drained, dark grayish brown to dark yellowish-brown, gravelly sandy loam soils, severely to very severely eroded and occur on very steeply sloping to strongly sloping upper hillside slopes. (Loamy-skeletal Lithic Udorthents)
		1.Gng1cH4g3	Very shallow, excessively drained, dark grayish brown to dark yellowish-brown, gravelly sandy loam soils on strong slopes with sandy loam surface, very severely eroded, rubbly.
		2.Gng1cG3g3	Very shallow, excessively drained, dark grayish brown to dark yellowish-brown, gravelly sandy loam soils occur on very steep slopes with sandy loam surface, severely eroded, rubbly.
2.	Jaledi		Shallow, excessively drained, dark grayish brown to dark yellowish-brown, gravelly sandy loam soils, moderately to severely eroded occurring on steeply to very steeply sloping upper hillside slopes. (Loamy-skeletal Lithic Udorthents)
		3.Jld2cG3g3	Shallow, excessively drained, dark grayish brown to dark yellowish-brown, gravelly sandy loam soils occur on very steep slopes with sandy loam surface, severely eroded and rubbly.
		4.Jld2cF2g2	Shallow, excessively drained, dark grayish brown to dark yellowish-brown, gravelly sandy loam soils occur on steep slopes with sandy loam surface, moderately eroded and extremely stony.
3.	Birogi		Moderately shallow, somewhat excessively drained, dark grayish brown to dark yellowish-brown, gravelly sandy loam to gravelly loam soils severely eroded occurring on very steeply to strongly sloping upper hillside slopes. (Loamy-skeletal Typic Udorthents)
		5.Brg3cH3g2	Moderately shallow, somewhat excessively drained, dark grayish brown to dark yellowish-brown, gravelly sandy loam soils on strong slopes with sandy loam surface, severely eroded and extremely stony.
		6.Brg3cG3g1	Moderately shallow, somewhat excessively drained, dark grayish brown to dark yellowish-brown, gravelly sandy loam soils occur on very steep slopes with sandy loam surface, severely eroded and very stony.
		Soils of Lower Hill Side slopes	
4.	Nakot		Shallow, well-drained, brown to dark yellowish-brown, gravelly loam soils, moderately eroded occur on moderately to moderately steeply sloping lower hillside slopes. (Coarse-Loamy Lithic Udorthents)
		7.Nkt2cE2g1	Shallow, well-drained, brown to dark yellowish-brown, gravelly sandy loam soils occur on moderately steep slopes with sandy loam surface, moderately eroded, and very stony.
		8.Nkt2dD2g1	Shallow, well-drained, brown to dark yellowish-brown, gravelly loam soils occur on moderate slopes with loam surface, moderately eroded and very stony.
5.	Arakot		Moderately shallow, well-drained, brown to dark yellowish-brown, gravelly sandy loam to gravelly loam soils, moderately eroded occurring on moderately steeply to steeply sloping lower hillside slopes. (Fine-loamy Typic Udorthents)
		9.Akt3cF2g2	Moderately shallow, well-drained, brown to dark yellowish-brown, gravelly sandy loam soils occur on steep slopes with sandy loam surface, moderately eroded, and extremely stony.
		10.Akt3dE2g1	Moderately shallow, well-drained, brown to dark yellowish-brown, gravelly loam soils occur on moderately steep slopes with loam surface, moderately eroded, and very stony.

Sr. No.	Soil series	Mapping Unit	Description
6.	Hadam	Moderately deep, excessively drained, very dark grayish brown to dark yellowish-brown, gravelly sandy loam to gravelly loam soils severely eroded occurring on steeply to very steeply sloping lower hillside slopes. (Fine-loamy Typic Dystrudepts)	
		11.Hdm4cG3g2	Moderately deep, excessively drained, very dark grayish brown to dark yellowish-brown, gravelly sandy loam soils occur on very steep slopes with sandy loam surface, severely eroded and extremely stony.
		12.Hdm4cF3g2	Moderately deep, excessively drained, very dark grayish brown to dark yellowish-brown, gravelly sandy loam soils occur on steep slopes with sandy loam surface, severely eroded and extremely stony.
7.	Kot	Deep, well-drained, dark yellowish-brown, gravelly loam to clay loam soils, moderately eroded occurs on moderately steeply to steeply sloping lower hillside slopes. (Fine Loamy Typic Dystrudepts)	
		13.Kot5dF2g1	Deep, well-drained, dark yellowish-brown, gravelly loam soils on steep slopes with loam surface, moderately eroded, and very stony.
		14.Kot5dE2g1	Deep, well-drained, dark yellowish-brown, gravelly loam soils on moderately steep slopes, moderately eroded and very stony.
Soils of River Terraces/River Valley			
8.	Nagni	Moderately deep, somewhat excessively drained, dark grayish brown to olive-brown, gravelly sandy loam soils, slightly eroded occurring on very gently to gently sloping river terraces (Sandy-skeletal Typic Udifluvents)	
		15.Nag4cC1g1	Moderately deep, somewhat excessively drained, dark grayish brown to olive-brown, gravelly sandy loam soils occurring on gentle slopes with sandy loam surface, slightly eroded and very stony.
		16.Nag4cB1g1	Moderately deep, somewhat excessively drained, dark grayish brown to olive-brown, gravelly sandy loam soils occur on very gentle slopes with sandy loam surface, slightly eroded and very stony.
9.	Nagni-II	Deep, well-drained, very dark grayish brown to dark yellowish-brown, gravelly loam soils, moderately eroded occurs on gentle slopes river terraces. (Fine-loamy Typic/Mollicfluaquents)	
		17.Lkt5cC2g1	Deep, well-drained, very dark grayish brown to dark yellowish-brown, gravelly sandy loam soils occur on gentle slopes with sandy loam surface, moderately eroded and very stony.

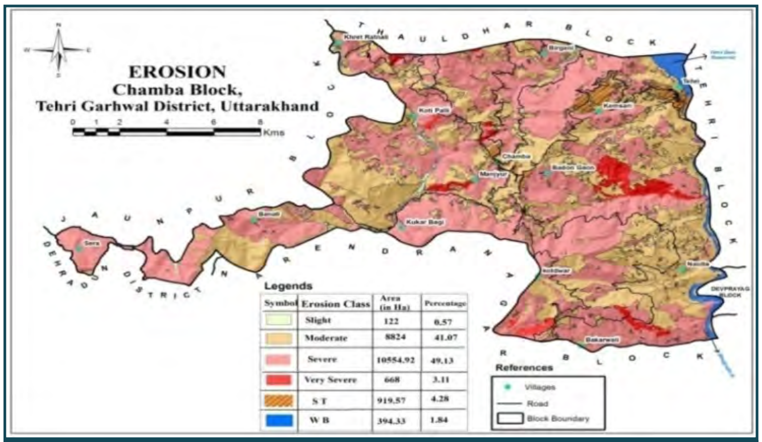


Fig.2.2.5. Soil erosion in Chamba block

From the thematic maps, it is revealed that the major area is severely eroded (49%) followed by moderate (41%) and very severe (3%) (**Fig.2.2.5**). Soils are moderately shallow in-depth (37%) followed by shallow (29%), moderately deep (15%), very shallow (8%), and deep (5%). Soil drainage is mostly excessive (47%) followed by well (26%) and somewhat excessive (20%).

Pangi Block of Chamba district, Himachal Pradesh

Pangi block (32°48’30’’ N to 33°13’00’’ N latitude and 76°13’45’’E to 76°47’20’’E longitude, Area: 160052 ha) is a representative of South Kashmir and Kumaun Himalayas, warm moist to dry sub-humid eco-region (14.2). Major physiographic units delineated are ridge tops, mountain valley glacier, sides/reposed slopes, and Glacio-fluvial valley. The soils are mapped into 22 soil phases of thirteen soil series (**Fig.2.2.6** and **Table 2.2.18**).Soil depth varied from shallow on summit and ridge tops, deep on mountain and valley glaciers, shallow to deep on side/reposed slopes, and moderately deep to deep in glacio-fluvial valley. Soil erosion affects crop productivity particularly in areas of higher slopes.

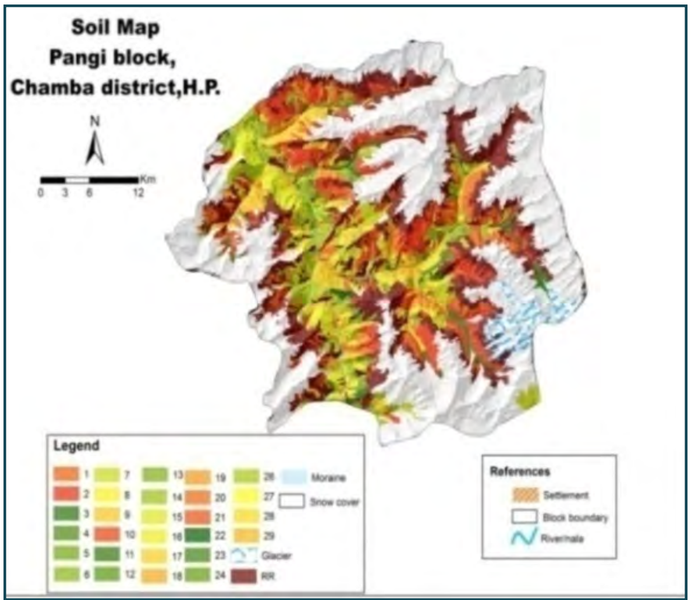


Fig.2.2.6. Soils of Pangi block, Chamba district, Himachal Pradesh.

Table 2.2.18. Soil legend of Pangi block, Chamba district, Himachal Pradesh

Mapping Unit no.	Mapping unit symbol	Description
1	Kth2cG3g3 (Kuthah)	Shallow, excessively drained, dark grayish brown to dark brown, gravelly loamy sand soils on very steeply (23-33%) sloping summit and ridge tops with gravelly sandy loam surface, severe erosion, and rubbly stoniness.
2	Kth2bH3g4 (Kuthah)	Shallow, excessively drained, dark grayish brown to dark brown, gravelly loamy sand soils on strongly sloping (33-50%) summit and ridge tops with gravelly loamy sand surface, severe erosion and very rubbly stoniness.
3	Prg5cG2g2 (Pregram)	Deep, excessively drained, dark grayish brown to very dark grayish brown, gravelly sandy loam soils on very steeply (25-33%) sloping mountain and valley glaciers with gravelly sandy loam surface, moderate erosion and extremely stoniness.
4	Prg5bH3g3 (Pregram)	Deep, excessively drained, dark grayish brown to very dark grayish brown, gravelly sandy loam soils on strongly sloping (33-50%) mountain and valley glaciers with gravelly loamy sand surface, severe erosion and rubbly stoniness.
5	Prg3cG2g2 (Pregram)	Deep, excessively drained, dark grayish brown to brown, gravelly sandy loam soils on very steeply (25-33%) side slopes/ reposed slopes with gravelly sandy loam surface, moderate erosion and extreme stoniness.
6	Prg3cH3g2 (Pregram)	Deep, excessively drained, dark grayish brown to brown, gravelly sandy loam soils on strongly (33-50%) sloping side slopes/ reposed slopes with gravelly sandy loam surface, severe erosion and extreme stoniness.
7	Kws3bG3g2 (Kawas-Adhwari)	Moderately shallow, excessively drained, darkgrayish brown to very dark grayish brown, gravelly loamy sand soils on very steeply (25-33%) sloping side slopes/ reposed slopes with gravelly loamy sand surface, severe erosion, and extreme stoniness.
8	Kws3bH3g2 (Kawas-Adhwari)	Moderately shallow, excessively drained, dark grayish brown to very dark grayish brown, gravelly loamy sand soils on strongly sloping (33-50%) side slopes/ reposed slopes, gravelly loamy sand surface, severe erosion and extreme stoniness.

Mapping Unit no.	Mapping unit symbol	Description
9	Tmh5bG2g2 (Thamoh)	Deep, excessively drained, dark grayish brown to very dark grayish brown, gravelly loamy sand soils on very steeply(25-33%) sloping side slopes/ reposed slopes, gravelly loamy sand surface, moderate erosion, and extreme stoniness.
10	Sgl2cG2g2 (Sugalwas)	Shallow, excessively drained, brown to dark brown, gravelly sandy loam soils on very steeply (25-33%) sloping side slopes/ reposed slopes with gravelly sandy loam surface, moderate erosion, and extreme stoniness.
11	Sgl2cH3g3 (Sugalwas)	Shallow, excessively drained, brown to dark brown, gravelly sandy loam soils on strongly sloping (33-50%) side slopes/ reposed slopes with gravelly sandy loam surface, severe erosion and rubbly stoniness.
12	Cor3cG2g2 (Corei)	Moderately shallow, excessively drained, brown to very dark grayish brown, gravelly sandy loam soils on very steeply (25-33%) sloping side slopes/ reposed slopes with gravelly sandy loam surface, moderate erosion, and extreme stoniness.
13	Cor3cH2g3 (Corei)	Moderately shallow, excessively drained, brown to very dark grayish brown, gravelly sandy loam soils on strongly (33-50%) sloping side slopes/ reposed slopes with gravelly sandy loam surface, moderate erosion, and rubbly stoniness.
14	Kys4cG2g2 (Karyuni-Seri)	Moderately deep, excessively drained, dark grayish brown to very dark grayish brown, gravelly sandy loam soils on very steeply (25-33%) sloping side slopes/ reposed slopes with gravelly sandy loam surface, moderate erosion, and extreme stoniness.
15	Kys4cH3g2 (Karyuni-Seri)	Moderately deep, excessively drained, dark grayish brown to very dark grayish brown, gravelly sandy loam soils on strongly (33-50%) sloping side slopes/ reposed slopeswith gravelly sandy loam surface, severe erosion and rubbly stoniness.
16	Chw4bG2g2 (Chacharwas)	Moderately deep, excessively drained, dark grayish brown to brown, gravelly loamy sand soils on very steeply (25-33%) sloping side slopes/ reposed slopes with gravelly loamy sand surface, moderate erosion, and extreme stoniness.
17	Srt5cF2g2 (Sural-Tai)	Deep, well-drained, brown to dark yellowish-brown, gravelly loam soils on steeply (15-25%) sloping side slopes/ reposed slopes with gravelly sandy loam surface, moderate erosion and extreme stoniness.
18	Srt5cG2g2 (Sural-Tai)	Deep, well-drained, brown to dark yellowish-brown, gravelly loam soils on very steeply (25-33%) sloping side slopes/ reposed slopes with gravelly sandy loam surface, moderate erosion and rubbly stoniness.
19	Ajg3cF2g2 (Ajog)	Moderately shallow, well-drained, very dark gray, gravelly sandy loam soils on steeply (15-25%) sloping side slopes/ reposed slopes with gravelly sandy loam surface, moderate erosion, and extreme stoniness.
20	Ajg3cG2g3 (Ajog)	Moderately shallow, well-drained, very dark gray, gravelly sandy loam soils on very steeply (25-33%) sloping side slopes/ reposed with gravelly sandy loam surface, moderate erosion, and rubbly stoniness.
21	Shr4cF2g2 (Shour)	Moderately deep, somewhat excessively drained, very dark grayish brown, gravelly sandy loam soils on steeply (15-25%) sloping glacio-fluvial valley with gravelly sandy loam surface, moderate erosion and extremely stoniness.
22	Udn5cG2g2 (Udeen)	Deep, well-drained, brown to very dark grayish brown, gravelly sandy loam soils on steeply (15-25%) sloping glacio-fluvial valley with gravelly sandy loam surface, moderate erosion and extreme stoniness.

Patiala District, Punjab

Patiala district is located between 29°49'00'' and 30°47'00'' N latitude, and from 75°58'00'' to 76°54'00'' E Longitude and falls under the Agro-ecological subregion Northern plain, hot dry sub-humid ecosystem (9.1). The district comprises five tehsils and eight blocks. The climate of the district is semi-arid and monsoonal with severe summer and winter. The minimum temperature is 3°C and the maximum temperature is 40°C with an annual rainfall of 754 mm. The parent material of the area is recent to old alluvium. Hills, escarpment, foothills, interhill basins, uplands and lowlands (valley) form the major landforms in the region. Soil survey has been completed covering 3,25,000 ha area. Five different physiographic units were identified in entire district *viz*., *Undulating* old alluvial plain or reclaimed dunes, leveled old alluvial plain, Old alluvial plain with concave relief, the recent flood plain of Ghaggar and old flood plain of Ghaggar river. Majority of soils in the surveyed area are loam to clay loam/silty clay loam in texture. The major land use is paddy (80%), followed by maize, sugarcane, mustard, vegetables, and barley. Salt affected soils are also recognized in the study area. Poor quality groundwater and low water table are major constraints. A total of 22 series have been identified during the field survey and described in **table 2.2.19**.

Table 2.2.19. Brief description of soils of Patiala district

Soil Series	Description	Taxonomy
Soils of Undulating old Alluvial plain		
Bhanra	Very deep, excessively drained, pale brown to yellowish-brown, sand, on 1-5% slopes, slightly eroded	Typic Ustipsamments
Fatehpur	Very deep, somewhat excessively drained, dark brown to yellowish-brown, loamy sand over sandy loam on 1-3% slopes, slightly eroded	Fluventic Haplustepts
Paharpur	Very deep, somewhat excessively drained, brown to light yellowish-brown, loamy sand, calcareous, on 1-3% slopes, slightly eroded	Typic Ustipsamments
Soils of leveled old alluvial plain		
Labana	Very deep, well-drained, brown to yellowish-brown, sandy loam, calcareous on 0-3%	Typic Haplustepts
Samana	Very deep, well-drained, dark brown to dark yellowish-brown, sandy loam on 0-3% slopes	Udic Haplustepts
Nabha	Very deep,moderatelywell-drained, dark yellowish-brown to yellowish-brown, loam to clay loam, calcareous, 0-1% slopes	Typic Haplustepts
Tulewal	Very deep, well-drained, dark brown to yellowish-brown, sandy loam to sandy clay loam, calcareous, 0-3% slopes	Typic Haplustepts
Soils of old alluvial plain with concave relief		
Kishangarh	Very Deep, imperfectly drained, light olive-brown to olive-brown, loam, calcareous with lime and Fe-Mn nodules sodic soils on 0-1% slopes	Natraquic Calciustepts
Challaila	Very deep, imperfectly drained, well-drained, light olive-brown to olive-brown, sandy loam to loam,calcareous with Fe-Mn nodules on 0-1% slopes and soils are subjected to wetness in the rainy season	Aquic Haplustepts
Sadhu	Very deep, imperfectly drained, brown, silty clay to clay, calcareous, Fe-Mn nodules, and mottles, saline, with deep cracks and pressure faces on 0-1% slopes	VerticHaplustepts
Todarpur	Very deep, imperfectly drained, dark brown to reddish-brown, loam to clay loam, calcareous, Fe-Mn nodules, sodic soil on 0-3% slopes	Fluventic Haplustepts
Rohar	Very deep, imperfectly drained, dark brown to reddish-brown, silty clay over olive-brown loam, calcareous	NatricHaplustepts
Soils of a recent flood plain		
Sanaur	Very deep, somewhat excessively drained, brown to dark yellowish-brown, loamy sand, calcareous on 1-3% slopes	Typic Ustipsamments

Soil Series	Description	Taxonomy
Daun	Very deep, well-drained, dark brown to brown, stratified, sandy loam over loamy sand, calcareous on 1-3% slopes	Typic Ustifluvents
Nagawan	Very deep, moderately well-drained, brown, stratified, sandy loam over silty clay loam, calcareous on 1-3% slopes	Typic Ustifluvents
Kapoori	Very deep, moderately well-drained, brown, stratified, calcareous on 1-3% slopes	Typic Ustifluvents
Julkan	Very deep, moderately well-drained, brown to reddish-brown, stratified, loam to silt loam, calcareous on 1-3% slopes	Anthraquic Ustifluvents
Soils of old flood plain of Ghaggar		
Chole kalan	Very deep, moderately well-drained, sandy loam to loam,	Typic Haplustepts
Bahadurgarh	Very deep, moderately well-drained, dark brown to reddish-brown, silty loam to silty clay loam, calcareous with lime and Fe Mn nodules	Fluventic Haplustepts
Mandauli	Very deep, well-drained, brown to dark brown, silt loam to loam, calcareous with lime nodules on 0-3% slopes	Fluventic Haplustepts
Bhanru	Very deep, well-drained, brown to dark brown, sandy loam, calcareous, slightly saline on 0-3% slopes	Typic Haplustepts
Ghanaur	Very deep, moderately well-drained, dark brown to reddish-brown, silty clay loam to silty clay, calcareous with lime and Fe & Mn nodules, saline soils on 0-3% slopes	Typic Haplustepts

Sirsa District, Haryana

Morphological Characteristics of soils: Soils developed on nearly level recent alluvial plain with proneness to flooding are very deep, brown to dark yellowish/ reddish-brown, calcareous, sandy loam to clay loam and classified as coarse loamy, Ustic Torrifluvents and / fine-loamy Ustic Haplucambids. They are under cotton, rice, wheat and mustard. Soils developed on recent alluvial plain in low lying areas are deep, imperfectly drained and have brown to dark yellowish-brown, calcareous, silty clay with silty clay loam surface and slightly saline and mostly under rice and wheat cultivation and at places under pasture land. They are classified as Fine, Vertic Haplocambids. Soils of old alluvial plain are also very deep, well-drained, brown to dark grayish/dark yellowish-brown, calcareous sandy loam to clay loam on nearly level slope with loam surface texture and slight saline and sodic in nature. They are classified as coarse-loamy/fine-loamy Ustic Haplocambids. They are cultivated under cotton, wheat and mustard.

Soils developed on old alluvial plain with depressions are imperfectly to poorly drained, light olive-brown to olive-brown, calcareous sandy loam to loamy sand stratified and remain waterlogged for more than six months, have problem of moderately salinity to strong sodicity and are classified as Aquic Ustifluvent/ Typic Haplaquents. They are mostly under fallow/ wasteland and used for pasture/grazing. The soils developed on aeo-fluvial plain with reclaimed sand dunes on very gentle slopes are somewhat excessively drained, brown to olive-brown, excessively drained, calcareous loamy sand to sandy, Ustic Torripsamments. They are under cotton and wheat crops. Soils developed on Aeolian plain with reclaimed sand dunes occur on very gentle to gentle slopes are brown to dark yellowish-brown, loamy sand to sandy, lighter in colour and classified as Typic Ustipsamments. They are put under single crops like wheat, mustard and cluster beans.

Physico-chemical characteristics of soils: Physico-chemical characteristics of all nineteen soil series identified in the district are presented in **table 2.2.20**. Five soil series *viz*. Kelaniya, Sukhchain, Rattakhera, Rania and Mangla have been identified on recent alluvial plain with suscepticity to flooding. Kelaniya soils are fine-loamy over sandy in texture, whereas, Sukhchain and Rattakhera soils are coarse-loamy. Soils of Rania and Mangla series are fine-loamy to fine-silty in texture. The clay content in Kelaniya, Sukhchain, Rattakhera soils varies from 6.2 to 46 % and Rania and Mangla soils contain 14.8 to 42.2% clay. Very low (0.03-0.05%) organic carbon content has been found in all the soils except in Mangla series, where SOC ranges from 0.05 to 0.59%. The calcium carbonate content of all the series is low (0.57 to 7.2%). The majority of soils are moderately alkaline in nature and pH varies from 7.5 to 8.4. The EC value of all the soils are very low and ranges between 0.17 and 0.75 dSm^{-1}.

Soils developed (Rampur Tehari) on low lying recent alluvial plain are finer in texture having clay content from 35.2 to 46.5%. The organic carbon content of soils varies from 0.14 to 0.95%. These soils are medium in calcium carbonate content (7.8-8.7%), moderately to strongly alkaline in reaction (pH 7.8-8.7) and low in EC (0.17 to 0.71 dSm^{-1}). Six soil series *viz*. Khariyan, Mithri, Jalalana, Ganga, Ellanabad and Hassu have been identified on old alluvial plain. Majority of soils are coarser in texture having clay content from 7.5 to 18% except Ganga having clay content between 15.5 and 25%. The calcium carbonate content of major soils of this land form are low (0.25 to 2.48) except Ganga and Ellanabad series, which contain medium (1.6 to 18.2%) calcium carbonate. The EC of these soils ranges between 0.59 to 3.13 dSm^{-1}. The major soils of this land forms are strongly alkaline except Mithri and Ganga series which are very strongly alkaline (pH 9.24 to 9.32).

Three soil series *viz.* Kalanwali, Rori and Surtiya have been identified on old alluvial plain with depressions. The majority of soils are coarser in texture and clay content varies from 1.8 to 19.5% except Kalanwali soils having clay content between 13.3 and 19.5%. The organic carbon content of all the soils varies from 0.07-0.22%. The calcium carbonate content of major soils is low and it ranges between 0.57 to 1.81% except Kalanwali soils with 0.86 to 15% calcium carbonate. Major soils are moderately alkaline in reaction except Surtiya series which are strongly to very strongly alkaline in reaction (pH 8.8 to 9.7).

Two soil series *viz.*Modiyakhera and Roheranwali have been identified on Aeo-fluvial plain with reclaimed sand dunes. Mostly all the soils are coarser in texture having clay content ranging from 7.5 to 12.5%. All the soils are very low in organic carbon content (0.04-0.29%), medium in calcium carbonate (7.6-10.8%), strongly to very strongly alkaline in pH (8.8 to 10.8) and low in EC value (0.37 to 0.88 dSm^{-1}).

Two soil series *viz.*Chhatriyan and Umedpura have been identified on Aeo-fluvial plain with occasional sand dunes. They are also coarser in texture and clay content varies from 1.3 to 10%. They are very low in organic carbon content (0.02-0.19%), moderately alkaline in reaction (pH 7.7 to 8.6), EC ranges between 0.10 and 0.31 dsm^{-1}. The calcium carbonate content of Chhatriyan series varies from 0.23 to 2.23% and the soil is moderately to strongly alkaline in reaction (pH 8.1 to 8.6), whereas, Umedpura soils are moderately alkaline in reaction (pH 7.7 to 8.3) and non-calcareous in nature.

Table 2.2.20.Physical and -chemical characteristics of soilsof Sirsa district of Haryana

Soil Series & Soil Taxonomy	Sand (%)	Silt (%)	Clay (%)	O.C. (%)	$CaCO_3$ (%)	pH (1:2.5)	EC(1:2.5) (dSm^{-1})
Soils of Recent alluvial plain with susceptible to flooding							
Kelaniya (Ustic Torrifluvents)	45.82 (17.4-87.3)*	33.38 (6.5-52.1)	20.81 (6.2-31.6)	0.11 (0.03-0.29)	3.11 (2.86-3.90)	8.14 (8.08-8.43)	0.25 (0.19-0.41)
Sukhchain (Ustic Torrifluvents)	63.55 (61.5-85.9)	20.65 (2.8-45.7)	15.80 (10.3-19.2)	0.15 (0.09-0.38)	4.49 (1.90-7.14)	8.55 (8.20-8.65)	0.22 (0.10-0.44)
Rattakhera (Fluventic Haplocambids)	43.38 (18.7-77.4)	33.01 (10.7-52.8)	23.62 (8.3-46.0)	0.15 (0.05-0.50)	3.26 (1.90-7.62)	8.26 (7.50-8.50)	0.46 (0.40-0.70)
Rania (Ustic Haplucambids)	11.60 (7.2-18.3)	54.0 (43.3-61.2)	34.40 (28.2-42.2)	0.14 (0.07-0.40)	1.53 (0.76-2.86)	7.85 (7.56-8.45)	0.46 (0.10-0.75)
Mangla (Ustic Haplucambids)	50.10 (44.1-58.4)	27.00 (24.3-30.9)	22.90 (14.8- 26.3)	0.18 (0.05 – 059)	0.31 (0.57 – 0.95)	8.17 (7.94 – 8.37)	0.35 (0.17 – 0.71)
Soils of Recent alluvial plain with low-lying							
Rampur tehari (VericHaplucambids)	15.08 (10.9 – 18.6)	38.54 (34.2 – 46.2)	46.38 (35.2 – 50.5)	0.27 (0.14 – 0.95)	4.45 (0.86 – 6.95)	8.48 (7.80 – 8.73)	1.08 (0.72 – 2.30)
Soils of old alluvial plain							
Khariyan (Ustic Haplocambids)	68.73 (78.5 – 85.0)	16.58 (7.5 – 20.0)	14.70 (7.5 – 17.5)	0.19 (0.12 - 0.43)	2.47 (0.61 – 3.68)	8.66 (8.58-9.10)	2.17 (1.48-3.13)
Mithri (Ustic Haplucambids)	66.78 (62.5-82.5)	18.25 (7.5-22.5)	14.97 (10.0-17.5)	0.23 (0.18-0.28)	0.85 (0.48-1.95)	9.32 (9.02-9.57)	1.30 (0.99 – 1.68)
Jalalana (Ustic Haplucambids)	51.85 (43.0 – 72.5)	30.55 (17.5 – 38.0)	17.60 (10.0 – 20-0)	0.23 (0.18 – 0.35)	0.30 (0.25 – 0.36)	8.46 (8.29 – 8.60)	1.71 (1.26 – 2.04)
Ganga (Ustic Haplucambids)	51.11 (37.5 – 70.5)	27.36 (14 .0 – 37.5)	21.53 (15.5 – 25.0)	0.18 (0.08 – 0.58)	7.40 (1.60 – 14.20)	9.24 (8.68 – 9.46)	0.55 (0.44 – 1.04)
Ellanabad (Ustic Haplucambids)	65.47 (59.5 – 77.5)	18.27 (7.5 – 25.0)	16.25 (12.5 – 18.0)	0.13 (0.10 – 0.30)	10.09 (2.43 – 18.22)	8.61 (8.07 – 9.17)	1.83 (0.86 – 2.98)
Hassu (Ustic Haplucambids)	74.35 (70.5 – 83.0)	11.56 (7.0 – 14.0)	14.09 (10.0 – 15.5)	0.10 (0.04 – 0.29)	1.97 (1.35 – 2.48)	8.78 (8.60 – 8.93)	0.81 (0.59 – 1.17)
Soils of old alluvial plain with depressions/ low-lying							

Soil Series & Soil Taxonomy	Sand (%)	Silt (%)	Clay (%)	O.C. (%)	$CaCO_3$ (%)	pH (1:2.5)	EC(1:2.5) (dSm^{-1})
Kalanwali (Fluventic Haplucambids)	50.70 (40.2 – 73.4)	32.23 (13.3 – 40.8)	17.06 (13.3 – 19.5)	0.12 (0.07 – 0.16)	3.43 (0.86 – 15.0)	8.16 (8.10 – 8.50)	0.50 (0.20 – 0.60)
Rori (Typic Haplaquents)	66.96 (59.2 – 84.4)	17.94 (11.3 – 20.8)	15.10 (4.3 – 18.8)	0.15 (0.06 – 0.22)	0.87 (0.57 – 1.14)	8.52 (8.10 – 9.10)	0.59 (0.30 – 0.80)
Surtiya(Aquic Ustifluvents)	51.86 (25.5-91.7)	35.28 (4.5-55.0)	12.86 (1.8-19.5)	0.15 (0.12-0.17)	1.44 (0.95-1.81)	9.23 (8.80-9.70)	0.44 (0.05-0.70)
Soils of Aeo-fluvial plain with reclaimed sand dunes							
Modiyakhera(UsticTorripsamments)	83.28 (81.5 – 87.5)	6.47 (2.5 – 8.5)	10.25 (9.5 – 11.5)	0.16 (0.08 – 0.29)	5.62 (1.76 – 8.82)	8.89 (8.81 – 8.97)	0.63 (0.49 – 0.88)
Roheranwali (Ustic Torripsamments)	84.44 (81.5 – 87.5)	4.81 (2.50 – 7.5)	10.75 (7.5 – 12.5)	0.10 (0.04 – 0.18)	9.06 (7.11- 10.80)	9.40 (7.56 – 10.80)	0.51 (0.37 – 0.73)
Soils of Aeolian plain with occasional sand dunes							
Chhatriyan (Ustic Torripsamments)	82.78 (80.5 – 88.5)	8.24 (5.0 – 10.5)	8.98 (6.50 – 10.0)	0.17 (0.14 – 0.19)	1.15 (0.23 – 2.23)	8.47 (8.08 – 8.59)	0.23 (0.18 – 0.31)
Umedpura (Typic Torripsamments)	93.60 (85.9 – 97.2)	2.18 (1.5 – 3.8)	4.22 (1.3 – 10.3)	0.04 (0.02 – 0.08)	0.00 (NIL)	8.03 (7.70 – 8.20)	0.50 (0.10 – 2.20)

Western Region

Central State Farm, Suratgarh and Sardargarh, Sri Ganganagar district

Soil survey was carried out in Central State Farm (CSF), Suratgarh and Sardargarh, Sri Ganganagar district (29˚18'22.94" to 29˚25'2.48" N latitudes and 73˚39'45.71" to 74˚20'28.48" E longitudes) with an area of 10,844 ha. The soils of the farm were mapped into 14 phases of 7 series. Soil fertility was evaluated using 1640 plot-wise surface samples and the results showed that the soils were moderately alkaline (76.9%) to strongly alkaline (23.1%), low to medium in organic carbon, very low in available N (76.6%), medium (54.0%) to high (40.2%) in available P, and low in available K. The soils are moderately suitable for wheat, groundnut and chick pea in 78.9, 61.9 and 49.7% of the area, respectively and marginally suitable for rice.

Soils of Mahi ravine ecosystem

The Mahi river basin is an undulating topography coupled with sandy to sandy loam soil rendering the area highly susceptible to land degradation and erosion. The absence of vegetative cover aggravates the situation, leading to the formation of deep gullies and ravines. Among the land use categories, agriculture covers an area of 53847 ha (58.8%), waste and ravine land with an area of 37310 ha (40.47%), horticulture with an area of 227 ha, estuary land and mudflat with an area of 31ha, and forest land with an area of 155 ha.The soils of Mahi ravine area were mapped into 11 phases of 3 series (**Table 2.2.21**).

Table 2.2.21. Soil series description of Mahi ravine area, Gujarat

Soil series	Soil phases	Description of soil characteristics	Area (ha)	Percent
Pricha (Pri)	Pri-hC3	Very deep, moderately well-drained, brown, sandy loam to sandy clay loam soils on gently sloping alluvial plain, sandy clay loam surface, and severe erosion.	6910	10.98
	Pri-mB1	Very deep, well-drained, very dark gray to dark yellowish-brown, clay to clay loam soils on very gently sloping alluvial plain, clay surface, and slight erosion.	4794	7.62
Rajipura (Raj)	Raj-cB2	Very deep, imperfectly drained, pale brown to brown, calcareous, sandy clay loam to clay loam soils on very gently sloping flood plain, sandy loam surface and moderate erosion.	7707	12.25
	Raj-fB2	Very deep, moderately well-drained, pale brown to brown, calcareous, sandy clay loam to clay loam soils on very gently sloping flood plain,clay loam surface and moderate erosion.	406	0.65
	Raj-hB1	Very deep, imperfectly drained, pale brown to dark yellowish-brown, sandy clay loam to clay loam soils on very gently slopingpediplain, sandy clay loam surface and slight erosion.	6151	9.78
	Raj-hB3	Very deep, well-drained, brown to dark yellowish-brown, sandy loam to sandy clay loam soils on very gently sloping pediplain, sandy clay loam surface and severe erosion.	4550	7.23
Vasad (Vas)	Vas-cB2	Very deep, well-drained, brown to dark yellowish-brown, sandy loam texture soils on very gently sloping alluvial plain,sandy loam surface and moderate erosion.	9851	15.66
	Vas-cC3	Very deep, well-drained, light yellowish-brown to yellowish-brown, sandy loam soils on gently sloping alluvial plain,sandy loam surface andsevere erosion.	4799	7.63
	Vas-cD4	Very deep, well-drained, light yellowish-brown to dark yellowish-brown, sandy loam texture soils on moderately sloping alluvial plain, sandy loam surface and very severe erosion.	6534	10.38
	Vas-kB4	Very deep, well-drained, light yellowish-brown to dark yellowish-brown, sandy loam soils onvery gently sloping alluvial plain, silty clay surfaceand very severe erosion.	4572	7.27
	Vas-mC3	Very deep, well-drained, light yellowish-brown to yellowish-brown, sandy loam soils on gently sloping alluvial plain, clayey surface and severe erosion.	815	1.29

Soil series	Soil phases	Description of soil characteristics	Area (ha)	Percent
Mud Flat			222	0.35
Water-bodies			5614	8.92
Total			**62925**	**100.00**

Churu district, Rajasthan

In the Churu district twenty land ecological units have been identified. The soils were mapped into 27 phases of 11 series and the brief description of soil is presented in **table 2.2.22**. The partially stabilized and unstablized dunes of aeolian plains have moderate to severe risk of wind erosion.

Table 2.2.22.Soils of Churu district, Rajasthan

Soil phases (soil series)	Brief Description
Bag-bB2 (Bagsara)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on very gently sloping partially stabilized high intensity of dunes, moderate erosion
Bag-bC2 (Bagsara)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on gently sloping partially stabilized high intensity of dunes, moderateerosion
Kola-cC2 (Kolasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy loam soils on gently sloping partially stabilized high intensity of dunes, moderateerosion
Mala-cB2 (Malaksar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy loam soils on very gently sloping partially stabilized high intensity of dunes, moderate erosion
Mala-cC2 (Malaksar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy loam soils on gently sloping partially stabilized high intensity of dunes,moderate erosion
Dasu-bC3 (Dasusar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on partially stabilized medium dunes, severe erosion
Dasu-cC3 (Dasusar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy loam soilson gently sloping partially stabilized medium dunes, moderate erosion
Gol-bC2 (Golsar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on gently sloping partially stabilized medium dunes, moderate erosion
Gol-bC3 (Golsar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on gently sloping partially stabilized medium dunes, severe erosion
Padu-bC2 (Padusar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on gently sloping partially stabilized high intensity of dunes, moderate erosion
Padu-bC3 (Padusar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soilson gently sloping partially stabilized high intensity of dunes, severe erosion .
Ran-bC2 (Ranasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils ongently sloping partially stabilized high intensity of dunes, moderate erosion
Boja-bB3 (Bhojasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on very gently sloping partially stabilized medium dunes, severe erosion
Boja-bC3 (Bhojasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on gently sloping partially stabilized medium dunes, severe erosion
Boja-cB3 (Bhojasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy loam soils on very gently sloping partially stabilized medium dunes, severe erosion
Deva-bB2 (Devasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on very gently sloping partially stabilized medium dunes, moderate erosion

Soil phases (soil series)	Brief Description
Deva-bB3 (Devasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on very gently sloping partially stabilized medium dunes, severe erosion
Deva-bB4 (Devasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on very gently sloping partially stabilized medium dunes, very severe erosion
Nab-aB2 (Nabbsar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy soils on very gently sloping sandy arid plains with low intensity of dunes, moderate erosion
Nab-aB3 (Nabbsar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy soils on very gently sloping sandy arid plains with low intensity of dunes, severe erosion
Nab-bB2 (Nabbsar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on very gently sloping sandy arid plains with low intensity of dunes, moderate erosion
Nab-bB3 (Nabbsar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on very gently sloping sandy arid plains with low intensity of dunes, severe erosion
Sala-bB2 (Salasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on very gently sloping sandy arid plains with low intensity of dunes, moderate erosion
Sala-cB2 (Salasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy loam soils on very gently sloping sandy arid plains with low intensity of dunes, moderate erosion
Nab-bC2 (Nabbsar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on gently sloping sandy arid plains with low intensity of dunes, moderate erosion
Nab-bC3 (Nabbsar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, loamy sand soils on gently sloping sandy arid plains with low intensity of dunes, severe erosion
Sala-cB2 (Salasar)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy loam soils on very gently sloping sandy arid plains with low intensity of dunes, moderate erosion

Bikaner district, Rajasthan

Soil survey was carried out in Bikaner district (27° 07’ to 29° 04’ N latitude and 71° 55’ to 74° 13’ E longitude, Area 29 lakh ha). Dunes, interdunes and sandy arid plain are the major landforms of the district and 10 LEUs were delineated. The soils were mapped into 21 phases of 12 series (**Table 2.2.23**).

Table 2.2.23. Description of soil series and phases in Bikaner district

Soil phases (soil series)	Description of soil characteristics
Sur-aC3 (Surjara)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy soils on gently sloping sand dunes, sandy surface, severe erosion
Sur-aD3 (Surjara)	Very deep, well-drained, brown to dark yellowish-brown , calcareous, sandy soils on moderately sloping sand dunes, sandy surface, severe erosion
Nok-aB3 (Nokha)	Very deep, well-drained, brown to dark yellowish-brown , calcareous, sandy soils on very gently sloping sand dunes, sandy surface, severe erosion
Nok-bB3 (Nokha)	Very deep, well-drained, brown to yellowish-brown , calcareous, loamy sand soils on very gently sloping sand dunes, loamy sandy surface, severe erosion
She-aB3 (Sheesha)	Very deep, well-drained, brown to dark yellowish-brown , calcareous, sandy soils on very gently sloping inter dunes, sandy surface, severe erosion
She-aD3 (Sheesha)	Very deep, well-drained, brown to dark yellowish-brown , calcareous, sandy soils on moderately sloping inter dunes, sandy surface, severe erosion
Srd-bB2 (SriDungargarh)	Very deep, well-drained, brown to yellowish-brown , calcareous, loamy sandy soils on very gently sloping sandy plains, loamy sand surface, moderate erosion

Soil phases (soil series)	Description of soil characteristics
Srd-bB3 (SriDungargarh)	Very deep, well-drained, brown to dark yellowish-brown , calcareous, loamy sand soils on very gently sloping sandy plains, severe erosion
Srd-bB4 (SriDungargarh)	Very deep, well-drained, brown to yellowish-brown , calcareous, loamy sand soils on very gently sloping sandy plains, loamy sand surface, very severe erosion
Srd-cB2 (SriDungargarh)	Very deep, well-drained, brown to light yellowish-brown , calcareous, sandy loam to loamy sand soils on very gently sloping sand plains, sandy loam surface, moderate erosion.
Mag-bB3 (Maghogarh)	Very deep, well-drained, brown to yellowish-brown, calcareous, loamy sand soils on very gently sloping sand plains,loamysandsurface, severe erosion
Mag-bB3g1 (Maghogarh)	Very deep, well-drained, brown to yellowish-brown, calcareous, loamy sand soils on very gently sloping sand plains, loamy sandsurface, severe erosion
Sind-cB3 (Sindhu)	Very deep, well-drained, brown to light yellowish-brown, calcareous, sandy loam to loamy sand soils on very gently sloping sandy plains, sandy loam surface, severe erosion.
Khaj-bC4 (Khajuwala)	Very deep, well-drained , brown to yellowish-brown, calcareous, loamy sand soils on very gently sloping interdunes, loamy sand surface, very severe erosion
Khaj-cC4 (Khajuwala)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy loam soils on gently sloping interdunes, sandy surface, very severe erosion
Goy-cC3 (Goyalri)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy loam soils on gently sloping sandy plains, sandy surface, severe erosion
Goy-cC3S1N1 (Goyalri)	Very deep, well-drained, brown to dark yellowish-brown , calcareous, sandy loam soils on gently sloping sandy plains, severe erosion and slightly salinity and sodicity
Jag-cC3 (Jagloo)	Very deep, well-drained, brown to yellowish-brown, calcareous, sandy loam soils on very gently sloping sandy plains, severe erosion
Jaga-bB3 (Jagasar)	Very deep, well-drained, brown to yellowish-brown , calcareous, loamy sand soils on very gently sloping sand plains, severe erosion
Jug-bA2 (Jugaldas)	Very deep, well-drained, brown to yellowish-brown, calcareous, loamy sand soils on nearly level sandplains, moderate erosion
Ram-aB3 (Ramsinghpura)	Very deep, well-drained, brown to dark yellowish-brown, calcareous, sandy soils on very gently sloping sandy plains, severe erosion

Neem Ka Thana Tehsil, Sikar District (Rajasthan)

Soil survey was carried out in the Neem Ka Thana tehsil of Sikar district. Five landforms were delineated *viz*., Aeolian pediment, Aeolian plain, denudational footslope, dissected hills and valley and valley fill and thirteen soil series were identified (**Table 2.2.24**).

Table 2.2.24. Description of Soil series phase of Neem Ka Thana Tehsil, Sikar District.

Series	Description
Banna Ki Dhani (Bkd)	Shallow, well-drained, brown, sandy loamy surface horizon and brown sandy clay B horizon, strongly effervescence. They have developed from weathered sandstone and occur on nearly level topography with 1 to 3 percent slope.
Karjo (Krj)	The soils of Karjo are moderately shallow (50-75 cm), moderately well-drained, brown sandy loam surface horizon and brown sandy loam B horizon, violent effervescence. They have developed from weathered sandstone and occur on nearly level to gently sloping lowlands with 1 to 3 percent slope.
Dhabala (Dbl)	The soils of Dhabala are moderately deep (75-100 cm), moderately well-drained, dark brown sandy loam surface horizon and dark brown sandy B horizon, slight effervescence. They have developed from weathered sandstone and occur on undulating topography with 3 to 8 percent slope.

