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Annual Report

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नागपुर – 440 033

ICAR-National Bureau of Soil Survey and Land Use Planning
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Compilation and Editing
Director and Scientists
ICAR-National Bureau of Soil Survey and Land Use Planning

Technical Assistance
S.S. Nimkhedkar
A.P. Nagar

Layout and design
Prakash Ambekar

Word Processing
Wasudha Khandwe
Rohini Watekar
Nilofar Sheikh

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For further information and to obtain copies of this report, please write to:

Director
ICAR-National Bureau of Soil Survey and Land Use Planning
Amravati Road, NAGPUR-440033

Tel.: (0712) 2500386; 2500226; 2500545; 2500664, Telefax : +91(0)712-2500534
E-mail : director.nbsslup@icar.gov.in,
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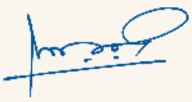
PREFACE

As the conditions improved after severe pandemic crisis, the ICAR-National Bureau of Soil Survey and Land Use Planning adopted hybrid approach to meet its objectives of land resource inventorization. Using the legacy data and the data provided by Soil and Land Use Survey of India, land resource inventory (LRI) of 14 districts in the Bundelkhand region was built to identify unrepresented areas. These unrepresented parts were surveyed using conditional latin hypercube sampling to identify soil profile study sites and later digital soil mapping was used to generate thematic soil properties maps. Later, soil and water conservation plan, crop suitability evaluation, and land use plan (LUP) for the Bundelkhand was prepared based on the LRI. Similarly, LRI & LUP of 11 districts in Vidarbha region of Maharashtra was completed. Thus, Digital Soil Mapping has been adopted by the Bureau to hasten the pace of LRI, while reducing time and resources/expenses. These two reports have been shared with the concerned state agencies for utilization in development planning.

The Bureau entered into an agreement with Govt. of Maharashtra to support its Project on Climate Resilient Agriculture in 4500 villages. The agreement follows commendable work done earlier by the scientists in 500 villages located in 15 different districts. Similarly, Karnataka and Odisha Governments signed an MoU with the Bureau for land resource inventory work under the project "Rejuvenating Watershed for Agriculture Resilience through Innovative Development".Other states like Bihar, Chhattisgarh, Jharkhand and Rajasthan have also evinced interest and sought technical expertise. Few other notable developments during 2022 are (i) initiating digital soil archives system, (ii) spectral signature library, and (iii) enrichment of BHOOMI Web Portal to disseminate soil information.

I express my sincere gratitude to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR and Dr. Himanshu Pathak, who succeeded Dr. Mohapatra for their leadership and guidance throughout the year. Deputy Director General (NRM), Dr. S.K. Chaudhari is profusely thanked for constant encouragement of the Bureau staff especially in achieving LRI of Vidarbha and Bundelkhand region within a short period of 8 months. ADG (S&WM) and staff of the NRM division at the HQ is thanked for smooth flow of information between the Bureau and ICAR Headquarters. My scientists and other colleagues deserve a special appreciation for their special efforts throughout the year.



(B S Dwivedi)
DIRECTOR

Place: Nagpur

Date: December, 2022

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EXECUTIVE SUMMARY

The need for faster acquisition of soil information and the proven utility of Remote Sensing technologies and Geographic Information System (GIS) has seen global acceptance of new techniques in soil surveys. ICAR-NBSS&LUP deployed a mix of these techniques to hasten the soil data acquisition in the Bundelkhand region (14 districts) spread in the states of Uttar Pradesh and Madhya Pradesh using legacy data, surveying blind spots (unrepresented areas for which no soil information is available), and digital soil mapping (DSM) in collaboration with Soil and Land Use Survey of India. Spatial distribution maps of nine key soil properties, *viz.*, depth, pH, EC, Soil Organic Carbon (SOC), $CaCO_3$, sand, silt, clay, and available water capacity (AWC) across six standard depths as per global soil map specifications at high resolution (30m) were generated. Soil and water conservation plans, land suitability assessment for 20 major crops grown in the region using the analytical hierarchical process (AHP), and crop suitability maps were generated in the GIS environment. The results showed that the Bundelkhand soils are low in SOC, clay, available N, and AWC. Land use options were suggested for the region.