Series	Description
Ram Singh Nagar (Rsn)	The soils of Ram Singh Nagar are moderately deep (75-100 cm), well-drained, dark brown clay loam surface horizon and dark brown loamy sand B horizon, strongly effervescence. They have developed from weathered sandstone and occur on nearly level topography with 1 to 3 percent slope.
KhudakBinjpur (kdb)	The soils of KhudakBinjpur are deep (100-150 cm), well-drained, dark brown clay loam surface horizon and dark brown sandy loam B horizon, strongly effervescence. They have developed from weathered sandstone and occur on hilly topography with 15 to 30 percent slope.
Ballupura (Blp)	The soils of Ballupura are deep (100-150 cm), moderately well-drained, brown clay loam surface horizon and dark brown clay loam B horizon, violent effervescence. They have developed from weathered sandstone and occur on level topography with 0 to 1 percent slope.
Bhogat (Bg)	The soils of Bhogat are deep (>100 cm), well-drained, dark brown loam surface horizon and dark brown loam B horizon. They have developed from weathered sandstone and occur on level topography with 0 to 1 percent slope.
Sirohi (Sri)	The soils of Sirohi are deep (100-150 cm), well-drained, dark reddish-brown clay surface horizon and dark reddish-brown clay B horizon, strongly effervescence. They have developed from weathered sandstone and occur on level topography with 0 to 1 percent slope.
BhitraliGavadi (Btg)	The soils of Bhitrali Gavadi are very deep (>150 cm), moderately well-drained, very dark brown sandy surface horizon and very dark brown sandy clay B horizon. They have developed from weathered sandstone and occur on undulating topography with 3 to 8 percent slope.
Ranasar (Rns)	The soils of Ranasar are very deep (>150 cm), moderately well-drained, brown loam surface horizon and dark grey clay loam B horizon, strongly effervescence. They have developed from weathered sandstone and occur on level topography with 0 to 1 percent slope.
Bhagoth (Bgt)	The soils of Bhagoth are very deep (>150 cm), moderately well-drained, strong brown loam surface horizon and brown loam B horizon, strong effervescence. They have developed from weathered sandstone and occur on level topography with 0 to 1 percent slope.
Natha Ki Nangal (Nkn)	The soils of Natha Ki Nangal are very deep (>150 cm), moderately well-drained, strong brown loam surface horizon and strong brown loam B horizon, strongly effervescence. They have developed from weathered sandstone and occur on undulating topography with 3 to 8 percent.
Mahawa (Mhw)	The soils of Mahawa are very deep (>150 cm), well-drained, dark brown loam surface horizon and dark brown loam B horizon, no effervescence. They have developed from weathered sandstone and occur on level topography with 0 to 1 percent slope.

Central Region

Amravati district, Maharashtra

Soil survey has been completed and eight soil series were identified in Dhamangaon Railway block *viz*. Virul, Jalgaon arvi, Dhabada,Wathoda, Mangrul, Nargawardi, Nimbora raj and Sonegaonkharda. Similarly, eleven soil series namely Chirodi, Sawangimagrapur, Jalkajagtap, Manjarkhurd, Mandwa, Palaskhed, Satefal, Habitpur, Baggi, Jawala and Kawthakadu were identified in Chandur Railway block. In Bhatkuli, Daryapur and Anjangaon talukas, nine, seven, and six soil series respectively were identified.

Yavatmal district, Maharashtra

Yavatmal district represents basaltic region of North Deccan plateau. The area of the district is 13582 Km^2 Soils of Yavatmal districts are mapped into 205 phases of 31 tentative soil series (**Fig.2.2.7**).

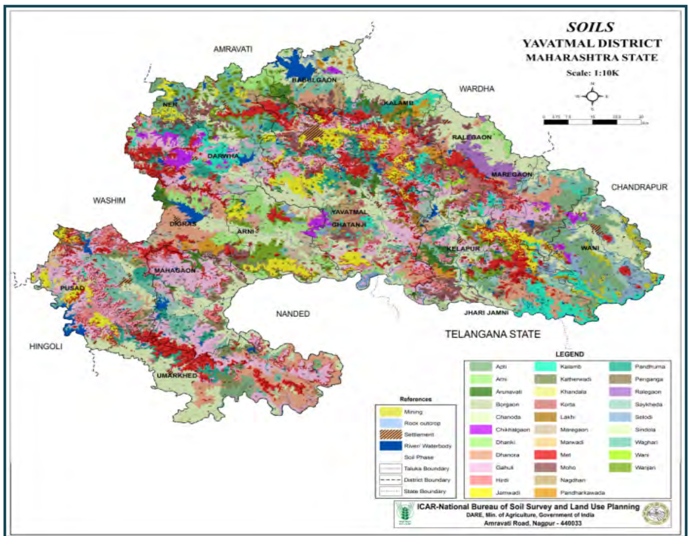


Fig.2.2.7. Soil map of Yavatmal district

Rahuri Taluka of Ahmadnagar District, Maharashtra

Rahuri tehsil of Ahmednagar district represents basaltic region of North Deccan Plateau and covers an area of 935.32 km^2. Soils of Rahuri tehsil are mapped into 59 phases of 20 tentative soil series. The extent and details of soils of Rahuri tehsil is given in **figure 2.2.8** and an example of the legend is given in **table 2.2.25**.

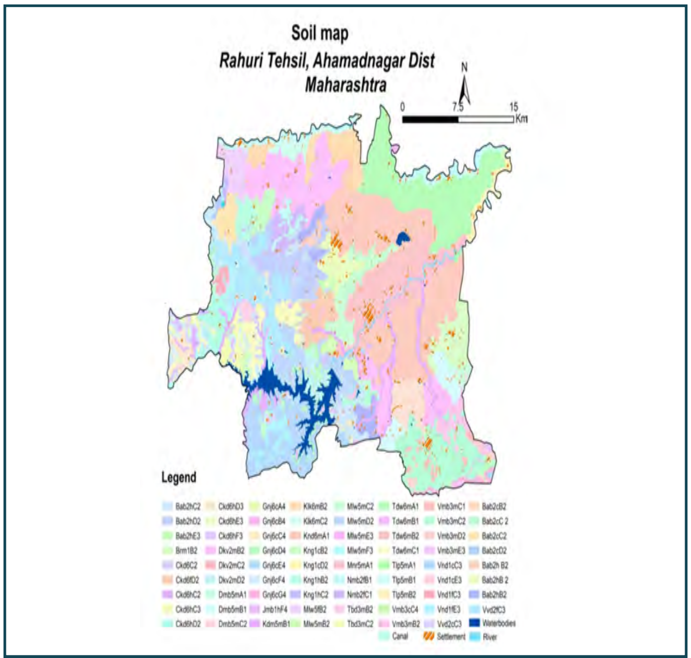


Fig.2.2.8. Soil map of Rahuri tehsil of Ahmednagar district of Maharashtra State

Table 2.2.25. Soils of Rahuri tehsil of Ahmadnagar district, Maharashtra

Sr. No.	Soil Phase	Description
1	Bab2hC2 Babulgaon	Moderately shallow, well-drained, dark grayish brown, sandy clay loam soils on gently sloping undulating uplands with sandy clay loam surface, moderate erosion.
2	Bab2hB2 Babulgaon	Moderately shallow, well-drained, dark grayish brown, sandy clay loam soils on very gently sloping undulating uplands with sandy clay loam surface, moderate erosion.
3	Bab2cB2 Babulgaon	Moderately shallow, well-drained, dark grayish brown, sandy clay loam soils on very gently sloping undulating uplands with sandy loam surface, moderate erosion.
4	Bab2cC2 Babulgaon	Moderately shallow, well-drained, dark grayish brown, sandy clay loam soils on gently sloping undulating uplands with sandy loam surface, moderate erosion.
5	Bab2hD2 Babulgaon	Moderately shallow, well-drained, dark grayish brown, sandy clay loam soils on moderately sloping undulating uplands with sandy loam surface, moderate erosion.

Sr. No.	Soil Phase	Description
6	Bab2hE3 Babulgaon	Moderately shallow, well-drained, dark grayish brown, sandy clay loam soils on moderately steeply sloping undulating uplands with sandy loam surface, severe erosion.
7	Brm1iB2 Brahmni	Very shallow, well-drained, brown, sandy clay soils on very gently sloping undulating lowland with sandy clay surface, moderate erosion.
8	Ckd6hC2 Chikaldhan	Very deep, moderately well-drained, dark grayish brown, sandy clay loam soils on gently sloping undulating uplands with sandy clay loam surface, moderate erosion.
9	Ckd6hC3 Chikaldhan	Very deep, moderately well-drained, dark grayish brown, sandy clay loam soils on gently sloping undulating uplands with sandy clay loam surface, severe erosion.
10	Ckd6hD2 Chikaldhan	Very deep, moderately well-drained, dark grayish brown, sandy clay loam soils on moderately sloping undulating uplands with sandy clay loam surface, moderate erosion.

2.3 Basic Pedological Research

Role of crystalline and non-crystalline nano clays in pedogenetically important soil orders of tropical India

Relationship of organic carbon with CEC in humid tropical soils

Soils of humid tropical regions originating from contrasting parent material were studied to establish the factors governing the organic carbon (OC) accumulation in the soils. The OC content is >1 % at 0-30 cm depth in zeolitic and smectitic soils of humid tropical Deccan basalt area of the Bhimashankar Plateau, whereas, accumulation of OC in surface and sub-surface of cultivated and forest soils of Nilgiri with mixed mineralogy is nearly five times higher than the soils of Bhimashankar (**Table 2.3.1**). The observation of higher CEC of Bhimashankar soils than Nilgiri soils indicate the weak role of CEC (in terms of surface area) in OC accumulation

Table 2.3.1. Weighted mean of OC, pH, and CEC of soils of Bhimashankar Plateau (Maharashtra) and Nilgiris (Tamil Nadu)

Profile	Land-use	OC (%)		pH		CEC (cmol(P)/kg)	
		0-30 cm	0-100 cm	0-30 cm	0-100 cm	0-30 cm	0-100 cm
Bhimashankar Plateau, Maharashtra							
P1	Agriculture	1.02	0.92	7.23	7.17	54.72	58.15
P2	Fallow	1.09	0.90	6.39	6.19	20.65	19.04
P3	Forest	1.22	0.91	6.04	6.02	38.24	33.71
Nilgiris, Tamil Nadu							
P1	Pine Forest	10.24	7.40	4.51	4.76	23.87	17.49
P2	Forest (*Acacia sp.*).	4.82	2.55	4.03	4.17	18.96	16.33
P3	Tea	4.59	1.59	4.79	5.60	22.49	9.87
P4	Tea	3.63	3.11	4.15	4.35	23.70	24.43
P5	Tea	6.37	6.83	4.15	4.13	17.88	20.56
P6	Shola Forest	5.49	2.25	5.42	5.44	17.61	6.55

Modelling soil-forming processes and genesis of red and black soils of Peninsular India

Effect of climate and land-use change on soil pH and soil organic carbon for coastal soils (South Gujarat) was modelled using soil data of two time periods (1990 and 2018) and the contributory effect of climate, soil, and land related predictors was estimated using random forest (RF) regression. The soil profile data of 1990 (n=51) represent grassland (21), cotton (16) and millets (14) sites from arid, semi-arid and humid climates whereas the data of 2018 (n=206) represent grassland (31), cotton (80), plantation (42), rice (26) and sugarcane (33) sites. The results indicated that, during 1990, climate dominantly influenced SOC but significantly upto 20 cm depth only. Climate and land-use interaction were marginally significant at $p<0.1$ for 0-10 cm depth **(Fig.2.3.1a)**. SOC decreased with depth under all the three climates in the order of humid>semi-arid>arid. SOC content was marginally higher in the 10-20 cm layer than 0-10 cm due to sandy surface soils characteristic of coastal arid and semi-arid regions. Climate had a weak effect on soil pH while land-use and climate interaction significantly controlled the pH for 0-100 cm depth (**Fig.2.3.1b**). Soil pH generally increased with depth. The soils under cotton had higher pH whereas soils under grassland and millets had similar pH range. PET, soil type, and clay were strong predictors of soil pH for the topsoil.

Land-use change after 1990 resulted in an increased area under commercial fruit plantations, cotton, rice,

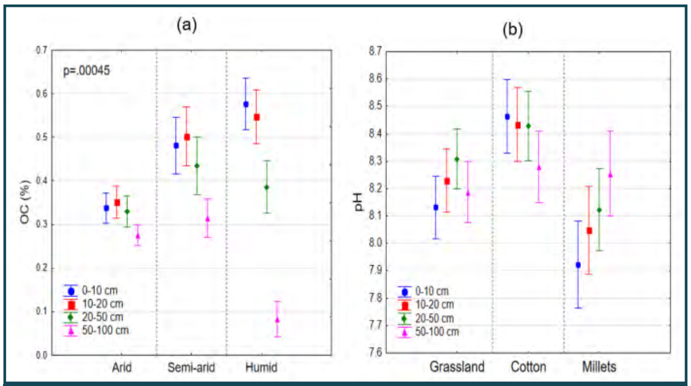


Fig.2.3.1. Effect of climate on SOC content (a) and land-use on soil pH (b) in coastal soils of South Gujarat during 1990 (n=51). The vertical bars denote standard errors.

and sugarcane in South Gujarat. The change in land-use affected SOC content in all the soil depth intervals (**Table 2.3.2**). However, the effect of climate was significant in the topsoil (0-20 cm) and for 0-100 cm depth. The climate and land-use interaction were marginally significant at p <0.1 for 0-100 cm depth. SOC decreased with depth in all the climate with soils of humid climate having higher SOC than semi-arid (dry) and semi-arid (moist) climates. SOC content was highest in soils under plantation and lowest in soils under cotton, whereas, soils under sugarcane, rice, and grassland have similar SOC content upto 50 cm (**Fig. 2.3.2**). However, the relationship of SOC with mean annual rainfall and potential evapotranspiration was highly significant (P<0.00001) for all the depth intervals, contradicting the linear ANOVA model results. Moreover, RF regression results indicated that, during 2018, SOC was controlled by both climate (MAR and PET) and land-use (**Fig.2.3.3**).

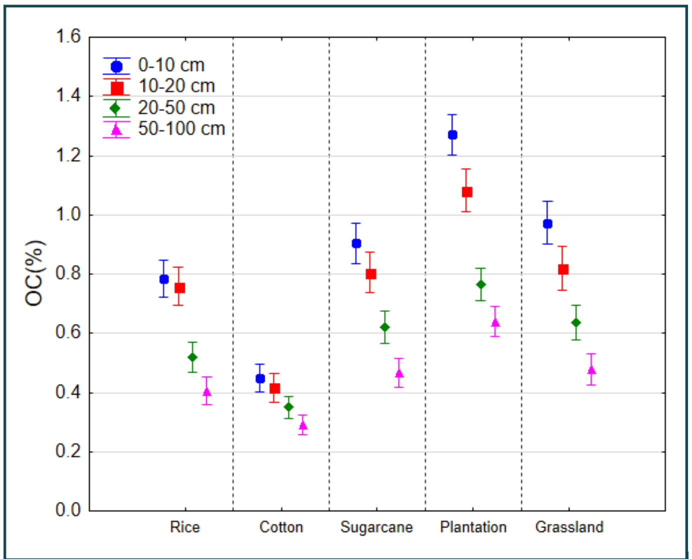


Fig.2.3.2. Main effect of land-use on SOC content during 2018 in coastal soils of south Gujarat

Table 2.3.2. Effect of climate and land-use on SOC content at different depth intervals during 2018 (n=206)

Source	Depth (cm)	F	Sig.
Climate	0-10	4.75	0.013
	10-20	3.42	0.037
	20-50	2.56	0.058
	50-100	1.09	0.339
	0-100	4.57	0.008
Land-use	0-10	19.32	0.000
	10-20	16.96	0.000
	20-50	12.47	0.000
	50-100	10.14	0.000
	0-100	21.07	0.000
Climate * land-use	0-10	0.70	0.664
	10-20	0.96	0.208
	20-50	1.12	0.145
	50-100	1.10	0.369
	0-100	1.04	0.080

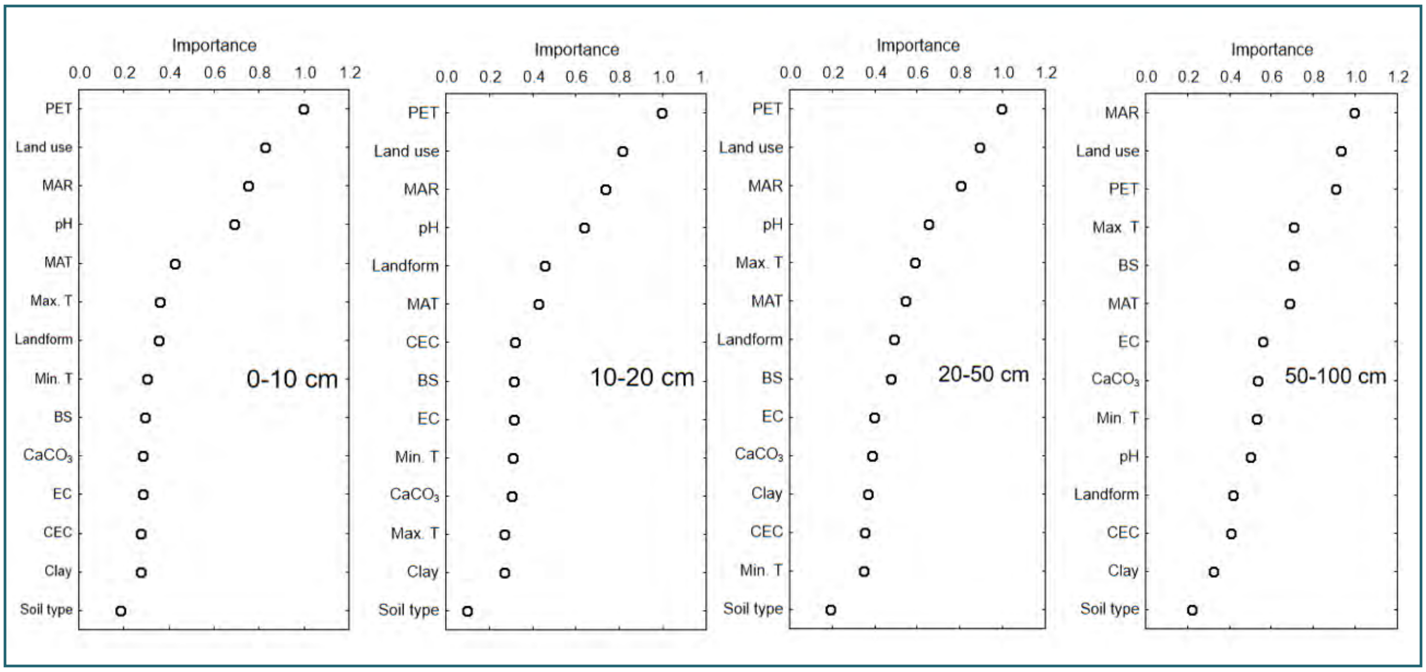


Fig.2.3.3. Results of RF regression showing the importance of predictors on SOC content at different depth intervals for coastal soils of south Gujarat

It was found that soil pH also played a major role in controlling SOC content, whereas, clay, CEC, and soil type were weak predictors. Similar to the results of 1990, climate influenced soil pH only in the topsoil (0-20 cm) during 2018. Soil pH increased with depth under all three climates and pH under SA(d) climate was slightly higher than SA(m).Soils under humid climate have pH 0.3 units lower than SA climate. Land use controlled the soil pH at all the depth intervals ($p<0.0001$). Climate and land-use interaction effects on soil pH were significant at the surface (0-10 cm) and subsurface up to 50cm (20-50 cm). Soil pH generally increased with depth under all the 5 land-use systems and it was highest under cotton and lowest under grassland.

Generation and modeling of carbon datasets in different agro-ecosystems for climate-resilient agricultural planning (NICRA)

Soil carbon status

The soil samples collected from five sites including two benchmark sites, viz., Nimone, and Konheri (**Table 2.3.3**), were analyzed for physical and chemical properties. They represent moderately deep sandy clay to very deep clay soils under different bio-climates (arid to per-humid) with either irrigated or rain-fed agriculture. In soils of Pattambi and Trivandrum, the SOC is >1% at 0-30 and 0-100 cm depth, whereas the SOC is lowest in the soils of Konheri. Though the MAR of Nimone is lower than Kohneri, the SOC is higher in Nimone soils due to irrigated agriculture. However, the SIC ($CaCO_3$) content is higher in the soils of drier areas with lower MAR (Konheri and Nimone soil series) and rainfed agriculture (Konheri soil series). The results highlight the importance of climate and land-use in SOC and SIC formation in the soils.

Table 2.3.3. Characteristics of the sites from different bio-climates

Soil Series	Soil Type	Bio-climate	Land-use
RRS, Pattambi, Palakkad, Kerala	Moderately deep sandy clay soils (Typic Haplustalfs)	Per Humid (MAR 2700 mm)	Irrigated Agriculture (Rice-Rice)
Nedumancad, Trivandrum, Kerala	Deep clay soils (Typic Haplustepts)	Humid (MAR 2000 mm)	Irrigated Agriculture (Rice)

Soil Series	Soil Type	Bio-climate	Land-use
Kattuthottam, Tanjavur, Tamil Nadu	Very deep clay loam soils(Typic Haplustepts)	Semi-arid dry (MAR 800 mm)	Irrigated agriculture (Maize-Rice)
Konheri Solapur, Maharashtra	Very deep clay soils (Leptic Haplusterts)	Semi-arid dry (MAR 740 mm)	Rainfed (*Rabi*sorghum)
Nimone, MPKV, Rahuri, Maharashtra	Deep Clay soil (Aridic Haplusterts)	Arid (MAR 500-510 mm)	Irrigated Agriculture (Soybean-Wheat/chickpea)

Simulation of soil organic carbon under climate change scenarios

The soil organic carbon was simulated for four representative concentration pathways (RCPs) using Century carbon model and datasets of long term fertilizer experiments (LTFE) carried out at TNAU, Coimbatore. This site represents the Coimbatore soil series which is deep black soils (Vertisols: Sodic Haplusterts) under semi-arid climate (MAR 632 mm). The experiment includes different combinations of inorganic and organic nutrient sources. Century carbon model was used to simulate soil organic carbon (0-23 cm soil depth) for millet-maize cropping systems for baseline (existing climatic condition) as well under three nutrient management treatments: (i) Control, (ii) 100% NPK and (ii) 100% NPK and 10-ton farmyard manure (FYM). The climatic data, *viz.*, rainfall, maximum temperature (T_{max}) and minimum temperature (T_{min}) of four representative concentration pathways (RCPs: RCP2.6, RCP4.5, RCP6.0, and RCP8.5) was used and the simulation was carried for three time periods, viz., 2020, 2050 and 2080.

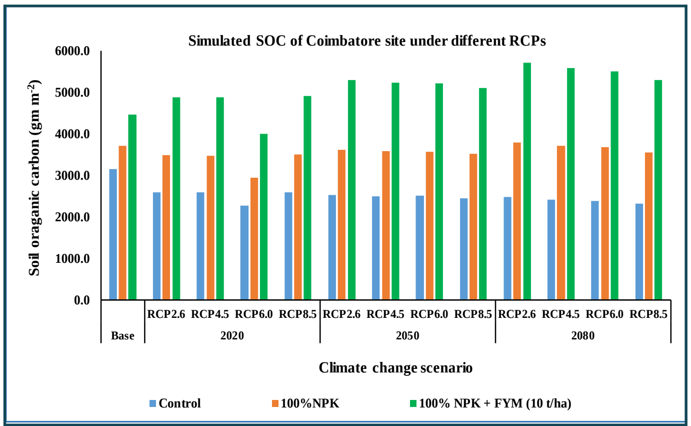


Fig.2.3.4. Simulated soil organic carbon under different RCPs at Coimbatore benchmark site

There is a significant increase in soil organic carbon (SOC) under treatment of 100% NPK plus FYM for RCP2.6, RCP4.5, RCP6.0 and RCP8.5 (except RCP 6.0 in 2020) in comparison to the base period for 2020, 2050 and 2080 (**Fig.2.3.4**). However, under control treatment, there is a significant decrease in soil organic carbon under four RCPs. Even in the treatment of 100% NPK, a slight decrease in SOC was observed. Therefore, the addition of inorganic fertilizer in combination with FYM could be an important strategy for maintaining the soil organic carbon and thus, the soil quality under climate change scenarios.

Soil quality assessment and developing indices of major soils and production regions of India

Soil quality assessment was carried out using grid sampling (20 km) for AESR 6.1 and 18.4. In AESR 6.1, which is dominated by cotton and sugarcane-based cropping systems, eight soil parameters, *viz*., pH, clay, an active pool of soil organic carbon, available water content and soil bulk density, available zinc, boron, and phosphorus were identified as soil quality indicators. In AESR 18.4, representing the rice-based cropping system, five soil parameters *viz*., electrical conductivity, CEC, active C pool, pH, and available Zn were selected.

Based on the Relative Soil Quality Index (RSQI), majority of the districts with cotton-based cropping systems have RSQI of Class II (80-90) whereas the districts with the sugarcane-based cropping systems have RSQI of Classes II and III (70-80) in AESR 6.1. The RSQI class is III and IV (60-70) in the majority of the districts with small patches of classes I (>90) and II in AESR 18.4 (**Fig. 2.3.5**). Thus, RSQI could serve as a unified criterion for comparing regional soil quality. From the relationship between RSQI and crop yields, it is concluded that the soil parameters identified as the soil quality indicators could help to monitor the soil quality, and sustaining and improving crop yields in AESRs 6.1 and 18.4.

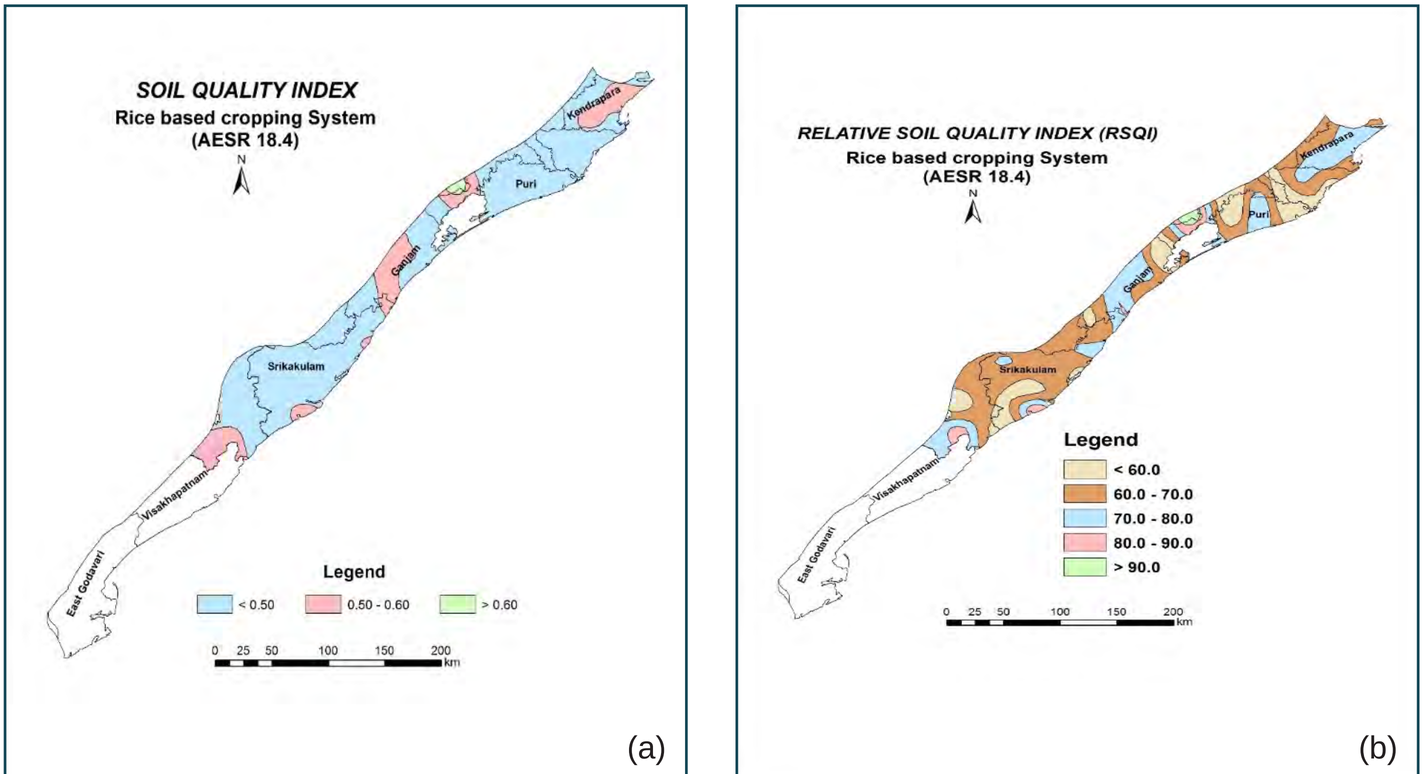


Fig.2.3.5. Maps of a) SQI and b) RSQI for rice based cropping system in AESR 18.4

The RSQI is significant and positively correlated with the yields of cotton (r = 0.68) and sugarcane (r=0.77) crops indicating that the identified soil parameter/ indicators can define the soil quality of cotton and sugarcane-based cropping systems in AESR 6.1. Similarly, for AESR 18.4, a significant and positive correlation (r = 0.75) is observed between the RSQI and the yield of rice crop.

2.4 Interpretation of Soil Survey Data

Pedotransfer function for predicting the soil hydraulic properties in the semi-arid region of Karnataka Plateau (Sujala III project)

Pedotransfer function (PTF) was developed to predict field capacity and permanent wilting point for Northern (512 soil samples) and Southern Karnataka Plateau (228 soil samples), separately. Further, PTF to predict the infiltration rate for Karnataka state was developed using 100 soil samples. Cross-validation results are satisfactory with low RMSE and higher R^2.

Northern Karnataka Plateau:

- FC= 13.82 +0.205 (Clay)-0.088 (Sand)+ 0.316(CEC) R^2= 83%, RMSE=5.25%
- PWP = -5.78 +0.315 (Clay)+0.050 (Sand)+ 0.271(CEC) R^2= 88%, RMSE=3.71%

Southern Karnataka Plateau:

- FC= 39.18 -0.041(Clay)-0.371(Sand)+ 0.257 (CEC) R^2= 84%, RMSE=3.05%
- PWP = 8.227 +0.168 (Clay)-0.101(Sand)+ 0.217 (CEC) R^2= 83%, RMSE=2.17%

Visual signs of biophysical indicators for assessing the status of degradation in drylands of Pulivendula tehsil, Kadapa district, Andhra Pradesh

The rainfall anomaly index (RAI) and temperature anomaly index (TAI) for Pulivendula tehsil, Kadapa district, Andhra Pradesh was calculated using the rainfall and temperature data from 1901 to 2002 for trend analysis of biophysical indicators.

The results showed that there were 16 extremely dry years (RAI >-4.0), twenty very dry years (RAI= -4 to -2.0), and 21 dry years (RAI =-2 to 0) suggesting the higher frequency of dry periods than wet periods. The incidence of the decrease of wet periods can be observed by the reduction of the crop growing season. In addition to direct environmental impacts, such as soil degradation and loss of biodiversity.

The mean temperature is an important climate variable that has a direct effect on agriculture and the ecosystem. From 1901 to 2002, the mean temperature is 26.2^{0}C with a standard deviation of 0.64. The TAI showed distinct and negative trends from 1978 onwards to 2002 indicating that there is cooling and lowering of air temperature from the baseline temperature in the region. However, the mean air temperature gradually increased by ±0.87. The warmest years started from 1917, 1933, 1949, and 1955 which confirms the droughts occurrence in these years leading to a severe famine. Our results confirm that spatial and temporal variations in temperatures were noticed in Pulivendula tehsil from 1955. The findings of this study are in agreement with IPCC prediction which stated in 2007 that, the Earth could warm by 3 ^{0}C this century.

Two key assumptions were implicitly made in this evaluation of linking pedological systems with climatic variability in the region. The first assumption is that evenly distributed seasonal rains (close to or above the long-term average) have resulted in good yields but poorly - distributed rainfall such as mid-season droughts, prolonged dry spells during critical stages often resulting in poor productivity. These assumptions are from the outcomes of socio-economic surveys and also from district level crop statistics. The second assumption is that consecutive crop loss and prolonged poor yields of groundnut (below state average) in drought-hit Pulivendula region (as evident from crop yield statistics and discussions with local farmers during surveys), there is a need for appraisal of land resources for suitability assessment for groundnut both in terms of physical and economic terms.

Soil erosion risk assessment in Harve 1 micro-watershed, Chamarajnagar district

Soil erosion risk assessment was carried out in Harve 1 micro-watershed in Chamrajnagar district with an annual rainfall of 763 mm. Corine model was employed for estimating soil erosion risk qualitatively using soil erodibility, rainfall erosivity, topography, and land-use land cover. The potential erosion risk map was generated using slope indices (**Fig.2.4.1**). The area under high erosion risk is 267.35ha (52.1% of total area), whereas, moderate erosion risk zone covers 26.9% of the total area.

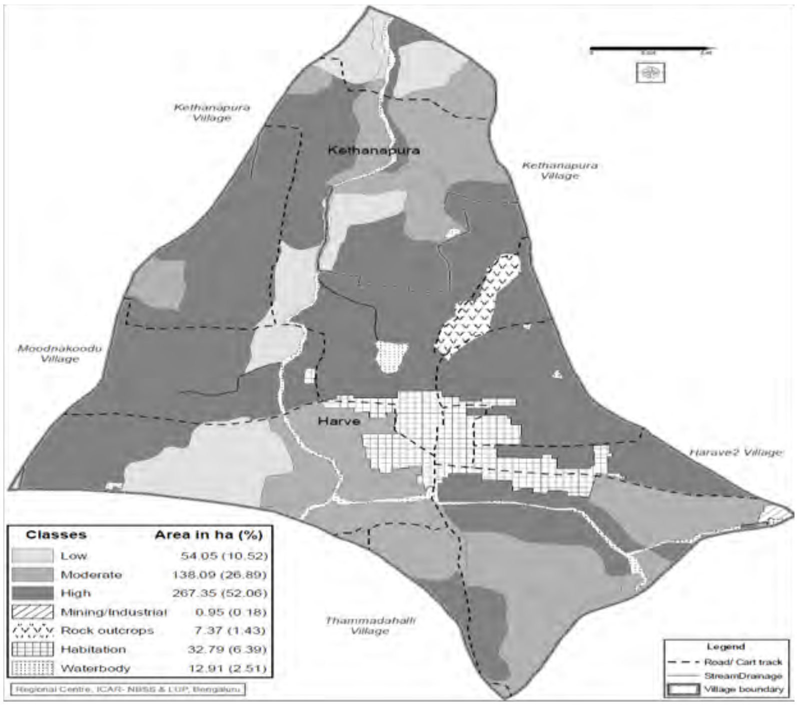


Fig.2.4.1. Map of Potential soil erosion risk in Harve 1

GIS-based digital library (DL) for the land resources of Sujala III watershed development project

Digital database of 204 watersheds was created and atlases were prepared with thematic maps on - soil phases, depth, land capability class (LCC), slope, texture, erosion, gravelliness, available water holding capacity, fertility status, current land-use, water resources and suitability maps for different horticultural, cereals and floricultural crops. Using the Digital Library (DL) software about 83,000 LRI cards were generated in the Kannada language and sent to respective JDA's for issuing to the farmers (**Table 2.4.1**).

Table 2.4.1. LRI Cards provided to districts of Karnataka (1st January 2019 to 31st October 2019)

District Name	Taluk Name	Details of LRI card generated	
		No. of Micro-watershed	No. of cards generated
Chamarajanagar	Chamarajanagar	4	1502
	Gundlupet	20	3251
Gadag	Gadag	4	733
	Shirahatti	23	2728
Gulbarga	Gulbarga	9	1,483
	Chitapur	6	1033
	Aland	9	1433
	Afzalpur	6	661
	Sedam	9	1591
	Jewargi	8	1024
Koppal	Koppal	160	28,048
Tumkur	Chikkanayakanahalli	9	3456

District Name	Taluk Name	Details of LRI card generated	
		No. of Micro-watershed	No. of cards generated
	Gubbi	9	1983
Yadgir	Yadgir	155	33,258
Bidar	Humnabad	5	768
	Total	436	82,952

Soils of Palani block of Dindigul District, Tamil Nadu

A total of 127 surface soil samples (0-15 cm) were collected from Plani block of Dindigul district, Tamilnadu (77° 18' 22" to 77° 38' 6" E, 10° 20' 12" to 10° 32' 33" N) covering an area of 39,960 ha in AESR 8.1 and analyzed for pH, organic carbon, available phosphorus, potassium and DTPA extractable micronutrients (**Table 2.4.2**). Soil pH varied from strongly acidic to strongly alkaline. About 48 % of the samples were acidic in reaction. About 60 percent of the soils are low in organic carbon and about 52 percent of the soils are medium in available phosphorus and potassium content. The available copper (Cu) ranged from 0.18 to 7.5 mg kg^{-1} with a mean of 1.57 mg kg^{-1}, iron (Fe) from 0.84 to 169 mg $kg^{-1}$with a mean of 26 mg kg^{-1}, manganese (Mn) from 1.58 to 30.8 mg $kg^{-1}$with a mean of 9.5 mg kg^{-1} and zinc (Zn) from 0.08 to 1.56 mg kg^{-1} with a mean of 0.42 mg kg^{-1}.

Table 2.4.2. Soil fertility status of Palani block, Dindigul district, Tamil Nadu

Nutrients	Percentage of soil samples (%) in different fertility category		
	Low	Medium	High
Organic carbon	59.8 (<0.5%)	23.6 (0.5-0.75%)	16.5 (>0.75%)
Available Phosphorus	16.5 (<11 kg ha^{-1})	33.9 (11-22 kg ha^{-1})	49.6 (>22 kg ha^{-1})
Available Potassium	26.8 (<118 kg ha^{-1})	51.2 (118-280 kg ha^{-1})	22.0 (>280 kg ha^{-1})
Available Sulphur	59.1 (<10 $mgkg^{-1}$)	23.6(10-20 $mgkg^{-1}$)	17.3(>20 $mgkg^{-1}$)
Available Boron	79.5(<0.5 mg/kg)	20.5(0.5-1.0 $mgkg^{-1}$)	0.0(>1.0 $mgkg^{-1}$)
Micronutrients	**Sufficient**	**Deficient**	
Iron (Fe)	74.8(>4.5 $mgkg^{-1}$)	25.2(<4.5 $mgkg^{-1}$)	
Manganese (Mn)	100.0(>1.0 $mgkg^{-1}$)	0.0(<1.0 $mgkg^{-1}$)	
Zinc (Zn)	19.7(>0.6$mgkg^{-1}$)	80.3(<0.6 $mgkg^{-1}$)	
Copper (Cu)	100.0(>1.2 $mgkg^{-1}$)	0.0(<1.2 $mgkg^{-1}$)	

Nutrient mapping of Dhanpatganj Block, Sultanpur District, Uttar Pradesh

Soil nutrients of Dhanpatganj block (Sultanpur district, U.P.) were mapped and the results showed that nearly 24% area is under imperfectly drained soils followed by moderately well-drained (21%), well-drained (20%), poorly drained (17%) and some-what excessively drained soils (11%) Soil pH ranged from 7.0 to 9.29 and nearly 12% area of the area is strong to very strongly alkaline. The organic carbon varied from 0.16 to 0.96% and about 48% soils is medium in organic carbon content. The entire block is low in

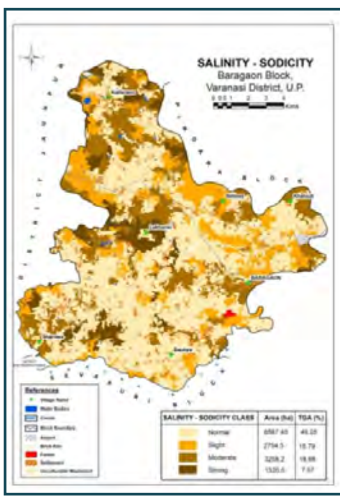


Fig.2.4.2. Soil salinity-sodicity map of Baragaon block of Varanasi district, U.P.

available N and nearly 21% area is low in available P. About 57% area is low in available K. About 21% area is under moderate to strong sodicity.

Soil salinity/sodicity in Baragaon Block, Varanasi District, Uttar Pradesh

LRI of Baragaon block Varanasi district, Uttar Pradesh was carried out to characterize the soils. Results showed that 6.14% and 1.34 % area is under slight and moderate erosion, respectively. The soils are well (20%) to moderately (45%) drained. About 21% of the area is under moderate and strong salinity (**Fig.2.4.2**). Soil texture varied from loamy sand (3%), sandy loam (47%), loam (11%), and clay loam (19%).

Interpretation of soil survey data of Kachchh district, Gujarat

The identified landforms in the Mandvi and Abdasa talukas are rocky uplands, pediment, pediplains, colluvial plains and coastal alluvial plains. A total of 29 soils (18 in Mandvi and 11 in Abdasa) were identified. The soils occurring on rocky uplands, pediments and pediplains were shallow to moderately deep and the soils of coastal alluvial plains were deep to very deep. Except few (Nagalpur and Bera series), most of the soils were well-drained. The soil texture varied from loamy sand to sandy loam in surface and from sandy clay loam to clay in the subsurface. The clay content varied from 10.9 to 30.3 % in the surface horizons and from 14.0 to 40.4 % in the subsurface horizons (**Fig.2.4.3**). The soil pH varied from 8.1 to 9.1 in surface horizons and from 8.1 to 9.5 in the subsurface horizons. Organic carbon, generally, decreased with depth and it varied from 0.39 to 1.35% in surface and from 0.21 to 1.15% in the subsurface. The cation exchange capacity (CEC) varied from 7.2 to 44.5 cmol (p^+) kg^{-1}. The ESP in the subsurface horizons was as high as 100 indicating severe sodicity in these soils.

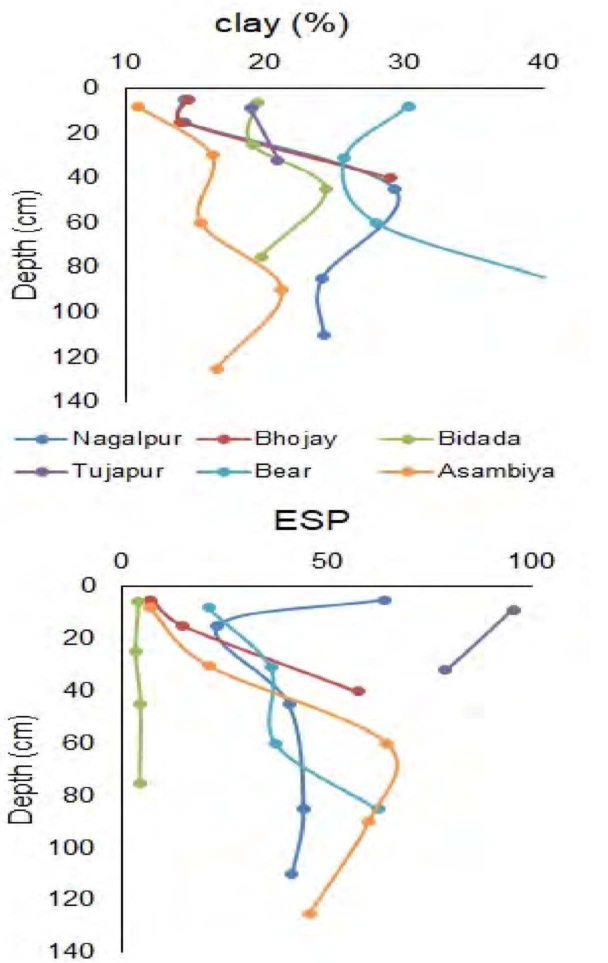
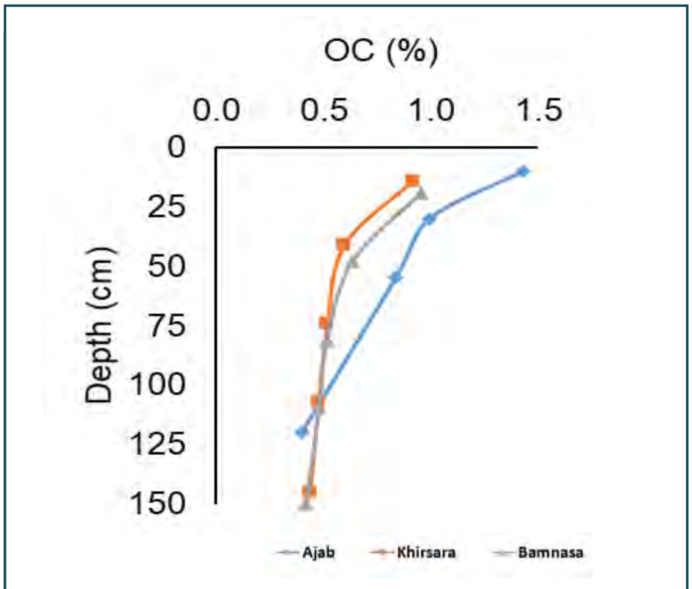


Fig.2.4.3. Depth distribution of clay and ESP in major soil series of Mandvi and Abdasa talukas, Kachchh, district, Gujarat

Fourteen soil series were identified from Bhuj (10) and Mundra (4) talukas. The soils of Bhuj taluka were slight to moderately alkaline (pH 7.6-8.8). Organic carbon content was low to medium in the surface horizons (0.16-0.67%) and decreased with depth. The $CaCO_3$ content varied from 1.2 to 44.3%. The clay content varied from 10.8 to 33.0%. The soils of Mundra taluka were slight to moderately alkaline (pH 7.8-8.8). Organic carbon varied from low to medium (0.12-0.60%). The $CaCO_3$ varied from 6.8 to 11.4% and generally, increased with depth. Clay content varied from 12.6 to 32.6 % and it increased with depth. Four soil series were identified in Nakhatrana and three each in Lakhpat and Gandhidham talukas. Soil depth varied from 38 to 150 cm. Soil texture varied from sandy loam to sandy clay loam. The clay content varied from 16.2 to 27.6 % and OC varied from 0.28 to 1.8% Calcium carbonate content ranged from 2.2% to as high as 56.2% and generally, increased with depth.

Interpretation of soil survey data of Junagadh District, Gujarat

Three soil series each were identified from Keshod and Vanthali talukas. The soil pH varied from slightly alkaline (7.8) to alkaline (8.9). Organic carbon was high in the surface layers of the soils and decreased with depth (**Fig.2.4.4**). The $CaCO_3$ varied from 7.3 to 32.4% and increased with depth. The clay content varied from 24.4 to 44.4% with a slight increase in the subsurface horizons. In Manavadar and Mangrol talukas, three soil series each were identified. The soils on the piedmont plain were moderately deep to very deep, sandy clay loam to clay loam, moderately to strongly alkaline, low to medium in organic carbon, and high in calcium carbonate. The soils on pediment were shallow, sandy loam to sandy clay loam, moderately alkaline, and low in organic carbon. The soils on coastal plain were very deep, sandy clay to sandy clay loam, moderately to strongly alkaline, medium in organic carbon, high in calcium carbonate and CEC.



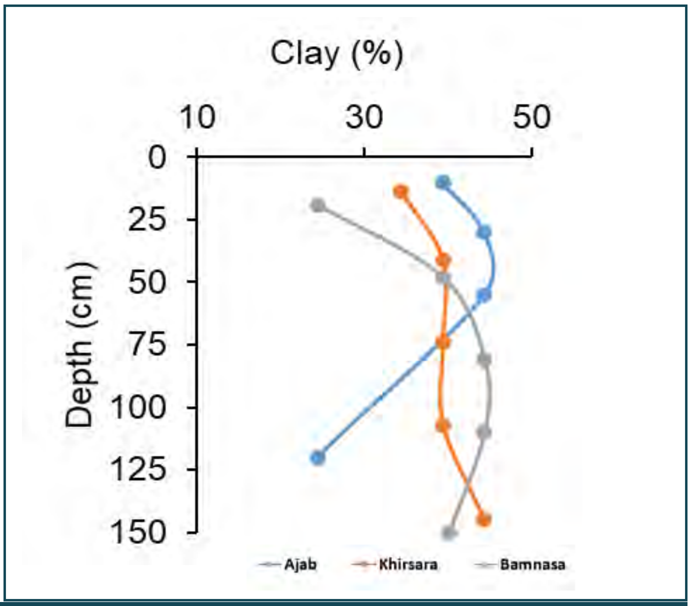


Fig.2.4.4. Organic carbon and clay in soils of Keshod and Vanthali talukas, Junagadh district, Gujarat

Development and management of integrated water resources in different agro-ecological regions of India

Soil hydrological group (HSG) maps of Arunachal Pradesh, Assam, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Manipur, Meghalaya, Odisha, Punjab, Sikkim, and Uttarakhand states were prepared and submitted to the consortium for run-off estimation and further use. The criteria for hydrological grouping included slope of the unit, land-use land cover and soil texture. The data on graveliness and parent material were also accessed based on the necessity. The hydrological soil group maps of selected states are presented in **figure 2.4.5** and the aerial extent of each group in the state is shown in **table 2.4.3**.

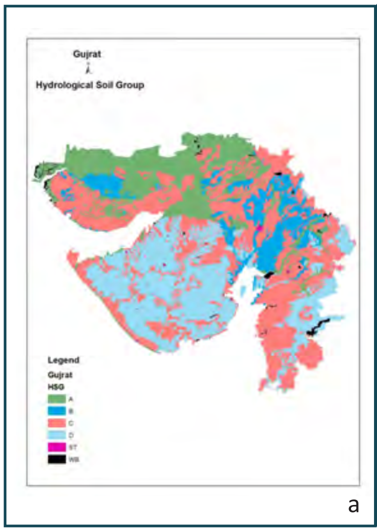


Fig.2.4.5. Soil hydrological group map of a) Gujarat, b) Jharkhand

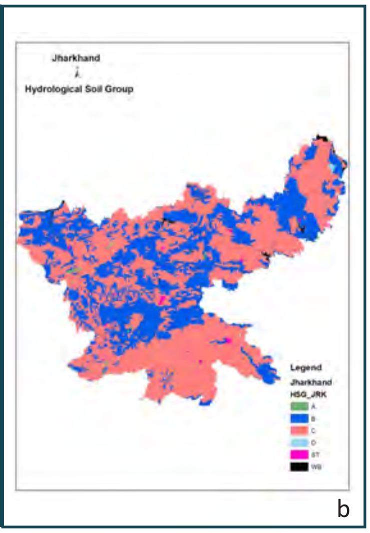


Table 2.4.3. The extent of area under different hydrological soil groupings in different states

State/HSG	Area in Sq. Km			
	A	B	C	D
Arunachal Pradesh	747.36	59754.96	10419.99	7943.34
Assam	3187.03	20145.83	40913.32	7263.86
Chhattisgarh	4443.36	3431.05	116678.76	5782.44
Gujarat	35966.99	17527.15	70115.38	49730.03
Himachal Pradesh	2099.13	4503.37	25218.40	21997.26
Haryana	11669.98	19046.12	12132.15	-
Jharkhand	255.01	28657.43	46950.16	77.02
Meghalaya	1809.40	17387.03	1451.76	764.88
Manipur	5.00	14562.34	4309.26	2466.27
Odisha	18563.59	54068.59	74094.82	935.91
Punjab	7563.92	12717.22	28684.33	-
Sikkim	-	2198.70	1633.98	2957.43
Uttarakhand	3804.78	2776.10	38633.27	6571.89

Development of an algorithm to predict soil depth using legacy data and terrain attributes

An innovative methodology was developed to predict soil depth and the likelihood of a rock layer within 2m from the surface for laying optical fibre cables in an industry (M/s Sterlite Technologies Limited) sponsored project. An algorithm was developed for prediction of the spatial pattern of soil depth from topographic and land cover attributes. Topographic attributes, derived from a digital elevation model (DEM), intended to have the explanatory capability for soil depth, was combined with the visual interpretation of Google Earth images and expert knowledge. Various land cover attributes were derived from Landsat remote sensing images. Primary geospatial data included a DEM (obtained from the USGS Web site), Landsat TM imagery, and the soil resource map. The geospatial explanatory attributes namely drainage lines and density, topographic wetness index, topographic position index, aspect, and curvature were derived from the DEM. The 1/3 arc sec DEM was projected to a 30 m grid for the derivation of the landform units considered as potential explanatory variables for predicting soil depth over the landscape. Approximately, 17000 km of data have been analyzed.

Application of Soil Resource database for Geospatial planning of Power transmission towers in India

The angle of repose, bulk density, and ultimate bearing capacity of the soils at 500 m interval along the transmission route is required by the company for structural design/foundation to raise power transmission towers in different countries. Global gridded soil information maintained by ISRIC (1:500000 scale) has been used to procure primary soil information like textural composition and other related information. The three engineering properties were derived from the textural composition. ASTER DEM data were used to derive terrain attributes like slope, mean elevation, and contours. Visual inspection of the route has been done using the Google Earth image to identify land-use. The secondary data on geology, rainfall, crops, and water table were collected from different open sources. All these data were correlated to estimate the engineering properties. The typical output file (**Table 2.4.4**) is given below for a route in Ghana.

Table 2.4.4. Engineering properties estimated using terrain parameters

Distance (m)	X Co-ordinates	Y Co-ordinates	Near to	LULC	DEM	Slope	Angle of repose	Ultimate bearing capacity KN/sqm	Bulk soil density g/cm3
0	-0.21217	5.549491	Accra Railway station	Habitation	10	0-5	30	350-400	1.4-1.5
0	-0.21369	5.550459		Habitation	10	0-5	30	300-400	1.4-1.5
400	-0.21523	5.551394		Habitation	11	0-5	30	300-400	1.4-1.5
600	-0.21678	5.552329		Habitation	10	0-5	30	300-400	1.4-1.5
800	-0.21831	5.55328		Habitation	13	0-5	30	300-400	1.4-1.5
2600	-0.21895	5.568826		Habitation	9	0-5	15-20	300-350	1.4-1.6
2800	-0.21911	5.570628		Habitation	13	0-5	15-20	250-300	1.3-1.5
3000	-0.21926	5.572429		Habitation	6	0-5	15-20	250-300	1.3-1.5
3200	-0.21941	5.57423		Habitation	23	5-10	17-19	450	1.5-1.6
3400	-0.21957	5.576032		Habitation	35	5-10	17-19	450	1.5-1.6
3600	-0.21972	5.577833		Habitation	23	5-10	17-19	450	1.5-1.6
3800	-0.21987	5.579635		Habitation	47	5-10	17-19	450	1.5-1.6
4000	-0.21999	5.581438		Habitation	22	5-10	17-19	450	1.5-1.6
4200	-0.21968	5.583206		Habitation	39	5-10	17-19	450	1.5-1.6
4400	-0.21923	5.584958		Habitation	10	0-5	15-20	250-300	1.3-1.5
4600	-0.21879	5.58671		Habitation	30	5-10	15-20	250-300	1.3-1.5
4800	-0.21834	5.588462	Highway Bridge	Habitation	29	5-10	15-20	250-300	1.3-1.5
5000	-0.21809	5.590239		Habitation	49	5-10	15-20	250-300	1.3-1.5

Assessment of heavy metal contamination in the soil surrounding an iron ore mining area of Northern Goa

Heavy metal contamination was assessed in an iron ore mine surrounding area (15˚37'7"to 15˚34'20" N and 73˚53'11"to 73˚56'43" E) of Bicholim Taluka, Goa state by collecting soil samples from two transects. The absolute concentration of Fe and Mn was high whereas Cd and Co were the lowest in both the surface and sub-surface soils of transect1 and 2. The average concentration of each metal is higher in the surface soils than the subsurface soils. The mean I_{geo} values indicated that the contamination of Cu, Cd, Mn, and Co was moderate to heavy (class 3; I_{geo}=2-3); Pb moderate (class 2; I_{geo}=1-2); Fe heavy to the extreme (class 5 -I_{geo}=4-5; class 6- I_{geo}>5); Cr nil to moderate (class 1; I_{geo}=0-1). The 10 times higher degree of contamination (Cdeg) values than the sample number (n) indicate a very high degree of contamination.

The Ecological risk (Er) of individual metal varied significantly in the surface soils of T1 (**Table 2.4.5a**) for Cu (41.61-46.40), Pb (15.77-18.88), Cd (52.54-55.47), Cr (11.31-15.37) and Mn (4.81-28.41). Also in sub-surface of T2 (**Table 2.4.5b**), the Er varied significantly as Cu (40.56-42.74), Pb (14.47-19.05), Cd (50-56.45), Cr (9.53-14.01) and Mn (0.56-6.43). In all the cases, Cr and Pb having less toxic responses show less average ecological risk, where, Cu, Cd, and Mn with high toxic responses show comparatively high mean ecological risk to the soil. The sensitivity of the biologic environment to the toxic substances has been assessed by potential ecological risk (RI) for the sample site. The results showed that the mean RI value as 129.62, 127.08, 124.42, and 123.14 for T1 surface, T1 sub-surface, T2 surface, and T2 sub-surface, respectively. The value indicates moderate ecological risk potential over the entire study area.

Table 2.4.5a. Ecological risk factor (ER_i) and Potential ecological risk index (RI) of Transect-1

Site	Cu	Pb	Cd	Cr	Mn	RI
	ER_i	ER_i	ER_i	ER_i	ER_i	
Surface soil sample						
T_1DS	41.61	18.88	55.47	15.37	5.19	131.32
T_1P_1S	43.74	17.95	54.98	11.31	28.41	127.99
T_1P_2S	46.05	15.77	52.54	13.69	7.81	128.05
T_1P_3S	46.40	17.53	54.30	14.60	5.49	132.82
T_1P_4S	44.64	16.38	53.61	13.27	4.81	127.90
Mean	44.49	17.30	54.18	13.65	10.34	129.62
Max	46.40	18.88	55.47	15.37	28.41	132.82
Min	41.61	15.77	52.54	11.31	4.81	127.90
Sub-surface soil sample						
T_1DSS	41.53	17.93	56.05	14.24	3.49	129.76
T_1P_1SS	45.73	13.36	53.22	9.40	6.79	121.72
T_1P_2SS	45.71	16.55	53.61	11.70	5.91	127.57
T_1P_3SS	45.03	16.34	53.91	14.02	3.22	129.30
Mean	44.50	16.04	54.20	12.34	4.85	127.08
Max	45.73	17.93	56.05	14.24	6.79	129.76
Min	41.53	13.36	53.22	9.40	3.22	121.72

Table 2.4.5b. Ecological risk factor (ER_i) and Potential ecological risk index (RI) of Transect-2

Site	Cu	Pb	Cd	Cr	Mn	RI
	ER_i	ER_i	ER_i	ER_i	ER_i	
surface soil sample						
T_2DS	41.53	17.93	58.01	12.54	3.49	130.01
T_2P_1S	41.67	16.55	54.10	11.80	5.01	124.12
T_2P_2S	41.14	16.25	55.86	11.05	8.98	124.30
T_2P_3S	40.43	14.82	51.76	10.55	1.79	117.56
T_2P_5S	42.12	18.53	54.10	11.38	4.65	126.13
Mean	41.38	16.82	54.77	11.47	4.78	124.42
Max	42.12	18.53	58.01	12.54	8.98	130.01
Min	40.43	14.82	51.76	10.55	1.79	117.56
Sub-surface soil sample						
T_2DSS	41.61	19.05	56.45	14.01	5.19	131.11
T_2P_1SS	41.91	16.69	53.91	11.16	5.48	123.66
T_2P_2SS	41.97	16.40	51.76	11.83	3.89	121.95
T_2P_3SS	41.80	14.47	51.95	9.58	0.71	117.80

Site	Cu	Pb	Cd	Cr	Mn	RI
	ER_i	ER_i	ER_i	ER_i	ER_i	
T_2P_4SS	40.56	15.79	50.00	9.53	0.56	115.87
T_2P_5SS	42.74	18.86	54.00	12.81	6.43	128.41
Mean	41.76	16.88	53.01	11.49	3.71	123.14
Max	42.74	19.05	56.45	14.01	6.43	131.11
Min	40.56	14.47	50.00	9.53	0.56	115.87

Distribution of Sodic Soils in Krishnagiri (KRP) dam catchment in Kaveripattinam block

The Krishinagiri Reservoir Project (KRP) dam catchment area covers around 3500 ha. The fluctuation of the water table is higher near the dam and it decreases with increasing distance, hence, the rice-growing soils are poorly drained and are sodic. Surface salt accumulation is observed in the soils and the crop performance is poor.

To study the extent of sodicity, soil profiles from single (P1), double (P2), and triple rice (P3) cropping systems were characterised. The soil P3 near the dam has higher exchangeable calcium (11.8 to 31.8 cmol(p^+) kg^{-1}) than the other two soils. The exchangeable Mg and Na gradually increased with increasing distance from the dam. The ESP of the soils was high and increased with depth indicating sodicity (**Fig.2.4.6**).

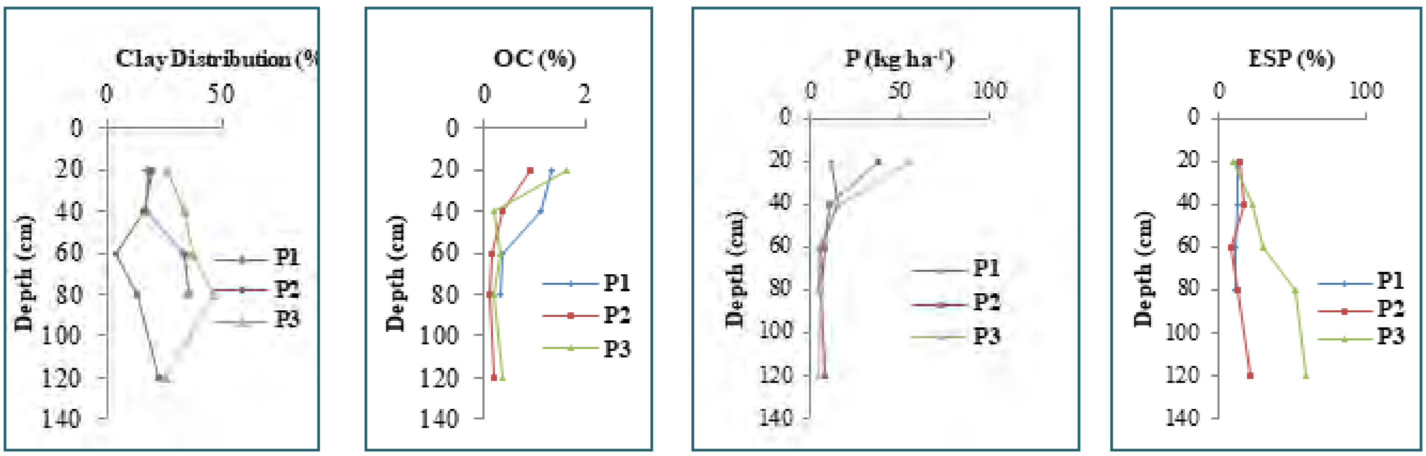


Fig.2.4.6. Depth wise distribution of clay, OC, available P and ESP in the dam catchment

2.5 Land Evaluation and Land Use Planning

Agricultural Land-use Planning for Kultali block, 24 Pgs(S) using LRI database in 1:10,000 scale

Construction of land embankments (Ail bund) for the cultivation of paddy cum fish culture in the mainland and vegetable–vegetable in *Ail bunds was* demonstrated in four small and marginal beneficiaries fields in the mouzas Binodpur (Jl No 166), Baikunthapur (Jl No 167), Dakshin Gorankati (Jl No 152) and Madhya Gurguriya (Jl No 162) under LMU 1, 2, 4 and 5, respectively. The *Ail* bunds were cropped with the vegetable-vegetable system (**Table 2.5.1**) using the stored rainwater from the ponds and trenches dug around the mainland.

Table 2.5.1. LMU wise land-use options for Kultali block

LMU	Farmer	Mouza	Land Holding (Acres)	*Ail* (Acres)	*Kharif*	*Rabi*
I	Susanta Mandal	Binodpur	1.60	0.40	Paddy (var Pankaj); Vegetables (Bitter gourd and cowpea)and fish	Pulses (Khesari)
II	Ashish Mahapatra	Baikunthapur	1.20	0.40	Paddy (var Pankaj); Vegetables (Okhra +celery) and fish	Pulses (Khesari)
III	Gopal Sardar	Dakshin Garankati	0.92	0.60	Paddy (var Pankaj); Vegetables (Okhra +celery)	Vegetables (Okhra, cucurbit, celery)
V	Mukul Haldar	Madhya gurguriya	1.00	0.25	Paddy (var Pankaj); Vegetables (cowpea) and fish	Pulses (Moong)

Up-scaling of land shaping Technology in Gosaba block, South 24 Parganas district for enhancing the livelihood of the farmers in the coastal region of West Bengal (STC Programme).

Four soil series, namely, Pathankhali, Bali-II, Rangabelia, and Uttar Danga, were mapped into 13 mapping units at phase level during the LRI of Gosaba block on 1:10,000 scale. Soils of the block were grouped into three Land Management Units (LMU) for management practices. The soil characteristics and LMU are presented in t**able 2.5.2**. Based on LRI data, site-specific land shaping technology was applied to increase the cropping intensity (**Table 2.5.3**) as well as the income of the farmers. Application of land shaping technology enhanced the income by 7 to 9.5 times depending on the type of land shaping technology.

Table2.5.2. Soil Characteristics and Land Management Units of Gosaba

Soil Series	Phases	LMU	Land Management Plan	Crop planning
Pathankhali	Pat-sic-B-S2-f1 Pat-sicl-B-S3-f1 Pat-sicl-B-S2-f1	LMU 1	1. Liming, green manuring and fertilization with rock phosphate to improve soil health and productivity. 2. Adoption of 3-tier approach by farm pond land shaping technology with fish in pond, vegetables, and fruit crops in upland, multipurpose tree species (MPTs) in pond dykes and paddy in low land. 3. Adoption of integrated soil nutrient management with the use of available organic and inorganic sourcesthat are ecologically sound and economically viable.	3-tier approach by farm pond land shaping technology created: • Water harvest structure (pond), upland, midland, and low land. Fish culture may be practiced in the pond and pond dykes may be utilized for fruit crops and multipurpose tree species (MPTS). • Uplands may be utilized for vegetable cultivation throughout the year. • Mid lands may be utilized for pulses, oilseeds during the rabi season and paddy during the Kharif season. • Low land may be utilized for paddy.

Soil Series	Phases	LMU	Land Management Plan	Crop planning
Bali-II	Bal-sicl-B-S3-f1	LMU 2	1. Liming, green manuring, and fertilization with rock phosphate to improve soil health and productivity. 2. Adoption of 2 tier approach by shallow furrow and medium ridges land shaping technology for soil units no. 7, 8 & 9 with vegetation/fruit crops on the ridge and paddy on the furrow. 3. Adoption of integrated soil nutrient management with the use of available organic and inorganic sourcesthat are ecologically sound and economically viable.	2-tier approach by shallow furrow and medium ridges of land shaping technology was adopted where acid sulphate layers occur within 60 cm of soil depth: • The medium ridges were utilized for vegetables. • The shallow furrows are utilized for paddy-cum-fish during Kharif rice.
	Bal-sil-B-S4-f1			
	Bal-sicl-A-S2-f1			
Rangabelia	Ran-sicl-B-S2-f1			
	Ran-sil-B-S2-f1			
	Ran-sic-B-S2-f1			
Uttar Danga	Utd-sic-A-S3-f1	LMU 3	1. Adoption of 2 tier approach by deep furrow and high ridges of land shaping technology / 2 tier approach of paddy-cum-fish land shaping technology with wide dyke for vegetable cultivation ditch for fish and the mainland for paddy and pulses.	**Case 1.** 2-tier approach by deep furrow and high ridges of land shaping technology created: • Water harvest structure in a deep furrow and high ridges. • Fish culture may be practiced in the deep furrow and high ridges may be utilized for vegetables, fruit crops, and multipurpose tree species (MPTS) throughout the year. **Case 2** • Adoption of the 2-tier approach of paddy-cum-fish land shaping technology provides trenches of 4ft. wide and 4ft. deep in the outer boundary of the land. During *Kharif*, paddy and fish will grow together. Winter vegetables like chilli, tomato, cauliflower, cabbage can be grown on the dykes of the trenches. During *rabi* season, pulses, oilseed crops can be grown with water in trenches (life-saving irrigation) and summer vegetables on the dykes.
	Utd-sicl-A-S2-f1			
	Utd-sic-A-S3-f2			
	Utd-sic-A-S2-f2			

Table2.5.3. Impact of adopted technology on cropping pattern (model for 1ha land)

LMU	Land Shaping Model	Pre-intervention		Post-intervention			Cropping Intensity (%)	
		Kharif season	*Rabi* season	Land situation created (area in m²)	*Kharif* season	*Rabil* summer season	Before	After
LMU 1	Farm Pond (50% area)	Rice	Mostly fallow	Pond (400)	Fish	Fish	112	283
				Dikes (162)	Vegetables & fruit crops	Vegetables & fruit crops		
				High land(1438)	Vegetables	Vegetables		
				Medium land (3000)	Rice	Vegetables, Pulses		
	Low land (50%) Paddy cum fish	Rice	Mostly fallow	Trenches (396)	Fish	Fish		
				Dike (432)	Vegetables	Vegetables		
				Original low land(4172)	Paddy	Pulse/oilseed		

LMU 2	Shallow furrow and medium ridges (75%)	Rice	Mostly fallow	Ridges (3750)	Vegetables & fruit crops	Vegetables & fruit crops	112	296
				Furrow (3750)	Paddy cum fish	Pulses/oilseed		
	Original low land (25%)			Original low land (2500)	Paddy	Pulse/oilseed		
LMU 3	**Option 1** Deep furrow and high ridges (50%)	Rice	Mostly fallow	Ridges (3750)	Vegetables, fruit crops & horticultural crops	Vegetables, fruit crops& horticultural crops	112	257
				Furrow (3750)	Fish	Fish		
	Original low land (50%)			Original low land (2500)	Paddy	Pulse/oilseed		
	Option 2 Paddy-cum-fish			Trenches (846)	Fish	Fish	112	198
				Field dikes (882)	Vegetables	Vegetables		
				Original low land (8272)	Rice	Pulses/ Vegetables		

Optimizing agricultural land-use plan for Susnigaria village of Ghatshila block, East Singbhum district, Jharkhand (under STC programme)

The village Susnigaria, Ghatshila block, East Singhbhum district, Jharkhand located in the catchment of Subarnarekha River has a diverse topography. The geo-dynamic forces have contributed to the formation of undulating topography leading to gently sloping plain with an elevation of 109 to 123 m above the mean sea level. Acidity is the major cause of plant mortality. Lack of irrigation water except very few natural ponds restricts the expansion of irrigated agriculture in the village. Moreover, poverty, high unemployment, and illiteracy are the characteristic features of the village. The farming community of the village is dominated by very poor, marginal

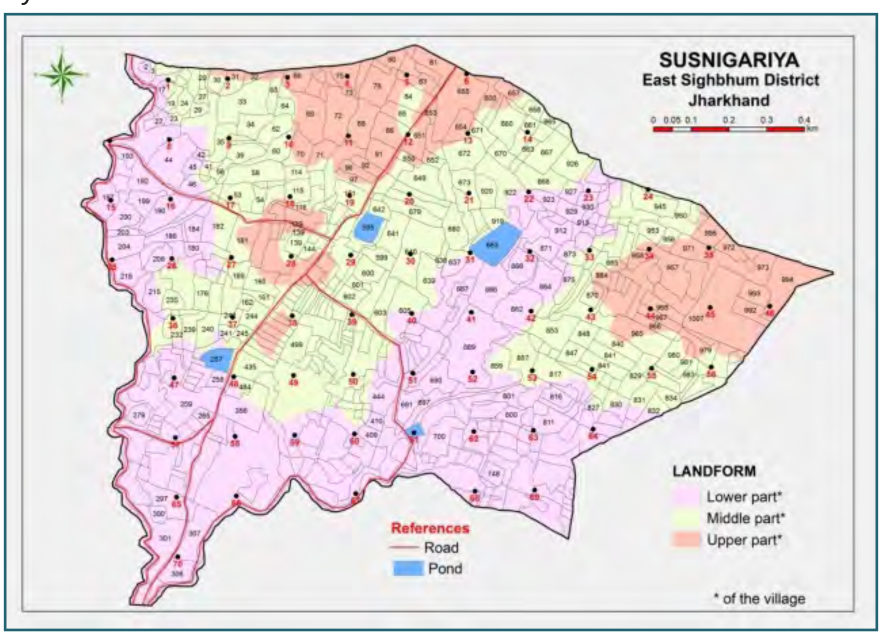


Fig.2.5.1. Landform and grid map of Susnigaria village

and landless farmers of "Munda" tribes. Hence, the study has been undertaken in the above location for enhancing productivity and improving the livelihood security of the resource-poor farmers.

- A socio-economic survey was carried out in the village to understand the inherent problems and discuss suitable adoption of the technologies/strategies like water harvesting, soil amendments, nutrient management, site-specific crop selection for enhancing productivity and improving the livelihood of the tribal farming community in the village.
- Broad landform and 2.5 ha interval grid map (**Fig.2.5.1**) of the village was prepared and 64 soil samples were collected for preparation of soil health cards. The analysis of soils indicates that the village has major constraints of extreme to very strong soil acidity, low organic carbon content, low in available phosphorus and potassium, and deficient available boron.
- Scientists-farmers interaction meet was organized and 1000 horticultural plants consisting of mango, lemon, and guava plants we

Livelihood improvement of Tribal communities in selected hamlets of H.D. Kote, Mysore through integrated land-use planning (TSP)

Bt cotton hybrid was evaluated as a component of an integrated farming system (IFS) in shallow, moderately deep, deep, and very deep soils with best management practices. The productivity of cotton was highest in moderately deep soils as compared to other soils (**Table 2.5.4**). In normal monsoon year, deep, well-drained sandy clay loams and deep to very deep clay soils recorded higher productivity. However, the productivity of Bt cotton in 2018 and 2019 was different due to high rainfall during boll development and maturity stage that led to water stagnation and boll drop in deep and very deep soils. Net return was also the highest in moderately deep soils followed by deep, well-drained sandy clay loams. The results indicated that moderately deep soils are better suited as evidenced by consistently higher yields of cotton either in normal or high rainfall years.

Table 2.5.4. Performance of Bt cotton hybrid on different soils

Soils	Seed cotton yield (q/ha)	Net returns (Rs/ha)
Shallow, well-drained, gravelly red loam soils	5.0	10000
Moderately shallow, well-drained, sandy clay loam soils	7.5	22500
Moderately deep, well-drained, sandy clay loam soils	17.5	72500
Deep, well-drained, sandy clay loam soils	15.0	60000
Very deep, well-drained to moderately well-drained, clayey soils	12.5	47500

Performance of maize on different soils

Maize was evaluated as a component of IFS in moderately deep, deep, and very deep soils with the best management practices. Due to continuous rains during September and October, water stagnation occurred in deep to very deep clayey soils during grain filling and maturity stage. Therefore, the productivity of maize was low in clayey soils as compared to deep and moderately-deep red sandy clay loam soils (**Table 2.5.5**). A similar trend was observed in net returns too.

Table 2.5.5. Performance of maize on different soils

Soils	Grain yield (q/ha)	Net returns (Rs/ha)
Medium deep, well-drained, sandy clay loam soils	40.0	38000
Deep, well-drained, sandy clay loam soils	50.0	51000
Very deep well-drained to moderately well-drained, clayey soils	32.0	28400

Validation of suggested integrated land-use plans

Shallow, well-drained, gravelly red loam soils (LMU 1)

In shallow soils, two land-use models were tested in which, model II recorded a higher BCR of 1.89 as compared to the model I (**Table 2.5.6**). However, there was no significant difference in net returns between the two models. Among the crops and cropping systems tested in shallow soils, finger millet + sesame intercropping system and finger millet sole crop was found more profitable and economically viable.

Table 2.5.6.Economic analysis of different LUP models in shallow soils in relation to farmers' practice

LUP	Land-use		Av. Yield (q/ha)		Net return of CS (Rs./ ha/yr)	B:C ratio
	Kharif	***Rabi***	***Kharif***	***Rabi***		
Model I	Cotton	-	5.0	-	10000	0.66
	Finger millet + sesame	-	20.0 + 1.5		42500	2.83
	Foxtail millet	-	10.0	-	20000	2.00
	Average				**24166**	**1.83**
Model II	Cotton	-	6.0	-	15000	1.00
	Finger millet	-	22.0	-	40000	2.67
	Sesame	-	3.0	-	10000	2.00
	Average				**21667**	**1.89**

Moderately shallow, well-drained, sandy clay loam soils (LMU-2)

In moderately shallow soils, the model I recorded the highest net returns of Rs.36866 per ha with BCR of 2.46 as compared to Model II (**Table 2.5.7**). Among the crops and cropping systems tested in moderately shallow soils, finger millet intercropped with sesame and finger millet sole crop was found more remunerative.

Table 2.5.7. Economic analysis of different LUP model in moderately shallow soils

LUP	Land-use (Cropping system)		Av. Yield (q/ha)		Net return of CS (Rs/ha/yr)	B:C ratio
	Kharif	***Rabi***	***Kharif***	***Rabi***		
Model I	Cotton	-	7.5	-	22500	1.50
	Finger millet + Sesame	-	25.0 + 2.0	-	57500	3.83
	Maize	Field bean	38.0	-	30600	2.04
	Average				**36866**	**2.46**
Model II	Cotton	-	7.0	-	20000	1.33
	Finger millet	Field bean	25.0	-	47500	3.16
	Maize	Cowpea	35.0	-	27000	1.80
	Average				**31500**	**2.10**

Moderately deep, well-drained, sandy clay loam soils (LMU-3)

Three land-use models were assessed in moderately deep sandy clay loam soils, of which model III recorded highest net returns of Rs. 1,88,025 per ha with BCR of 2.81 (**Table 2.5.8**). The model I and Model II were under rainfed conditions and model III was under irrigated conditions. Under the rainfed situation, finger millet followed by cowpea and marigold followed by finger millet proved a more economical and viable system. Under the irrigated system, banana intercropped with brinjal and tomato is more remunerative than cotton/maize followed by finger millet/vegetables.

Table 2.5.8. Economic analysis of different LUP model in medium deep soils

LUP	Land-use (Cropping system)		Av. Yield (q/ha)		Net return of CS (Rs./ha/yr)	B:C ratio
	Kharif	***Rabi*-summer**	***Kharif***	***Rabi***		
Model I	Cotton	Horse gram	16.0	2.5	75000	3.00
	Maize	Field bean	40.0	4.0	49000	3.26
	Finger millet	Cowpea	24.0	2.0	53000	3.53
	Average				**59000**	**3.26**
Model II	Cotton	-	18.0		70000	3.50
	Marigold	Finger millet	180.0	20.0	110000	3.66
	Maize	Field bean	42.0	6.0	54400	2.72
	Average				**78133**	**3.29**
Model III (Irrigated)	Cotton	Finger millet	17.0	30.0	125000	3.57
	Maize	Chottu	53.0	50.0	88600	2.53
	Maize	Tomato	55.0	355.0	178500	2.75
	Banana+Brinjal/tomato		250.0+ 150+120		360000	2.40
	Average				**188025**	**2.81**

Deep, well-drained, sandy clay loam soils (LMU-4)

In deep, well-drained, sandy clay loam soils, three IFS models were tested. Model III (irrigated) recorded the highest net profit of Rs. 2,33,750/ha/year with BCR of 3.03. Model I and Model II were tested under rainfed situation (**Table 2.5.9**). Among the crops tested in Model I and II, finger millet followed by field bean and marigold followed by finger millet recorded the highest returns as compared to other cropping systems. In the irrigated system, growing vegetables was more remunerative, (chilli, brinjal, and tomato) as intercrops with banana. Intercrops in the initial growth period of banana recorded the highest net returns and BCR.

Table 2.5.9. Economic analysis of different Land-use model in deep soils

LUP	Land-use (Cropping system)		Av. Yield (q/ha)		Net return of CS (Rs./ha/yr)	B:C ratio
	Kharif	**Rabi-summer**	**Kharif**	**Rabi**		
Model I	Maize	Field bean	52.0	5.0	62400	3.12
	Cotton	Horse gram	15.0	4.0	71000	3.55
	Finger millet	Field bean	35.0	5.0	87500	4.37
	Average				**73633**	**3.68**
Model II	Cotton	Cowpea	16.0	3.5	74000	3.70
	Marigold	Finger millet	182.0	20.0	106000	3.02
	Maize	*Chottu (Yardlong bean)*	48.0	55.0	77600	2.22
	Average				**85867**	**2.98**

LUP	Land-use (Cropping system)		Av. Yield (q/ha)		Net return of CS (Rs./ha/yr)	B:C ratio
	Kharif	Rabi-summer	Kharif	Rabi		
Model III (Irrigated)	Maize	*Chottu*	50.0	65.0	90000	2.57
	Cotton	Tomato /Chilli	14.0	300/150	220000	2.93
	Tomato/Brinjal/Chilli		250+200+150		225000	3.00
	Banana+ chilli/tomato/brinjal		250+75+150+180		400000	3.63
	Average				**233750**	**3.03**

Deep to very deep, well-drained to moderately well-drained, clayey soils (LMU-5)

Three models *viz*., Model-I (rainfed): cotton –cowpea, marigold-finger millet, maize-*Chottu*; Model-II (Irrigated): cotton-tomato/chilli, Bitter guard-*Chottu* and maize-*Chottu*; Model-III (Irrigated): *Chottu* + beans+bhendi+tomato+chilli- finger millet/maize, banana+chilli/brinjal/tomato) and Coffee+drumstick+ pepper+ yam+ ginger+turmeric were evaluated. All the crops in different models received recommended doses of fertilizers based on soil test except model III (organic) with water conservation practices like contour cultivation with conservation furrow, ridging, sowing across slopes, graded bunds, and field bunds. Net return per ha per year and BCR was highest in Model-III (Rs.3,28,200/ha/year and 3.36, respectively) followed by Model-II and Model I (**Table 2.5.10**). Among the crops and cropping systems tested in deep to very deep soils, the inclusion of vegetables as intercrops in banana and the multi-storied system was found more remunerative.

Table 2.5.10. Economic analysis of different Land-use model in deep soils in relation to farmers practice

LUP	Land-use (Cropping system)		Av. Yield (q/ha)		Net return of CS (Rs./ha/yr)	B:C ratio
	Kharif	*Rabi/summer*	*Kharif*	*Rabi*		
Model I	Cotton	Cowpea	11.0	4.0	51000	2.55
	Marigold	Finger millet	120.0	25.0	87500	2.50
	Maize	Field bean	30.0	8.0	48000	2.40
	Average				**62167**	**2.48**
Model II (Irrigated)	Cotton	Tomato/ Chilli	12.0	250/120	200000	4.44
	Rice (Aerobic)	Rice (aerobic)-cowpea	25.0	20.0	60000	2.00
	Maize	*Chottu*	25.0	45.0	45000	1.50
	Average				**101667**	**2.65**
Model III (Irrigated)	*Chottu*+ beans + bhendi + tomato + chilli	-	10.0 + 15.0 + 20.0 + 100.0 + 40.0	-	80000	2.28
	banana+tomato+chilli +brinjal		75.0 + 100.0+ 50.0+150.0		175000	3.50
	Coffee+drumstick+pepper+yam+ginger+turmeric		0+500 sticks + 1.0 + 70.0 + 3.5 + 1.0		85500	2.85
	Average				**113500**	**2.88**

Delineation of potential areas for agricultural land-use planning

Potential areas for major crops have been delineated at the national level by considering (i) soil resource information prepared at 1:1 m scale, (ii) Soil morphological, physical and chemical properties, and (iii) Climate data.

Potential areas for Rice

Rice is the most important staple food crop in India covering about one-fourth of the total cropped area (44.11 m ha) and providing food to about half of the Indian population. This is the staple food of the people living in the eastern and the southern parts of the country, particularly, in the areas having over 150 cm annual rainfall. There are about 10,000 varieties of rice in the world, out of which about 4,000 varieties are grown in India**.**

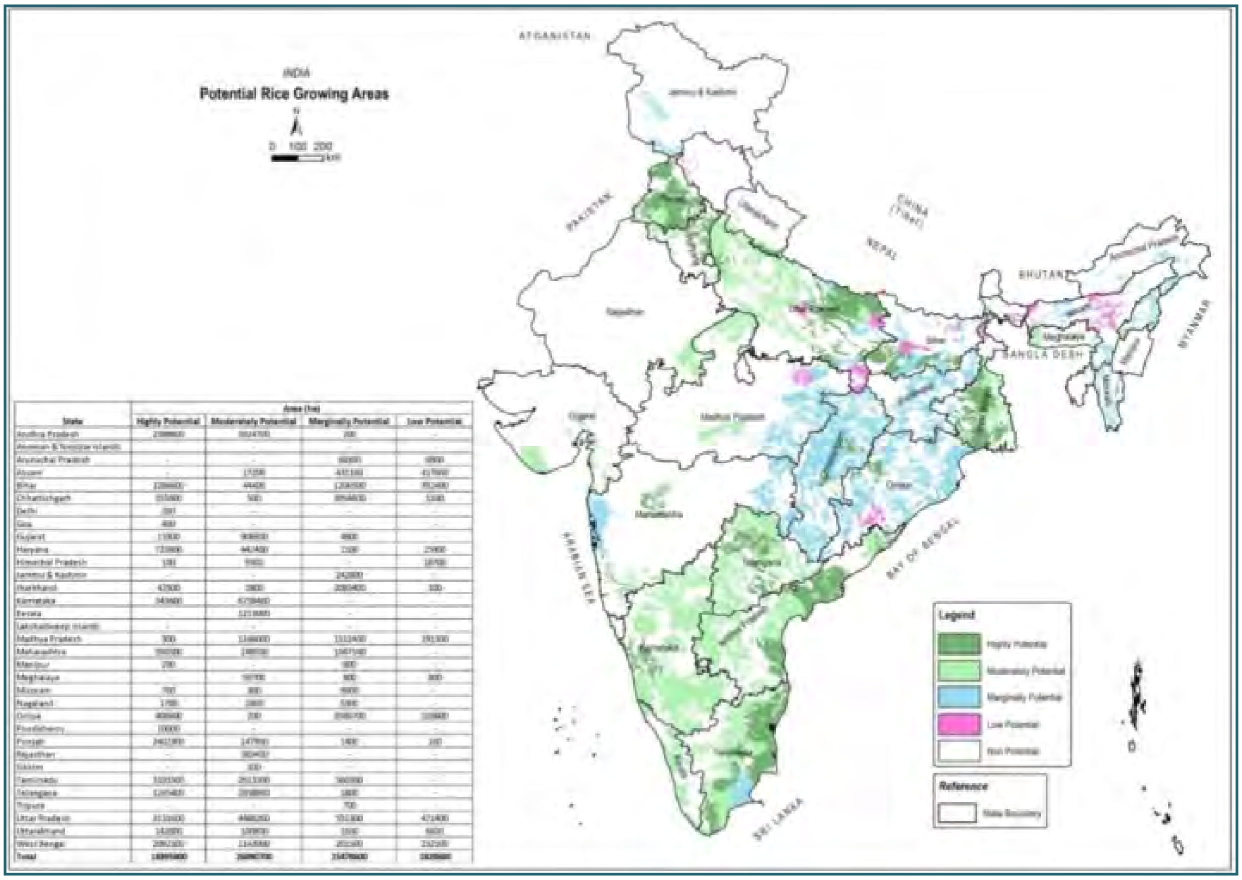


Fig.2.5.2. Potential areas of rice

In India, around 18.4 m ha area is highly potential, while 26.9 m ha is moderately potential and 15.5 m ha is marginally potential for rice production (**Fig.2.5.2**). Among the highly potential areas for rice, maximum area is in Tamil Nadu (3.19 m ha), Uttar Pradesh (3.13 m ha), Punjab and Andhra Pradesh (2.40 m ha each), West Bengal (2.09 m ha), Bihar (1.28 m ha) and Telangana (1.26 m ha). Maximum area under moderately potential area is in Karnataka (6.73 m ha), Uttar Pradesh (4.49 m ha), Andhra Pradesh (3.92 m ha), Telangana (2.86 m ha), Tamil Nadu (2.61 m ha), Madhya Pradesh (1.25 m ha) and Kerala (1.21 m ha) states. Marginally potential areas are more in Odisha (3.59 m h), Jharkhand (2.08 m ha), Madhya Pradesh (1.50 m ha), Bihar (1.20 m ha) and Maharashtra (1.05 m ha). Marginally potential areas for rice can be diverted to other potential crops to enhance productivity and profitability.

Socio-economic evaluation of agricultural land-use in India–Phase-I (Sub Project of Sujala-III)

Socio-economic evaluation can guide better watershed planning and implementation as well as raises awareness of the benefits of ecosystem restoration for food security and poverty alleviation programmes. Soil resource map was used as a base for sampling farm households to test the hypothesis that soil quality influences crop selection and conservation investment of farm households. The level of technology adoption, productivity gaps, and livelihood patterns was analyzed. The cost of soil degradation and ecosystem services were quantified. From January to December 2019, about 8400 farm households were surveyed and 240 micro watersheds reports were completed in Koppal and Yadgiri Talukas of Karnataka.

All the 240 micro watersheds reports aim to characterize the socio-economic status of farm households, assess the land and water use status, evaluate the economic viability of land-use, estimate the on-site cost of soil erosion, and ecosystem services provided by the watershed. Constraints faced by the farmers were analyzed and presented for suggesting alternatives for sustainable agriculture production. Automated Land Potential Evaluation System (ALPES) framework was used.

Brief findings of Ramapura-2 micro-watershed in Yadgir taluk

Ramapura-2 micro-watershed (Yadgir taluk and district) is located in between $16^0$33' to $16^0$34'23.736" N latitudes and $77^0$16' – $77^0$19' E longitudes, covering an area of about 576.6 ha, bounded by Ramapura, Balacheda, Rachanalli and Daddala villages.

- **Social Indicators:** Younger age group (18 to 50 years) is 57.7 percent. Major social groups are scheduled caste / scheduled tribes comprising-36.8% of the population. About 23.7% households have Yashaswini health card 15.8% have MGNREGA cards for rural employment. Dependence on ration cards for food grains through the public distribution system is around 94.7%. Swatch Bharat program provided closed toilet facilities to 36.8% of sample households. About 94.7% of households involve women in decision making.

- **Economic Indicators:** The average land holding of 1.7 ha indicates that the majority of farm households are small and marginal. Agriculture is the main occupation among 44.7 percent and non-agriculture labour is a predominant subsidiary occupation for 30.2 percent of sample households. The average value of domestic assets is around Rs.12212 per household. Mobile and television are popular mass communication devices. The average value of farm assets is around Rs.1944.8 per household, about 38.4 percent of sample farmers are owning plough. The average value of livestock is around Rs.38265 per household; about 82.7 percent of households are having livestock. The average per capita food consumption is around 2632.7kilo calories against national institute of nutrition (NIN) recommendation at 2250 kcal per day. Even though the average per capita consumption is more than the NIN recommendation, the small and marginal farmers (31.6 %) are consuming less than the NIN recommendation. The annual average income is around Rs. 63498 per household. About 7.6 percent of farm households are below the poverty line. The per capita monthly average expenditure is around Rs.3279.