Further, land degradation in the Bundelkhand region was assessed using a modified Global Assessment of Land Degradation and Improvement method based on time series analysis. Nearly 53% area is assessed to be degraded owing to sheets/rills/gullies/ravines erosion. Further, 95% of the ravines area in the Bundelkhand is located in Uttar Pradesh part of the region, mainly in the adjoining areas of Jhansi, Jalaun and Banda districts. The status of desertification and land degradation in the states of Karnataka, Andhra Pradesh, and Telangana was estimated using IRS AWiFS data from 2018-19.

DSM for five regions of Maharashtra was initiated during the year. Digital terrain analysis and characterization of landforms in different regions of Maharashtra, *viz.*, Vidarbha, Marathwada, Western Maharashtra, North Maharashtra and Konkan regions were carried out. The terrain parameters, *viz.*, contour, slope, drainage, aspect, hill shade, plan curvature, profile curvature and total curvature were generated from SRTM DEM (30 m) for the five regions. The conditioned latin hypercube sampling model was used to identify 220 profile study sites across the Vidarbha region, and digital maps of soil properties were generated. Further, 300 sampling points for Western Maharashtra, 250 for the North Maharashtra region and 340 for the Marathwada region were generated. DSM using AVIRIS-NG data was employed to predict SOC, available P, and available K in the Chhindwara and Chamrajnagar districts of Madhya Pradesh and Karnataka, respectively. Similarly, SOC, soil depth (Barmer district), and soil salinity (Suratgarh tehsil) were determined using the quantile regression forest (RF) algorithm. Terrain mapping units (TMU) of ten selected aspirational districts *viz.*, Baran (Rajasthan), Barwani (Madhya Pradesh), YSR Kadapa (Andhra Pradesh), Fatehpur (Uttar Pradesh), Khammam (Telangana), Mewat (Haryana), Moga (Punjab), Osmanabad (Maharashtra), Raichur (Karnataka) and Ramanathapuram (Tamil Nadu) were developed by superimposing physiography, sub-physiography, broad landforms, landform units, slope and land use/ land cover themes in GIS. Landform identification and mapping have been completed for 19 aspirational districts of Jharkhand.

Reflectance spectra of 3691 soil samples from different districts of Maharashtra, Madhya Pradesh and Gujarat were generated. The partial least square regression models showed higher accuracy (r^2, RMSE and RPD values) in predicting clay content, pH, SOC and $CaCO_3$. The most relevant wavelengths for differentiating soil properties in the soils of the study area were found to be 560 and 1900 nm for clay, 2220 nm for pH, 2250 and 480 nm for SOC, and 380 and 420 nm for $CaCO_3$.

A total of 66 soil series were identified from Yavatmal district, 15 and 12 from the Seloo and Samudrapur tehsils of the Wardha district from large-scale LRI. Similarly, 18 series from Andaman and Nicobar Islands, 18 from the Katihar district, 24 from the Bolangir district, and one from the Hazaribagh district were recognized. Eleven soil series from Arunachal Pradesh were identified for the North Eastern Region. The Southern Region had 42 soil series documented

and mapped. Additionally, in the Western Region, 35 soil series were identified. LRI of Arunachal Pradesh state was continued during the reporting year. Longding district is mapped into 10 soil series with 16 phases. The TMUs were delineated for the districts *viz.*, Kamle (50), Kurung Kumey (40), Leparada (51), Lower Subansiri (42), Upper Subansiri (56), Shiyomi (17), and West Siang (54). Similarly, 49 TMUs were delineated for Mandi district of Himachal Pradesh. A total of 8 and 7 soil series were identified and mapped in Rangjuli block of Goalpara district and Baska block of Baska district, Assam, respectively. LRI in Sahibganj district of Jharkhand was completed and mapped into 31 series and 48 phases. Similarly, 56 series were identified and mapped into 59 phases in Maldah district of West Bengal. LRI of four divisions of Forest Development Corporation of Maharashtra, namely Chandrapur, Yavatmal, Markhanda, and Pranhita, covering 10 ranges and 28 compartments were carried out in 1115 ha area. Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD) programme in Odisha is supported by this Bureau through LRI and technical backstopping. A launching workshop cum training on LRI was conducted at Sambalpur for the project officials from the Department of Soil Conservation and Watershed Development and other line departments of the Odisha Government and Odisha University of Agriculture and Technology. Similarly REWARD programme is also being supported in Karnataka. The climate resilience project in Maharashtra, spanning more than 4500 villages (scattered in 15 districts), entered its second phase as the Bureau extended earlier investigations in 500 villages to generate soil information through DSM. LRI of 1500 villages was completed during the year.