- **Environmental Indicators:** The on-site cost of different soil nutrients lost due to soil erosion is around Rs.2236 ha/year. The total cost of annual soil nutrients is around Rs 11,15717 per year for the total area of 576.6 ha. The average value of ecosystem services for food grain production is around Rs 5610/ ha/year. Per hectare, food grains production is maximum in greengram (Rs.8370) followed by redgram (Rs.7306), cotton (Rs.3491) and groundnut has a negative return. The average value of ecosystem services for fodder production is around Rs. 3775/ ha/year. Per hectare, fodder production is maximum in groundnut (Rs. 2400), paddy (Rs.1500), cotton (Rs.1406), and redgram (Rs.270 /ha). The data on water requirement for producing one quintal of grain is considered for estimating the total value of water required for crop production. The value of per hectare water used and the value of water was maximum in greengram (Rs. 75812) followed by redgram (Rs. 47218), cotton (Rs. 39009), and groundnut (Rs. 22905).

- **Economic Land Evaluation:** The major cropping pattern is redgram (58.8 %), cotton (26.8 %), bengal gram (3.9 %), groundnut (3.9 %), greengram (3.5 %) and paddy (3.1 %). The total cost of cultivation and benefit-cost ratio (BCR) in the study area for red gram is Rs. 43158/ha in YLR soil (with BCR of 1.25) and Rs. 15877/ha in KYT soil (with BCR of 1.95). The cost of cultivation of cotton is recorded as Rs. 43132/ha in HGN (Hegganakera: very deep, calcareous, dark gray to very dark grayish, cracking clay soils) soils in Rampura -2 micro watershed with a yield of 12q/ha (with BCR of 1.1) and Rs. 32505/ha in YLR (Yalleri: moderately shallow, brown to reddish, gravelly sandy clay red soils) soil with a yield of 9.2 q/ha (with BCR of 1.12). In greengram, the cost of cultivation ranges between Rs. 40480/ha in HLG soil (with BCR of 1.22) and Rs. 31151/ha in SWR soil (with BCR of 1.19). In the groundnut, the cost of cultivation in HLG soil is Rs. 33168/ha (with BCR of 1.04) and paddy cultivation in KDR soil is Rs. 28742/ha (with BCR of 1.7). The land management practices adopted by farmers are crop rotation, tillage practices, fertilizer application, and use of farmyard manure (FYM). Due to higher wages, the farmers are not adopting labour intensive soil and water conservation measures. Less ownership of livestock limits the application of FYM. It was observed that soil quality influences the type and intensity of land-use. More fertilizer application was noted in deeper soils to maximize returns.

- **Suggestions:** Involving farmers in watershed planning helps to strengthen institutional participation. The per capita food consumption and monthly income are low. Diversifying income generation activities from crop and livestock production will reduce risk related to drought and market prices. Strengthening agricultural extension, timely advice and improved technology would increase the net income of farm households. By adopting the recommended package of practices by following the soil test fertilizer recommendation, there is scope to increase the yield of redgram (9.1 to 61 %), cotton (35.2 % to 50.5 %), paddy (9.1 %) and groundnut (7.4 %).

Enhancing the Economic Viability of Coconut Based Land-use Systems for Land-use Planning in Kerala State.

This is a multi-Institutional collaborative research project on coconut based mixed cropping system that covers 7.88 lakh ha in Kerala. It is reported that one-fifth of the land area of the state is suffering from very low productivity of around 30 nuts per palm per year owing to widespread incidence of pests and diseases, root wilt disease spreading to hitherto unaffected areas, wildfire, the incidence of mites, leaf-mining caterpillars, yellowing of coconut fronds.

The soil-related constraints for low productivity of the palms are very strong soil acidity, extensive deficiency of secondary nutrients such as calcium and magnesium, micronutrient boron. Scientific documentation of these soil-related constraints to coconut production was initiated in the project to develop the Best Management Practices (BMP) for coconut and selected intercrops and validation and demonstration of BMP for enhancing crop production. As a part of this project, an extensive survey was carried out in six sites covering AEU 1,3,9,10 and 2 sites in AEU 11, where, coconut is being grown to a large extent in Kerala.

The experiments were designed with five treatments: T1 -All treatments minus gypsum application, T2- All treatments minus gypsum and chlorine application,T3- treatments in full,T4- with additional application of PROBIO a micronutrient cum biological input and T5 is farmers' practice. Treatment T1, T2, T3, and T4 are the set of recommended practices with subtle variations. All the treatments have shown superiority over farmer's practice, with a remarkable increase after the third year of treatment (**Fig.2.5.3)**.

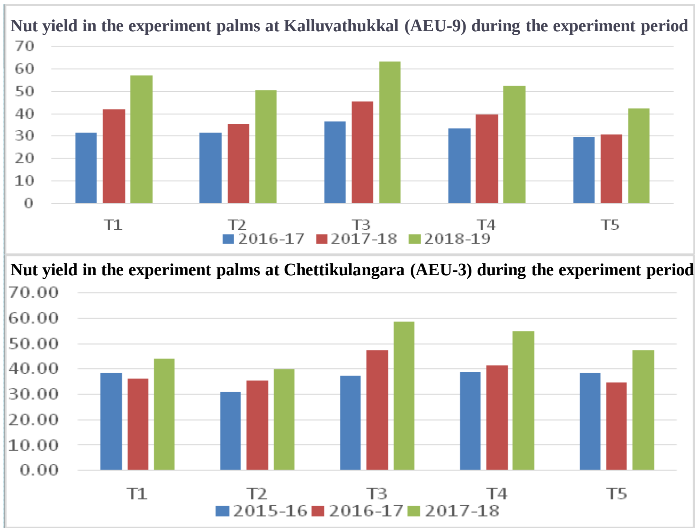


Fig.2.5.3. Coconut yield under different treatments at Kalluvathukkal and Chettikulangara

The bunch of practices perfected as the outcome of the project to enhance the productivity of coconut includes: discontinue the practice of making basins around the palm, application of 2kg lime, gypsum in May, residue cycling, application of 1kg urea, 2kg Muriate of Potash in 2 splits, 100g of copper and zinc sulphate each, boron in 2 splits but reduce to 50g after 3 years, the annual addition of 20g ammonium molybdate per palm, 2kg NaCl in splits of 1kg each with 2 kg sand.

Results in experimental plots: The three years of field experiment during 2015 to 2018 conducted in Kannur (Knr), Kozhikode (Kkd), Alleppy (Alpy) and Quilon (Klm) districts showed an increase in yield of coconut (**Fig. 2.5.4A** and **Fig.2.5.4B**).

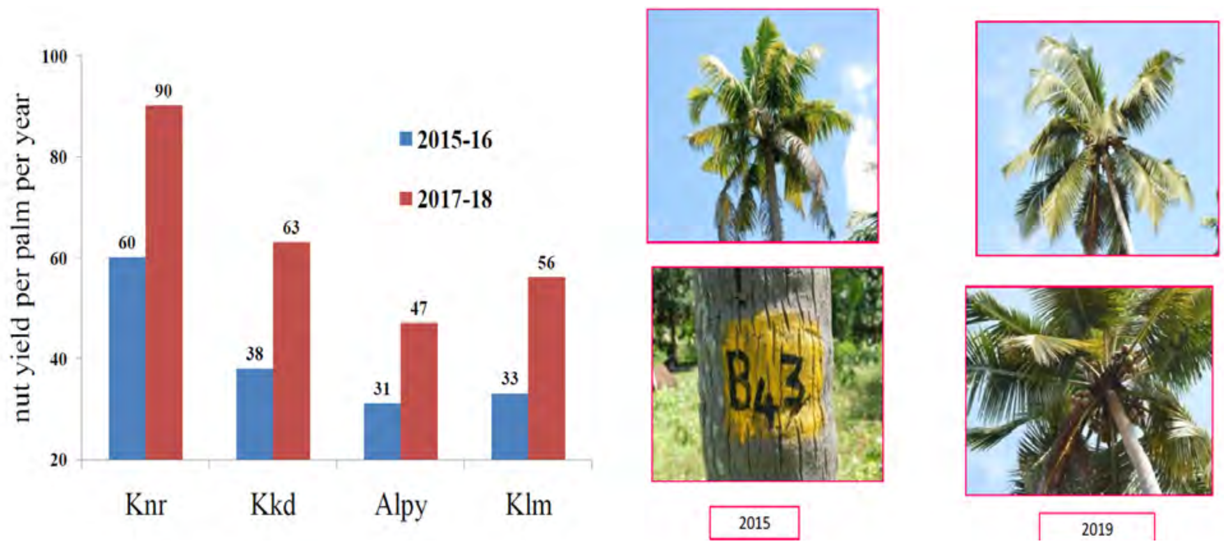


Fig.2.5.4.(A). Coconut yield across experimental sites, (B). Visual signs of coconut palms before (2015) and after (2019) experimentation

Land-use plan of Charilam block, Tripura

Charilam block of Sepahijala district of Tripura lies between 23°34'05″ to 23°41'26″N latitudes and 91°12'49″ to 91°22'49″E longitudes. The low productivity of agricultural crops in the block is the combined effect of problems of the soils, water, and climate. Major soil-related problems are acidity, soil erosion, light texture, and low fertility status. Besides these, natural disasters like flooding cause water-logging and damage to rice and other crops.

Based on major problems like soil reaction (pH), soil fertility, soil erosion, and drainage condition, a land management unit (LMU) map (**Fig.2.5.5**) of the block was prepared. The description of constraints for crop production in each unit along with the area is given in **table 2.5.11**. In the block, four land management units were delineated based on the problems and potentials of soil. In each soil management unit, the present land-use and alternate land-use option are given for the block (**Table 2.5.12**).

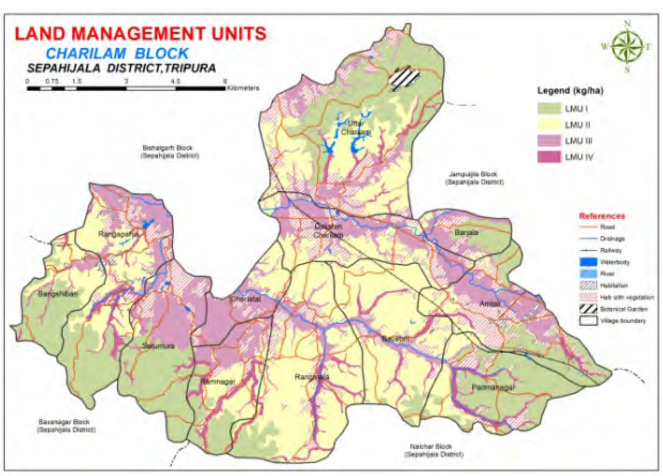


Fig.2.5.5. Land management unit map of Charilam block of Sepahijala district of Tripura

Table 2.5.11.Land management units of Charilam block based on problems and potentials of soils

LMU	Description	Area (ha)	TGA (%)
I	Very deep, excessive to well-drained, very strongly acidic, sandy loam to sandy clay loam soils, moderate to severe erosion	2940	27.7
II	Very deep, moderate to well-drained, extremely to very strongly acidic, sandy clay loam to silty clay loam soils, slight to moderate erosion	3557	33.5
III	Deep, somewhat to poorly drained, strongly acidic, sandy loam to sandy clay soils, slight to moderate erosion	1857	17.5
IV	Deep to very deep, somewhat to poorly drained, strongly acidic, sandy clay loam to silty clay soils, slight to moderate erosion	529	5.0
	Miscellaneous (habitation / river / water body)	1726	16.3
	Total area	**10,608**	**100.0**

Table 2.5.12.Present and suggested land-use of Charilam block, Tripura

LMU	Present land-use	Suggested Land-use options	Suggested Management:
I & II	Rubber plantation / rubber plantation + forest (mixed)	• Rubber plantation with an application of the recommended dose of NPK fertilizer in two equal splits. • Inter-cropping with pineapple, ginger, and turmeric for the first three years.	i) Amelioration of soil acidity with an application of 200-250 kg lime/ha in furrows. ii) Use of biofertilizers particularly phosphate solubilizing micro-organisms. iii) Use of manures to reduce the adverse effect of soil acidity (particularly high Al) and increase of soil fertility. iv) Use of specific management practices like mulching, ridge and furrow system, *etc*. which can help in conserving soil moisture for intercropping.
III	*Kharif* paddy / fallow	• Paddy / maize – mustard / lentil / pea / groundnut. • Summer green gram can also be included where paddy cultivation is problematic due to water scarcity.	• i) Green manuring of Dhaincha can be included after medium duration HYV of paddy. ii)Raised bed furrow irrigation method for maize cultivation. iii) Zero tillage or minimum tillage for mustard/lentil cultivation
IV	Paddy – paddy	• No change. Preference should be given to medium duration HYV paddy varieties.	• i) Adopt SRI paddy cultivation. ii) Use paddy transplant machine for timely quick sowing

Scheduled Tribe Components (STC) programme

The results on the adoption of the suggested land-use plan under the STC programme in Bahphalagaon, Namdeurigaon, and Kalbari villages of Jorhat district are given in **table 2.5.13**. It is observed that the farmers obtained the highest profit in potato followed by mustard and pea. But the benefit-cost ratio (B:C) was highest in the mustard crop in all the villages. The highest net return and B:C ratio (3.54) from the *rabi* crop was obtained in Kalbari village followed by Bahphalagaon and Namdeurigaon.

The soil of Kalbari is imperfectly drained, fine-loamy soils on younger alluvial flood plains. In this village, the highest yield was obtained due to suggested land-use with high yielding crop varieties (Mustard-TS-38, Potato-Kufri Jyoti, and Pea-F1 hybrid) and recommended dose of fertilizers. The study concludes that soils play a very important role in selecting the crop and cropping pattern for a given situation.

Table 2.5.13.Output Analysis of STC Activities on *rabi crop* -2018-19

Name of the village	Crops	State-level yield (t/ ha) *	Yield at Research Station (t/ ha) #	Obtained yield (t/ ha)	Net Returns (Rs./ ha/ year) **	Benefit-cost Ratios
Bahphalagaon	Mustard	0.50-0.75	0.85-1.0	1.7	36,953/-	3.35
	Potato	5.0-7.5	7.5-10.0	14.6	83,977/-	2.35
	Pea	0.3-0.5	0.5-1.0	1.32	23,485/-	2.46
Kalbari	Mustard	0.50-0.75	0.85-1.0	1.8	40,053/-	3.54
	Potato	5.0-7.5	7.5-10.0	15.2	89,977/-	2.45
	Pea	0.3-0.5	0.5-1.0	1.4	25,885/-	2.61
Namdeuri	Mustard	0.50-0.75	0.85-1.0	1.6	33,853/-	3.15
	Pea	0.3-0.5	0.5-1.0	1.5	28,885/-	2.79

#With respect to maximum yield at research station; *With respect to maximum state-level yield; ** With respect to net returns.

Nagrota Bagwan block of Kangra District in Himachal Pradesh

Nagrota Bagwan block lies between 32°03'00'' to 32°10'50'' N latitudes and 76°20'55'' to 76°28'00'' E longitudes having total geographical area 18010.56 ha. The climate of the region is sub-tropical to sub-humid. Among the land-uses, forest occupies the highest area (32.52%) followed by net area sown (31.44%). The study area was delineated into 9 land management units (LMUs) based on the similarity in responding to a particular set of treatments (**Fig.2.5.6**). Based on the constraints and potentials, scientific measures have been suggested for policy interventions for enhancing the existing production potentials of LMUs (**Table 2.5.14**). Do-able technologies could be bench terracing to arrest soil erosion, irrigation of the field during a severe cold to avoid frost damage and application of lime to check the soil acidity problem.

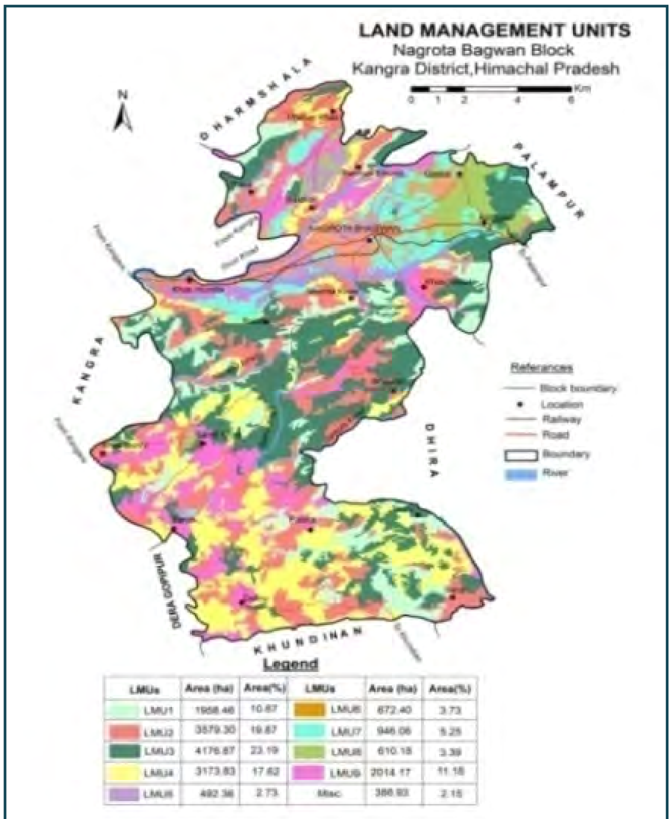


Fig.2.5.6. Land Management Units of Nagrota Bagwan Block of Kangra district, Himachal Pradesh

Table 2.5.14. Constraints as well as potentials of LMUs and suggested measures for policy interventions for sustainable agricultural land-use planning of Nagrota Bagwan Block in Kangra District, Himachal Pradesh

LMUs	Constraints	Potentials		Suggested measures for policy interventions
		Natural vegetation	Production systems	
1	Very shallow to shallow excessively drained, slightly acidic gravelly sandy loam soils on very steep slopes severely eroded, severe stoniness and severely rocky	Eucalyptus, Mulberry, Kharak, Bamboo, Pipal, Mango, Shisham, Mausambi, Khair, Gular, Jamun, Citrus, Arjun, Tuni, Aonla, Semal, Kaith, Karipatta, Jatropha, Bargad, Datepalm, Guava, Lemon, Banana, Lantana, Teak, Cactus, Shrubs and Grasses	Agriculture, horticulture, and livestock-based production systems. However, soils are not suitable in major part of the LMU but farmers prefer to grow crops on very small patches which are suitable for cultivation. Small patches *i.e.,* area of less than a *kanal* (400 sq. m area) to few *kanals* were under rice, wheat, and vegetables, mainly to cater to the family need.	Natural vegetation offers great scope for agroforestry based systems for food and livelihood security. Policy intervention may include incentives for social and community-based agroforestry practices. Jatropha cultivation may be promoted for bio-fuel and other usages. Likewise mulberry for silk production and bamboo for furniture. Soil conservation measures including cultivation on bench terracing.
2	Shallow, excessively drained, slightly acidic, gravelly loam soils on moderate slopes, severely eroded, moderate stoniness and moderately rocky	Eucalyptus, Bamboo, Shrubs And Grasses, Mango, Pipal, Shisham, Wastelands (Barren Lands)	Agriculture, horticulture, and livestock-based production systems. However, soils are not suitable in major part of the LMU but farmers prefer to grow crops on very small patches which are suitable for cultivation. Small patches *i.e.,* area of less than a *kanal* (400 sq. m area) to few *kanals* were under rice, wheat, and vegetables, mainly to cater to the family need.	Natural vegetation offers great scope for agroforestry based systems for food and livelihood security. Policy intervention may include the reclamation of wastelands. Boost up may be given to bamboo-based small scale industries. Soil conservation measures including cultivation on bench terracing.
3	Excessively drained, slightly acidic	Eucalyptus, Bamboo, Neem, Mulberry, Mango, Pipal, Aonla, Guava, Kharek, Litchi, Kaith, Tuni, Buckain, Karal, Semal, Shisham, Shrubs and Grasses, Datepalm, Gular, wastelands	Agriculture and livestock, Agro-forestry (Silvi-horticulture) based systems. Small patches were under rice, wheat, maize, potato, and other vegetables, mainly to cater to family needs.	Natural vegetation offers great scope for agroforestry based systems for food and livelihood security. Organic and inorganic amendments for improving water retention and correction of soil acidity. Policy intervention may include the reclamation of wastelands. Boost up may be given to bamboo-based small scale industries.
4	Slightly acidic, moderate stoniness and moderately rocky	Eucalyptus, Arjun, Neem, Bamboo, Mango, Shrubs and Grasses, Kharek, Pipal, Litchi, Semal, Dhaman, Shisham, Kaith, Poplar, Guava, Badho, Mulberry, Jatropha, Swampy areas, wastelands	Agriculture and livestock, Agro-forestry (Silvi-horticulture) based systems. Small patches were under rice, wheat, maize, potato, and other vegetables.	Timber based market opportunities. Jatropha cultivation on wastelands may be promoted after their reclamation to give a boost bio-fuel based economy. Organic and inorganic amendments for the amelioration of soil acidity. Fruits and vegetable export during the offseason. Poly-house construction at large scale for off season high tech horticulture.

LMUs	Constraints	Potentials		Suggested measures for policy interventions
		Natural vegetation	Production systems	
5	Slightly acidic, severe stoniness and moderately rocky	Litchi, Mango, Dhaman, Shisham, Bamboo, Kharek, Pear, Neem, Datepalm, Aonla, Guava	Agriculture and livestock, Agro-forestry (Silvi-horticulture) based systems. Small patches were under rice, wheat, maize, potato, and other vegetables.	Poly-house construction at large scale for off season high tech horticulture to encourage vegetablesand fruits export. Organic and inorganic amendments for the amelioration of soil acidity. Stoniness is a severe problem, and thus, proper soil conservation measures need to be adopted for better production.
6	Slightly acidic, moderately eroded and slight stoniness	Bamboo, Gular, Eucalyptus, Dhaman, Kaith, Semal, Jamun, Mango, Aonla, Shisham, Arjun, Tuni, Pipal, Buckain, Bargad, Guava, Mausambi, Banana, Mulberry, Litchi, Bushes, Lantana	Agriculture and livestock, Agro-forestry (Silvi-horticulture) based systems. Small patches were under rice, wheat, maize, potato, and other vegetables.	Organic and inorganic amendments for the amelioration of soil acidity. Lantana is a severe menace to agricultural production and also to land productivity thus, the eradication programme needs to be implemented at a large scale. Mulberry cultivation for silk production and silk based market linkages, fruit exports, timber, and furniture product for income generation. Poly-house construction at large scale for off season high tech horticulture to encourage vegetablesand fruits export.
7	Slightly acidic, moderately eroded and slight stoniness	Bamboo, Gular, Eucalyptus, Dhaman, Kaith, Semal, Jamun, Mango, Aonla, Shisham, Arjun, Tuni, Pipal, Buckain, Bargad, Guava, Mausambi, Banana, Mulberry, Litchi, Bushes, Lantana	Agriculture and livestock, Agro-forestry (Silvi-horticulture) based systems. Small patches were under rice, wheat, maize, potato, and other vegetables.	Organic and inorganic amendments for the amelioration of soil acidity. Lantana is a severe menace to agricultural production and also to land productivity thus, the eradication programme needs to be implemented at a large scale. Mulberry cultivation for silk production and silk based market linkages, fruit exports, timber, and furniture product for income generation. Poly-house construction at large scale for off season high tech horticulture to encourage vegetables and fruits export.
8	Slightly acidic soils	Eucalyptus, Mulberry, Bamboo, Mango, Shisham, Arjun, Gular, Poplar, Semal, Kaith, Jamun, Karal, Grasses And Bushes, Lantana, Lemon, Mango, Bael, Pipal	Agriculture and livestock, Agro-forestry (Silvi-horticulture) based systems. Small patches were under rice, wheat, maize, potato, and other vegetables.	Mulberry cultivation for silk based market, Poplar for match stick and other usage-based markets, timber, and furniture based product for income generation. Organic and inorganic amendments for the amelioration of soil acidity. Poly-house construction at large scale for off season high tech horticulture to encourage vegetables and fruits export.
9	Slightly acidic, slight stoniness	Mango, Eucalyptus, Arjun, Bamboo, Pipal, Kaith, Jamun, Mulberry, Dharek, Litchi, Shrubs, Tuni, Siris, Bushes, Kaner, Banana, Semal, Lemon, Aonla, Jackfruit	Agriculture and livestock, Agro-forestry (Silvi-horticulture) based systems. Small patches were under rice, wheat, maize, potato, and other vegetables.	Organic and inorganic amendments for the amelioration of soil acidity. Jackfruit and mulberry cultivation may open up a window of opportunities for the farmers to earn more income. Poly-house construction at large scale for off-season high-tech horticulture to encourage vegetables and fruits export.

Rajpura block, Patiala district, Punjab

Land Capability Classification: The soils of the Rajpura block of Patiala district, Punjab were assessed for the land capability classes and sub-classes based on site characteristics, constraints, and potentials of the soils. The major area of the block is grouped under land capability sub-class IIs covering 49% area followed by sub-class IIIsw (27.98%), IIse (4.72%), and IIIse (1.78%), respectively (**Table 2.5.15**).

Land Irrigability Classification: The land irrigability classification indicates that the major area of the block is grouped under class 1 which covers 50.13% area, followed by sub-class 2sd (30.49%), 2ds (1.78%) and 3sd (1.78%), respectively.

Table 2.5.15. Land Capability Classification of Rajpura block, Patiala district, Punjab

Soil Series	Potentials / Limitations	Land capability sub-class	Management recommendation
Gopalpur Aluna and Jansui	Good cultivable land with slight limitations of soil texture.	IIs	Cultivation with precaution, need simple management practices. Suited to all climatically adapted crops.
Chakkalan	Good cultivable land with slight limitations of soil texture.	IIs	Cultivation with precaution, need simple management practices and levelling of lands. Suited to all climatically adapted crops.
Akar	Moderately good cultivable land with limitations of soil texture and drainage.	IIIsw	Cultivation with careful management practices with sufficient drainage facility of excess water.
Lehlan	Good cultivable land with slight limitations of soil.	IIs	Cultivation with precaution, need simple management. Suited to all climatically adapted crops.
Basantpura and Takhtu Majra	Moderately good cultivable land with limitations of soil texture, salinity, and drainage.	IIIsw	Cultivation with careful management practices with sufficient drainage facility of excess water and salinity.
Urdan	Good cultivable land with slight limitations of soil texture and erosion.	IIse	Cultivation with precaution, need simple management practices and levelling of lands. Suited to all climatically adapted crops.
Shamdo	Fairly with severe limitations of soil textures, draughtiness, and erosion.	IIIse	These soils are not economical for cultivation. Need frequent irrigation, high doses of fertilization, and other management practices. Selection of crops adapted to the limitation of soils and drought.

Soil site suitability for crops

Soil site suitability has been evaluated for major cereals, pulses, and oilseeds to develop sustainable land-use options. Rice is moderately suitable for 50.11% area, highly suitable for 15.15% area, and marginally suitable for 18.92% area. Wheat is highly suitable in 52% area, moderately suitable for 30.39% area and marginally suitable for 1.79% area. Sorghum is moderately suitable for 68.97% area, suitable for 13.42% area and marginally suitable for 1.79% area. Maize is suitable for 42.87% area, moderately suitable for 39.53% area and marginally suitable for 1.78% area.

Soil site suitability for pulses

Pigeonpea is highly suitable for 60.02 % area, moderately suitable for 22.38% and marginally suitable for 1.78% area. Gram is highly suitable for 42.89% area, moderately suitable for 39.51% and marginally suitable for 1.78% area. Cluster Bean is highly suitable for 50.13% area, moderately suitable for 34.05% and marginally suitable for 1.78% area.

Soil site suitability for Oilseeds

Mustard is highly suitable for 46.6% area followed by marginally suitable in 20% area and moderately suitable in 16% area. Groundnut is moderately suitable for 41% area, highly suitable for 21% and marginally suitable for 20% area. Approximately 56% area of the block is highly suitable for sunflower, whereas, 23% area is marginally suitable and 3.5% area is moderately suitable. Approximately 50% area of the block is highly suitable for soybean followed by 22% marginally suitable area and 11% moderately suitable.

Land-use Planning of Scheduled Caste (SC) Dominated Villages of Mathura District of Uttar Pradesh for Livelihood Improvement- under Scheduled Caste Sub Plan (SCSP)

Villages namely-Gopalgarh, Moji ka nagla, Surir ka nagla, Sumer ka nagla, Ramtaal, and Sakraya ka Nagla and Sunrakh panchayat with the majority of the SC population was selected. Initially, the project work will be started in two villages of Sunrakh panchayat in Mathura block and later on extended to other villages of the Mathura district for their livelihood improvement through various activities. During the interaction with several households of these villages, the quality of water remained a serious constraint for the villagers. Agriculture is also affected due to the poor quality of water. The workforce is diversified *i.e.*, engaged in agriculture, daily wage earners, and other subsidiary occupations. Livestock is also a dominant means of livelihood. Horticulture also has good scope in the area. Sunrakh Panchyat has the SC population in the range of 51-75% (Census, 2011).

Revision of Agro-Ecological Sub-Regions of the Country

The average monthly rainfall and minimum-maximum temperature data of 30 years (1988 to 2018) for 620 observations across the country have been used

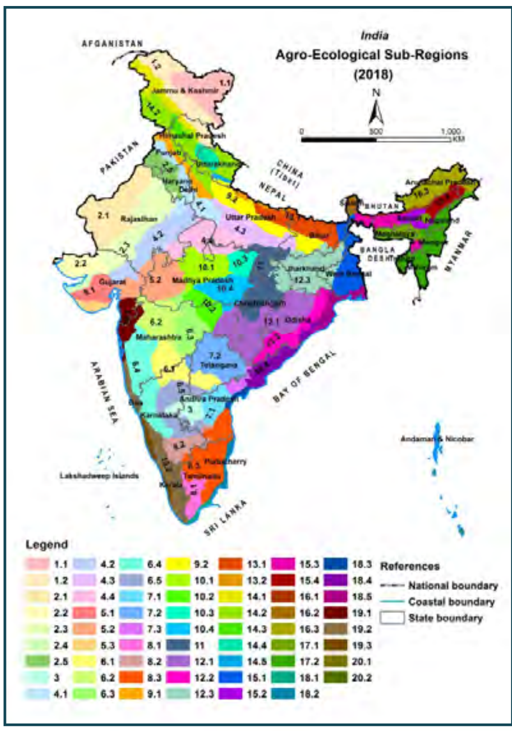


Fig.2.5.7. Revised AESR map of India

to develop the revised bio-climatic map of India. Potential evapo-transpiration (PET) was computed by using monthly rainfall, mean temperature, altitude, solar radiation, wind velocity, relative humidity. The tentative revised 62 agro-ecological regions of India have been delineated by integrating physiography, sub-physiography, bioclimate, LGP, and selected soil parameters in a GIS environment. The areas under arid and semiarid agro-ecosystems are revised from 53.2 to 45.0 and 116.4 to 145.3 million hectares respectively. The draft document on "Revised Agro-ecological regions of India" has been developed. The revised AESR map of India is shown in **figure 2.5.7**.

Potential areas for oil palm cultivation in India (*Inter-institutional Collaborative Project with IIOPR*)

In consultation with ICAR-*IIOPR*, GIS-based crop suitability criteria was revised and the potential areas for *Oil Palm in rainfed and irrigated conditions* in India were delineated. The thematic maps on land-

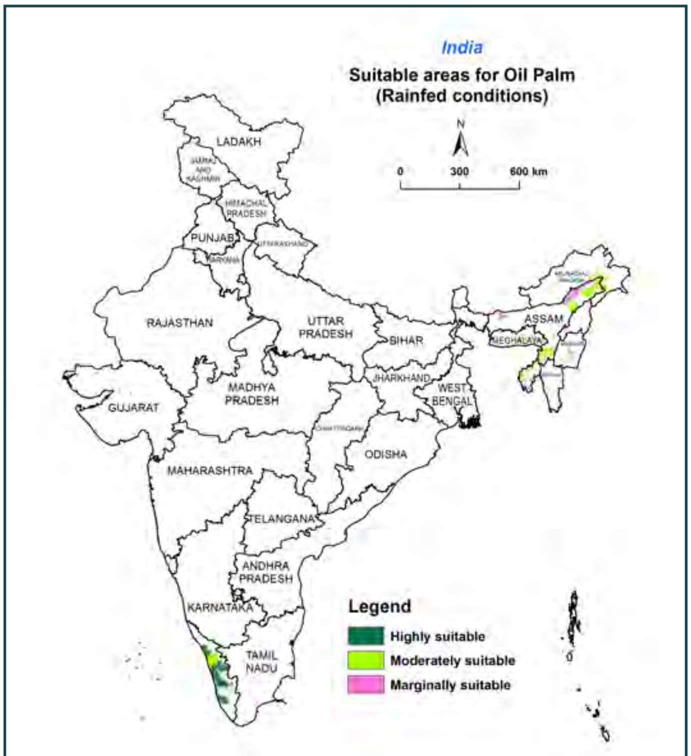


Fig. 2.5.8. Revised Oil palm suitability map of India for rained condition

use classes for the rainfed and irrigated areas have been developed based on the LULC data of 2018 and the same was used in the evaluation of suitability classes for oil palm. Using the developed GIS-based suitability criteria model, the thematic maps on state-wise oil palm suitability have been generated. *The revised oil palm suitability for rainfed conditions* of India is shown in **figure 2.5.8**.

Suitable area for pomegranate cultivation in India (Inter-institutional Collaborative Project with ICAR-NRCP, Solapur)

The suitability criteria for pomegranate has been revised using district-wise mean minimum and maximum temperatures. Based on the revised criteria, the soil suitability map for the Pomegranate of Maharashtra has been prepared and given in **figure 2.5.9**.

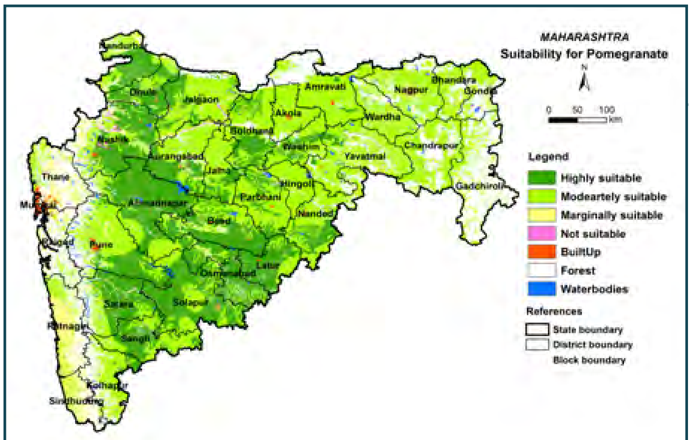


Fig.2.5.9. Revised soil suitability map for Pomegranate in Maharashtra

shallow soils mainly on undulating topography and hill slope areas. Some moderately deep soils have a higher percentage of gravels. Kawdimet village has deep black soil up to 150 cm soil depth.

Taxonomically, the soils were grouped into five major types of *viz*. Ghubadi I: loamy-skeletal, mixed, hyperthermic Lithic Ustorthents; Ghubadi II: clayey-skeletal, mixed, hyperthermic Typic Ustorthents; Ghubadi III: clayey, smectitic, hyperthermic Calcic Haplustepts; Ghubadi IV: very-fine, smectitic, hyperthermic Typic Haplusterts and Ghubadi V: very fine, smectitic, hyperthermic Typic Haplustepts.

Majority of the area is rainfed and faces serious challenges of water scarcity, hence sorghum is the only suitable crop though other crops like cotton (*Gossypium spp*.), soybean (*Glycine max*), pigeonpea (*Cajanus cajan*) are also grown during *Kharif* season, while, gram (*Cicer arietinum*) and wheat (*Triticum aestivum*) and some vegetable crops are cultivated during *Rabi* season. Intercropping with soybean and pigeonpea, cotton and pigeonpea in 6:2 ratio and citrus orchard with wheat (Lok-1) crop have been observed. Efforts were made to evaluate the performance of different crops under different soil types.

Growth of crops under different soil types

Growth and yield parameters clearly indicate that the crops responded better as soil depth increased (**Table 2.5.17**). In sorghum, plant height significantly increased from 125 to 160 cm when depth increased from 45 cm to 64-150 cm and the number of leaves also showed a similar trend. The maximum rooting depth varied with soil depth in each crop. The influence of soil properties especially depth and texture are more pronounced in the case of long duration crops like cotton and pigeonpea. The deep soil with finer texture holds more water and nutrient holding capacity, which buffered the crops against sudden changes in weather or long dry spells.

Table 2.5.17. Plant performance of different crops grown under different soil types of Ghubadi watershed

Soil type (depth)	***Kharif* crop**						***Rabi* crop**	
	Sorghum		Soybean		Cotton	Pigeonpea	Wheat	Gram
	Plant height (cm)	No of leaves	Plant height (cm)	No of pods	Plant height (cm)	Plant height (cm)	Plant height (cm)	Plant height (cm)
Ghubadi I (10-14 cm)	125.3	5.45	58.4	42.6	102.8	145.6	Not recommended	
Ghubadi I, (42 cm)	148.3	8.14	64.0	50.8	128.7	156.3	88.3	38.6
Ghubadi III (35 cm) Calcic	150.1	8.34	64.5	50.1	124.3	150.2	83.4	36.8
Ghubadi IV (150 cm)	160.8	11.1	74.2	54.3	145.6	180.6	100.6	45.6
Ghubadi V (64 cm)	152.4	9.24	75.3	55.2	130.2	173.6	96.4	44.8

The yield of sorghum grown under different soil types and management practices

While comparing two types of production practices (farmers' practice and recommended packages), the result showed that as the depth increases, the crop height increased significantly and yield parameters and also were in the same order and increased the yield in the range of 400 to 550 kg per ha over farmers' practices. The highest yield of sorghum under farmers' practice was recorded 2041 kg/ha at 150 cm depth but soil depth of 42 and 64 cm produced significantly higher yield *i.e.* 2124 and 2387 kg/ha, respectively (**Table 2.5.18**). Hence, it is recommended that the soil depth for the sorghum crop should be around 50 to 75 cm to realize more yield.

Table 2.5.18. Performance of Sorghum under different soils of Ghubadi watershed in *kharif* season

Soil types (depth)	Farmers Practice			Recommendation of NBSS & LUP		
	Grain Yield (kg/ha)	Fodder yield (kg/ha)	Total monitory returns (Rs)	Grain Yield (kg/ha)	Fodder yield (kg/ha)	Total monitory returns (Rs)
Ghubadi I (10-14 cm)	1140.3 (28849)	3351.6 (20,109)	48,959	Not Recommended		
Ghubadi II (42 cm)	1720.5 (43,529)	7212.8 (43,277)	86,806	2124.3 (53745)	7965.3 (47792)	1,01,537
Ghubadi III (35 cm) Calcic	1630.1 (41,242)	6252.5 (37,515)	78,757	1984.6 (50210)	6857.4 (41144)	91,355
Ghubadi IV (150 cm)	20,40.9 (51635)	10124.4 (60,746)	1,12,381	Not Recommended		
Ghubadi V (64 cm)	1820.0 (46,046)	9310.0 (55,860)	1,01,906	2387.4 (60401)	10235.8 (61415)	1,21,816

(Figures in parenthesis -cost of the produce in Rupees) Sorghum (grain @Rs.25.3 /kg, Fodder Rs. 6.0/kg)

The yield of soybean + pigeon pea intercropping under different soil types and management practices

Pigeonpea grown on 64-150 cm soil depths produced maximum grain, fodder, and stubble yields over farmer's practice. The higher monetary return was also realized with depth level at 64 and 150 cm deep soils (**Table 2.5.19**).

Table 2.5.19. Performance of Soybean + Pigeon pea under different soil types of Ghubadi watershed in *Kharif* season

Soil types (depth)	Farmers practice						Site specific crop management (SSCM) / Soil suitability based recommendation of NBSS & LUP					
	Soybean Yield (kg/ha)		Pigeonpea yield (kg/ha)			Total monitory returns (Rs.)	Soybean Yield (kg/ha)		Pigeonpea yield (kg/ha)			Total monitory returns (Rs.)
	Grain	Foliage	Grain	Fodder	Stubbles		Grain	Fodder	Grain	Fodder	Stubbles	
Ghubadi , (10-14 cm)	840.8 (25,224)	1900.4 (5,701)	196.8 (10,824)	330.6 (992)	660.8 (330)	43,071	1260.4 (37,812)	3654.7 (10,964)	Not Recommended			48,776
Ghubadi II (42 cm)	1240.2 (37,206)	2210.3 (6,631)	310.2 (17,061)	384.6 (1154)	1365.2 (683)	62,734	1865.3 (55,959)	4651.0 (13,953)	Not Recommended			69,912
Ghubadi III (35 cm) Calcic	1180.0 (35,400)	2140.5 (6,422)	286.3 (15,747)	354.1 (1062)	1447.1 (724)	59,354	1778.4 (53,352)	4336.1 (13,008)	Not Recommended			66,360

Soil types (depth)	Farmers practice						Site specific crop management (SSCM) / Soil suitability based recommendation of NBSS & LUP					
	Soybean Yield (kg/ha)		Pigeonpea yield (kg/ha)			Total monitory returns (Rs.)	Soybean Yield (kg/ha)		Pigeonpea yield (kg/ha)			Total monitory returns (Rs.)
	Grain	Foliage	Grain	Fodder	Stubbles		Grain	Fodder	Grain	Fodder	Stubbles	
Ghubadi IV (150 cm)	1340.7 (40,221)	2320.6 (6962)	878.6 (48,323)	968.7 (2906)	3564.7 (1782)	1,00,194	1987.4 (59,622)	5364.1 (16,092)	984.6 (54,153)	1123.5 (3371)	3784.1 (1892)	1,35,130
Ghubadi V (64 cm)	1520.6 (45,618)	2300.2 (6900)	654.8 (36,014)	720.3 (2161)	2230.1 (1115)	91,809	1884.6 (56,538)	3897.2 (11,692)	780.4 (42,922)	940.2 (2821)	2874.2 (1437)	1,15,409

(Figures in parenthesis are the cost of the produce in Rupees)

Soybean (Seed @ Rs. 30/ kg; Forage @ Rs. 3/kg); Pigeon pea (seed @ Rs. 55/kg, foliage@ Rs. 3/kg, stalk @ Rs. 0.50/kg)

The yield of Cotton + pigeon pea intercropping under different soil types and management practices

Cotton + pigeon pea intercropping is commonly practiced in the Vidarbha region of Maharashtra. It is being grown by the farmers on almost all the soil types. But these crops/cropping system is recommended only on moderate to deep clay soils. Yield observations (**Table 2.5.20**) showed that deep soils (150 cm) produced more, followed by moderately deep (64 cm) soils. The yield of both the crops was significantly low on all other shallow soils and not economical.

Table 2.5.20. Performance of Cotton + Pigeon pea under different soil types of Ghubadi watershed in *Kharif* season

Soil Types (depth)	Farmers practice						Site specific crop management (SSCM) / Soil suitability based recommendation of NBSS & LUP					
	Cotton Yield (kg/ha)		Pigeonpea yield (kg/ha)			Total monitory returns (Rs.)	Cotton Yield (kg/ha)		Pigeonpea yield (kg/ha)			Total monitory returns (Rs.)
	Cotton	Stalk	Grain	Fodder	Stubbles		Grain	Foliage	Grain	Fodder	Stubbles	
Ghubadi , (10-14 cm)	250.3 (13,641)	524.3 (210)	144.5 (7,948)	225.6 (677)	456.8 (228)	22,494	Not Recommended					
Ghubadi II (42 cm)	486.3 (26,503)	1024.5 (410)	210.3 (11,567)	330.2 (991)	810.2 (405)	39,466	Not Recommended					
Ghubadi III (35 cm) Calcic	442.7 (24,127)	987.6 (395)	200.8 (11,044)	287.9 (864)	786.5 (393)	36,428	Not Recommended					
Ghubadi IV (150 cm)	1134.5 (61,830)	2784.6 (1114)	846.7 (46,569)	1126.8 (3380)	3256.4 (1628)	1,13,407	1453.8 (79232)	3657.4 (1463)	197.6 (63547)	1155.4 (5056)	1685.3 (2282)	1,51,579
Ghubadi V (64 cm)	887.4 (48,363)	1964.3 (786)	567.3 (31,202)	874.3 (2623)	2145.3 (1073)	83,260	1056.9 (57601)	2453.6 (981)	188.4 (39798)	723.6 (2906)	968.7 (1382)	1,02,668

(Figures in parenthesis are cost of the produce in Rupees) Cotton (seed cotton @ Rs. 54.5/kg, stalk @ Rs. 0.40/kg); Pigeon pea (seed @ Rs. 55/kg, foliage@ Rs. 3/kg, stalk @ Rs. 0.50/kg)

The yield of wheat and gram in rabi season under different soil types and management practices

With the availability of irrigation water, wheat and gram crops are preferred crops in the *rabi* season. The performance of both the crops was monitored at different soil depths and it was noted that grain and fodder yields of both the crops increased with increasing soil depth. Monetary benefits followed a similar trend. The highest yield (1587 kg and 950 kg) and monetary return (Rs. 36995 and Rs. 55066) were noted in Ghubadi IV soil type in wheat and gram crops under farmers' practice, respectively. While, soil type - Ghubadi-I, II, and III in wheat crop and Ghubadi-I *i.e.* shallow soil in gram crops were not found suitable for the crops. In recommended practices, the highest yield levels with the highest monetary returns were recorded in Ghubadi-IV soil type with 150 cm soil depth. Monetary return enhancement of Rs. 7434 and Rs. 13925 obtained with the recommended practices (**Table 2.5.21**).