A total of 442 Vertisol soil profile data was compiled from 9 different agroecological regions (AER) to study their pedodiversity. The depth of the Vertisols varied from shallow (37 cm) to very deep (>150 cm), with a mean depth of 133 cm across the AERs. The soil depth varied considerably (37-160 cm) in AER 6, 10 and 12, whereas the Vertisols of AERs 7 and 11 did not vary significantly in depth. Semi-quantitative estimation of Fe-Mn nodules, pedogenic carbonate, non-pedogenic carbonate, voids, and weatherable minerals present in humid tropical climate to arid dry climate indicated variability from surface to subsurface soils. The iron nodules in different forms indicated a nearly complete transformation from ferrous to ferric, showing the impact of climate change. The morphological data of Godavari Delta soils in Andhra Pradesh was used to evaluate pedogenic variations in the colour of matrix and textural layers. Numerical and clustering techniques were used to identify facies of soil patterns that can be used as carriers of pedo-hydrological dataset to define internal drainage.

SOC sequestration map of India was simulated under different scenarios *viz.*, Business as Usual, Low: 5 per cent increase in C input, Medium: 10 per cent increase in C inputs, High: 20 per cent increase in C inputs as a part of Global SOC Sequestration Potential Map. Soil carbon sequestration potential (CSP) was mapped using a Random Forest (RF) regression algorithm over two depth ranges (0-30 cm and 0-100 cm) in parts of the Western Ghats, Kerala, India, using 150 soil profile data. Higher CSP was observed for soils of annual crops (18.7 kg m^{-2}) compared to soils of plantation (10.4 kg m^{-2}) and forest land use (9.5 kg m^{-2}). Four machine learning algorithms, namely RF, Support Vector Machine (SVM), Cubist and Artificial Neural Network (ANN) were compared for the prediction of SOC stock and CSP using 99 soil profiles data collected in Vemagal Hobli, Kolar district. RF model performed better than SVM, Cubist and ANN by explaining the variability of 28.3% and 28.3% in the prediction of SOC stock and CSP, respectively. Total carbon stocks (above-ground biomass carbon, below-ground biomass carbon, and SOC) were estimated by collecting samples from selected restoration sites of Pench National Park. The total carbon stock of 0-30 cm (biomass + soil) was highest at 13036 kg/1024 m^2. The estimated SOC stock and CSP in the mango orchard ranged from 4.0 to 18.3 kg m^{-2} and 12.8 to 34.7 kg m^{-2}, respectively, in mango-growing soils of Kolar district, Karnataka. The soil fertility and suitability of the Nagpur and Bhandara forests were assessed to recommend appropriate interventions for restoring the forest ecosystem. Thematic maps for soil properties such as pH, OC, available N, P, K, Zn, calcium carbonate, surface texture, and erosion were generated for eleven blocks in the Maldah district's lower Indo-Gangetic plains.

An online application and an Android mobile application were created under the Indian National Soil Archive project. The project seeks to gather and preserve processed soil samples, along with their soil-site characteristics, morphological and physico-chemical properties in digital form that can be retrieved with the use of a quick response code generated for each sample box. Numerous web apps and dashboards have been created using the BHOOMI Geoportal version 2.0 platform to rapidly catalogue, retrieve, query, and visualize geospatial data. Annual climatic indices, *viz.*, aridity index, humidity index and moisture index, were generated using potential evapotranspiration, and accumulated water potential loss to develop spatial models for delineation of agro-ecological zones of India.

Potential zones for 71 different crops in Telangana were delineated based on relative crop yield, relative crop spread/area, legacy soil information and climate data in collaboration with Professor Jayashankar Telangana State Agricultural University, Hyderabad. Soil suitability maps for pomegranate for 15 states have been modified using the revised climate, terrain and soil parameters in the GIS-based multi-criteria model in collaboration with ICAR-National Research Centre for Pomegranate, Solapur. Similarly, the delineation of potential areas for soybean cultivation in India was initiated in collaboration with the Indian Institute of Soybean Research, Indore. Further, suitable areas for 6 major crops of the Vidarbha region (*i.e.,* rice, soybean, maize, cotton, citrus and gram) were demarcated using an integrated approach of AHP and GIS. About 34.4% (20,91,917 ha) is highly suitable, 34.3% (20,89,576 ha) is moderately suitable, and 31.3% (19,06,244 ha) is marginally or not suitable for cultivating the above crops. The study showed that the high potential zone for *kharif* crops (rice, maize, soybean and cotton) is 33% (20,02,964 ha). About 23,68,264 and 21,51,418.5 ha are suitable for *rabi* gram and citrus cultivation, respectively.

Soil site suitability criteria for major crops were revised using the rainfall, temperature, soil depth, soil texture, soil pH, drainage, erosion, slope, elevation and soil $CaCO_3$ data collected from different locations for rice, soybean, red gram, mango and grapes crops. Soil depth, drainage and texture were found to influence the productivity of mango, whereas soil depth and texture influence the productivity of grapes, red gram and soybean. Rainfall, soil depth and texture were key for rice productivity in upland conditions, the system of rice intensification and aerobic situation. Soil suitability in the Mathura district was evaluated and mapped for 15 major crops, and suitable land use options were suggested. Similarly, alternate land use options were suggested for the cinchona and other medicinal plant growing areas of the Darjeeling and Kalimpong districts of West Bengal. A study in Vattavada and Marayoor gram panchayats in the Idukki district, Kerala indicated that the soils are acidic, rich in organic carbon, available P, and deficient in boron. In Vattavada, banana is the most suitable for cultivation, and large areas in Marayoor are highly suitable for potato, cassava, coffee, areca nut and banana. A spatial crop plan for sustainable resource use and conservation of ecological resources in high-range mountain landscapes was proposed.

The year 2022 could be considered a year of digital initiatives. The DSM and land use planning of Vidarbha and Buldelkhand regions sets a precedent for more regional and national level products to facilitate the stakeholders for implementing sustainable agriculture practices in the country. Further, substantial progress has been made in creating a national soil archive, soil spectral library and enhancement of BHOOMI – Geoportal, which holds promise to enhance data availability and accessibility.

कार्यकारी सारांश

मृदा की जानकारी के तेजी से अधिग्रहण की आवश्यकता और रिमोट सेंसिंग प्रौद्योगिकियों और भौगोलिक सूचना प्रणाली (जीआईएस) की सिद्ध उपयोगिता ने मृदा सर्वेक्षण में आधुनिक तकनीकों की वैश्विक स्वीकृति देखी गई है।

ब्यूरो ने उत्तर प्रदेश और मध्य प्रदेश राज्यों में फैले बुन्देलखंड क्षेत्र के 14 जिलों में मृदा के डेटा अधिग्रहण में तेजी लाने के लिए इन तकनीकों का उपयोग विरासती डेटा की मदद से किया गया तथा भारतीय मृदा एवं भूमि उपयोग सर्वेक्षण के सहयोग से ब्लाइंड स्पॉट (अप्रतिनिधित्व वाले क्षेत्र जिनके लिए कोई मिट्टी की जानकारी उपलब्ध नहीं है) का सर्वेक्षण और डिजिटल मृदा मानचित्रण (डीएसएम) किया गया है।

उच्च रिज़ॉल्यूशन (30 मी) पर आधारित वैश्विक मृदा मानचित्र विनिर्देशों के अनुसार छः मानक गहराइयों में नौ प्रमुख मृदा गुणों जैसे गहराई, पीएच, ईसी, मृदा जैविक पदार्थ (एसओसी), कैल्शियम कार्बोनेट, बालू, सिल्ट, क्ले और उपलब्ध जल क्षमता (एडब्ल्यूसी) के स्थानिक वितरण के मानचित्र ज़ारी किये गए।

जीआईएस के तहत विश्लेषणात्मक पदानुक्रमित प्रक्रिया (एएचपी) का उपयोग करते हुए मृदा और जल संरक्षण योजनाएं, विदर्भ क्षेत्र में उगाई जाने वाली बीस प्रमुख फसलों के लिए भूमि उपयुक्तता और फसल उपयुक्तता मानचित्र तैयार किए गए। परिणामों से पता चला कि बुन्देलखण्ड की मृदाओं में एसओसी, क्ले,नत्रजन, और एडब्ल्यूसी कम है। बुन्देलखण्ड क्षेत्र के लिए वैकल्पिक भूमि उपयोग के विकल्प भी सुझाए गए। साथ ही, बुंदेलखंड क्षेत्र के भूमि क्षरण मानचित्र समय श्रृंखला विश्लेषण के आधार पर भूमि क्षरण और सुधार पद्धति के संशोधित वैश्विक मूल्यांकन का उपयोग करके किया गया।