Table 2.5.21.Performance of wheat and gram under different soil types of Ghubadi watershed in *rabi* season

Soil types (depth)	Wheat						Gram					
	Farmers practice			(SSCM / Soil suitability based recommendation of NBSS&LUP			Farmers practice			(SSCM / Soil suitability based recommendation of NBSS&LUP		
	Grain Yield (kg/ ha)	Straw yield (kg/ha)	Total monitory returns (Rs.)	Grain Yield (kg/ ha)	Straw yield (kg/ha)	Total monitory returns (Rs.)	Grain Yield (kg/ ha)	Fodder yield (kg/ ha)	Total monitory returns (Rs.)	Grain Yield (kg/ ha)	Fodder yield (kg/ ha)	Total monitory returns (Rs.)
Ghubadi, (10-14 cm)				Not Recommended						Not Recommended		
Ghubadi II (42 cm)	785.3 (14,135)	1584.2 (3168)	17,304	Not Recommended			745.6 (35,789)	2132.2 (6397)	42,185	955.4 (45859.2)	2456.8 (7370.4)	53,229
Ghubadi III (35 cm) Calcic	741.3 (13,343)	1451.0 (2902)	16,245	Not Recommended			710.2 (34,089)	2018.4 (6055)	40,145	944.3 (45326.4)	2365.4 (7096.2)	52,423
Ghubadi IV (150 cm)	1586.9 (28,564)	4215.6 (8431)	36,995	1953.2 (35157.6)	4635.8 (9271.6)	44,429.2	950.6 (45,629)	3145.6 (943)	55,066	1203.4 (57763.2)	3742.6 (11227.8)	68,991
Ghubadi V (64 cm)	1253.1 (22,556)	3452.7 (6905)	29,461	1652.3 (29741.4)	3884.1 (7768.2)	37,509.6	906.4 (43,507)	2863.4 (8590)	52,097	1120.8 (53798.4)	3541.0 (10623.0)	64,421

(Figures in parenthesis are cost of the produce in Rupees), Wheat (Grain @ Rs. 18/kg, straw @ Rs. 2/kg) Gram (seed @ Rs. 48/kg, Forage @ Rs. 3/kg)

Monitory evaluation of different cropping systems in Kharif season under different soil types and management practices

Different cropping systems *viz*. sorghum, soybean + pigeon pea, cotton + pigeonpea adopted by the farmers irrespective of soil site characteristics were compared with the recommendedsite-specific crop management (SSCM) based on NBSS&LUP Module I for *Kharif* crops grown in the region. It was observed that (**Table 2.5.22**) amongst farmers practice highest monitory returns were under sole sorghum, mainly due to higher prices for fodders followed by soybean + pigeon pea and was lowest under cotton + pigeonpea cropping system. Highest monitory returns were observed under site-specific crop management (SSCM) / Soil suitability based recommendation of NBSS&LUP, where, different crops were grown as per the soil types and soil suitability of different crop.

Amongst different soil types, Ghubadi –IV (150 cm, clayey) soil fetched maximum yield and returns in the range of Rs. 100194 to 113407 followed by Ghubadi –V (64 cm, clayey). While in the recommended practices this enhanced the return by around Rs. 38000 at 150 cm soil depth in the cotton-pigeonpea cropping system. The highest return was realized in sole crop followed by for cotton-pigeonpea and soybean-pigeonpea cropping systems, respectively.

Table 2.5.22. Monitory returns (Rs.) under SSCM based different cropping systems for *Kharif* season

Soil types (depth)	Sole Sorghum system	Soybean + pigeon pea system	Cotton + pigeon pea system	SSCM based NBSS Module I for Kharif	
Ghubadi (10-14 cm)	48959.2	43071.4	22494.05	Soybean	48776.1

Soil types (depth)	Sole Sorghum system	Soybean + pigeon pea system	Cotton + pigeon pea system	SSCM based NBSS Module I for Kharif	
Ghubadi II (42 cm)	86805.5	62734.3	39465.55	Sorghum	101536.6
Ghubadi III (35 cm) Calcic	78756.5	59353.9	36428.1	Sorghum	91354.8
Ghubadi IV (150 cm)	112381.2	100194.3	113407.35	Cotton + pigeon pea	151579.6
Ghubadi V (64 cm)	101906.0	91808.6	83260.35	Soybean + pigeon pea	115409.3
Total returns per ha.	467560.6	395864.3	315492.7		551418.9

Sorghum (grain @Rs.25.3 /kg, Fodder Rs. 6.0/kg); Soybean (Seed @ Rs. 30/ kg; Forage @ Rs. 3/kg); Pigeon pea (seed @ Rs. 55/kg, foliage@ Rs. 3/kg, stalk @ Rs. 0.50/kg); Cotton (seed cotton @ Rs. 54.5/kg, stalk @ Rs. 0.40/kg)

Monitory evaluation of different cropping systems in rabi season under different soil types and management practices

In *rabi* season, under irrigated conditions, highest yield and monetary returns of both wheat and gram crop were obtained from Ghubadi–IV (150 cm, clayey) followed by Ghubadi–V (64 cm, clayey soils The returns under gram were substantially higher in as compared to wheat in all soil types (**Table 2.5.23**).

Table 2.5.23. Monitory returns (Rs.) under different cropping systems under different soil types for *rabi* season

Soil types (Soil depth)	Wheat	Gram	NBSS Module for *rabi*	
Ghubadi I (10-14 cm deep)	Not taken		Not recommended	
Ghubadi II (42 cm deep)	17303.8	42185.4	Gram	53229.6
Ghubadi III (35 cm deep) Calcic	16245.4	40144.8	Gram	52422.6
Ghubadi IV (150 cm deep)	36995.4	55065.6	Wheat	44429.2
Ghubadi V (64 cm deep)	29461.2	52097.4	Wheat	37509.6
Total returns per ha.	1,00,005.8	1,89,493.2		1,87,591.0

Wheat (Grain @ Rs. 18/kg, straw @ Rs. 2/kg) Gram (seed @ Rs. 48/kg, Forage @ Rs. 3/kg)

Monitory evaluation of different soil suitability based cropping systems (Modules) in Kharif followed by rabi season under different soil types

Different soil suitability based modules (**Table 2.5.24**) were tested based on monitory returns. It was observed that the growing *Kharif* sorghum followed by the gram in the *rabi* season yielded maximum returns amongst all the modules. Substantially higher prices of sorghum stubbles (fodder) and gram grain fetched maximum returns. This was followed by Module IV (Sorghum-Gram and Cotton-Pigeonpea cropping system). The yields obtained under Module III (soybean-gram and soybean-wheat) were lowest amongst all the systems.

Table 2.5.24. Monitory returns under different cropping systems for *Kharif* and rabi season

Soil types	MODULE I	Monitory returns	MODULE II	Monitory returns	MODULE III	Monitory returns	MODULE VI	Monitory returns
Ghubadi , (10-14 cm)	Soybean	48776	Soybean	48776	Soybean	48776	Soybean	48776
Ghubadi II (42 cm)	Jowar~ Gram	140035	Soybean ~ Gram	95992	Soybean ~ Gram	95992	Sorghum ~Gram	140035
Ghubadi III (35 cm) Calcic	Jowar~ Gram	131179	Soybean ~ Gram	101198	Soybean ~ Gram	101198	Sorghum ~Gram	131179

Soil types	MODULE I	Monitory returns	MODULE II	Monitory returns	MODULE III	Monitory returns	MODULE VI	Monitory returns
Ghubadi IV (150 cm)	Jowar~ Gram	181372	Soybean ~ Gram	138903	Soybean ~ Wheat	114341	Cotton ~ Pigeonpea	151579
Ghubadi V (64 cm)	Jowar~ Gram	166327	Soybean ~ Gram	130781	Soybean ~ Wheat	103869	Cotton ~ Pigeonpea	102668
Total returns per ha.		6,67,689		5,15,651		4,64,178		5,74,238

Sorghum (grain @Rs.25.3 /kg, Fodder Rs. 6.0/kg); Soybean (Seed @ Rs. 30/ kg; Forage @ Rs. 3/kg); Pigeon pea (seed @ Rs. 55/kg, foliage@ Rs. 3/kg, stalk @ Rs. 0.50/kg); Cotton (seed cotton @ Rs. 54.5/kg, stalk @ Rs. 0.40/kg); Wheat (Grain @ Rs. 18/kg, straw @ Rs. 2/kg) Gram (seed @ Rs. 48/kg, Forage @ Rs. 3/kg)

High-Resolution Land Resource Inventory and Land Use Planning for Climate Resilient Agriculture (PoCRA)

Land resource inventory at cadastral level for selected cluster(s) in 15 districts of Maharashtra (Aurangabad, Beed, Jalna, Osmanabad, Latur, Parbhani, Hingoli, Nanded, Jalgaon, Amravati, Akola, Washim, Buldhana, Yavatmal and Wardha) was carried out. Landform maps were prepared for 500 villages in these districts. Landform maps (base maps) were derived using ALOS data (12.5 m resolution) for DEM, Sentinel data (10 m resolution) for identifying features, while Google Earth image(s) were accessed for reference. **Fig.2.5.10** shows landform map of a Deoli cluster in the Wardha district. At the time of reporting, these maps are being used by the fieled parties conducting soil survey work (**Fig.2.5.11).** Soil survey has been conducted in 463 villages.

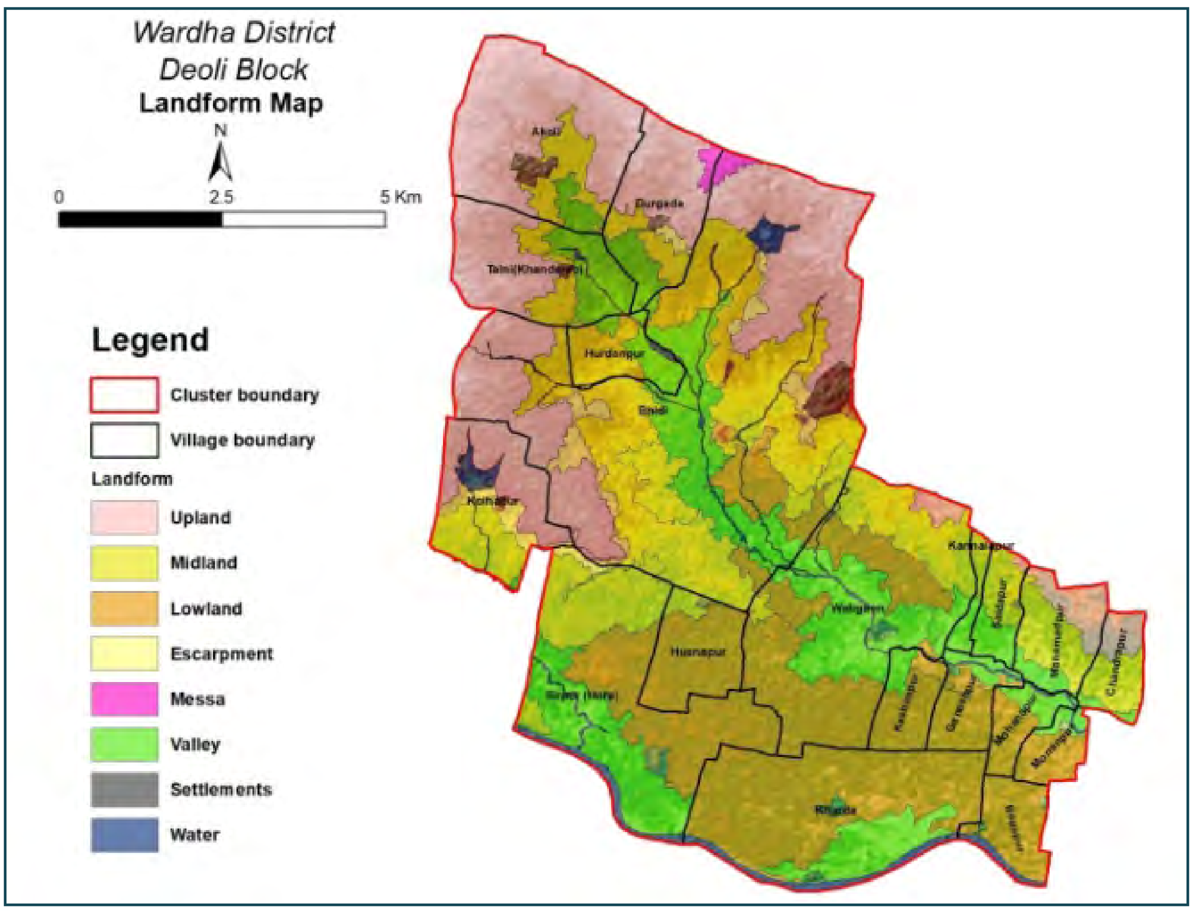


Fig. 2.5.10. Landform map of Deoli block, Wardha district, Maharashtra

Besides, an app developed by IIT Mumbai in consultation with NBSS&LUP was launched for collecting soil depth and texture data. Trainees from PoCRA districts were trained in using the app. Lectures were delivered by the scientists on the importance of soil survey and mapping, types, methods, and scale of mapping and details about the importance of various soil site characteristics. Field demonstrations were conducted in farmers' field(s) for collection of data.

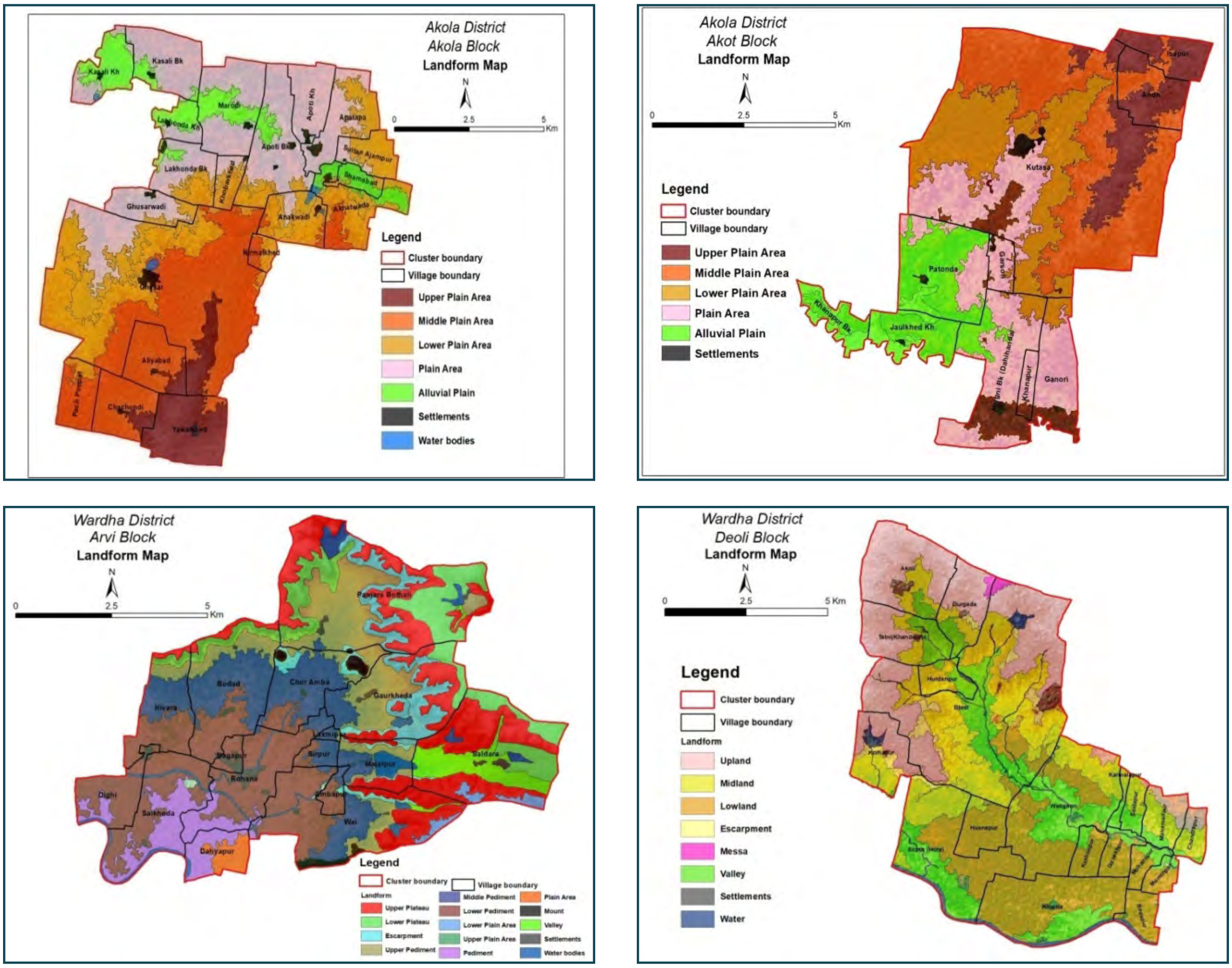


Fig.2.5.11. Landform map of cluster of villages of two blocks in Akola and Wardha districts (Akola, Akot, Arvi and Deoli blocks, respectively)

2.6 IT Enabled Extension Programme

Enrichment of BHOOMI Geoportal Platform

BHOOMI Geoportal was enriched by deploying various soils based thematic layers as WMS for 27 aspirational districts spreading in different states of India. Developed various dashboards for visualization and query of spatial and non-spatial databases of socio-economic data, physiography, agro-ecology, soils, soil fertility, land degradation, land-use planning, and aspirational districts. An additional section has been developed to visualize the information of aspirational districts in BHOOMI Geoportal. The MODIS NDVI (250m) data of India has been processed and deployed for the *Kharif* season for the year from 2000 to 2018.

Designed and developed BHOOMI Geoportal interoperability dashboard to test the interoperable services of BHOOMI and KRISHI Geoportal. Standard Metadata format (IS-16439) has been developed and generated metadata for selected thematic layers and uploaded in the Geoportal. Developed additional data query modules and data visualization tools as dashboards to query spatial and non-spatial databases. Visitors count in Geoportal using cluster maps that have been developed to show visitors (hits) on day to day basis. NDVI for the year 2018 (*Kharif* season) and potential areas for rice cultivation and rice cultivated areas as shown through interoperable mode are depicted in **figure 2.6.1**.

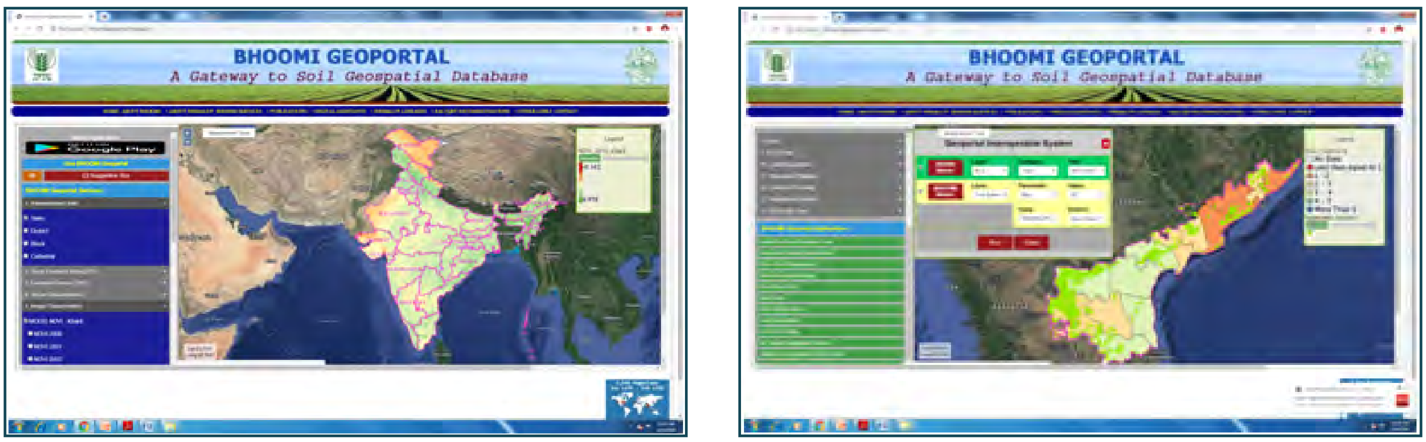


Fig.2.6.1. NDVI for the year 2018 (kharif season) and potential areas for rice cultivation and rice cultivated areas as shown through interoperable mode in BHOOMI Geoportal

AR Research Data Repository for Knowledge Management (KRISHI)

Metadata format for KRISHI Geoportal was finalized for online metadata generation for the geospatial datasets provided by various ICAR institutes. ICAR-NBSS&LUP further developed metadata for 8 spatial datasets of soil and allied resources for KRISHI Geoportal. Data received from ICAR-NIVEDI on 13 animal disease outbreaks for the years 2017 and 2018 have been processed in GIS and developed thirteen thematic maps. The same has been sent for deployment in KRISHI Geoportal. Organized two days User's Workshop on *"ICAR-KRISHI Geoportal – Challenges and Way Forward"* during 9-10 January 2020. About 35 participants from 18 ICAR institutes took part in the two days workshop and assessed the

Fig.2.6.2. FMD outbreak in India (2018) processed and deployed in KRISHI Geoportal

progress made and worked out the way forward.FMD outbreak in India during the year 2018 as available in KRISHI Geoportal is shown in **figure 2.6.2**.

HySIS: An android based mobile GIS application

HYSIS, an android based mobile app was developed for visualizing, disseminating, sharing, and also data mining of the hyperspectral signatures in a digital manner. This application provides the hyperspectral information in point data over the Goa state, to view the information in the graphical format, There are three different spectral ranges, (i) VNIR (350-2500 nm) visible and near-infrared, (ii) FTIR (2501-15000 nm) Fourier-transform infrared spectroscopy, (iii) Entire Spectra (350-15000 nm). It also has the feature of matching wavelength, which means it finds the nearest matching wavelength. The HySIS (**Fig.2.6.3**) has information such as administrative layers (State Boundary, District Boundary, Taluka Boundary, Panchayat Boundary, and Cadastral Boundary) thereby reaching out to the farmers in a more realistic manner. The App provides the easy to reach location in a hierarchical pattern like State, District, Taluka, Panchayat, and Cadastral. The point data provides the attribute information of soil and site characteristics and fertility information. The legend information is also available. The App can locate the user's location on a hierarchical drop-down selection basis or else the GPS enabled location tracking. The real-time GPS based tracking allows the user to collect information while on the go. The App will be updated at regular intervals based on the technological developments as well as the user's feedback. This indeed will be the part of Digital India platform. The operating steps in this App are displayed below:

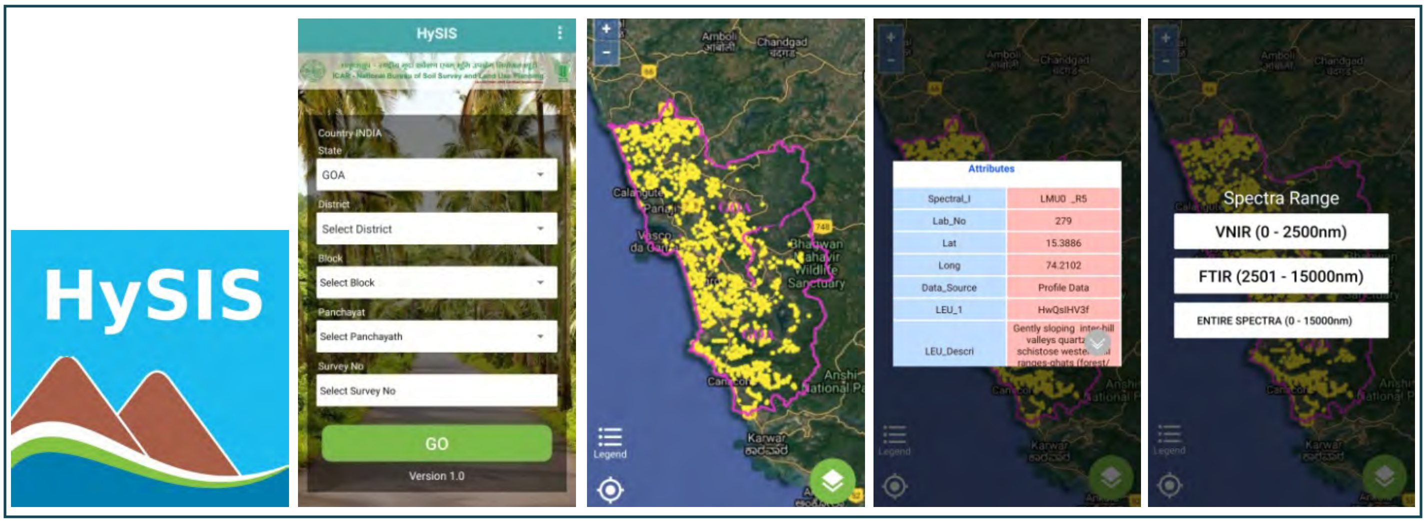


Fig.2.6.3. The HySIS App

National Spatial Data Infrastructure: Soil Resource Database

Under NSDI-NDR, the Mysore district of Karnataka has been selected by the NSDI to develop prototype applications. Under this initiative, the schema has been developed for legends of various thematic maps on various soil properties. The XML code based Style Layer Descriptor (SLDs) was developed to implement in application development at NSDI server. The metadata for the soils of the Mysore district has been developed as per the BIS Metadata standard 16439 format.

3 RESEARCH PROGRAMME

INSTITUTE PROJECTS (ONGOING)

INVENTORYING NATURAL RESOURCES

Land Resource Inventory at 1:10000 scale for agricultural land use planning using geo-spatial techniques

- Alwar district, Rajasthan
- Anjar and Bhachau taluka, Kachchh district, Gujarat
- Anupgarh Taluka, Sriganganagar district, Rajasthan
- Atchutapuram Mandal of Visakhapatnam district, Andhra Pradesh
- Baska block, Baksa district, Assam
- Bemetara block, Bemetara District, Chhattisgarh state
- Bhimtal block of Nainital district, Uttarakhand
- Bhuj and Mundra taluka, Kachchh district, Gujarat
- Bikaner district, Rajasthan
- Bobbili mandal, Vizayanagaram district, Andhra Pradesh
- Bolangir district, Odisha
- Chakia block, East Champaran district, Bihar
- Chakchaka block, Barpeta district, Assam
- Chamba block of Tehri Garhwal district, Uttarakhand
- Chinthakani mandal, Khammam district, Telangana
- Churu district, Rajasthan
- Dhanpatganj block of Sultanpur district, Uttar Pradesh
- Fatehgarh tehsil of Jaisalmer district, Rajasthan
- Ghatanzi, Pandharkhawda and Ner tehsils, Yavatmal district, Maharashtra
- Hanumangarh district, Rajasthan
- Hassan Jalashakthi Abhiyaan areas
- Hazaribagh district, Jharkhand
- Hemtabad block, Uttar Dinajpur district, West Bengal
- Jagdevpur block, Siddipet district, Telangana state
- Jalihalhobli, Sindhanur taluk, Raichur district, Karnataka
- Jalpaiguri district, West Bengal
- Kakodonga block, Golaghat district, Assam
- Katihar district, Bihar
- Katkamdag block, Hazaribagh district, Jharkhand
- Keshod and Vanthali taluka, Junagadh district, Gujarat
- Lahul block of Lahul & Spiti District, Himachal Pradesh
- Land resource inventory for adopted villages
- Land resource inventory (1:10000 scale) and Impact Assessment of Canal Irrigation on the Arid Agro-ecosystem- A Case Study in five blocks of IGNP Command Area
- Leh block of ladakh district, Jammu & Kashmir
- Machi block, Chandel district, Manipur
- Maldah district, West Bengal
- Maliya and Mendarda talukas, Junagadh district, Gujarat
- Mandapam block, Ramanathapuram district, Tamil Nadu
- Mandvi and Abdasa talukas, Kachchh district, Gujarat
- Mangrol and Manavadar taluka, Junagadh district, Gujarat
- Maynaguri block, Jalpaiguri district, West Bengal

- Mehabubnagar Rural mandal, Mehabubnagar district, Telangana
- Motihari block, East Champaran district, Bihar
- Murshidabad district, West Bengal
- Muskara block of Hamirpur district, Uttar Pradesh
- Nadia district, West Bengal
- Nagrota Bagwan block, Kangra district, Himachal Pradesh
- Nakhtrana, Lakhpat and Gandhidham taluka, Kachchh district, Gujarat
- Nalchar block, Sepahijala district, Tripura
- Needamangalam block, Thiruvrur district, Tamil Nadu
- North & Middle Andaman district, Andaman & Nicobar Islands
- Northern Ahmednagar, Maharashtra
- Palani block, Dindigal district, Tamil Nadu
- Pangi block of Chamba district, Himachal Pradesh
- Parabhani taluka, Parabhani district, Maharashtra
- Patiala district, Punjab
- Pokharan and Jaisalmer tehsil, Jaisalmer district, Rajasthan
- Rahuri taluka, Ahmednagar district, Maharashtra State
- Ranjuli block, Goalpara district, Assam
- Raychoti mandal, YSR Kadapa district, Andhra Pradesh
- Sadulsahar, Padampur, Karanpur and Raisinghnagar tehsils, Sri Ganganagar district, Rajasthan
- Sahibganj district, Jharkhand
- Sambepalle Mandal, YSR Kadapa district, Andhra Pradesh
- SBS Nagar district, Punjab
- Sirsa district, Haryana
- Southern Ahmednagar, Maharashtra
- Sri Ganganagar district, Rajasthan
- Tangi block of Khurda district, Odisha
- Thadlaskein block, West Jaintia Hills district, Meghalaya
- Tripura state
- Wani, Jhari-Jamni and Maregaon taluka, Yavatmal district, Maharashtra
- Yavatmal district, Maharashtra

REMOTE SENSING AND GIS APPLICATIONS

- Assessment of land degradation and prime agricultural land in the country using MODIS time series NDVI and legacy data
- Automated landform delineation of desert ecosystem of India
- Design and Development of Land Resource Information System and NBSS Geoportal for Geospatial Database Management and Dissemination
- Development of Digital Terrain Database and Landform Mapping at Tehsil/Block Level in Different Agro-Ecological Sub-Regions of Central India using Geospatial Techniques
- Enrichment of BHOOMI Geoportal platform and development of thematic services for application in agricultural land use planning
- Landform and land use / land cover mapping of some selected blocks of Eastern and North Eastern India
- Land form identification and mapping of Aspirational Districts of Eastern India.
- Landform mapping and characterization in selected aspirational districts of semi-arid tropics of India using geospatial techniques
- Mapping and Assessment of Land Degradation in Major Ecosystems of India Using Geospatial Technologies
- Soil erosion assessment and conservation planning using remote sensing and GIS of Dhanora block, Seoni district, Madhya Pradesh
- Soil Erosion Risk Assessment in Pulivendula Tehsil, Cudappa district, Andhra Pradesh
- Soil Hyperspectral data modeling for quantitative assessment and monitoring of soils of Goa state. (Institutional collaborative project with Central Coastal Agricultural Research Institute, Goa)

SOIL CORRELATION

- Correlation of soil series of India
- Correlation of soil series of eastern region (West

Bengal, Bihar, Jharkhand, Odisha and A&N islands)

LAND EVALUATION AND AGRICULTURAL LAND USE PLANNING

- Agricultural Land Use Planning for Canning II block of South 24-Parganas district, West Bengal using Land Resource Inventory database on 1:10,000 scale
- Agricultural Land Use Planning for Indo-Gangetic Plain Regions of India towards Sustainable Crop Production and Livelihood Security- A Case Study in Mathura District of Uttar Pradesh
- Agricultural land use planning for Kultali block of South 24-Parganas district, West Bengal using land resource inventory database on 1:10,000 scale
- Agricultural land use planning for Rajnagar block of Birbhum district, West Bengal using land resource inventory database on 1:10000 scale.
- Agricultural land use planning of Baragaon block of Varanasi district, Uttar Pradesh using land resource data on 1:10,000 scale
- Agricultural land use planning of Rajpura block of Patiala district, Punjab using land resource data on 1:10000 scale.
- Agronomic evaluation of crops for their suitability in different soils of Karnataka
- Assessment of heavy metal contamination in soil surrounding an iron ore mining area of Northern Goa
- Delineation of Potential Areas for Agricultural Land Use Planning
- Development of Decision Support System for Agricultural Land Use Planning
- Development of land resource inventory based long term soil organic carbon restorative land use plan in humid sub tropical region of Eastern India (Jalpaiguri district, West Bengal).
- Evolving Criteria for drainage line treatments designs
- Impact of Bt cotton cultivation on sustainable management of natural resources in Nagpur district of Maharashtra
- LRI based Land Use Planning – Data Analysis, Impact Assessment of Maynaguri block, Jalpaiguri district, West Bengal
- Management of natural resources and climate risk for environmentally sustainable land use planning - a case study of Rajpura Block , Punjab
- Protection and conservation of Aravalli landscape region through land resource inventory based agricultural land use planning intervention: A case study
- Revision of Agro-Ecological Sub-Regions of Red Soils of India for Land Use Planning.
- Socio economic Assessment of Agricultural Land Use Pattern in Darwha Block of Yavatmal District
- Socio Economic Evaluation of Agricultural Land use in India–Phase-I
- Sustainable Agricultural Land Use Planning for Aspirational Districts of Northern India (Ferojpur (Punjab), Chandauli, Fatehpur (Uttar Pradesh), Kupwara, Baramula (Jammu & Kashmir), Chamba (Himachal Pradesh), Mewat (Haryana), Siddharthnagar (Uttar Pradesh), Moga (Punjab), Udham Singh Nagar (Uttarakhand), Haridwar (Uttarakhand)
- Sustainable agricultural Land use planning of Aspirational district of Western India (Jaisalmer, Karauli, Baran, Sirohi, Dholpur, Rajasthan, Dahod and Narmada, Gujarat) using geospatial techniques.

BASIC PEDOLOGICAL RESEARCH

- Genesis and Classification of Soils in Bemetara Block, Bemetara District, Chhattisgarh
- Modelling soil forming processes and genesis of red and black soils in Peninsular India
- Role of crystalline and non-crystalline nano-clays for carbon stabilization in pedo-genetically important soil orders of tropical India

INTERPRETATION OF SOIL SURVEY DATA

- Visual signs of Biophysical indicators for assessing the status of degradation of dry Lands in Pulivendula tehsil, Cudappa district Andhra Pradesh
- Soil carbon sequestration potential in preservation plots in wet evergreen and most deciduous forests in Central Western Ghats of Karnataka (collaborative project with ICFRE-IWST).

TRIBAL SUB PLAN (TSP/STC)

- Soil & water conservation strategies for enhancing agricultural productivity in a cluster of tribal villages in Katol taluka, Nagpur district
- Land resource inventory (LRI) of Susnigaria village of Ghatshila block, East Singbhum district, Jharkhand (at 1:10000 scale) for optimizing agricultural land use plan using geo-spatial techniques (under STC programme)
- Livelihood improvement of Tribal communities of selected homeless in H.D. Kote, Mysore Dist, Through Integrates land use planning

EXTERNALLY FUNDED PROJECTS

- High-Resolution Land Resource Inventory and Land Use Planning for Climate Resilient Agriculture (POCRA project)
- Accompanying the adaption of irrigated agriculture to change (ATCHA Project)
- Application of soil resource database for geospatial planning of power transmission towers in India (M/s KEC International Ltd. Sponsored consultancy project)
- Bioremediation of chemical contaminants and their complexes present in drainage wastewater with high dynamic flux used for irrigation in urban and peri-urban agriculture (National Agricultural Science Fund (NASF) Funded project)
- Characterization and mapping of land resources of Goa in reference to cultivated and fallow land use system. A step towards enhancing agriculture productivity
- Desertification & Land degradation monitoring, vulnerability, Assessment and combating plan
- Development of an algorithm to predict soil depth using legacy data and terrain attributes (M/s Sterlite Technologies Ltd. Sponsored consultancy project)
- Development of digital terrain and land use dynamics geo-database on 1:10K scale for land resource inventory of cultivated and fallow land use systems of Goa (Funded by RKVY)
- Development and Management of Integrated Water Resources in Different Agro-Ecological Regions of India
- Digital soil mapping of India (IndianSoilGrid Project)
- Enhancing economic viability of coconut based land use systems for land use planning in Kerala (Funded by Govt. of Kerala).
- Generation and modelling of carbon datasets in different agro-ecosystems for climate resilient agricultural planning (NICRA)
- Hyperspectral remote sensing in characterization and mapping of red and associated soils of Southern India. (DST funded)
- ICAR Research Data Repository for Knowledge Management (KRISHI)
- Land resource inventory of Arunachal Pradesh in large scale for agricultural land use planning using geo-spatial techniques (Funded by Department of Agriculture, Govt. of Arunachal Pradesh)
- Land resource inventory of selected micro-watersheds in 11 districts of Karnataka under Sujala III watershed development project, Govt. of Karnataka (Karnataka Watershed Development Department, Bangalore – World Bank project)
- Land Suitability Mapping for optimum crop plan based on food scurrying requirement of Karnataka (funded by Karnataka Agricultural Price Commission)
- Management of Marihal Bamboo in Agro forestry blocks (Funded by ICFRE, Dehradun)
- Research study on soil sample collection and testing for assessing SHCs Scheme (Niti Aayog Consultancy project)
- Soil Quality Assessment and Developing Indices for Major Soil and Production Regions of India (Extramural research grant from ICAR-Indian Institute of Soil Science in collaboration with IIFSR, Modipuram, CRIDA, Hyderabad)
- Spatial Crop Planning for Sustainable Resource and Conservation of Ecological Resources under GoI-GEF-UNDP IHRML project

Completed Projects

INSTITUTE PROJECTS

INVENTORYING NATURAL RESOURCES

Land Resource Inventory at 1:10000 scale for agricultural land use planning using geo-spatial techniques

- Amod and Jambusar Talukas, Bharuch district
- Baisi block, Purnea district, Bihar
- Baragaon block of Varanasi district, Uttar Pradesh
- Bharuch taluka, Bharuch district
- Bikaner tehsil, Bikaner district, Rajasthan
- Charilam block,Sepahijala district, Tripura
- Jhagadia taluka, Bharuch district, Gujarat
- Kamrej taluka, Surat district
- Kaparada taluka, Valsad district
- Kaveripattinam block, Krishnagiri District of Tamil Nadu
- Land resource inventory for adopted villages under farmer first project of ICAR–IIHR
- Mandvi taluka, Surat district
- Mangrol taluka, Surat district
- Maynaguri block, Jalpaiguri district, West Bengal
- Motihari block, East Champaran district, Bihar
- Neem Ka Thana block, Sikar district, Rajasthan
- Odhan block of Sirsa district, Haryana
- Olpad taluk, Surat district
- Piprakothi block, East Champaran district, Bihar
- Santipur block, Nadia district, West Bengal
- Suratgarh block , Sriganganagar district, Rajasthan
- Umarpada taluka, Surat district
- Vagra taluka, Bharuch district
- Valia taluka, Bharuch district
- Valsad and Pardi talukas, Valsad district
- Vansda and Khergam taluka
- Vapi and Umergaon taluka, Valsad district

LAND EVALUATION AND AGRICULTURAL LAND USE PLANNING

- Agricultural land use planning in the western Himalayan regions of India using Land Resource Inventory database on 1:10000 scale – A case study of Nagrota Bagwan Block of Kangra district in Himachal Pradesh

REMOTE SENSING AND GIS APPLICATIONS

- Revisiting soil resource mapping information into finer segregable dataset for better applicability using modern geospatial techniques

TRIBAL SUB PLAN (TSP/STC)

- Land use option for enhancing productivity and improving livelihood in Bali Island of Sundarbans

EXTERNALLY FUNDED PROJECTS

- Land resource inventory of Chilkur, Huzurnagar, Garidepally blocks of NSLC command area in Suryapet district of Telangana State on 1:10000 scale for optimal agricultural land use planning, using geo-spatial techniques (Govt. of Andhra Pradesh)
- GIS based digital library for the Land Resources of Sujala–III watershed department project (Sub-project of Sujala –III)

4 PUBLICATIONS

Research Papers

1. Anil Kumar, K.S. and Karthika, K.S. 2019. Smart Agriculture through conservation of natural resources in connection with modern technologies. *Satsa Mukhaptra Annual Technical Issue,***23**:91-99.

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12. Dharumarajan, S., Hegde, Rajendra, Janani, N., Singh, S.K. 2019. The need for digital soil mapping in India, *GeodermaRegional,***16**. (*https: //doi.org/ 10.1016/ j.geodrs. 2019.e00204)*.

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Apart from the above reports, Regional Centre, Bangalore has published following reports under Sujala-III project during the period.

- LRI Atlases – English (204 Micro-watersheds)

- LRI Atlases – Kannada (318 Micro-watersheds)Version
- LRI Reports (464 Micro-watersheds)
- Baseline Reports (240 Micro-watersheds)
- Hydrology Atlases (76 Sub-watersheds)

Seminar/Symposium/Conference/Poster/ Abstracts:

International

ICAR-CSSRI golden jubilee International Salinity Conference "Resilient Agriculture in Saline Environments under Changing Climate: Challenges & Opportunities" held at ICAR-Central Soil Salinity Research Institute, Karnal, India During 7-9th February, 2019.

1. Srinivasan, R., Hegde, Rajendra, Bhaskar, B.P., Srinivas, S., Niranjana, K.V., Dhanorkar, B.A. and Singh, S.K. 2019. Pedogenesis of sodic soils in Somavati river basin of semi arid eco-region, Andhra Pradesh, India. Abstract p.13.

13th International Conference on Development of Drylands: Converting Dryland Areas from Grey into Green held at ICAR - Central Arid Zone Research Institute, Jodhpur during 11-14 February 2019.

1. Meena, R.L., Singh, R.S., Verma, T.P., Moharana, P.C. and Singh, S.K. 2019. Soil-site suitability evaluation of major crops in soil of north-western Rajasthan for sustainable agriculture. p 46.
2. Meena, R.S., Rao, S.S. and Singh, S.K. 2019. Characterization and classification of soils of Neem Ka Thana tehsil in Sikar district of Rajasthan-India. Abstract: p. 60.
3. Raghuvanshi, M.S., Dorjay, N., Manjunatha, B.L., Meena, H.M., Spalbar, E. and Bhatt, R.K. 2019. Climate resilient low cost housing with mud bricks for cold arid region. T-9/P-30-324 pp.
4. Raghuvanshi, M.S., Moharana, P.C., Spalbar, E., Dorjay, N. and Tewari, J.C. 2019. Doubling farmer's income through agronomic interventions in Cold Arid Region. Paper presented in: T-9/P-20-314 pp.
5. Rao, S.S., Meena, R.S. and Singh, S.K. 2019. Mapping soil variability of Fatehgarh tehsil in Jaisalmer district of Rajasthan (India) at 1:10000 scale using geospatial technique. Abstract: p. 73.
6. Regar, P.L., Rao, S.S., Tanwar, S.P.S., Sukla, M., Sukla, A.K. and Meena, S.R. 2019. Performance of henna-clusterbean intercropping system in arid regions of Rajasthan, India. Abstract: p. 239.

Joint Workshop for Digital Soil Mapping and Global Soil Map held in Santiago, Chile, from 12 to 16 March 2019.

1. Dharumarajan,S., Lalitha, M., Kalaiselvi, M.B.,Jena, Roomesh Kumar,Prasenjit Ray, Mukhopadhyay, S.,Reza, S.K.,Meena, Rajesh Kumar,Verma, Shilpi,Moharana, Pravash Ch.,Tailor, B.L.,Nirmal Kumar, Sahu, Nisha,Chattaraj, Sudipta,Sahoo,Sonalika,Daripa, Amrita,Hegde, Rajendra,Singhand S.K.,Philippe Lagacherie. 2019. IndianSoilGrids: implementing a bottom-up GlobalSoilMap approach for India. p.18.

Environmental Sustainability 2019 Conferenceheld at Tokyo, Japan during 23-25 April 2019.

1. Anil Kumar K.S., Karthika, K.S.,Lalitha, M.,Nair, K.M.,Hegde, R. and Singh,S.K. 2019. Evaluation of sustainability of coffee plantation ecosystem upon conversion from natural forest ecosystem. Abstract p.

9th International conference on Algae Biomass, Biofuels and Bio products; June 17-19, 2019; USA.

1. Sharma, G.K., Khan, S.A., Malla, F., Gupta, N. Biofertilizers and biodiesel production after phycoremediation of sewage wastewater: A sustainable approach. In Abstract p2-49.

2nd International conference on Recent advances on Agriculture, Environmental and Applied Sciences for Global Development held at Dr.Y.S.Parmar University of Horticulture and Forestry Solan from 27-29 September, 2019

1. Shamsudheen M., Nayak, M.G. and Prabha Susan Philip, 2019. Delineation of soil nutrient constraints of cashew orchards in India and management alternatives. pp.218.

International conference on "Soil and Water Resource Management for Climate Smart Agriculture, Global Food and Livelihood Security" at New Delhi during November 5-9, 2019.

1. Sharma, R.P., Chattaraj, S., Vasu, D., Karthikeyan, K, Tiwary, P., Naitam, R.K. and Dash, B. 2019. Spatial variability assessment of soil fertility in black soils of central India using geo-statistical modeling. pp-365.

National

National Conference on Application of Geo-spatial Technologies and ICTs in Smart Agriculture at UAS Dharwad, Karnataka during January 23-24, 2018

1. Hegde, R., Niranjana, K.V., Bardhan, Gopali, Dhanorkar, B., Srinivas, S., Maske, S., Bhaskar, B.P. and Singh, S.K. 2018. Geospatial analysis for assessing spatial variability of soil properties in Gopalapura micro watershed under Gundlupet taluk, Chamarajanagar district, Karnataka, India. *Proceedings ISBN: 978-81-88367-42-9: 1-9.*

Agriculture and Forestry Sciences Section of 106th Indian Science Congress 2019 organized by Indian Science Congress Association held at Lovely Professional University, Jalandhar, Punjab from 3-7th January, 2019

1. Das, K., Ghosh, B.N., Mukhopadhyay, S., Nayak, D.C. and Singh, S.K. 2019. Impact assessment studies of GIS based land resource inventory towards developing alternate agricultural land use plan in Titlagarh block of Bolangir district, Odisha.
2. Ray, P., Singh, S.K. and Ray, S.K. 2019. Nutrient management package for production of high yield and quality of mulberry (*Morus indica L.*) leaf in acid soil of Brahmaputra valley region of North Eastern India.
3. Ray, P. 2019. Effect of amendments on solubility, phytoavailability and distribution of Zn, Cd and Pb in soil environment polluted due to zinc smelter effluent irrigation: Implication on human health.

28th National conference on "Farmers friendly soil and water conservation technologies for mitigating climate change impact" held during 31st January-2nd February, 2019 at Hotel GEM park, Ooty, Tamil Nadu, India.

1. Chandrakala, M., Srinivasan, R., Anil Kumar, K.S., Karthika, K.S., Sujatha, K.Rajendra Hegde and S. K. Singh. (2019). Problems and potentials of the rubber cultivation areas in Kerala for resource conservation. p 161-162
2. Kalaiselvi, B, Hegde, Rajendra,Vasundhara, R., Dharmarajan. S, Srinivasan. R, Anil Kumar, K.S, Lalitha, M and Singh,S.K. 2019. Assessment of SOC stock of different land use system of Western ghats- A case study.
3. Karthika, K.S., Anil Kumar, K.S., Kalaiselvi, B., Nair, K.M., Lalitha, M., Rajendra Hegde and Singh, S.K. 2019. Evaluation of soil quality on their conversion from natural forest ecosystem to coffee plantation in Western Ghats.p 145-146
4. Srinivasan, R., Hegde, Rajendra,Bhaskar, B.P., Srinivas, S., Niranjana, K.V.,Dhnorkar, B.A, Kalaiselvi, B., Chandrakala, M., Vasundhara, R., Maddileti, N. and Singh, S.K.2019. Mapping of soil erosion zones in a part of south Deccan Plateau, Ananthapur district, India for conservation-A geospatial approach.pp.99.
5. Vasundhara, R., Srinivasan, R., Kalaiselvi, B., Dharumarajan, S., Chandrakala, M. and Hegde,Rajendra. 2019.Assessment of soil fertility and crop suitability for doubling of farmer's income.

Farmers First for Conserving Soil and Water Resources in Eastern Region (FFCSWR-2019) held at CSWCRTI, Sunabeda, Koraput, Odisha from 6-8th February 2019.

1. Ghosh, B.N., Bandyopadhyay, S., Das, K., Nayak, D.C. and Singh, S.K. 2019. Land Resource Inventory based Land Use Planning: Dandakaranya and Easternghats Physiographic Confluence of India.

XIV Agricultural Science Congress, Innovations for Agricultural Transformation, Feb. 20-23, 2019, New Delhi.

1. Sunil Kumar, V.K., Phogat, Dahiya, Rita and Singh, R.S. 2019. Effect of different cropping systems on soil organic carbon dynamic in arid and semi-arid region of North-Western, India. p.667.

2. Sharma, G.K., Khan, S.A., Malla, F., Gupta, N. Microalgae from wastewater treatment to bio-fertilizers – A climate resilient technology of waste valorization. p. 658.

PLACROSYM 23rd Biennial Symposium on Plantation Crops Chikmagalore, Karnataka during 6-8 March 2019 at CCRI, Chikmagalore, Karnataka ISBN No. : 978-81-932263-8-4.

1. Jessy, M.D., Ulaganathan, A., Pradeep, B., James Jacob, Joshua Abraham, Annie Philip, Prasannakumari, P., Syamala, V.K., Ambili, K.K., Sherin George, Phebe Joseph, Thomas Eapen, Joyce Syriac, Mathew, P.M., Anil Kumar, K.S. and Nair, K.M. 2019. Spatial variability in soil available sulphur content in rubber-growing regions of South India. p.17.

2. Karthika, K.S., Anil Kumar, K.S., Sidharam Patil, Avinash, R.K., Arti Koyal, Nair, K.M., Lalitha, M., Rajendra Hegde and Singh S.K. 2019. Soil organic carbon content and stocks in forest, coffee, rubber and coconut plantations and field crops in red and lateritic soils of Western Ghats, South India, p. 85.

Biotic Science Congress, 2019 Bioscon,19 held at Sona College of Arts and Science, Salem, on 26-27 July, 2019, Souvenir-cum-e-Book

1. Ravi, N., Lubina, P.A., Rajan, Aparna, Pavithra, G.M., Sandhya, M.C., Anil Kumar, K.S. and Viswanath, S. 2019. Study on root architecture in two nationally prioritized bamboo species in semi-arid region of Karnataka, 154p.

22nd Annual convention and National conference on "Application of Clay and Allied Sciences in Agriculture, Environment and Industry" held during 23-24, September, 2019 at ICAR-IARI, New Delhi.

1. Chandrakala, M., Srinivasan,R., Anil Kumar K.S.,Hegde, Rajendra and Singh, S.K. 2019. Landform- soil relationship in tropical humid region of Kerala, India- A case study in Elamdesam block.p. 23.

2. Hota, S., Jena, R.K., Ray, P., Mourya, K.K., Ramachandran, S. and Ray, S.K. 2019. Impact of land form and land use changes on soil potassium pools in Meghalaya plateau of India. p. 60.

3. Jangir, A., Sharma, R.P., Tiwari, G., Dash, B., Naitam, R.K. and Singh, S.K. 2019. Morphological and physico-chemical characteristics of soils: a case study of Bharuch Taluka, Bharuch District of Gujarat. p. 67.

4. Kalaiselvi, B, Dharumarajan, S, Lalitha, M, Srinivasan, R., Anil Kumar, K.S., Hegde,Rajendra and Singh,S.K. 2019. Characterization and classification of shrink-swell soils developed from calcic-gneiss parent material. p. 54.

5. Kumar, A., Mahapatra, S.K. and Singh, S.K. 2019. Role of clay particles in sustainability of rice-wheat cropping system in Indo-Gangetic Plains- a case study. p. 64-65.

6. Lalitha, M., Anil Kumar, K.S., Dharumarajan, S., Kalaiselvi, B., Hegde, Rajendra and Singh, S.K. 2019. Mineralogical expression in red and lateritic soils of Eastern Ghats to East Coast. p. 29.

7. Mourya, K.K., Jena, R.K., Ray, P., Hota, S., Ramachandran, S. and Ray, S.K. 2019. Impact of land use on soil organic carbon stocks in Meghalaya plateau of India. p. 61.
8. Nagdev, Ritu, Mahapatra, S.K., Meena, R.K., Vikas, Surya, Jaya N. and Singh, S.K. 2019. Study of agri-environmental characteristics in Rajpura block of Patiala district in Punjab for sustainable productivity. p. 53.
9. Sharma, R.P. and Singh, R. 2019. Classical Cracking pattern in Sodic Vertisols of Gujarat. p.61.
10. Srinivasan,R., Singh, S.K., Nayak, D.C., Hegde, Rajendra and Chandrakala, M. 2019. Effect of climate on seasonal variation of soil salinity and alkalinity in Coastal Odisha for sustainable crop production. p. 58
11. Tiwari, G., Jangir, A., Dash, B., Vasu, D., Singh, R.S. and Singh, S.K. 2019.Large-scale soil mapping (1:10,000) using geospatial techniques-A Case Study of Gandhidham Block, Kutch District, Gujarat. p. 68.

National Dialogue on Land Use for Integrated Livestock Development organized by ILRI, TAAS, AZRAI and ICAR at TAAS, New Delhi from 1-2 November 2019

1. Singh, S.K., Raghuvanshi, M.S. and Ramamurthy, V. 2019. Status of land Use System for Livestock Sector: Current Status and Future prospects. p. 1-3.

84th Annual Convention and National Seminar on "Developments in Soil Science" organized by Indian Society of Soil Science, New Delhi in collaboration with Banaras Hindu University, Varanasi during November 15-18, 2019.

1. Sharma, R.P, Singh, S.K. and Nirmal Kumar 2019. Estimation of Soil Organic Carbon Stock (SOC) in Uttar Pradesh for Carbon Management Planning.
2. Chattaraj, S, Ramamurthy, V., Daripa, A., Sharma, R.P., Thakare, V., Srivastava, R., Raghuvanshi, M.S. and Singh, S.K. 2019. Geo-smart Soil Health Card- An advance android based GIS application in soil resource management.

Innovations in Plant and Animal Sciences for Sustainable Agriculture and Rural Development (IPASSARD 2019), December 07-09, 2019 Durgapora, Jaipur.

1. Sunil Kumar and Phogat, V.K., Dahiya, Rita and Rao, S.S. 2019. Long-term influence of agricultural land use and management practices on labile and non-labile pools of soil organic carbon in soil of arid and semi-arid regions North-western, India. p.355.

27th Annual Conference, Agricultural Economics Research Association, Changing Landscape of Rural India in Punjab Agricultural University, Ludhiana, Punjab during 17-19 December 2019.

1. Ramesh Kumar, S.C., Bhaskar, B.P., Hegde, Rajendra, Bhoora Prasad, Prakashanaik, M.K. and Singh, S.K.2019. Impact of urbanization on agricultural land in Rajanukunte micro watershed, Karnataka, p.214.

Brain storming Workshop on Third Pole Regional Climate Change (TPRCC) organized by India Meteorological Department, Ministry of Earth Sciences, GOI, New Delhi

1. Saxena, A., Gupta, V. and Raghuvanshi, M.S. 2019. Impact of climate change on subsistence agriculture and highland pastures of cold arid region. p. 45-46.

Media Coverage in News Paper

- **The achievements and activities of LRI programme at Hazaribagh district of Jharkhand has been published in 4 numbers of local daily news papers *viz.,***

  (i) *Dainik Bhaskar* (01.01.2019)

  (ii) *Hindustan* (01.01.2019)

  (iii) *Awaz* (03.01.2019)

  (iv) *The Face of India* (03.01.2019)

- **The achievements and activities of STC programme at Susnigaria tribal village of ghatshila block of East Singhbhum district, Jharkhand has been published in following local daily news papers *viz.,***

  (i) *Prabhat Khabar (25.07.2019)*

  (ii) *Prabhat Khabar (04.08.2019)*

  (iii) *Dainik Bhaskar (04.08.2019)*

Lecture Delivered

- Dr. B.N. Ghosh delivered lecture on "Soil and input management strategies in Odisha for productivity enhancement and resource conservation" in the brainstorming session on *"Bhoochetana"* for scaling up of science led development for productivity enhancement and livelihood security for the state of Odisha at ICRISAT, Hyderabad on 22ndFebruary 2019 .
- Dr. Amrita Daripa delivered lecture on 'Heavy metal pollution management in periurban agriculture under a climate change scenario' in a summer school training on Land Resource management for climate smart agriculture held at NBSS&LUP, Nagpur from 03-23 September 2019.
- Dr. Amrita Daripa delivered lecture on 'Soil pollutants and periurban agriculture' in a training entitled "Tools and Techniques of Soil Resource Survey for Land Use Planning" jointly organized by Ministry of External Affairs and ICAR from 2-13 August 2019 at NBSS&LUP, Nagpur.
- Dr. B.N. Ghosh delivered lecture on topic "Sustainable Management of Water Resource in Agriculture- A Few Recent Developments" on 59th Foundation day of Institute of Engineers (IEI) on 5thJuly, 2019 at Gokhle Road, Kolkata.
- Dr. M.S. Raghuvanshi delivered a lecture on Crop Planning based on Land Resource Inventory to mitigate abiotic stresses in training entitled,"Land Resources Management for Climate Smart Agriculture" held at Div. of Land Use Planning, ICAR-NBSS&LUP, Nagpur during 03-23 September, 2019
- Dr. M.S. Raghuvanshi delivered a lecture on Land Use Planning-A case study in training entitled "Tools and Techniques of Soil Resource Survey for Land Use Planning" jointly organized by Ministry of External Affairs and ICAR from 2-13 August 2019at NBSS&LUP, Nagpur
- Dr. M.S. Raghuvanshi delivered a lecture on "*Low-cost technologies for easy adoption by farmers*" at KVK, Sonapur, Gadchirauli on 24.04.2019.
- Dr. R.A. Marathe delivered lead lecture on '*Nutrition of citrus nursery plants'* in International training programme for the officer of Royal Government of Bhutan under Indi-Bhutan Bilateral Cooperation in Agriculture and Horticulture held at ICAR CCRI, Nagpur during March 25 to April 6, 2019. (05.4.2019).
- Dr. R.A. Marathe delivered lecture on functioning and activities of institute in museum of NBSS&LUP to Students of B.Sc. Agriculture, College of Agriculture, Nagpur on 15.05.2019.
- Dr. R.A. Marathe delivered lecture on functioning and activitiesof the institute in museum of NBSS&LUP to trainees from RAMETI, Nagpur on 29.08.2019.
- Dr. R.A. Marathe delivered lecture on functioning and activities of institutes in museum of NBSS&LUP to M.Sc. Geology students from Dept. of Applied Geology, University of Madras, TN on 02.12.2019.
- Dr. R.A. Marathe delivered lecture on '*Tools and techniques in land evaluation for horticultural crops'* in International Training Programme on 'Tools and Techniques of Soil Resource Survey for Land Use Planning held during August 2-13, 2019 at ICAR–NBSS&LUP, Nagpur.
- Dr. R.A. Marathe delivered lecture on Land Use Planning case study II in training in Soil Survey and Classification for the M.Sc. (Ag-SSAC) students of BHU, Varanasi, UP held during May 1 to June 1, 2019 at NBSS&LUP, Nagpur.
- Dr. R.A. Marathe delivered lecture on "*Land Use Planning for horticultural crops (Climate resilient horticulture*)" in Summer School on 'Land Resource Management for Climate Smart Agriculture' during September 3-23, 2019 at Division of Land Use Planning, ICAR–NBSS&LUP, Nagpur.
- Dr. R.A. Marathe delivered lecture on recent developments in soil health management in Agriculture and provided guidance on functioning and institute activities in museum of NBSS & LUP to trainees from Ramkrishna Bajaj College of Agriculture, Pipri-Wardha on 22.11.2019.
- Dr. R.K. Naitam delivered guest lectures on *"Land Evaluation"* in 12 Days Short Term Training Programme by DARE on "Tools & Techniques of

Soil Resource Survey for Land Use Planning" For International Participants, Sponsored by Ministry of External Affairs (MEA), GOI held at ICAR-NBSS&LUP, Nagpur from 2nd – 13th August, 2019.

- Dr. R.K. Naitam delivered guest lectures on *"Soil Landform Relationships"* in training programme "Soil Survey and Classification" For the M.Sc. (Ag-SSAC) students of Banaras Hindu University, Varanasi held at ICAR-NBSS&LUP, Nagpur from May 20th -1st June, 2019.
- Dr. R.K. Naitam delivered guest lectures on *"Soil productivity, preparation of soil map and their utility in Land Use Planning"* in a one day Workshop for forest officers organized by FDCM at FDCM Bhavan, Nagpur on 3rd October, 2019.
- Dr. R.K. Naitam delivered guest lectures on *"Soil survey and interpretation of soil survey data"* in ICAR sponsored 21 days Summer School Training Programme on "*Land Resources Management for Climate Smart Agriculture*" held at ICAR-NBSS&LUP, Nagpur from 3rd – 23rd September, 2019.
- Scientists of the Regional Centre, Kolkata (Dr. D.C. Nayak, Dr A.K. Sahoo, Dr. K. Das, Dr. S. Mukhopadhyay, Dr. S.K. Reza, Dr. S. Bandyopadhyay and Dr. S. Gupta Choudhury) delivered the lectures on different topics to teachers and 36 students of Howrah High School, West Bengal on 14thJanuary, 2019.
- Udaya bhaskar K., Radhika. C., Sripathy K.V. and Vijayakumar H.P. 2019. Seed quality enhancement through the application of innovative techniques. In national training on Technological interventions for quality seed production of nutritional crops sponsored by NAHEP-ICAR: CAAST-NC Project; Dated: 23-24th Oct., 2019 at CSAUAT, Kanpur.
- Dr. G.P. Obi Reddy presented BHOOMI Geoportal and its capabilities in the interactive meeting held at ICAR-CRIDA on 1st October, 2019.
- Dr. G.P. Obi Reddy presented invited talk on *"Geoportal - A Digital transformation platform for sustainable land resources management and geosmart agriculture-Indian Experiences* in 'GovTech2019' International Conference during 27-30, October, 2019 at Durban, South Africa.
- Dr. G.P. Obi Reddy attended Data Science Summit 2019 on 12th November 2019 at G.H. Raisoni College of Engineering, Nagpur.
- Dr. G.P. Obi Reddy delivered the talk on "*BHOOMI Geoportal Platform: A gateway to disseminate innovative geospatial services for geosmart agricultural land use planning*" in Geosmart 2019 at Hyderabad during 3-4th December, 2019.
- Dr. G.P. Obi Reddy presented BHOOMI Geoportal and its capabilities in fourth KRISHI National Workshop of Nodal Officersheld 10-11th December, 2019 at New Delhi.
- Dr. G.P. Obi Reddy delivered the invited talk on "Information Technology in Natural Resources Management in International Conference on 'Big Data Analytics (BDA2019)'at Ahmadabad University during December 17 to 20, 2019.

5 PARTICIPATION IN WORKSHOP AND MEETING

Seminar /Symposia/Conferences/Workshop

Date	Details of the programme	Participants
January 3 to 7	106th Indian Science Congress at Lovely University, Jalandhar, Punjab	S.K. Singh R.P. Yadav Prasenjit Ray
January 29	Sujala – Brown Bag Lunch seminar at the World Bank office, New Delhi.	Rajendra Hegde
January 30	District level Sujala workshop (LRI partners' workshop) Koppal, Karnataka	Rajendra Hegde
January 30-February 1	Directors' Conference in ICAR, New Delhi	P. Chandran
January 31-February 2	28thNationalConference on "Farmer's friendly soil and water conservation technologies for mitigating climate change impact" Ooty, Tamil Nadu.	K.S.Karthika Kalaiselvi, B. R. Srinivasan, Chandrakala, M. Vasundhara, R.
February 6-8	Farmers First for Conserving Soil and Water Resources in Eastern Region (FFCSWR-2019) at Sunabeda, Koraput, Odisha.	B.N. Ghosh
February 7-9	International Salinity Conference on "Resilient Agriculture in Saline Environments under Changing Climate: Challenges & Opportunities, Karnal Haryana.	R. Srinivasan Chandrakala, M.
February 9-11	Agri Summit 2019 at Motihari.	S.K. Singh
February 11-14	International Conference on "Development of Drylands: Converting Dryland Areas from Grey to Green".	S.S. Rao M.S. Raghuvanshi
February 15	National Seminar on "Soil erosion in North Eastern Region"	Prasenjit Ray
February 15	Brainstorming session on "Land Erosion in Brahmaputra & Barak Basin".	S. K. Ray
February 16	Smallholder farming: potentials and constraints at ICAR-NDRI, Bangalore	Rajendra Hegde S.C. Ramesh Kumar
February 16	Foundation Day of Indian Association for Productivity, Quality & Reliability Seminar – 2019 on "Economics of Indian Agriculture".	S.K. Singh D.C. Nayak A.K. Sahoo S.K.Gangopadhyay K. Das D. Dutta B.N. Ghosh K.D. Sah T. Chattopadhyay S. Mukhopadhyay S.K. Reza S. Bandyopadhyay S. Gupta Choudhury

Date	Details of the programme	Participants
February 22	Brainstorming Session on “Bhoochetana” for scaling up of science led development for productivity enhancement and livelihood security for the state of Odisha	B.N. Ghosh
February 20-23	XIV Agricultural Science Congress held at National Agricultural Science Complex New Delhi.	Mahaveer Nogiya G.K. Sharma
February 26 to March 1	5th Meeting of Asian Soil Partnership (ASP) FAO and ICAR NRM Division at NASC Complex, New Delhi.	R.P. Yadav Jaya N. Surya
February 28 to March 1	2nd All India Progressive Farmer Convention, New Delhi.	S. K. Singh
March 1	6th Dr. Sushil Kumar Mukherjee and Dr. Krishna Kamini Rohatgi-Mukherjee Annual Endowment Lecture organized by the Indian Society of Soil Science, Kolkata Chapter at ICAR-NBSS & LUP, Regional Centre, Kolkata.	D.C. Nayak A.K. Sahoo S.K.Gangopadhyay K. Das D. Dutta B.N. Ghosh K.D. Sah T. Chattopadhyay S. Mukhopadhyay S. Bandyopadhyay S.K. Reza S.Gupta Choudhury
March 6	National Seminar on “Technology Innovation: A Savior Indigo Farmers” organized by Indian National Science Academy (INSA) at Asiatic Society, Kolkata.	B.N. Ghosh S. Bandyopadhyay
March 8-9	National Conference on Drought Management and made a presentation on “LRI under Sujala for Drought Mitigation Planning” organized by KSNMDC, Govt. of Karnataka.	Rajendra Hegde
March 11	Workshop of C-SAG (centre for spatial Analysis and GIS), NIAS, Bangalore	Rajendra Hegde S. Srinivas
March 19	Workshop on Developing methodology Indexing of weather forecast at KSNMDC, Bangalore.	Rajendra Hegde
March 21	Sujala- Hydrology DSS- workshop conducted at the centre. All the partner institutes, IISC, Bangalore, Ceinsys, the vendor company, WDD- Officials participated in the event.	Rajendra Hegde
March 21	Workshop on DSS-Hydrology under Sujala 3 project in ICAR-NBSS&LUP, Regional Centre, Bangalore.	R. Srinivasan
April 13	Participated in “Soil and Land Use Policy” meeting at New Delhi.	V. Rama murthy
April 15	Sujala III workshop on Decision support system at Watershed development department, Bangalore.	S. Dharumarajan
June 18	DSM networking meeting at NBSS&LUP, Nagpur.	S. Dharumarajan
July 26	Workshop on “Agriculture and fertilizer situation and soil health management issues in South India.	Rajendra Hegde
July 29	DoLR, Govt. of India -Sujala workshop at Bangalore. Sujala 15 min video and ppt presented to DOLR & SLNA-Andhra, Telangana, Kerala, Tamilnadu& Karnataka.	Rajendra Hegde
July 29	One day workshop on PMKSY- SUJALA Workshop in Conference hall, Kumara Krupa state Guest House, Bangalore.	R. Srinivasan

Date	Details of the programme	Participants
September 02	Jal Shakti Abhiyan of Government of India at Vidhya Bhawan, Udaipur.	S S Rao R L Meena Sunil Kumar
September 9	JalashakthiAbhiyaan" workshop in Hassan district	Rajendra Hegde S. Dharumarajan
September 14-15	Sujala ICRR (Implementation Completion Results and Report) workshop at WDD (World Bank Team).	Rajendra Hegde
September 17	Inception workshop of Sujala M & E by New Space India Limited (ISRO) at WDD, Bangalore	Rajendra Hegde
September 19	"JSW-TOI" Earth care award workshop at WDD	Rajendra Hegde
September 23-24	22nd Annual Convention and National Conference on Application of Clay and Allied Science in Agriculture, Environment and Industry organized by CMSI, New Delhi.	S.K. Ray S.K. Mahapatra Jaya N. Surya Ashok Kumar RituNagdev
September 27	Agro-ecological zoning for crop planning-Kerala, Meeting	K.S. Anil Kumar
October 1	Exploring synergies between Agro-ecological regions/sub-regions prepared by NBSS&LUP and Agro-climatic Atlas prepared by AICRPAM-CRIDA" at CRIDA, Hyderabad	V. Ramamurthy
October 10	Workshop on National Aquifer mapping (NAQUIM) by Central Ground Water Board (CGWB) Govt. of India.	Rajendra Hegde
October 11	Scientist-farmer interaction meet **"**Enhancing the Economic Viability of Coconut Based Land Use Systems for Land Use Planning in Kerala State	K.S. Anil Kumar
October 18	Wrap up workshop of Sujala ICRR-with WDD officials and World Bank ICRR team.	Rajendra Hegde
October 21	Sujala workshop on SOC, Micronutrients & Hydrological studies	Rajendra Hegde S.Dharumarajan R. Srinivasan
October 21- 24	Hassan district JalashakthiAbhijaan workshop	Rajendra Hegde
October 23	One day workshop on Upscaling Catchment Processes for Sustainable Water Management in Peninsular India (UPSCAPE).	R. Srinivasan
October 23-24	Rashtriya bhautiki paryogshala ke samagar in Rajbhasa Mahotsav organized by Nagar Rajbhasha Samiti (Narakas) North Delhi.	K.K. Bhardwaj Sunita Mittal Kamlesh Sharma
October 30	Thematic Consultations on "Biodiversity and Ecosystem Services" and "Biodiversity, Climate Change and Disaster Risk Mitigation" at National Centre for Biological Sciences, Bengaluru, Karnataka 560065.	S. Dharumarajan
November 1-2	National dialogue on land use for Integrated Livestock Development" organized by TAAS at New Delhi.	V.Ramamurthy Ashok kumar
November 18	Workshop on Sujala LRI & Hydrology for the benefit of "Sujala Impact Assessment agency NSIL (ISRO) and WDD officials. 30 participants participated in the one day event. made a presentation on Sujala-LRI methodology, out puts and their utility.	Rajendra Hegde S.Dharumarajan R. Srinivasan

Date	Details of the programme	Participants
November 18	Eighth International Conference on Agricultural Statistics (ICAS-VIII) at New Delhi, India.	S.K. Mahapatra Jaya N. Surya Dharam Singh R.K. Meena Vikas Ashok kumar RituNagdev
November 26	State-level workshop on “Capacity Building for adaptation planning under NHSME” organised by the Department of Science and Technology & Biotechnology, Govt. of West Bengal and Indian Himalays Climate Adaptation Programm (IHCAP) and NABCONS at CII- Suresh Neotia Centre for excellence for leadership at Salt Lake, Kolkata.	S.K. Gangopadhyay S. Mukhopadhyay
November 27	Farmers’ Day programme organised by ICAR- Central Soil Salinity Research Institute, Regional Research Staion, Canning Town at RRS, Canning Town.	K.D.Sah
November 30	Seminar on *“Quality in Journalism”* on the occasion of World Quality Day, organized Indian Association for Productivity, Quality and Reliability in collaboration with Bhawanipur Education Society, Kolkata.	A.K. Sahoo
December 17-18	7th Annual Review Workshop of NICRA chaired by the DG (ICAR), held for partner institutes at NASC, New Delhi.	P. Tiwary

Meetings

Date	Details of the programme	Participants
January 10	Meeting Vice-Chancellor, Prof. Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad to discuss NLSC project. Discussion on a new collaborative project on crop colony in Telangana state was held and the decision to work on this project jointly by ICAR-NBSS&LUP, Nagpur and PJTSU, Hyderabad.	S.K. Singh
January 10 & February 9	Meeting on Crop Colonies of Telangana state held at PJSTAAU, Hyderabad	V. Ramamurthy
January 24	Divisional Committee Meeting for Monitoring and Reviewing the Progress of Foreign Aided Projects at NASC complex, ICAR New Delhi	S. Dharumarajan
January 24	Divisional Committee Meeting for Monitoring and Reviewing the Progress of Foreign Aided Projects at NASC complex, ICAR New Delhi	S.Dharumarajan
January 30	5th Annual Review Meeting of NASF Funded Projects	Ashok Kumar
February 4-5	ICAR Regional Committee-VI meeting	S S Rao
February 06	Meeting with the Chairman and the Superintending Engineer, Brahmaputra Board in connection with a project proposal on LRI of Majuli river island in Guwahati	S.K. Ray
February 07	Meeting with the Chief Engineers of Civil and Electrical Divisions of the CPWD in Shillong in connection with hastening of our pending works.	S.K. Ray
February 10-12	*Agri Summit 2019* held at Gandhi Maidan,Motihari,Biharfor depicting the activities/technologies/publications of our Institute.	D.C. Nayak S.K. Gangopadhyay K. Das
February 13	QRT report presentation to Hon’ble Director General by Dr. S.M. Virmani, Chairman QRT and Dr. N.G. Patil, Member-Secretary QRT.	N.G. Patil R.P. Yadav

Date	Details of the programme	Participants
February 14-16	District Krishi Mela, Arapanch, Sonarpur organized by SasyaShyamala Krishi Vigyan Kendra, Arapanch, Sonarpur, South 24 Parganas, West Bengal during 14.02.2019 to 16.02.2019.	S. Bandyopadhyay Ms. S. Gupta Choudhury
February 15	Brainstorming session on "Land Erosion in Brahmaputra & Barak Basin" organized by Brahmaputra Board at Assam Administrative Staff College, Guwahati as a panel member.	S.K. Ray
February 15	IMC meeting of ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya as its member.	S.K. Ray
February 15	Meeting of Rajbhasa Parliament Committee – Evidence and Proof.	R.P. Yadav
February 21	Meeting with Director, BISAG, Ahmedabad to discuss and decide about the aspirational districts	S. K. Singh
February 22	State-level consultation meeting in connection with the management of Acid soils of Odisha state at ICRISAT, Hyderabad as an expert member.	S.K. Ray
February 24	Function on "Pradhan Mantri Kisan Sämman Nidhi Yojna" organized by ICAR-CCRI	P. Chandran
February 26 to March 1	5th meeting Asian Soil Partnership (ASP) of Food and Agricultural Organization (FAO) including Steering Committee meeting of Centre of Excellence of Soil Research in Asia (CESRA) scheduled at NASC Complex, Pusa, New Delhi.	S. K. Singh
March 1	Meeting of the Committee formed to monitor Prime Minster Krishi Sanchayi Yojana under the Aspirational Districts Programme at Delhi.	S. K. Singh
March 02, March 08, March 09 and March 11	Selection Committee as an expert member nominated by the ICAR to select Assistant Professors (for various subjects) under both teaching and research categories of Assam Agricultural University, Jorhat.	S.K. Ray
March 6	An interactive-cum-workshop, chaired by the Secretary (DARE) and DG (ICAR), on emerging areas in ICTs in agriculture and way forward held at NASC Complex, New Delhi.	P. Tiwary
March 08	Meeting chaired by DDG (NRM &Engg.), ICAR and provided feedbacks and suggestions to enhance the working capacity of young scientists posted at remote areas at KAB-II, Pusa, New Delhi.	Prasenjit Ray
March 10-20	Special Assignment (on deputation) on Aspirational districts of Eastern and North-Eastern India at HQ., Nagpur.	B.N. Ghosh S. Bandyopadhyay
March 11	1st Meeting of C-SAG Agri-GIS Technical Advisory Committee Meeting at NIAS, IISc Campus, Bengaluru. Dr. S. Ayyappan, Former Secretary DARE and Director-General, ICAR was also present in the meeting. A collaborative project to link land use plans of Kalahandi and Rayagada districts of Orissa with the aspirational districts as proposed by Niti Aayog, Govt. of India was discussed in the meeting.	S. K. Singh
March 16	Council Meeting of "*The Indian Society of Soil Science"* at ICAR- IARI, New Delhi.	S.K. Mahapatra
March 23	Scientific Advisory Committee (SAC) meeting of Krishi Vigyan Kendra, Sivasagar nominated by the HRC, Jorhat.	S. Ramachandran
March 27	Meeting of Assessment Committee as member for assessing cases of promotion of scientists (Soil Science) at Indian Institute of Soil and Water Conservation, Dehradun	R.P.Yadav
April 03	Meeting on "potential crop zones (crop colonies)" with officials of PJSTAU and other ICAR institutes.	V. Ramamurthy

Date	Details of the programme	Participants
April 05	Council Meeting of "*The Clay Minerals Society of India*" at ICAR-NBSS&LUP, Regional Centre Delhi to transect the various activities of the Society.	S.K. Mahapatra Jaya N. Surya Ritu Nagdev
April 22	1st Half-yearly meeting of Town Official Language Implementation Committee, Kolkata (Karyalay-2), at APC Roy Seminar Hall, CSIR-Central Glass and Ceramic Research Institute, Jadavpur, Kolkata.	K.D. Sah Dipak Maurya
May 03	230th meeting of the Academic Council of AAU, Jorhat.	S.K. Ray
May 03	251st meeting of the Board of Management of AAU, Jorhat.	S.K. Ray
May 03	Meeting of all KVKs under Zone VI for developing action plans of KVKs under TSP held at ICAR-ATARI, Zone-VI, Guwahati.	S. Ramachandran
May 04	21st Convocation of the Assam Agricultural University, Jorhat as a member of the Board of Management and a member of the Academic Council of the University.	S.K. Ray
June 01	Member in the Scientific Advisory Committee Meeting of Krishi Vigyan Kendra, Burdwan, West Bengal held at Krishi Vigyan Kendra, Bud Bud, Burdwan.	A.K. Sahoo
June 08	NARACAS (North Delhi) second meeting at NASC Complex, New Delhi	S.K. Mahapatra Arvind Kumar
June 12	Mid-term Review Meeting of XXVth Regional Committee- II at ICAR-CIFRI.	A.K. Sahoo
June 14	Meeting with officials of Brahmaputra Board, Govt. of India and CPWD.	S.K. Ray
June 14	Meeting of Standing Committee on Policy & Byelaws and Technical Programme of "*The Indian Society of Soil Science*" at ICAR- IARI, New Delhi.	S.K. Mahapatra
June 17	UNCCD meeting on world day to combat desertification at Vigyan Bhawan, New Delhi	S. Dharumarajan
June 17, 18, 20, 21 and 25	Selection Committee for the posts of Assistant Professor, Faculty of Agriculture, Assam Agricultural University as Expert member (nominated by the ICAR).	S.K. Ray
June 18	Inception Meeting held at Rain Forest Research Institute nominated by Head, Regional Centre, Jorhat.	Prasenjit Ray
June 26	Meeting regarding action plan meeting of the NEH component under NRM Division with the Director, ICAR Research Complex for NEH Region, Umiam.	S.K. Ray
July 04	Meeting on "Expenditure under NEH Component has driven through NRM Division" at NASC Complex, New Delhi.	S.K. Ray
July 05	State-level interface meeting on enhancing the preparedness for agriculture contingencies Kharif 2019 at Nabanna, Howrah.	A.K Sahoo K. Das
July 19	Selection Committee for the post of Assistant Professor (Agro-meteorology), Faculty of Agriculture, Assam Agricultural University at Khanapara, Guwahati as Expert member (nominated by the ICAR).	S.K. Ray
July 19-21	Sub-committee meeting constituted for finalizing the methodology for preparation of futuristic crop planning for 2030, 2040 and 2050 at Modipuram.	V. Rama murthy
July 20	Divisional review meeting of foreign aided projects at CSSRI, Karnal	S. Dharumarajan

Date	Details of the programme	Participants
July 22	Meeting of the State Level Committee of West Bengal State Watershed Development Agency (WBSWDA) for verification of Detailed Project Reports (DPR) of Watershed Projects under Pradhan Mantri Krishi Sinchayee Yojana- Watershed Development Component (PMKSY-WDC) in the office of the Chief Executive Officer & Secretary of WBSWDA, Sec V, Salt Lake, Kolkata.	A.K. Sahoo
July 24	Scientists'-farmers' Interaction meeting at Darisai KVK, Ghatshila, Jharkhand and field visit to Susnigaria village under SCSP & STC Programme on the project Land Use Options for Enhancing Productivity and Improving Livelihood of Tribal Farmers of Susnigaria Village, Ghatshila Block, East Singhbhum District, Jharkhand.	A.K. Sahoo K.D. Sah S.K. Reza S. Bandyopadhyay
July 24	Selection Committee for the position of Heads (Plant Breeding & Genetics, Agril. Bio-Chemistry, Tea Husbandry & Technology, Crop Physiology, Agril. Biotechnology, Horticulture, Soil Science, Nematology, Entomology, Sericulture, Agronomy and Plant Pathology), Faculty of Agriculture, Assam Agricultural University at AAU, Jorhat as Expert member (nominated by the ICAR).	S.K. Ray
July 25-26	Review meeting of NICRA project chaired by the DDG (NRM) and expert members, held for NRM partner institutes at NASC, New Delhi.	P. Tiwary and Dr. D. Vasu
July 30	252nd meeting of the Board of Management of AAU held at Board Room, Khanapara, Guwahati.	S.K. Ray
August 28	Review meeting of the activities of National ICAR-Bureaus held at NASC Complex, New Delhi.	S.K. Mahapatra
September 10-11	Innovation Summit on UN Environment Programme India held at Dr. Ambedkar International Centre, New Delhi.	S.K. Mahapatra
September 11	2nd Half-yearly meeting of Town Official Language Implementation Committee, Kolkata (Karyalay-2), at APC Roy Seminar Hall, CSIR-Central Glass and Ceramic Research Institute, Jadavpur, Kolkata.	K.D. Sah Dipak Maurya
September 16	Executive Committee (Extended) meeting of the Assam Chapter of Soil Conservation Society of India organized at Seminar Hall, Dept. of Soil Science, AAU.	S.K. Ray
September 23	Annual General Body Meeting of *"The Clay Minerals Society of India"* held at ICAR-IARI, New Delhi.	S.K. Mahapatra Jaya N Surya Ritu Nagdev
September 23-24	22nd Annual Convention and National Conference on Application of Clay and Allied Science in Agriculture, Environment and Industry organized by CMSI in New Delhi.	S.K. Ray
September 25	Meeting of the State Level Committee of WBSWDAon verification of Detailed Project Reports of Watershed Projects under PMKSY-WDC at the office of WBSWDA, Salt Lake.	A.K. Sahoo
September 26	6th meeting of the Scientific Advisory Committee (SAC) of Sasya Shyamala KVK at Sasya Shyamala KVK, RKMVERI, Arapanch, Sonarpur.	A.K. Sahoo
October 18	Research Advisory Group meeting of Rain Forest Research Institute, Jorhat as its member.	Dr. S.K. Ray
October 18	Meeting of Standing Committee on Policy & Bylaws and Technical Programme of "*The Indian Society of Soil Science"* at ICAR- IARI, New Delhi.	S.K. Mahapatra
October 18	Council Meeting of "*The Indian Society of Soil Science"* at ICAR- IARI, New Delhi.	S.K. Mahapatra

Date	Details of the programme	Participants
October 25	Meeting organized at Rain Forest Research Institute, Jorhat on deputed by Head, Regional Centre, Jorhat and gave the presentation on "Advances in delineation of management zones – A step towards Precision Agriculture.	R.K. Jena
November 04-07	Annual review meeting of ATCHA project at Montpellier, France.	S. Dharumarajan
November 06	"Agricultural Scientists' Meet" under the umbrellaof Indian International Science Festival (IISF) at Viswa Bangla, Convention Centre, Salt Lake, Kolkata.	A.K. Sahoo K. Das B.N. Ghosh S. Bandyopadhyay
November 07	Luncheon meeting on Land Use Planning at Krishi Bhawan, New Delhi.	S.K. Mahapatra
November 07	"Extempore Competition" organized by Town Official Language Implementation Committee, Kolkata (Karyalay-2) at ICAR-NBSS&LUP, Regional Centre, Sector-II, Salt Lake, Kolkata.	Sita Ram
November 08	Hindi Unicode Karyashala on 8th November 2019 at C-DAC, Kolkata.	K. Das
November 11	NARACAS (North Delhi) second meeting at NASC Complex, New Delhi.	S.K. Mahapatra
November 13	Meeting with the Director of Agriculture, Govt. of Arunachal Pradesh regarding Arunachal Pradesh project.	S.K. Ray Prasenjit Ray
November 14	"Kavya Aavriti Pratiyogita" organized by Town Official Language Implementation Committee, Kolkata (Karyalay-2) at ICAR-NINFET, 12, Regent Park, Kolkata.	Rituparna Basu Soma Saha
November 22	Board of Management meeting of the Assam Agricultural University at Khanapara, Guwahati.	S.K. Ray
November 23-24	24th meeting of the ICAR Regional Committee No.III. held in Guwahati.	S.K. Ray
December 23	Board of Management meeting of Assam Agricultural University, Jorhat in Guwahati.	S.K. Ray

6 MEETINGS ORGANIZED

25th Meeting of ICAR Regional Committee No.VII

The 25th meeting of Indian Council of Agricultural Research (ICAR)-Regional Committee VII comprising members from the states of Maharashtra, Madhya Pradesh and Chhattisgarh was convened at ICAR-National Bureau of Soil Survey & Land Use Planning, Nagpur on 9-10 August 2019. The meeting was inaugurated by Shri Mahadeo Jagannath Jankarji, Hon'ble Minister of Animal Husbandry, Dairy and Fisheries, Govt. of Maharashtra on 9th August 2019 in Dr. S.P. Raychaudhary Auditorium of ICAR-NBSS&LUP, Nagpur. Dr. Trilochan Mohapatra, Secretary, Department of Agricultural Research and Education (DARE) and Director General, ICAR, New Delhi presided over the meeting. Shri Sushil Kumar, Additional Secretary, DARE and Secretary, ICAR and Shri Bimbardhar Pradhan, Additional Secretary and Financial Advisor, DARE/ICAR were the Guest of Honours. Dr. K. Alagusundaram, Deputy Director General (DDG), Agricultural Engineering and Natural Resource Management, ICAR and Dr. Joykrushna Jena, Deputy Director General (DDG) (Fisheries) shared the Dias. Functionaries of agricultural institutions including Secretaries and Directors of State Agricultural Departments, Vice Chancellors of State Agriculture, Veterinary and Fishery Universities, Directors of ICAR Institutes and Project Coordinators, Incharges, KVKs of Maharashtra, Madhya Pradesh and Chhattisgarh participated in the meeting to discuss the agenda of agricultural development in the region. The Regional Committee provided a platform for the stakeholders to examine in depth the major gaps in current research and training efforts, to identify priorities and to decide agenda of research, education and extension in agriculture, animal husbandry and fisheries for the region for the next two years.





Project Review Meeting at Kolkata

A project review meeting was conducted during 3-4th September 2019 to review the progress of ongoing projects at Regional Centres, Kolkata and Jorhat. Dr. S. K. Singh, Acting Director, Dr. N.G. Patil, Principal Scientist and Incharge, PME Cell, Dr. S.K. Ray and Dr. A.K. Sahoo, Head of Regional Centre and Scientists of both regional centres attended the meeting.

Project Review Meeting at Delhi

A project review meeting was conducted during 5-6 September 2019 to review the progress of ongoing projects at Regional Centres, Delhi and Udaipur. Dr. S.K. Singh, Acting Director, Dr. N.G. Patil, Principal Scientist and Incharge, PME Cell, Dr. S.K. Mahapatra and Dr. S.S.Rao, Head of Regional Centres and Scientists of both regional centres attended the meeting.

RAC meeting during 13-14 September 2019

Research Advisory Committee (RAC) meeting was held on 13-14 September 2019 under the Chairmanship of Dr. J.C. Katyal to discuss the ongoing research programmes and the future action plan. Dr. A. Nayak, Dr. Sesha Sai, Dr. S.K. Singh, Dr. N.G. Patil, Heads of Divisions and Regional Centres were present in the meeting.

48th Institute Management Committee Meeting

48th Institute Management Committee Meeting was held during 20th December 2019. Dr. P. Chandran, Acting Director, ICAR-NBSS&LUP, Nagpur, Dr. Vilas Kharche, Associate Dean and Head, Department of Agricultural Chemistry and Soil Science, Dr. PDKV, Akola, Dr. Ajit Kumar, Nagesh Deshpande, Dr. S.K. Ray, Head, Regional Centre, ICAR-NBSS&LUP, Jorhat, Dr. A.K. Srivastava, Principal Scientist, ICAR-CCRI, Nagpur, Dr. A.K. Shukla, Project Coordinator (Micro-nutrient) ICAR-IISS, Bhopal, Dr. Rajendra Hegde, Head, Regional Centre, ICAR-NBSS&LUP, Bangalore, Sh. Yashwant Sorte, Incharge, Finance and Accounts, ICAR-CICR, Nagpur and Shri. Sanjay Bokolia, Chief Administrative Officer were present in the meeting. They reviewed the research /technical/ administrative progress and related matters of the Bureau for the period November2017 to October 2019.

Heads Meeting

A meeting of all the Heads of Regional Centres and Divisions of ICAR-NBSS&LUP was convened on 20-21 December 2019 at Hqrs., Nagpur. All the Heads of Regional Centre and Divisions along with Chief Administrative Officer attended the meeting. Progress of ongoing projects, future programme and administrative issues were discussed.

7 MAJOR EVENTS

QRT Report Submission

QRT report (2012-2017) of the Bureau was submitted to the Hon'ble Director General, ICAR Dr. Trilochan Mohapatra on January 9, 2019 in presence of Dr S K Chaudhari, ADG (SWM). Contents of the report and the recommendations were discussed. Dr. S.M. Virmani, Chairman, QRT and Dr. N. G. Patil, Member Secretary, QRT attended the meeting.

Soil Museum Visits

The soil museum at HQrs. (Nagpur) had about 1000 visitors during the year that included farmers, ministers from Maharashtra Government, parliament members, secretaries from Maharashtra Government, highly ranked officers from line departments, reputed scientists, teachers and students. Regional centres also received many visitors. About 36 students along with teachers of Howrah High School, Kolkata visited different sections of Jorhat centre on 14th January, 2019

National Productivity Week

The week **l2th to l8th February, 2019** was celebrated as National Productivity Week on the theme: "Circular Economy for Productivity and Sustainability" at the HQrs. as well as five Regional Centres.

International Women's Day – 2019

The Headquarters and Regional Centres of Bureau celebrated the International Women's Day on 08.03.2019.

Women's day celebration at Head Quarters and Regional Centres

World Water Day

World Water Day was celebrated on 22.03.2019 at ICAR-NBSS&LUP, Regional Centre, Jorhat. Dr. P.G. Ingole, Scientist, Division of Engineering and Technology, CSIR-NEIST, Jorhat delivered a lecture on the occasion.

Dr. P.G. Ingole addressing during World Water Day

MoU with PoCRA

Memorandum of Understanding was signed on 24th May, 2019 between ICAR-NBSS&LUP and Govt of Maharashtra for collaborative implementation of Project on Climate Resilient Agriculture (PoCRA). The sub project “High-Resolution Land Resource Inventory and Land Use Planning for Climate Resilient Agriculture” will be executed by the Bureau. Dr S. K. Singh, Director, ICAR-NBSS&LUP and Sh. Vikas Chandra Rastogi, Project Director, PoCRA were the signatories. Dr. N.G. Patil, Principal Investigator and Dr. Vijay Kolekar, Agronomist, PoCRA along with other scientists of the bureau attended the event.

Dr. S.K. Singh and his team exchanging MoU with Sh.Vikas Rastogi

5th International Day of Yoga

The 5th International Day of Yoga (IDY) was celebrated at the Bureau including its Regional Centres, Bangalore and Kolkata on 21/06/2019. All the staff members participated in the event and the programme was conducted in two sessions. Yoga expert at HQrs. and its regional centres were invited for delivering the lecture and demonstration of basic Yoga Asanas as per the Common Yoga Protocol (CYP 2019) of Govt. of India *viz.*, Tadasana, Vrukshasana, Padahasthasana, Ardha Chakrasana, Trikonasana, Bhadrasana, Veerabhadrasana, Vajrasana, Uttana Mandukasana, Vakrasana, Shalabhasana, Uttanapadasana, Ardh Halasana, Pavanamuthasana and finally Shavasana were performed.



Yoga at Headquarters, ICAR-NBSS&LUP, Nagpur



Yoga at Regional Centre, ICAR-NBSS&LUP, Bangaluru



Yoga at Regional Centre, ICAR-NBSS&LUP, Kolkata

Yoga at Regional Centre, ICAR-NBSS&LUP, Jorhat

MoU with Govt. of Arunachal Pradesh

Govt. of Arunachal Pradesh entered into an agreement with ICAR-NBSS&LUP to implement the project "Land resource inventory of Arunachal Pradesh at large scale for agricultural land use planning using geo-spatial techniques" in collaboration with Department of Agriculture. A MoU to this effect was signed at Itanagar on 04.06.2019. Dr. S.K. Ray, Principal Scientist & Head and Dr. S. Ramachandran, Scientist attended the Meeting.

XXV Meeting of ICAR Regional Committee No.VII

The XXV meeting of ICAR-Regional Committee No. VII comprising members from the states of Maharashtra, Madhya Pradesh and Chhattisgarh was convened at

ICAR-National Bureau of Soil Survey & Land Use Planning, Nagpur on 9-10 August 2019. The meeting was inaugurated by Shri Mahadeo Jagannath Jankarji, Hon'ble Minister of Animal Husbandry, Dairy and Fisheries, Govt. of Maharashtra on 9th August, 2019 in Dr. S.P. Raychaudhary Auditorium of ICAR-NBSS&LUP, Nagpur. Dr. Trilochan Mohapatra, Secretary, Department of Agricultural Research and Education (DARE) and Director General, ICAR, New Delhi presided over the meeting.

Hindi activities

Hindi Fortnight was observed with regular intensity by the Bureau. Regional centres also organized many events like Hindi essay competition, quiz, lectures by dignitaries, workshop, conference, poem recitation *etc*.

Mr. Prodip Kumar, Hindi Teacher, Central School, Jorhat addressing in Hindi Week inauguration programme on 14.09.2019

Kisan mela-cum-swachhta-Hi-Sewa

In its outreach programme, the Bureau organized many events for farmers. Kisan mela-cum-swachhta-Hi-Sewa programme was held in Mhasada and adjoining 2 more villages (Malkapur, and Miniwada) of Nagpur on 02.10.2019 where about more than 80 farmers, farm-women and children participated in the gathering. Students and staff from village schools, Aaganwadi, and Residential school for tribals participated in the programme.

Kisan-Mela-Cum-Swachhta-Hi-Sewa gathering

Farmers, farm-women and Children

Rally in Mhasada

Mhasada School

Residential school for tribals

Aangan-wadi, Malkapur

Scientists examining the insect attack

'Say NO to Plastic' campaign

ICAR Zonal Sports Tournaments (Central Zone)

ICAR-NBSS&LUP, Nagpur organized ICAR-ZONAL Tournament (Central Zone) at RTMNU Ground, Ravi Nagar, Nagpur during 8th to 10 November, 2019. The event was inaugurated by Deputy Commissioner of Police Sh. Vivek Masal as Chief Guest and Dr. S.K. Chaudhari, Asstt. Director General (S&WM), ICAR, New Delhi in the presence of Dr. P Chandran, Director ICAR-NBSS&LUP, Nagpur.

Some snippets of ICAR-ZONAL Tournament (Central Zone)

Rashtriya Ekta Diwas

Rashtriya Ekta Diwas was observed at ICAR-NBSS&LUP, Regional Centre, Kolkata on 31st October, 2019. Staff of Headquarters and Regional Centres took pledge.

Pledge at Regional Centre, Bangalore

Celebration of Vigilance Awareness Week at Regional Centre, Kolkata

Constitution Day

The Bureau HQ. and its regional stations organized Constitution Day- 2019 involving staff members and neighbourhood community. An event was also organized at village Masada and adjoining villages in Katol Taluka, Dist. Nagpur on 26.11.2019.

Celebration of Constitutional day at Hqrs. and Regional Centres

Constitution day organized at Masada village on 26.11.2019

Oath ceremony on constitution day

World Soil Day at ICAR-NBSS&LUP, Nagpur on 5th December 2019

'World Soil Day 2019' was celebrated on 5th December. During the daylong event, importance of soils to the human existence was emphasized. An exposure and awareness visit of Nagpur city based school students (Class IX to XII standard) was arranged. The research activities were explained to sensitize them about the importance of healthy soils for the food chain. The current year theme of the World Soil Day was "Stop soil erosion, Save our future". More than 400 students and teachers had a glimpse of different soil types distributed in various agro-climatic conditions of Indian sub-continent. In the afternoon, eminent Soil Scientist Dr. Tapas Bhattacharyya, former Vice Chancellor, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli delivered a lecture on "Pedology: Basics of Soil Science" that was attended by scientists of ICAR-NBSS&LUP, under-graduate students of Agriculture Colleges of Amravati and Nagpur and other citizens. Dr. Bhattacharyya discussed about the use of soil survey database to arrest land degradation, monitoring of soil quality, sustainable land use planning and how soils touch different facets of agricultural research.

Dr. T. Bhattacharyya delivering invited lecture

Guests in World Soil Day events

Swachh Bharat Abhiyaan

The institute and its 5 regional stations organized Swachh Bharat Abhiyan (16-31 December 2019). During the fortnight, daily swachhta drive was conducted including cleaning work, removal of unwanted weeds and cleanliness in office premises. During the programme, awareness on no-to-single use plastic was also organzised at Headquarters, Regional centres and Masada village.

Oath taking ceremony during Swachhta Abhiyan at HQrs. and Masada Village

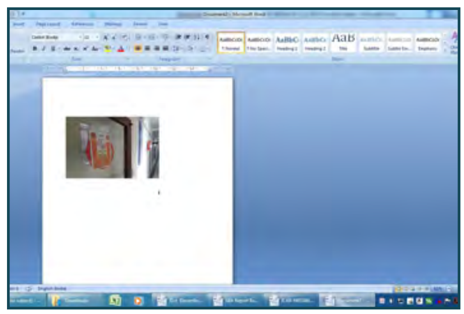
SBA team giving awareness to the students at Bangalore

Plantation drive organzised at HQrs. and Masada village

Weeding and cleaning at Regionmal Centre, New Delhi

Cleaning drive at Regional Centre, Kolkata

Essay competition at Regional Centre, New Delhi



Single use plastic awareness in office

Kisan Diwas

Kisan Diwas was celebrated by organizing Kisan Melas on 18.11.2019 jointly with Sakshi Chem. India Ltd. Nagpur at Masada village, Katol Taluka, Nagpur with 45 farmers and second Kisan Mela during Swachhta Abhiyan (16-31 December 2019) on 23.12.2019. Total 66 farmers along with farm women participated in the Kisan Mela. Simulatneously *Prashna-Manch* was also organzied regarding pest problems and growth of cotton in the fields of Masada village. Five regional centres also conducted events to mark the day.



Kisan Mela on 23.12.2019 at Masada village, Nagpur



Kisan Mela on 18.11.2019 at Masada village, Nagpur


Kisan Mela on 23.12.2019 at Udaipur Centre

Kisan Mela on 23.12.2019 at Bangalore centre and progressive farmers attended the Kisan Mela


Kisan Diwas at Regional Centre, Delhi

Kisan Diwas at Regional Centre Kolkata with farmers from South 24 Pgs. District of West Bengal

Staff of ICAR-NBSS&LUP, Regional Centre, Jorhat and farmers celebrating Kisan Diwas (Farmer's Day) at Kalbari village, Jorhat on 23.12.2019

Kisan Mela-cum-Exhibition at Khera Khalilpur District Nuh (Haryana)

8 LINKAGES AND COLLABORATIONS

Name of the Institution	Purpose
State Departments of Agriculture	
Department of Agriculture, Govt. of West Bengal.	Collaboration in Soil Survey, Fertility Mapping and Soil Correlation activities.
Department of Agriculture and Cane Development, Govt. of Jharkhand.	Block-level fertility mapping in Jharkhand.
Department of Agriculture, Govt. of Sikkim	Collaboration in Soil Survey, Fertility Mapping and Soil Correlation activities.
West Bengal State Watershed Development Agency (WBSWDA)	Integrated Watershed Management Programme (IWMP) in West Bengal
Director of Agriculture, Government of Goa	Land Resource Inventory (LRI) on 1:10000 scale
Odisha Watershed Development Mission (OWDM), Bhubaneswar	Collaboration for developing linkage in Watershed Management in Odisha State.
Department of Agriculture, Govt. of Telangana	Execution of Land Resource Inventory of 3 blocks of Telangana state
Dept. of Agriculture, Govt. of Meghalaya	The land resource inventory programme
Dept. of Agriculture, Govt. of Nagaland	Soil nutrient mapping, land resource inventory programme
Dept. of Agriculture, Govt. of Assam	Soil nutrient mapping, land resource inventory programme
Watershed Development Department (WDD), Govt. of Karnataka	Land resource inventory programme of selected microwatersheds of backward districts (Sujala-III Project)
Department of Agriculture, Govt. of Tripura	For initiating land resource inventory programme on1:10000 scale
Department of Agriculture (DAC), New Delhi	Extending education and training on soil survey and land use planning
Govt. of Maharashtra, Irrigation Department, Pune	Education and training of officials of irrigation department
Project on Climate Resilient Agriculture (PoCRA), Govt. of Maharashtra	Soil survey and training.
KSCSTE-Kerala Forest Research Institute, Peechi, Trissur	Making and supply of 16 Soil Monoliths representing major forest ecosystems.
Kerala State Department of Soil Survey and Soil Conservation	Making and supply of Soil Monoliths for soil museum.
Central Govt./ ICAR organizations	
National Remote Sensing Centre (NRSC), Deptt. of Space, GOI, Hyderabad	Collaboration for sharing of satellite data for land resource inventory programme

Name of the Institution	Purpose
Regional Remote Sensing Centre (RRSSC), Nagpur	Collaboration for sharing of satellite data for land resource inventory programme
Space Application Centre (SAC), Ahemadabad	Collaborative project on desertification status mapping of India
Bhaskaracharya Institute for Space Applications and Geo Informatics (BISAG), Gandhinagar, Gujarat	Collaboration for sharing of satellite data and expertise for land resource inventory programme, and development of soil information system
National Informatics Centre (NIC), Govt. of India.	Collaboration in development of Web based farmers advisory.
Department of Science & Technology (DST)	Financial assistance for research projects on spectral reflectance of soil
ICAR-Indian Institute of Soil and Water Conservation (IISWC), Dehradun	Land Degradation Status/Assessment
ICAR-Central Soil Salinity Research Institute (CSSRI)	Land Degradation Status/Assessment
ICAR-Indian Institute of Soil Science (IISS), Bhopal	Soil Fertility Status and organic carbon mapping
ICFRE-Institute of Wood Science and Technology, Malleswaram, Bangalore	Research in area of carbon sequestration in forests and management of Marihal Bamboo and Dendrocalamusstrictus in agroforestry
Rubber Research Institute of India (RRII) Puthuppally, Kottayam	Fertility mapping of rubber growing areas of North-Eastern region
State Agriculture Universities (SAUs)	
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia.	Research, Teaching and Training programme.
Dr. PDKV, Akola, Maharashtra	Post Graduate education and research leading to Masters and Doctoral degree
Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan	Post Graduate education and research leading to Masters and Doctoral degree
Indira Gandhi Krishi Vishwavidyalaya, Raipur	Post Graduate education and research leading to Masters and Doctoral degree
CCS Haryana Agricultural University, Hisar	Post Graduate education and research leading to Masters and Doctoral degree
Tamil Nadu Agricultural University, Coimbatore	Post Graduate education and research leading to Masters and Doctoral degree
GKVK, Bangalore	Post Graduate education and research leading to Masters and Doctoral degree
Mahatma Phule Krishi Vidyapeeth, Rahuri	Knowledge partners
Marathwada Krishi Vidyapeeth, Parbhani	Knowledge partners
Maharashtra Animal and Fishery Science University, Nagpur	Knowledge partners

Name of the Institution	Purpose
Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad	Collaborative research
SKN Agriculture University, Jobner	Post Graduate education and research leading to Masters and Doctoral degree
Private Institutions/ NGOs	
Sterlite Technologies Ltd., Mumbai	For assistance in optical fibre cable laying program
KEC International Ltd., Mumbai	For assistance in tower laying program
International Organizations	
CIMMYT India (International Maize and Wheat Improvement Centre)	Developing demonstrations for Borlaugh Institute of South Asia, Samastipur, Bihar.
International Plant Nutritional Institute (IPNI), Asia & Africa programme, Gurgaon, Haryana.	For exchanging ideas on Integrated Nutrient Management Programme in Eastern Region of India.
ISRIC, ITC, The Netherlands	Developing geo-referenced Indian Soil Resource Information System
Food and Agriculture Organization (FAO), Rome	Development of soil organic carbon map and soil atlas of Asia.

9 TRAINING AND CAPACITY BUILDING

A. Participation in Training

Bureau officials

Date	Training details and venue	Participants
January 10-30	ICAR sponsored 21 days CAFT on "Recent Advances in Statistical Techniques for Data Analysis in Agriculture" held at Division of Statistical Genetics, ICAR-IASRI, New Delhi.	Gopal Tiwary Prasenjit Ray
February 18-22	DST sponsored training program on "Emotional Intelligence at the Scientists" at Centre for Organizational Development Hyderabad	Rajendra Hegde
February 19-25	Automobile maintenance, road safety and behavioral skills at ICAR-CIAE, Bhopal	Vijay Kumar Technical Officer (Driver)
February 23 - March 15	21 days ICAR sponsored Centre of Advance Faculty Training (CAFT) programme on "Recent Advances in Statistical Modeling and Forecasting for Agricultural Data Analysis" is organized by ICAR-IASRI, New Delhi	R.K. Jena Prasenjit Ray Abhshek Jangir
March 7-8	User's Training Workshop on "ICAR KRISHI Geoportal- A digital Platform for Sustainable Agriculture" at ICAR-NBSS&LUP, Nagpur.	Nisha Sahu B. Dash S. Chattaraj
May 13 - July 05	NNRMS-ISRO Sponsored Certificate Course for Remote Sensing and GIS applications in Agriculture & Soils at Indian Institute of Remote Sensing (IIRS), Dehradun.	Shilpi Verma
July 01-12	Training program on Scientific Administration and Research management at Administrative staff college of India, Hyderabad	Rajendra Hegde
July 10- 12	Schedule of trainings for Intergraph products supplied under KWDP-II (Sujala-III) Project in ICAR-NBSS&LUP, RC, Bangalore	R.Srinivasan
July-November	Training *on "Praveen"* Hindi Course Scheme of the Department of Official Language, Ministry of Home Affairs has been continued in the Regional Centre, Kolkata	13 staff of the Regional Centre (4 Scientists, 8 Technical and 1 Administrative) were participated and also appeared in the *Praveen* Examination held on 16th November 2019.
September 02-09	Training programme on "Pensions & Other Retirement Benefits" organized by Institute of Secretariat Training & Management, MoPPG&P, GoI.	Nirmala Kumar
September 21 - October 11	21 days training programme on National Facilitators Development Program (NFDP) entitled Advances in Data Science using R" at ICAR-IASRI New Delhi.	Rajesh Kumar Meena
September, 21 – October 10	ICAR sponsored Centre of Advanced Faculty Training on Advances in Data Science using R	P.C. Moharana

Date	Training details and venue	Participants
October 28- 30	Training programme on “Indo-French monsoon school on Remote Sensing” sponsored by the French Government at Department of Civil Engineering, Interdisciplinary Centre for Water Research (ICWaR), Indian Institute of Science (IISc), Bangalore	R.Srinivasan S. Dharamrajan
October 29-31	3 days training on Indo-French monsoon school on Remote sensing organised by IISc, Bangalore	Chandrakala Kalaiselvi Beemam

B. Training organized for staff of other organizations

Date	Training details
January 7 - 12	A training programme of Stenographer Grade-III, PA, PS and PPS of ICAR Hqrs./Institutes (Batch - IX) on “Enhancing Efficiency and Behavioural Skills” in collaboration with ICAR-NAARM, Hyderabad at Regional Centre, ICAR-NBSS&LUP, Kolkata.    Resource persons along with participants of the training programme  Inaugural programme of the Training on 07.01.2019
March 26	ICAR–NBSS&LUP RC, Bangalore organized a training session on “Remote sensing and GIS applications for Land Resources Inventory” for 20 International Trainees from 10 countries under NIRDPR, Hyderabad program
May 20 - June 1	Division of Soil Resource Studies organized two weeks training in “Soil Survey and Classification” for the M.Sc. (Ag.) (SSAC) 12 students (5 male and 2 female) of Banaras Hindu University, Varanasi.

Date	Training details
	
June 11-20, 2019	Organized 10 days training programme on "Analytical methods for the determination of macro- and micronutrients in soil", for the officers of Govt. of Nagaland. Seven participants participated in the training programme.
August 2 – 13	International training programme (12 days) sponsored by Ministry of External Affairs (MEA), GOI on "Tools & Techniques of Soil Resource Survey for Land Use Planning" for the participants of 7 African countries, organized at ICAR-NBSS, Nagpur.  Resource persons along with participants of the International training programme
August 21-23	Organized dairy farming and vermicomposting training programme at Regional Centre, Bangalore.  Training on dairy farming and vermicomosting at Regional Centre, Bangalore

Date	Training details
August 24	Organized training programme on fishery  Training on fishery and distribution of fingerlings to farmersat Regional Centre, Bangalore
September 3-23	Summer school on 'Land Resources Management For Climate Smart Agriculture' at ICAR-NBSS&LUP, Nagpur. Total of 25 trainee officers participated in the training programme.  Group photograph of trainee officers
November 26 -27	Two days hands-on training programme on "RS & GIS" to four PG students of the Department of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh.

Training for farmers

Date	Training details
September 24-26	Organized 3 days training programme on 'Fish farming as an economically viable livelihood option' to 12 farmers of Nimati Bharaligaon (TSP village), Jorhat district, Assam at Fisheries Research Centre, Assam Agricultural University, Jorhat in collaboration with Assam Agricultural University.
December 12-13	Organized training on "Agricultural land use planning of Aspirational districts of Assam" to the officials of state line departments of at ICAR-NBSS&LUP, Kolkata. Fourteen participants participated in the training programme.  Training on land use planning of Aspirational districts of Assam at Regional Centre, Kolkata

Date	Training details
December 16-17	Organized training on "Agricultural land use planning of Aspirational districts of Bihar" to the officials of state line departments of Bihar ((Total No. of participants-15) at ICAR-NBSS & LUP, Kolkata  Training on land use planning of Aspirational districts of Bihar at Regional Centre, Kolkata

Lectures delivered during the training programme

- Dr. P. Chandran delivered three lectures on "Soil Taxonomy, Its Structure and Soil Correlation" during the training on "Soil Survey and Classification" for Post Graduate (M.Sc. (Ag-SSAC).) Students of Institute of Agricultural Sciences Banaras Hindu University, Varanasi organized by Division of Soil Resource Studies, ICAR-NBSS&LUP, Nagpur during May 20 – June 1, 2019.
- Dr. P. Chandran delivered a lecture on Soil Taxonomy and World reference base for classification, an International training programme Sponsored by Ministry of External Affairs (MEA), GOI on "Tools & Techniques of Soil Resource Survey for Land Use Planning" organized by ICAR-NBSS, Nagpur during 2nd to 13th August 2019.
- Dr. P. Chandran delivered a lecture on "Soil Taxonomy – its structure and correlation" during the summer school during 3-23 September 2019.
- Dr. S.K. Ray, Principal Scientist & Head delivered a lecture on "Agro-Technology Transfer for Organic Farming: Some Issues of Natural Resource Information" on 11.02.2019 at the ICAR sponsored 21 days CAFT training organized at Department of Soil Science, Assam Agricultural University, Jorhat during 6-26 Feb., 2019.
- Dr. S.K. Ray, Principal Scientist & Head was invited and gave a presentation on "Acid Soils of Odisha: Priority Setting for Effective Management" at the state level consultation meeting in ICRISAT, Hyderabad on 22.02.2019.
- Dr. S.K. Ray, Principal Scientist & Head was invited to deliver the keynote address on "Soil Resource Information *vis-a-vis* Climate Change" at the National Seminar on Recent Trends in Ecological Research organized by Department of Ecology and Environmental Sciences, Assam University, Silchar, Assam on 07.03.2019.
- Dr. S.S. Rao delivered a lecture at CTE, MPUAT Udaipur during winter school from 3-23 October 2019 entitled as "Up-scaling of Water Productivity in Arid and Semi-arid Areas for Sustainable Agriculture" on the topic of Land Resource Information for Increasing Farmers Income through Agricultural Development, Research and Technology Transfer
- Dr. S.S. Rao delivered a lecture at Deputy Director Office (ATMA) Udaipur entitled as "Soil health management and crop diversification in Rajasthan" on the topic of "Land Use Planning Based Crop Diversification, its Need and Technology Transfer using Land Resource Information".
- Dr. P. Tiwary delivered a lecture on "Watershed management and LRI for mitigating climate change challenges" to the trainees of a *Summer School on "Land Resources Management for Climate Smart Agriculture*" held during 03- 23 September 2019 at NBSS&LUP, Nagpur and helped them in their project work.
- Dr B.N. Ghosh delivered a lecture on "Soil and input management strategies in Odisha for productivity enhancement and resource conservation" in the brainstorming session on *"Bhoochetana"* for scaling up of science led development for productivity enhancement and livelihood security for the state of Odisha at ICRISAT, Hyderabad on 22nd February 2019.

- Dr. B.N. Ghosh delivered a lecture on the topic "Sustainable Management of Water Resource in Agriculture- A Few Recent Developments" on 59th Foundation day of Institute of Engineers (IEI) on 5thJuly, 2019 at Gokhle Road, Kolkata.
- Dr. R.P. Sharma delivered a lecture in a 5 days training programme on "Promotion of Organic Farming, It's Certification & Marketing" to 50 participants of Govt. of Maharashtra on "Role of soils and plant nutrition in organic farming" organized by VANAMATI, Nagpur on 26th September 2019.
- Dr. R.P. Sharma delivered a lecture on "Characterization and mapping of natural resources of India" to 34 Range forest officers trainees, Gujarat Forest Rangers College, Rajpipla on 16th Sept.2019.
- Dr. R.P. Sharma delivered a lecture on "Observation of Soil Depth and Surface Textures: Tools and Techniques" to 34 participants of PoCRA FFS facilitators and its coordinators at KVK, Latur on 23rd April 2019.
- Dr. R.P. Sharma delivered a lecture on "Observation of Soil Depth and Surface Textures: Tools and Techniques" to 40 participants of PoCRA FFS facilitators and its coordinators at KVK, Nanded on 24th April 2019.
- Dr. R.P. Sharma delivered a lecture on "Soil fertility assessment and soil health card" in a 21 days Summer School training programme sponsored by ICAR on "Land Resources Management for Climate Smart Agriculture" organized by ICAR-NBSS, Nagpur during 3rdto 23rdSeptember 2019.
- Dr. R.P. Sharma delivered two lecture on "Types of Soil Survey and Mapping", Soil Health Mapping and "Soil Resource Data Interpretation" during an International training programme Sponsored by Ministry of External Affairs (MEA), GOI on "Tools & Techniques of Soil Resource Survey for Land Use Planning" organized by ICAR-NBSS, Nagpur during 2nd to 13thAugust 2019.
- Dr. R.P. Sharma delivered two lectures on "Types of soil survey and mapping and "Soil health mapping" to post-graduate students of the department of soil science and agricultural chemistry, IAS, Banaras Hindu University, Varanasi in a training programme from 20th May to 1st June 2019 organized by ICAR-NBSS&LUP, Nagpur.
- Dr. R.P. Sharma identified as a resource person to deliver a lecture in a foundation training programme to 37 newly recruited group B officer's in Dept. of agriculture, Govt. of Maharashtra on "Land Resource Inventory for Land Use Planning" organized by VANAMATI, Nagpur during 6th May to 15thJune 2019.
- Dr. D. Vasu delivered a lecture on "Pedogenic processes" in the training on "Soil Survey and Classification" for M.Sc. (Agriculture) students of BHU, Varanasi from 20th May to 1st June 2019.
- Dr. D. Vasu delivered lectures on "Soil forming processes under different climates" and "Climate change and SOC sequestration in the summer school training course on "Land Resources Management for Climate Smart Agriculture" during 03-23 Sept. 2019.
- Dr. Prasenjit Ray, Scientist was invited and gave a lead talk on "Land resource inventory for assessing soil erosion in North Eastern Region" at the Seminar on "Land Erosion in Brahmaputra & Barak Basin" organized by Brahmaputra Board at Assam Administrative Staff College, Guwahati on 15th Feb. 2019.
- Dr. R. Paul associated with the lecture on "Laboratory methods of soil analysis" to the trainees of. ICAR sponsored Summer School on "Land Resources Management for Climate Smart Agriculture" by ICAR-NBSS&LUP, Nagpur during 03- 23 September 2019.
- Dr. R. Paul delivered a lecture on "Principles and applications of Nano-science and technology in Natural Resource Management" to the trainees of. ICAR sponsored Summer School on "Land Resources Management for Climate Smart Agriculture" by ICAR-NBSS&LUP, Nagpur during 03- 23 September 2019.
- Dr. Sunil Kumar delivered a lecture at CTE, MPUAT Udaipur during winter school entitled as "Up-scaling of Water Productivity in Arid and Semi-arid Areas for Sustainable Agriculture" on the topic of Role of potassium in improving water use efficiency through stress management.
- Dr. Sunil Kumar delivered a lecture at CTE, MPUAT Udaipur during winter school entitled as "Up-scaling of Water Productivity in Arid and Semi-arid Areas for Sustainable Agriculture" on the topic of Soil organic carbon management for enhancing water productivity.

- Dr. Sunil Kumar delivered a lecture at Deputy Director Office (ATMA) Udaipur entitled as "Soil health management and crop diversification in Rajasthan" on the topic of "Soil testing methodology and its application in cropping pattern through success stories".
- Mr. A. Jangir delivered a lecture on detailed and reconnaissance soil survey (field class) to the summer school on "Land Resources Management for Climate Smart Agriculture".
- Scientists of the Regional Centre, Kolkata (Dr. D.C. Nayak, Dr A.K. Sahoo, Dr. K. Das, Dr. S. Mukhopadhyay, Dr. S.K. Reza, Dr. S. Bandyopadhyay and Dr. S. Gupta Choudhury) delivered the lectures on different topics to teachers and 36 students of Howrah High School, West Bengal on 14th January, 2019.
- Sh. R. L. Meena delivered a lecture at CTE, MPUAT Udaipur during winter school from 3-23 October, 2019 entitled as "Up-scalling of Water Productivity in Arid and Semi-arid Areas for Sustainable Agriculture" on the topic of Agronomic management for higher water productivity in arid regions.
- Ms. R. Vasundhara delivered a lecture on How to use the LRI Atlas prepared under Sujala -III project to agricultural officers at Department of agriculture training centerNagenahalli, Mysore, Karnataka on February 6, 2019.
- Dr. V. Ramamurthy delivered a lecture on Participatory land use planning in the Summer school of land resource management for climate-smart agriculture on September 12, 2019.
- Dr. Bhaskar, B.P. delivered a lecture on Land Resource Inventory (LRI) in IWMP", "Advances in Integrated Watershed Management for Rural Livelihood" at the ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Udhagamandalam on December 3, 2019.
- Anil Kumar K.S. and Karthika K.S., 2019. Land Resources, Land Use and Land Cover Planning in Integrated Watershed Management for Land quality restoration and monitoring. Lecture Note Published and to be presented at 12 days DST sponsored training programme on "Advances in Integrated Watershed Management for Rural Livelihood" at the ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Udhagamandalam on 9th December 2019.

Post Graduate Education in Land Resource Management (LRM)

Human Resource Development in Post-Graduate Education and Research in Land Resource Management (LRM), Dr. PDKV, Akola and ICAR-NBSS&LUP, Nagpur.

A post-graduate teaching and research programme is being conducted by the ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur in collaboration with Dr.Panjabrao Deshmukh Krishi Vidyapeeth (Dr. PDKV), Akola since 1987. Subsequently, this activity was introduced at Regional Centre, Kolkata in collaboration with BCKV, Mohanpur in 1999, at Regional Centre, Bangalore with UAS, Bangalore in 2002 and at Regional Centre, Udaipur with RAU, Udaipur in 2004. Besides, the Scientists of Regional Centre, Jorhat are participating as visiting faculty at the Department of Soil Science, AAU, Jorhat.

A Memorandum of Understanding (MOU) has been signed between NBSS&LUP, Nagpur and Department of Soil Science and Agricultural Chemistry, Indira Gandhi Agricultural University, Raipur (C.G.) for undertaking collaborating teaching and research programmes. Under this MOU two students are pursuing their Ph.D. programmes at NBSS&LUP, Nagpur.

At the HQrs., Nagpur, this programme is conducted by the Division of Land Use Planning. The programme has two major components i.e. Teaching and Research.

The Regional Centre, Kolkata undertake a collaborative programme with Bidhan Chandra Krishi Vishwa Vidyalaya, Mohanpur, Nadia, West Bengal for post-graduate teaching in Agricultural Chemistry and Soil Science with specialization in land resource management (LRM). The courses namely, Soil Genesis and Classification (ACSS-508) and Remote Sensing and its applications (ACSS-754) for M.Sc. students is being carried out in BCKV, Mohanpur, Nadia.

Achievements	Nagpur		Bangalore		Kolkata		Udaipur		Total	
	M.Sc.	Ph.D.	M.Sc.	Ph.D.	M.Sc.	Ph.D.	M.Sc.	Ph.D.	M.Sc.	Ph.D.
Degree awarded upto December 2019	143	28	--	--	--	--	--	--	143	28
On Roll	05	02	--	--	--	--	--	--	05	02

HQrs., Nagpur

(i) Post Graduate Teaching

Course No.	Title	Credit
Courses offered for M.Sc. Programme		
Soils-516	Introduction to Land Resource Management	(2+1)
Soils-517	Land Evaluation	(2+1)
Soils-518	Land Resource Constraints and their Management	(1+1)
Soils-591	Seminar	(0+1)
Courses offered for Ph.D. Programme		
Soils-608	Advanced Soil Genesis	(2+0)
Soils-609	Advanced Soil Mineralogy	(2+1)
Soils-610	Land Evaluation for Land Use Planning	(2+1)
Soils-611	Remote Sensing and Geographical Information System for Land Resource Management	(2+1)
Soils-612	Visual and Digital Interpretation Techniques in Soil Mapping	(2+1)
Soils-691	Seminar-I and Seminar-II	(0+1)

Scientists of Regional Centre, Udaipur are associated with MaharanaPratap University of Agriculture and Technology, Udaipur with post-graduate teaching and research, guidance to M.Sc., B.E., M.E. and Ph.D. students.

(ii) Research

M.Sc. Programme

The following M.Sc. (LRM) students have admitted in 2016 at Dr.PDKV, Akola and later joined NBSS&LUP, Nagpur in September 2017 for their specialized course in LRM and have completed their courses and have submitted their theses and awarded the degree.

Sr.No.	Name of student	Thesis Title
1.	Tushar G. Tonde	Assessment of soil organic carbonfractions under major cropping systems of Agro-ecological region 6.0

The following M.Sc.(LRM) students were admitted in 2018 at Dr. PDKV, Akola and who later joined NBSS&LUP, Nagpur in August 2019 for their specialized course in LRM. They have completed their course work and at present engaged in research work for their theses. Name of the students along with the respective thesis title is mentioned below.

SrNo.	Name of student	Thesis Title
1.	Priyanka V. Deshmukh	Assessment of length of the growing period using meteorological and remote sensing data of Nagpur district, Maharashtra
2.	Shital K. Wankhede	Characterization of pomegranate growing soils in different landforms of Ahmednagar district, Maharashtra
3.	Ravi M. Warhade	Characterization and evaluation of cotton growing soils of Samudrapur block in Wardha district, Maharashtra

Ph.D. Programme

The following Ph.D.(LRM) student was admitted in 2016 at Dr. PDKV, Akola who later joined NBSS&LUP, Nagpur in October 2017 for his specialized course in LRM. He is undergoing the course work along with research work. Name of the student along with thesis title is mentioned below.

SrNo.	Name of student	Thesis Title
1.	Deepak Mohekar	Development of land use options for Goa state using large scale land Resource Inventory

Regional Centre, Kolkata

Education

Post Graduate Education in Land Resource Management (LRM)

- The Regional Centre, Kolkata undertakes a collaborative programme with Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal for Post Graduate teaching in Agricultural Chemistry and Soil Science with specialization in Land Resource Management (LRM). Two courses, namely, Soil Genesis and Classification (ACSS-551) and Remote Sensing and its Applications (ACSS-754) for M.Sc. students is being carried out in BCKV, Mohanpur, Nadia.

Regional Centre, Bengaluru

Internship Guidance

S.No.	Period	Student Name	University/Institute	Supervisor
1	February 8 -June 7	Mr. Suryakant, M.SC (Geoinformatics),	KSRDPR University, Gadag	Dr.S.Dharumarajan
2	May 10 - July 8	Mr. Sakthivel R, M.Tech. Geo-informatics	University of Madras, Chennai	Dr.S.Dharumarajan
3	May 25 – July 8	Ms. Tanishka Sharma, M.Tech. Geo-informatics	Central University of Tamil Nadu, Thiruvarur	Dr.S.Dharumarajan
4	May 15 – June 20	Mr. SaligramaAbhiram, M.Tech. Geo-informatics	Central University of Tamil Nadu, Thiruvarur	Dr.S.Dharumarajan
5	May 13-June 15.	Ms. Raja Niruthia, R	Central University of Tamil Nadu, Thiruvarur	Dr.S.Dharumarajan

Research

M.Sc / Ph.D thesis

Sl. No.	Name of student	M. Sc./ Ph.D.	University	Guided/ Co-Guide	Title
1.	Mrs. R. Vasundhra	Ph.D.	UAS Bangalore	Dr. K.S. Anil Kumar	"Assessment of soil carbon stocks under arecanut and coconut plantations in Southern Karnataka".
2.	Mr. Sabyasaji Majumdar	Ph.D.	UAS Bangalore		"Quantification of different silicon pools and distribution of Phytoliths in soils of rice, sugarcane and forest"
3.	P. Nideesh	Ph.D.	KAU, Vellanikkara		"Taxonomy and organic carbon-nutrient interactions in selected wetland soils of Kerala"
4.	Mr. Pradeep Kumar	M.Sc. Ag.	UAS Bangalore		"Assessment of Soil Carbon Sequestration potential of soils under different Agro-climatic zones of Southern Karnataka"

Regional Centre, Jorhat

Teaching

1. Three students pursuing M.Sc (Chemistry) from Kaziranga University, Assam, have undergone their M.Sc. dissertation work under the guidance of three scientists of this Centre in various topics *viz.* soil potassium, soil available boron and soil acidity.

Higher Education

1. Smt. Prabha Susan Philip, Scientist proceeded on leave for Ph. D. programme with effect from 29.01.2019.

Human Resource Development (HRD), training acquired by various categories of staff.

(A) Physical targets and achievements (2019-20)

Sl. No.	Category	Total No. of Employees	No. of training planned for each category during 2019 as per ATP	No. of employees undergone training	No. of employees undergone training	Total No. of employees undergone training	% realization of training planned
1	**2**	**3**	**4**	**5**	**6**	**7(5+6)**	**8**
1.	Scientist	11	2	-	-	-	-
2.	Technical	19	6	-	2	2	33.3
3.	Administrative & Finance	4	2	1	2	3	100
4.	SSS	5	-	-	-	-	-
	Total	**39**	**10**	**1**	**4**	**5**	**50**

(B) Financial target and achievement

S.No.	RE 2019 for HRD	Actual Expenditure up to Dec. 2019 for HRD	% Utilization of allotted budget
1	**2**	**3**	**3*100/2=4**
1	350000/-	21957/-	6.3

10 WORKSHOPS/ SEMINARS ORGANIZED

Date	Topic	Venue
February16	Organized Foundation Day Seminar – 2019 on "Economics of Indian Agriculture" by Indian Association for Productivity, Quality & Reliability in collaboration with ICAR - National Bureau of Soil Survey and Land Use Planning held on Saturday, February 16, 2019, at ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Kolkata.	ICAR-NBSS&LUP, Regional Centre, Kolkata
March 14	Hindi Workshop on the topic "Bharat Sarkar ki Rajbhasha Nitievam Anupalan" and "Unicode".	ICAR-NBSS&LUP, Regional Centre, Kolkata
March 29	1st Hindi workshop " Apna karyalik (Prashahnik) kary shat-pratishat hindi mein kese karein"**.**	ICAR-NBSS&LUP, Regional Centre, Delhi
June 04	Hindi Workshop on the topic "Hindi me Noting evam Drafting" and "*Computer par Hindi*".	ICAR-NBSS&LUP, Regional Centre, Kolkata
June 28	2nd Hindi workshop **"**Hindi mein adhikarik sarkari kary karne ki vidhi**".**	ICAR-NBSS&LUP, Regional Centre, Delhi
July19	9th Prof. P.K. Dey Memorial Lecture was organized by ISSS, Kolkata Chapter on at ICAR-NBSS&LUP, Regional Centre, Kolkata.	ICAR-NBSS&LUP, Regional Centre, Kolkata
August 02	All the scientists of ICAR-NBSS&LUP, Regional Centre, Kolkata have participated in the special lecture on "*Paleosols-climate change-polygenesis*" delivered by Dr. D.K. Pal At Regional Centre, Kolkata.	ICAR-NBSS&LUP, Regional Centre, Kolkata
September 05	Hindi Workshop on the topic "Rajbhasha Karyanayan" and "Hindi-Takniki Samadhan".	ICAR-NBSS&LUP, Regional Centre, Kolkata
23 - 24 September 2019	The Clay Minerals Society of India (CMSI), New Delhi and ICAR- NBSS&LUP, Regional Centre Delhi jointly organized 22nd Annual Convention and National Conference on *Application of Clay and Allied Sciences in Agriculture, Environment and Industry.*	ICAR- Indian Agriculture Research Institute (IARI), New Delhi.

Date	Topic	Venue
	   	
September 27	30th Prof. S.P. Raychowdhury Memorial Lecture was organized by ISSS, Kolkata Chapter on September 27, 2019, at ICAR- NBSS&LUP, Regional Centre, Kolkata.	ICAR-NBSS&LUP, Regional Centre, Kolkata
October 31	3rd Hindi workshop "Rajbhasha niti, niyam evam kiryanvat ke vividh charan".	ICAR-NBSS&LUP, Regional Centre, Delhi
November 04	1st Prof. S.K. Gupta Memorial Lecture was organized by ISSS, Kolkata Chapter on November 4, 2019, at ICAR- NBSS&LUP, Regional Centre, Kolkata.	ICAR-NBSS&LUP, Regional Centre, Kolkata
November 07	Hindi Extempore Competition was organized in the Regional Centre under the aegis of Kolkata Town Official Language Implementation Committee, (Office-2).	ICAR-NBSS&LUP, Regional Centre, Kolkata
December 04	Hindi Workshop on the topic "Rajbhasha Adhiniyam" and "Samvidhan Diwas".	ICAR-NBSS&LUP, Regional Centre, Kolkata

11 AWARDS, RECOGNITION AND FOREIGN VISITS

Awards

- Dr. M.S.S. Nagaraju, Principal Scientist along with other scientists received Best Research Paper Award for the research paper "Mapping of spatial variability in soil properties for site-specific nutrient management of Nagpur Mandarin in Central India" from Indian Academy of Horticultural Sciences, New Delhi on November 29, 2019.

- Shri G.K. Sharma was awarded Young Scientist Award from DST-SERB, Govt. of India for attending 9th International conference on Algae Biomass, Biofuels and Bio products from 17th to 19th June 2019 held at Boulder CO, USA.

- Dr.Jaya N Surya, Principal Scientist received 'Outstanding Scientist Award" from Society of Tropical Agriculture in 10th International Conference on Agriculture, Horticulture and food Sciences -2019 held at New Delhi.

- Mrs. Ritu Nagdev, Scientist received the "Bharat Ratna Indira Gandhi Gold Medal Award" by Global Economic Progress & Research Association (GEPRA), New Delhi for Excellence in her respective field on the occasion of 70th National Unity Conference on Individual Achievements & National Development held at Bengaluru.

- Dr. R.P. Sharma received Best Paper award for the paper entitled "Spatial Variability Assessment of Soil Fertility in Black Soils of Central India Using Geostatistical Modelling" presented in an the International Conference on "Soil and Water Resources Management for Climate-Smart Agriculture, Global Food and Livelihood Security" jointly organized by Soil Conservation Society of India (SCSI), World Association of Soil and Water Conservation (WASWAC) and the International Soil Conservation Organization (ISCO) at NASC, Complex, New Delhi during 5-9 November 2019.

- Mrs. Ritu Nagdev, Scientist received the Consolation Prize (Certificate and Cash of Rs. 1000/-) for LokotiyaanPallavan Competition organized by NARACAS, New Delhi.

- Mrs. Sunita Mittal and Kamlesh Sharma Assistants received first prize (Cash of Rs. 5000/-) for working in Hindi language at ICAR-NBSS&LUP, Regional Centre Delhi.

- Sh. Arvind Kumar, Asst. Chief Technical Officer and Sh. Makan Singh, Technical Assistant received second prize (Cash of Rs. 3000/-) for working in Hindi language at ICAR-NBSS&LUP, Regional Centre Delhi.

- Dr.Dharam Singh, Senior Scientist received third prize (Cash of Rs. 2000/-) for working in Hindi language at ICAR-NBSS & LUP, Regional Centre Delhi.

- Dr. S.K. Mahapatra, Principal Scientist & Head and Sh. Sumit Sindhu, AAO received first prize (Cash of Rs. 5000/-) for dictation in Hindi Language at ICAR-NBSS&LUP, Regional Centre Delhi.

- Shri. Deepak Maurya, Technical Assistant (FFT) received *second prize* in essay writing competition (Hindi) conducted by *Nagar Rajbhasha Karyanvyan Samiti* (Offices-2), Kolkata under Department of Official Language, Ministry of Home Affairs, Government of India.

Recognitions

- Dr. S.K. Ray, Principal Scientist & Head was nominated by ICAR to act as Member of the Institute Management Committee of ICAR- Indian Institute of Soil Science, Bhopal.

- Dr. S.K. Ray, Principal Scientist & Head was a panel member at theSeminar on "Land Erosion in Brahmaputra & Barak Basin" organized by Brahmaputra Board at Assam Administrative Staff College, Guwahati on 15.02.2019.

- Dr. S.K. Ray, Principal Scientist & Head was nominated by the ICAR to act as a member of the Award Judgment Committee to select the Best Teacher/Researcher/Extension Personnel awardees in the Assam Agricultural University, Jorhat.

- Dr. S.K. Ray, Principal Scientist & Head was nominated by ICAR as a member ofthe committee to select Head of twelve departments of Assam Agricultural University, Jorhat.
- ICAR nominated Dr. S.K. Ray, Principal Scientist & Head as member of the Institute Management Committee (IMC) of the ICAR-NBSS&LUP, Nagpur for three years with effect from 10.06.2018 to 09.06.2021.
- Dr. S.K. Ray, Principal Scientist & Head was nominated by ICAR as an Expert Member of the Selection Committee to select Assistant Professors for both teaching and research position of the Assam Agricultural University, Jorhat from 02.03.2019 to 12.03.2019.
- Dr. Prasenjit Ray, Scientist of the Regional Centre, Jorhat has been selected as the Councillor of the Clay Minerals Society of India (CMSI), New Delhi for the North Eastern Region on India.
- Dr A.K. Sahoo, Principal Scientist & Head has been nominated as the council member of the Indian Society of Coastal Agricultural Research, ICAR-CSSRI, Regional Research Station, Canning,West Bengal for the year 2019-21.
- Dr. A.K. Sahoo, Principal Scientist& Head has been nominated as the examiner for the evaluation of Ph.D (Ag) thesis on “Amino Acid- Humic Acid Interactions” submitted by Sri Subhra Prakash Kajli, Department of Agricultural Chemistry and Soil Science, Institute of Agricultural Sciences, University of Calcutta, West Bengal.
- Dr. A.K. Sahoo, Principal Scientist& Head has been nominated as the moderator of the question papers for the M.Sc 3rd Semester, 2019 examination of Agriculture Chemistry and Soil Science, Institute of Agricultural Sciences, University of Calcutta, West Bengal.
- Dr. S.K. Gangopadhyay, Principal Scientist has been nominated as the external examiner for Comprehensive viva voice of Ms. Goutami Kataki and Mr. Sanjib Borah of Department of Soil Science, Faculty of Agriculture, Assam Agriculture University, Jorhat- 785013, Assam on 1st March, 2019.
- Dr. S. Bandyopadhyay, Principal Scientist has been elected as the Councilor of Eastern Zone of Clay Minerals Society of India (CMSI) for the year 2018-2020.
- Dr. A.K. Sahoo, Principal Scientist& Head acted as a member in the Board of Examiners relating to M.A/M. Sc Semester IV in Geography Practical Examination, 2019 in Paper- MGGMJP 405B (Soil & Agriculture Geography) on 23.07.2019 at the Department of Geography, The University of Burdwan, Golapbag, Burdwan- 713104.
- Dr. A.K. Sahoo, Principal Scientist & Head acted as a member in the Board of Examiners relating to M.A/M. Sc Semester IV in Geography Term Paper Examination, 2019 in Paper- MGGTP 406B (Soil & Agriculture Geography) on 26.07.2019 at the Department of Geography, The University of Burdwan, Golapbag, Burdwan- 713104.
- Dr. S. Dharumarajan, Scientist was invited by International Union of soil science- GlobalsoilMap working group to attend the 2019 Joint Workshop for Digital Soil Mapping and Global Soil Map held in Santiago, Chile, from 12 to 16 March 2019.
- Dr. Chandrakala, M., Dr. Srinivasan, R., Dr. Anil Kumar, K.S., Dr. Karthika, K.S., Dr. Sujatha, K., Dr. Rajendra Hegde and Dr. S.K. Singh. 2019 received Best Poster Award for Problems and potentials of the rubber cultivation areas in Kerala for resource conservation in 28th National Conference on Farmer’s friendly soil and water conservation technologies for mitigating climate change impact from 31st January to 02nd February 2019 at Hotel Gem Park, Ooty.
- Dr. Chandrakala, scientist received Bharath Rathna Indira Gandhi Gold Medal Award by the Global Economic Progress and Research Association, New Delhi Conference held on March 9th 2019 at Bangalore on the Occasion of International Women’s Day.
- Dr. Chandrakala, Scientist received Bharath Rathna Abdul Kalam Gold Medal Award by the Global Economic Progress and Research Association, New Delhi in National unity

Conference held on October 19th 2019 at Chennai.

- Certificate of Excellence to Dr. Chandrakala, Scientist in reviewing awarded in recognition of an outstanding contribution to the quality of the journal by the current journal of applied science and technology, Science domain international.

- Vasundhara. R., scientist was awarded Doctor of Philosophy (Ph.D) for work on ''Assessment of soil carbon stock under arecanut and coconut plantations in Karnataka'' from the UAS Bangalore in year march 2019.

- Dr.R.Srinivasan, scientist received Bharat Ratna Indira Gandhi Gold Medal Award-2019 by Global Economic Progress & Research Association, India held on 9th March 2019 at Hotel Sanctum, Bangalore, Karnataka.

- Dr. R. Srinivasan, scientist received Dr. APJ Abdul Kalam Life Time Achievement National Award-2019 by International Institute for Social and Economic Reforms (R), Bangalore for Teaching, Research & Publications under theme of Agriculture held at ADA Ranga Mandira, Bengaluru, Karnataka.

- N. Ravi, P.A. Lubina, Aparna Rajan, Pavithra, G.M., M.C. Sandhya, K.S. Anil Kumar and S. Viswanath, 2019. "Study on root architecture in two nationally prioritized bamboo species in semi-arid region of Karnataka" Biotic Science Congress, 2019 Bioscon,19 held at Sona College of Arts and Science, Salem 636005, on 26-27 July, 2019, Souvenir cum e- Book: 154 p. also. Best Poster Award for the research paper.

Foreign Visits

- Shri. G.K. Sharma, scientist, Regional Centre, Jorhat was awarded International Travel Scheme award from DST-SERB, Govt. of India for attending 9th International conference on Algae Biomass, Biofuels and Bio products from 17th to 19th June 2019 held at Boulder CO, USA.

- Dr. S. Dharumarajan, scientist, Regional Centre, Bangalore visited University of Chile, Santiago, Chile during 12 to 16 March 2019 and presented the paper on Indian Soil Grids: implementing a bottom-up Global Soil Map approach for India" in 2019 Joint Workshop for Digital Soil Mapping and Global Soil Map.

- Dr. S. Dharumarajan, scientist, Regional Centre, Bangalore visited Sup Agro, Montpellier, France to attend annual review meeting of ATCHA project during 4.11.2019 to 7.11.2019 and training on new digital soil mapping approaches during 8.11.19 to 15.11.2019 at INRA-LISAH, Montpellier, France

Presentation in 2019 joint workshop for digital soil mapping and GlobalSoilMap (12.03.2019 to 16.03.2019) at University of Chile, Santiago, Chile

12 DISTINGUISHED VISITORS

Headquarters, Nagpur

- Shri Mahadeo Jagannath Jankarji, Hon'ble Minister of Animal Husbandry, Dairy and Fisheries, Govt. of Maharashtra
- Dr. Trilochan Mohapatra, Secretary, Department of Agricultural Research and Education (DARE) and Director General, ICAR, New Delhi
- Shri Sushil Kumar, Additional Secretary, DARE and Secretary, ICAR, New Delhi
- Shri Bimbadhar Pradhan, Additional Secretary and Financial Advisor, DARE/ICAR, New Delhi
- Dr. K. Alagusundaram, Deputy Director General (DDG), Agricultural Engineering and Natural Resource Management, ICAR, New Delhi
- Dr. Joykrishna Jena, Deputy Director General (Fisheries), ICAR, New Delhi
- Dr. S.K. Chaudhari, Deputy Director General (NRM), ICAR, New Delhi
- Dr. Tapas Bhattacharyya, Former Vice Chancellor, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli
- Sh. Vikas Chandra Ratogi, IAS, Project Director, PoCRA, Maharashtra
- Dr. Vilas Kharche, Associate Dean and Head, Department of Agricultural Chemistry and Soil Science, Dr. PDKV, Akola,
- Dr. A. K. Shukla, Project Coordinator (Micro-nutrient) IISS, Bhopal,
- Dr. J.C.Katyal, Chairman, Research Advisory Committee
- Dr. A. Nayak, Member, Research Advisory Committee
- Dr. Sesha Sai, Member, Research Advisory Committee
- 100 Students of Santanji Mahavidyalaya, Nagpur
- Students of College of Agriculture, VNMKV, Parbhani, Maharashtra
- Students of Shri Shivaji College of Agriculture, Amravati, Maharashtra
- 26 Students of College of Agriculture, Nagpur
- DAESI-RBCA, Wardha (40 nos), Maharashtra
- 55 students of College of Horticulture, Kolar, Karnataka
- Students of College of Horticulture, Bidar, Karnataka
- 10 Students of Centre Point School, Nagpur
- 36 Students of Narayana Vidyalayam, Nagpur
- Students of College of Agriculture, Gadchiroli, Maharashtra
- 87 Students of K.K. Wagh College of Agriculture, Nashik, Maharashtra
- Students of College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh
- 46 Students of Mahatma Phule Mahavidyalaya, Warud, Amravati, Maharashtra
- 26 Students of Department of Applied Geology, University of Madras, Chennai

Regional Centre, Bengaluru

- Smt. K.V. Usha, MLA, Kalyanadurga, Andhra Pradesh
- Smt. Julian Jacquline & Dr. Ranjan Samantha Ray, World Bank team
- Dr. N.K. Tyagi, former member of ICAR-ASRB ICAR, New Delhi.
- Dr. V.N. Sharda, former member of ICAR-ASRB ICAR, New Delhi.
- Dr. S.P. Gupta, Principal Scientist (Retd.) ICAR-CSSRI, Karnal
- Dr. Mrs. Ravinder Kaur, Professor & Head/Director (I/C), Water Technology centre, IARI, New Delhi
- Dr. Manoj Khanna, Professor-Hydrology Water Technology centre, IARI, New Delhi.
- Dr. Vinay Sehgal, Principal Scientist, Division of

Agricultural Physics, IARI, New Delhi.

- 20-International visitors from 12 countries to understand more on Sujala LRI & its utility in NRM as a part of NIRDPR international training on Geo-spatial applications
- 16 International visitors from 10 countries visited the centre to understand LRI & success story of Sujala as a part of NIRDPR, Hyderabad, International training on NRM-Geospatial application
- 22 senior-level land resources officers from five African countries(Ethiopia, Kenya, Mozambique, Rwanda, Tanzania) under South-South knowledge exchange on climate-smart agriculture
- 25 Agriculture Diploma Students from School of Agriculture training & Research Mattikoppa, Bailahongal, Belgaum district, Karnataka

Regional Centre, Delhi

- Dr. K. Alagusundaram, Deputy Director General (Agriculture Engineering & NRM), ICAR, New Delhi
- Dr. S.K Chaudhari, Asst. Director General (SWM), ICAR, New Delhi
- Dr. J.S Samra, Ex. CEO, NRAA, New Delhi
- Dr. P.K. Chakraborty, Member ASRB, New Delhi
- Dr. A. K. Patra, Director, ICAR-IISS, Bhopal
- Dr. P.R. Rao, Member Secretary, North Zone, NARAKAS, New Delhi

Regional Centre, Kolkata

- Sh. V.D. Nanniwadekar, Ex-Dy. Secretary, ICAR
- Dr. Steve Phillips, Director, IPNI North America
- Dr. S.P. Mukhopadhyay, Chairman, QRT, ICAR-NBSS&LUP, Nagpur
- Dr. Amal Kar, Member, QRT, ICAR-NBSS&LUP, Nagpur
- Dr. Surinder S. Kukal, Member, QRT
- Dr. Tirthankar Banerjee, Member, QRT
- Dr. Arulmozhiselvan K, Member, QRT
- Dr. S.K. Singh, Director, ICAR-NBSS&LUP, Nagpur
- Dr. P. Chandran, Member, QRT, ICAR-NBSS&LUP, Nagpur
- Dr. Rajeev Srivastava, Member, QRT, ICAR-NBSS&LUP, Nagpur
- Dr. Tarun Sen, Member, QRT, ICAR-NBSS&LUP, Nagpur
- Dr. Sanjay Ray, Member, QRT, ICAR-NBSS&LUP, Jorhat
- Dr. Ram Prashad Yadav, Member, QRT, ICAR-NBSS&LUP, Nagpur
- Dr. R.S. Singh, Member, QRT, Head, ICAR-NBSS & LUP, Udaipur
- Dr. Rajendra Hegde, Member, QRT, ICAR-NBSS&LUP, Bangalore
- Shri Ashish Roy, Joint Director (Admin.) & Registrar, ICAR-NAARM, Hyderabad
- Sh. R.V.S. Rao, Head, I/C, NAARM, Hyderabad

Regional Centre, Jorhat

- Er. R.D. Meena, Executive Engineer, Assam Aviation Works Division, CPWD, Airport Colony, Borjhar, Guwahati visited the Centre on 19.01.2019.
- Prof. (Dr.) S.A.R. Hashmi, Chief Scientist and Head, Integrated Approach Design and Product Development (IADPD) Division, CSIR-Advanced Materials & Processes Research Institute (AMPRI), Bhopal visited the Centre on 28.01.2019.
- Dr. S.K.S. Rathore, Senior Principal Scientist & Head, Planning & Performance Division, CSIR-Advanced Materials & Processes Research Institute (AMPRI), Bhopal visited the Centre on 28.01.2019.
- Dr. S. Murali, Principal Scientist, CSIR-Advanced Materials & Processes Research Institute (AMPRI), Bhopal visited the Centre on 28.01.2019.
- Dr. T.K. Sen, Principal Scientist, ICAR-NBSS&LUP, Division of LUP, Nagpur visited the Centre on 16.02.2019.
- Dr. S.K. Gangopadhyay, Principal Scientist, ICAR-NBSS&LUP, Regional Centre, Kolkata visited the Centre on 28.02.2019 and 01.03.2019.
- Dr. R.K. Karmakar, Head, Dept. of Soil Science, AAU, Jorhat visited the Centre on 22.03.2019.
- Dr. Pravin G. Ingole, Scientist, Engineering Science and Technology Division, CSIR-NEIST,

Jorhat visited the Centre on 22.03.2019.

- Dr. Aditya Kumar Singh, Principal Scientist, ICAR-Indian Institute of Maize Research, Ludhiana, Punjab visited the Centre on 5.4.2019.
- ER. RD Meena, Executive Engineer, Assam Aviation Works Divn., CPWD, Airport Colony, Borjhar, Guwahati visited the Centre on 30.05.2019.
- Dr. R.K. Karmakar, Head, Dept. of Soil Science, Assam Agricultural University, Jorhat visited the Centre on 11.06.2019.
- Dr. Jayanta Deka, Dean, Faculty of Agriculture, Assam Agricultural University, Jorhat visited the Centre on 20.06.2019.
- Dr. Utpal Baruah, Former Principal Scientist & Head, Regional Centre, Jorhat visited the Centre on 20.06.2019 and 29.11.2019.
- Dr. S. Mukhopadhyay, Principal Scientist, ICAR-NBSS&LUP, R.C. Kolkata visited the Centre on 21.07.2019 and 30.11.2019.
- Dr. S.N. Gogoi, Former Head, RSRS, Jorhat visited the Centre on 23.07.2019.
- Dr. Danish Tamuli, Assistant Professor, Dept. of Soil Science, Assam Agricultural University, Jorhat visited the Centre on 24.07.2019.
- Dr. Girin Hazarika, Ex-Director of Research, AAU visited the Centre on 19.09.2019.
- ER. RD Meena, Executive Engineer, Assam Aviation Works Division, CPWD, Airport Colony, Borjhar, Guwahati visited the Centre on 27.09.2019.
- Dr. S.N. Gogoi, Former Head, RSRS, Jorhat visited the Centre on 22.10.2019.
- Mr. Prankrishna Tamuli, Centre I/c, National Institute of Electronics & Information Technology (NIELIT), Jorhat visited the Centre on 01.11.2019.
- Dr. Ruplekha Bora, Dean, Faculty of Community Science, Assam Agricultural University, Jorhat visited the Centre on 02.11.2019.
- Mr. Arunjoy Saikia, Social Worker & Secretary, Greater Jail Road Unnayan Samiti, Jorhat visited the Centre on 20.12.2019.
- Dr. Momi Dutta Kotoky, Assistant Professor, DCB College, Jorhat visited the Centre on 24.12.2019.

13 PERSONNEL

SCIENTIFIC

Dr. S.K. Singh, Director (upto 31st Jan. 2019) & Acting Director (upto 31st Oct. 2019)

Dr. P. Chandran, Acting Director (from 1st November 2019)

PRIORITY SETTING, MONITORING AND EVALUATION CELL

Dr N.G. Patil, Principal Scientist (Soil and Water Conservation Engg.) & In-charge

DIVISION OF SOIL RESOURCE STUDIES

1. Dr. P. Chandran, Principal Scientist (Soil Science) & Head
2. Dr. Pramod Tiwary, Principal Scientist (SWCE)
3. Dr. R.P. Sharma, Senior Scientist (Soil Science)
4. Dr. K. Karthikeyan, Senior Scientist (Soil Science)
5. Dr. U.K. Maurya, Senior Scientist (Soil Science)
6. Dr. Vasu, D., Scientist (Soil Science)
7. Sh. Abhishek Jangir, Scientist (Soil Science)
8. Sh. Gopal Tiwari, Scientist (Soil Science)
9. Dr. Ranjan Paul, Scientist (Soil Science)
10. Dr.(Ms) Sonalika Sahoo, Scientist (Soil Science)

DIVISION OF REMOTE SENSING APPLICATIONS

1. Dr. Rajeev Srivastava, Principal Scientist (Soil Science) & Head (Actg)
2. Dr. M.S.S. Nagaraju, Principal Scientist (Soil Science)
3. Dr. G.P. Obi Reddy, Principal Scientist (Geography)
4. Dr. H. Biswas, Principal Scientist (Soil Science)
5. Sh. Nirmal Kumar, Scientist (Soil Physics)
6. Dr. Sudipta Chattaraj, Scientist (Soil Physics)
7. Sh. Benukantha Dash, Scientist (SWCE)

DIVISION OF LAND USE PLANNING

1. Dr. N.G. Patil, Principal Scientist (SWCE) & Head (Actg)
2. Dr. R.A. Marathe, Principal Scientist (Soil Physics)
3. Dr. M.S. Raghuvanshi, Principal Scientist (Agronomy)
4. Dr. Ravindra Naitam, Scientist (Soil Science)
5. Dr. (Mrs.) Amrita Daripa, Scientist (Environmental Science)
6. Sh. H.L. Kharbikar, Scientist (Agril. Economics)
7. Ms. Radhika C., Scientist (Agril. Economics)
8. Dr. Lal Chand Malav, Scientist (Environmental Science)

REGIONAL CENTRE, KOLKATA

1. Dr. A.K. Sahoo, Principal Scientist (Soil Science) & Head (Actg)
2. Dr. S.K. Gangopadhyay, Principal Scientist (Soil Science)
3. Dr. B.N. Ghosh, Principal Scientist (Soil Science)
4. Dr. Krishnendu Das, Principal Scientist (Soil Science)
5. Dr. Dipak Dutta, Principal Scientist (Soil Science)
6. Dr. K.D. Sah, Principal Scientist (Soil Science)
7. Dr. S. Mukhopadhyay, Principal Scientist (Soil Science)
8. Dr. T. Chatopadhyay, Senior Scientist (Soil Science)
9. Dr. Sah Kausar Reza, Senior Scientist (Soil Science)
10. Dr. S. Bandyopadhyay, Senior Scientist (Soil Science)
11. Dr. (Ms) S. Gupta Chaudhary, Scientist (Soil Science)

REGIONAL CENTRE, BANGALORE

1. Dr. Rajendra Hegde, Principal Scientist (Agronomy) & Head
2. Dr. B.P. Bhaskar, Principal Scientist (Soil Science)
3. Dr. K.S. Anil Kumar, Principal Scientist (Soil Science)
4. Dr. V. Ramamurthy, Principal Scientist (Agronomy)
5. Dr. S.C. Ramesh Kumar, Principal Scientist (Agril. Economics)
6. Dr. S. Srinivas, Principal Scientist (Computer Application)
7. Dr. S. Dharmurajan, Senior Scientist (Soil Science)
8. Sh. S.P. Maske, Scientist (SWCE)
9. Dr. R. Srinivasan, Scientist (Soil Science)

10. Mrs. Vasundhara R., Scientist (Soil Science)
11. Dr.(Mrs) M. Lalitha, Scientist (Soil Science)
12. Dr.(Ms) M. Chandrakala, Scientist (Soil Science)
13. Dr.(Mrs) B. Kalaiselvi, Scientist (Soil Science)
14. Dr.(Mrs) Karthika, Scientist (Soil Science)

REGIONAL CENTRE, NEW DELHI

1. Dr. S.K. Mahapatra, Principal Scientist (Soil Science)& Head (Actg)
2. Dr. T.P. Verma, Principal Scientist (Soil Science)
3. Dr. (Mrs) Jaya N. Surya, Principal Scientist (Soil Science)
4. Dr. Dharam Singh, Senior Scientist (Agronomy)
5. Sh. Ashok Kumar, Scientist (Agronomy)
6. Dr. Rajesh Kumar Meena, Scientist (Soil Science)
7. Sh. Vikas, Scientist (Agricultural Statistics)
8. Ms. Ritu Nagdev, Scientist (Environmental Science)
9. Ms Prabha Susan Philip, Scientist (Soil Science)
10. Ms Shilpi Verma, Scientist (Soil Science)

REGIONAL CENTRE, JORHAT

1. Dr. S.K. Ray, Principal Scientist (Soil Science) & Head
2. Dr. S. Ramachandran, Scientist (Soil Science)
3. Dr. Roomesh Kumar Jena, Scientist (Soil Science)
4. Sh. Gulshan Kumar Sharma, Scientist (Environmental Science)
5. Dr. Prasanjit Ray, Scientist (Soil Science)
6. Sh. K.K. Mourya, Scientist (Soil Science)
7. Ms Surbhi Hota, Scientist (Soil Science)

REGIONAL CENTRE, UDAIPUR

1. Dr. S.S. Rao, Principal Scientist (Agronomy)&Head (Actg)
2. Dr. R.S. Meena, Scientist (Soil Science)
3. Sh. Roshan Lal Meena, Scientist (Agronomy)
4. Dr. Pravash C. Moharana, Scientist (Soil Science)
5. Sh. Sunil Kumar, Scientist (Soil Science)
6. Sh. Mahaveer Nogiya, Scientist (Soil Science)

TECHNICAL

HEADQUARTERS, NAGPUR

1. Dr. N.C. Khandare, Chief Technical Officer (FFT)
2. Sh. S.V. Bobade, Chief Technical Officer (FFT)
3. Dr. S.S. Nimkhedkar, Chief Technical Officer (FFT)
4. Dr. R.A. Nasre, Asstt. Chief Technical Officer (FFT)
5. Sh. S.G. Anantwar, Chief Technical Officer (FFT)
6. Sh. V.P. Patil, Chief Technical Officer (FFT)
7. Dr. A.P. Nagar, Chief Technical Officer (FFT)
8. Mrs. Smita Patil, Chief Technical Officer (FFT)
9. Sh. Vijay Bhongade, Chief Technical Officer (Photo.)
10. Dr. A.M. Nimkar, Chief Technical Officer (FFT)
11. Dr. (Mrs.) Ratna P. Roy, Asstt. Chief Technical Officer (FFT)
12. Sh. V.N. Parhad, Asstt. Chief Technical Officer (FFT)
13. Dr. (Mrs.) Jiji Cyriac, Asstt. Chief Technical Officer (LID)
14. Sh. S.S. Gaikawad, Asstt. Chief Technical Officer (FFT)
15. Sh. P.V. Ambekar, Asstt. Chief Technical Officer (Photo.)
16. Dr. M.T. Sahu, Asstt. Chief Technical Officer (P&E)
17. Sh. D.S. Mohekar, Senior Technical Officer (FFT)
18. Sh. P.S. Butte, Senior Technical Officer (FFT)
19. Sh. S.D. Meshram, Senior Technical Officer (LT)
20. Sh. H.J. Bhondwe, Technical Officer (FFT)
21. Sh. R.K. Bhalsagar, Technical Officer (FFT)
22. Mrs. Ujwala Tijare, Technical Officer (WS)
23. Sh. B.M. Khorge, Technical Officer (WS)
24. Sh. R.N. Zambre, Technical Officer (WS)
25. Sh. M.D. Kadhav, Technical Officer (WS)
26. Sh. S.K. Kalbande, Technical Officer (WS)
27. Sh. S.S. Dohatre, Senior Technical Assistant (FFT)
28. Sh. V.T. Sahu, Senior Technical Assistant (FFT)
29. Sh. U.B. Gaikawad, Senior Technical Assistant (WS)
30. Sh. S.K. Mendhekar, Technical Assistant (FFT)
31. Sh. M.M. Bhagat, Technical Assistant (FFT)
32. Sh. D.R. Borkar, Senior Technician (WS)
33. Sh. P.N. Jadhav, Senior Technician (FFT)
34. Sh. S.R. Singade, Senior Technician (FFT)
35. Sh. A.M.G. Sheikh, Senior Technician (FFT)
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38. Sh. Atul Dankhade, Technician (WS)
39. Sh. L.G. Sontakke, Technician (WS)
40. Sh. S.A. Bhoyar, Technician (FFT)
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6. Sh. D.H. Venkatesh, Asstt. Chief Technical Officer (LT)
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8. Mrs. K. Sujatha, Senior Technical Officer (WS)
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10. Sh. K. Paramesha, Technical Officer (FFT)
11. Sh. Jairamaiah, Technical Officer (FFT)
12. Mrs. K.V. Archana, Technical Officer (FFT)
13. Sh. N. Somasekhara, Senior Technical Assistant (FFT)
14. Sh. B.M.N. Reddy, Senior Technical Assistant (FFT)
15. Sh. N. Maddileti, Senior Technician (FFT)
16. Ms. S. Parvathy, Senior Technician (LT)

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9. Sh. Sita Ram, Technical Assistant (FFT)
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11. Sh. G.C. Sarkar, Senior Technician (FFT)
12. Sh. Sukonto Pal, Senior Technician (FFT)
13. Sh. Siddharth Karamkar, Senior Technician (LT)
14. Smt. Kalpana Biswas, Technician (LT)
15. Sh. Mahesh Roy, Technician (FFT)
16. Sh. Deepak Devdas Ganvir, Technician (FFT)
17. Sh. Abhijit Sampat Meshram, Technician (FFT)

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1. Dr. D.K. Katiyar, Chief Technical Officer (FFT)
2. Sh. Harjit Singh, Asstt. Chief Technical Officer (FFT)
3. Sh. K.K. Bharadwaj, Technical Officer (P&E)
4. Sh. S. Saboo, Technical Officer (WS)
5. Sh. Vijay Singh, Technical Officer (WS)
6. Sh. P.R. Kharwar, Senior Technical Assistant (FFT)
7. Sh. Kuldeep Singh, Senior Technical Assistant (FFT)
8. Sh. Makhan Singh, Technical Assistant (FFT)
9. Sh. Rajesh Rajpal, Technical Assistant (FFT)
10. Sh. Vas Dev, Technical Assistant (FFT)
11. Sh. Shiv Kumar, Technical Assistant (FFT)
12. Sh. Rajneesh Kumar, Technical Assistant (FFT)
13. Sh. P.S. Chaudhary, Senior Technician (FFT)
14. Sh. Roshan Lal, Senior Technician (FFT)

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2. Sh. Durnan Gogai, Technical Officer (WS)
3. Mrs. Shamoli Chetia, Technical Officer (WS)
4. Sh. Gopi Saikia, Technical Officer (WS)
5. Sh. Dilip K. Dutta, Senior Technical Assistant (WS)
6. Sh. N. Saikia, Technical Assistant (FFT)
7. Sh. Pradip Kotoky, Technical Assistant (FFT)
8. Sh. Chandeshwar Das, Technical Assistant (FFT)
9. Sh. Amitabh Baruah, Technical Assistant (FFT)

REGIONAL CENTRE, UDAIPUR

1. Sh. Bhagwati Lal Tailor, Senior Technical Officer (WS)
2. Sh. K.M. Soni, Technical Officer (FFT)
3. Sh. N.D. Khan, Technical Officer (WS)
4. Sh. Bansilal Jat, Technical Officer (FFT)
5. Sh. Devilal Oad, Technical Officer (FFT)
6. Sh. Nola Ram Ola, Senior Technical Assistant (FFT)
7. Sh. B.S. Kumawat, Senior Technical Assistant (FFT)
8. Sh. B.R. Meena, Technical Assistant (WS)
9. Sh. Ambalal Bhoi, Technical Assistant (WS)
10. Sh. C.K. Kumawat, Senior Technician (FFT)
11. Sh. Sohan Lal Sharma, Senior Technician (FFT)
12. Sh. J.S. Rao, Senior Technician (FFT)
13. Sh. Shiv Pal Singh, Senior Technician (FFT)
14. Sh. Manish Choudhary, Technician (WS)
15. Smt. Vandana Patil, Technician (FFT)
16. Sh. Devilal Prajapat, Technician (FFT)

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1. Sh. Sanjay Bokolia, Chief Administrative Officer
2. Sh. Anshul Gupta, Administrative Officer
3. Sh. Toran Prasad, Assistant Administrative Officer
4. Sh. A.P. Tembhurnikar, Assistant Administrative Officer
5. Sh. S.C. Kolhe, Assistant
6. Sh. Ajay Meshram, Assistant
7. Sh. Nitin Mohurle, Assistant
8. Sh. U.S. Kapse, Assistant
9. Mrs. ShaluNandanwar, Assistant
10. Sh. M.M. Khan, Private Secretary
11. Sh. S.M. Pathak, Private Secretary
12. Mrs. Rohini Watekar, Personal Assistant
13. Mrs. Wasudha D. Khandwe, Personal Assistant
14. Mrs. Ranjana Sharma, Personal Assistant
15. Mrs. Vaishali Arbat, Personal Assistant
16. Sh. N.B. Mankar, Upper Division Clerk
17. Sh. S.S. Kamble, Upper Division Clerk
18. Sh. S.J. Patil, Upper Division Clerk
19. Sh. Rahul Yadav, Stenographer Gr.III
20. Ms Kanta, Stenographer Gr.III
21. Sh. Swapnil B. Suryawanshi, Lower Division Clerk
22. Ms Sonal M. Rekhate, Lower Division Clerk
23. Ms Priya N. Kodape, Lower Division Clerk

REGIONAL CENTRE, BANGALORE

1. Sh. J. Unni, Assistant Administrative Officer
2. Mrs. P. Chandrakala, Assistant
3. Sh. Pankaj Gopal Wani, Lower Division Clerk

REGIONAL CENTRE, KOLKATA

1. Ms Bedantika Dutta, Assistant Administrative Officer
2. Mrs. Nirmala Kumar, Assistant
3. Mrs. Aparna Das, Personal Assistant

REGIONAL CENTRE, NEW DELHI

1. Sh. Sumit Sindhu, Assistant Administrative Officer
2. Mrs. Sunita Mittal, Assistant
3. Sh. Kamlesh Sharma, Assistant
4. Sh. Vivek Kumar Sharma, Stenographer Gr.III

REGIONAL CENTRE, JORHAT

1. Sh. P.K. Das, Assistant
2. Sh. Madan Das, PrivateSecretary
3. Sh. N.C. Baruah, Personal Assistant
4. Sh. Pradeep Kumar, Lower Division Clerk

REGIONAL CENTRE, UDAIPUR

1. Sh. Rajesh Choudhary, Assistant Administrative Officer
2. Sh. Harish Rajput, Personal Assistant
3. Sh. Unnikrishnan Nair, K.K., Assistant
4. Sh. V.S. Sankhla, Upper Division Clerk
5. Sh. Bhanwar Singh Devra, Lower Division Clerk

SKILLED SUPPORTING STAFF

HEADQUARTERS, NAGPUR

1. Sh. A.T. Kantode
2. Sh. G.B. Topre
3. Sh. N.T. Thawkar
4. Sh. Ramesh Khawle
5. Mrs. S.N. Gajbhiye

REGIONAL CENTRE, BANGALORE

1. Sh. M.T.N. Murthy
2. Sh. N. Sampangi
3. Sh. R. Balakrishna
4. Sh. C. Nagraj

REGIONAL CENTRE, KOLKATA

1. Sh. Nandlal Pramanik
2. Sh. V.N. Mishra
3. Mrs. Radha Turi
4. Mrs. Alpana Roy
5. Sh. Krishna Gu-chait

REGIONAL CENTRE, NEW DELHI

1. Sh. R.B.Mehto
2. Sh. Rakesh Kumar
3. Sh. Harender Singh Rawat

REGIONAL CENTRE, JORHAT

1. Sh. Nirmal Saikia
2. Sh. Dilip Borah
3. Sh. R.C. Rajak
4. Sh. Raju Balmiki
5. Sh. J.C. Baruah
6. Sh. J.P. Gogai
7. Sh. PabitraGogai

REGIONAL CENTRE, UDAIPUR

1. Sh. Mohanlal Meghwal
2. Sh. Shambhulal Meena

NEW ENTRANTS

- Dr. H. Biswas, Principal Scientist
- Dr. U.K. Maurya, Senior Scientist
- Sh. J. Unni, Asstt. Admn. Officer
- Sh. Rahul Yadav, Stenographer Gr.III
- Ms Kanta, Stenographer Gr.III
- Sh. Vivek Kumar Sharma, Steno. Gr.III

RETIREMENTS

- Sh. A.Z. Sarode, Skilled Supporting Staff, Division of SRS, Nagpur retired on superannuation on 30.04.2019.
- Dr, R.P. Yadav, Principal Scientist & Head, Regional Centre, New Delhi retired on superannuation on 31.05.2019
- Sh. Shivappa Angadi, Senior Technical Officer (T-6), Regional Centre, Bangalore retired on superannuation on 30.06.2019
- Sh. A.M. Kosare, Assistant, HQrs., Nagpur retired on superannuation on 30.06.2019
- Sh. S.P. Dimote, Skilled Supporting Staff, HQrs., Nagpur retired on superannuation on 31.07.2019
- Sh. R.K. Dutta, Assistant, Regional Centre, Kolkata retired on superannuation on 31.07.2019
- Sh. S.P. Awale, Assistant, HQrs., Nagpur retired on superannuation on 31.07.2019
- Smt. Sunita Das, Asstt. Chief Technical Officer (T-7-8), Regional Centre, Kolkata retired on superannuation on 31.08.2019
- Sh. Arvind Kumar, Asstt. Chief Technical Officer (T-7-8), Regional Centre, New Delhi retired on superannuation on 31.08.2019
- Sh. N.C. Saikia. Skilled Supporting Staff, Regional Centre, Jorhat retired on superannuation on 31.10.2019
- Sh. R.K. Dutta, Technical Officer (T-5) Regional Centre, Kolkata retired on superannuation on 31.10.2019
- Dr. T.K. Sen, Principal Scientist & Acting Head, Division of Land Use Planning, Nagpur retired on superannuation on 30.11.2019
- Sh. V.R. Vinchurkar, Technical Assistant (T-3), Sales and Publication Section, Nagpur retired on superannuation on 30.11.2019
- Sh. Someswar Das, Technical Assistant (T-3), Regional Centre, Jorhat retired on superannuation on 30.11.2019
- Sh. S. Islam, Senior Technical Assistant (T-4), Regional Centre, Kolkata retired on superannuation on 31.12.2019

STAFF MOVEMENT

- Dr. (Smt.) Nisha Sahu, Scientist, Division of RSA, Nagpur transferred to ICAR-IISS, Bhopal, relieved from the Bureau on 29.11.2019

PROMOTIONS

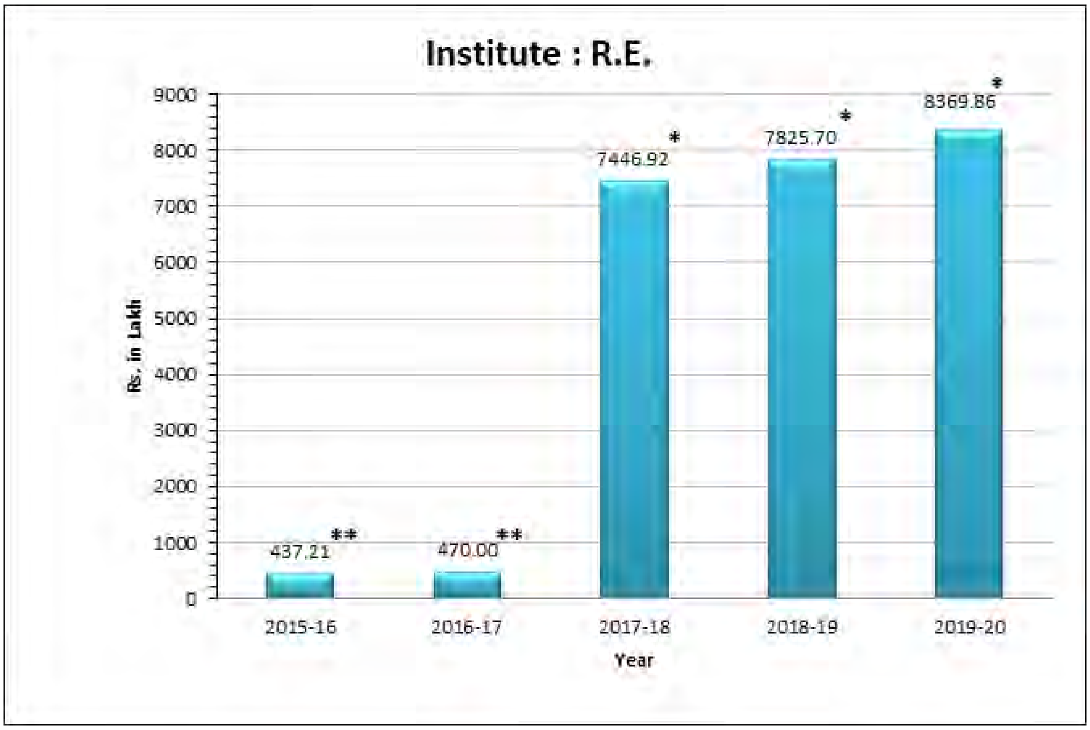
The following officials are promoted to the next higher grade in 2019-20

- Sh. Nirmal Kumar, Scientist, Division of RSA, Nagpur (RGP 8000 – Pay Level-12)
- Dr. Shilton Padua, Scientist, Regional Centre, Jorhat (RGP 7000 – Pay Level-11)
- Dr. P.C. Moharana, Scientist, Regional Centre, Udaipur (RGP 7000 – Pay Level-11)
- Dr. Prasanjit Ray, Scientist, Regional Centre, Jorhat (RGP 7000 – Pay Level-11)
- Dr. Ram Swaroop Meena, Scientist, Regional Centre, Udaipur (RGP 7000 – Pay Level-11)
- Dr. (Mrs.) M. Chandrakala, Scientist, Regional Centre, Bangalore (RGP 7000 – Pay Level-11)
- Sh. Ashok Kumar, Scientist, Regional Centre, New Delhi (RGP 7000 – Pay Level-11)
- Sh. Vikas, Scientist, Regional Centre, New Delhi (RGP 7000 – Pay Level-11)
- Sh. A.P. Tembhurnikar, Asstt. Admn. Officer, HQrs., Nagpur (GP 4600 – Pay level-7)
- Sh. U.S. Kapse, Assistant, HQrs., Nagpur (GP 4200 – Pay Level-6)
- Smt. Shalu Nandanwar, Assistant, HQrs., Nagpur (GP 4200 – Pay Level-6)
- Sh. B.R. Meena, Sr. Technical Assistant, Regional Centre, Udaipur (GP 4200 – Pay Level-6)
- Sh. Manish Choudhary, Senior Technician (T-2), Regional Centre, Udaipur(GP 2400 – Pay Level-4)
- Sh. Atul Dankhade, Senior Technician (T-2), Division of RSA, Nagpur(GP 2400 – Pay Level-4)

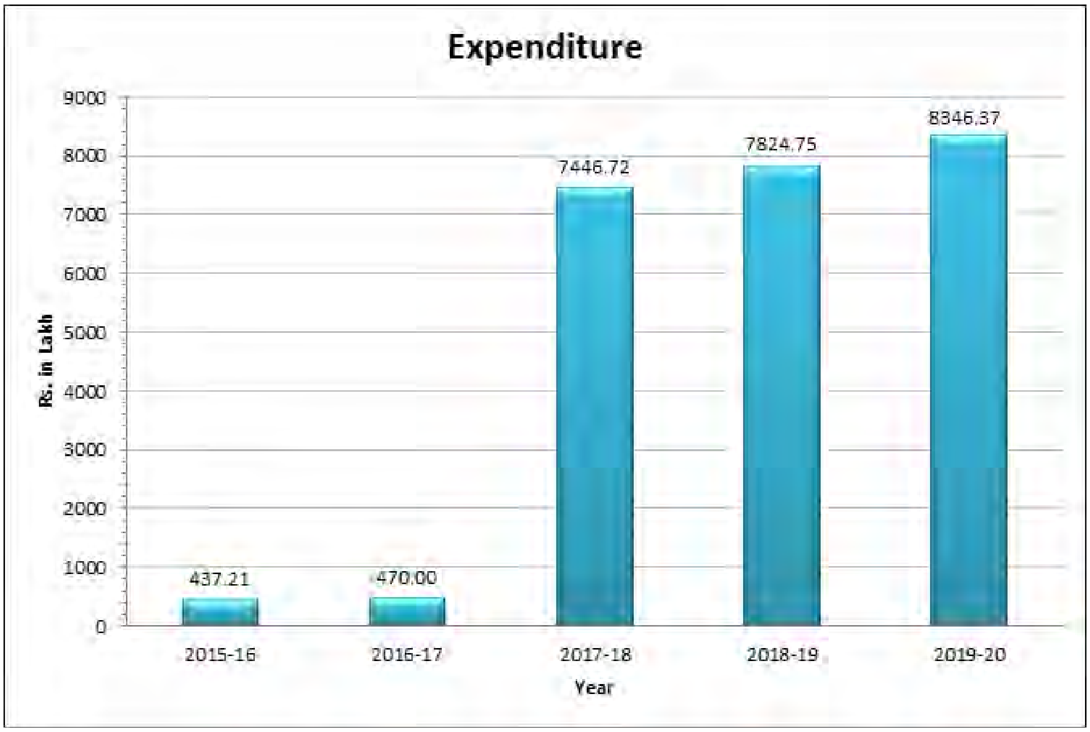
DECEASED

- Sh. S.C. Gharami, Senior Technical Officer (T-6), Regional Centre, Jorhat expired on 31.07.2019

14 BUDGET



* Institute Grants ** Plan Grants (Excluding Salary & Pension)



ICAR-NBSS&LUP IN MEDIA

TheHitavada

Nagpur City Line | 2019-08-10 | Page- 12

'Mah, Rajasthan are setting example for water mgmt'

By Kaushik Bhattacharya

"IT IS the peak time when we have to reduce our dependancy over monsoon for agriculture. Maharashtra and Rajasthan must be role models for other states for water management in agriculture," said Dr Trilochan Mohapatra, Secretary, Department of Agricultural Research and Education (DARE) and Director General, Indian Council of Agriculture Research (ICAR) while talking to The Hitavada on Friday.

Dr Mohapatra was in the city to attend ICAR-Regional Committee meeting that held at ...

Dr Trilochan Mohapatra

... the era of global warming," stated ICAR chief.

Dr Mohapatra emphasised on rain-water harvesting for better agriculture and urged stakeholders and researchers to do more work in this re...

'Valley needs private investment in agriculture sector'

"JAMMU and Kashmir has tremendous scope in agriculture sector. Private companies and farmers should have come forward to promote agricul...

नागपुर भास्कर

कृषि के विकास में पूरक व्यवसाय अहम

- भारतीय कृषि अनुसंधान परिषद की कार्यशाला

NAGPUR TIMES

Making farm soil health cards using satellite can save crores

... ber of health cards in less ... the bureau's ... 000 cards were ... the Kelapur ... after interpo... ,000 farmers ...

... reparing one ..., as fixed by ..., is ₹190. Go... rice, making ... uld cost aro...

गोमन्तक

शेतजमिनींबाबतचा अहवाल कृषी खात्याने स्वीकारला

NAGPUR TIMES

'India's land use tech far better, farmers need not end lives'

Oilseeds production likely to see major boost in 4 years

AFTER PULSES, OIL'S NEXT

- +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 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 Dist. (Chhattisgarh), NBSS Publ.95. ISBN:81-85460-73-6.
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- +Soils of Puruliya Dist. West Bengal for Optimizing Land Use. NBSS Publ.599 (SSR), 2010.
- *Land Resources of Medak Dist. Andhra Pradesh for Land Use Planning. NBSS Publ.791(SSR), 2005
- *Soil Resource data of Patiala Dist. of Punjab for perspective land use planning, NBSS Report No.795, 2004
- *Soil Resource for Land Use Planning, Balaghat Dist. (M.P.) NBSS Publ.827(SSR), 2005
- *Management of Acid Soils in NEH Region. NBSS Publ.909 (SSR), 2006
- +Planning and management of land resources. NBSS Report No.1033, 2009
- +Soil resource information of different agro-eco subregions of India for crop and soil carbon modeling. NBSS Report No.1035, 2011
- +Generation of Soil Database for Khulgad Watershed Development in Almora Dist. Uttarakhand, NBSS Report No.1043, 2014.
- +Reconnaissance Soil survey of Yavatmal Dist., Maharashtra, India. NBSS Report No.1059, 2015.
- +Georeferenced Soil Information System for Land Use Planning and Monitoring Soil and Land Quality for Agriculture, NBSS Report No. 1074, 2014.
- +Soil Nutrient Mapping of Nagaland, NBSS Report No. 1080, 2014
- +Soil Nutrient Mapping of Sikkim, NBSS Report No. 1086, 2016

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