अनुमान है कि लगभग 53% क्षेत्र सीट/रीलों/नालों/खड्डों के कटाव के कारण नष्ट हो गया है। इसके अलावा, बुन्देलखण्ड का 95% बीहड़ क्षेत्र उत्तर प्रदेश के मुख्यतः झाँसी, जालौन और बांदा जिलों के निकटवर्ती क्षेत्रों में स्थित है, तथा कर्नाटक, आंध्र प्रदेश और तेलंगाना राज्यों में मरुस्थलीकरण और भूमि क्षरण की स्थिति का अनुमान 2018–19 के आईआरएस AWiFS डेटा का उपयोग करके लगाया गया।

इस वर्ष के दौरान महाराष्ट्र के पांच क्षेत्रों जैसे कि विदर्भ, मराठवाड़ा, पश्चिमी महाराष्ट्र, उत्तरी महाराष्ट्र और कोंकण क्षेत्र के लिए डीएसएम का कार्य शुरू किया गया और डिजिटल भू–भाग विश्लेषण और भू–आकृतियों का लक्षण वर्णन किया गया। साथ ही पांचों क्षेत्रों के लिए एसआरटीएम डीईएम (30 मीटर) से इलाके के पैरामीटर, जैसे समोच्च, ढलान, जल निकासी, पहलू, पहाड़ी छाया, योजना वक्रता, प्रोफ़ाइल वक्रता और कुल वक्रता सृजित की गई। विदर्भ क्षेत्र में कंडीशंडलैटिन हाइपरक्यूब सैंपलिंग मॉडल का उपयोग करके 220 प्रोफ़ाइल अध्ययन स्थलों की पहचान की गई, और मिट्टी के गुणों के डिजिटल मानचित्र तैयार किए गए। इसके अलावा, पश्चिमी महाराष्ट्र के लिए 300, उत्तरी महाराष्ट्र क्षेत्र के लिए 250 और मराठवाड़ा क्षेत्र के लिए 340 नमूना बिंदु तैयार किए गए।

AVIRIS-NG डेटा के DSM का उपयोग करते हुए मध्य प्रदेश और कर्नाटक के क्रमशः छिंदवाड़ा और चामराजनगर जिलों में SOC, उपलब्ध फॉस्फोरस और उपलब्ध पोटाश का पूर्वानुमान किया गया।

इसी तरह, मृदा में अकार्बनिक कार्बन, मृदा गहराई (बाड़मेर जिला), और मिट्टी की लवणता (सूरतगढ़ तहसील) को क्वांटाइल रिग्रेशन फॉरेस्ट (आरएफ) एल्गोरिदम का उपयोग करके निर्धारण किया गया।

दस चयनित आकांक्षी जिलों जैसे बारां (राजस्थान), बड़वानी (मध्य प्रदेश), वाईएसआर कडप्पा (आंध्र प्रदेश), फतेहपुर

(उत्तर प्रदेश), खम्मम (तेलंगाना), मेवात (हरियाणा), मोगा (पंजाब), उस्मानाबाद (महाराष्ट्र), रायचूर (कर्नाटक) और रामनाथपुरम (तमिलनाडु) की भूभाग मानचित्रण इकाइयां (टीएमयू) का विकास जीआईएस में भौतिक विज्ञान, उप–भौतिकी, विस्तृत भू–आकृतियों, भू–आकृति इकाइयों, ढलान और भूमि उपयोग/भूमि आवरण विषयों को सुपरइम्पोज़ करके किया गया।

झारखंड के 19 आकांक्षी जिलों के लिए भू–आकृतियों की पहचान और मानचित्रण का काम पूरा कर लिया गया है।

महाराष्ट्र, मध्य प्रदेश और गुजरात के विभिन्न जिलों से 3691 मिट्टी के नमूनों का परावर्तन स्पेक्ट्रा तैयार किया गया। आंशिक रूप से न्यूनतम वर्ग प्रतिगमन मॉडल ने क्ले की मात्रा, पीएच, एसओसी और कैल्शियम कार्बोनेट की भविष्यवाणी के लिए उच्च सटीकता (R2, RMSE और RPD मान) दिखाई।

अध्ययन क्षेत्र की मृदा में मिट्टी के गुणों को अलग करने के लिए सबसे प्रासंगिक तरंग दैर्ध्य क्ले के लिए 560 और 1900 एनएम, पीएच के लिए 2220 एनएम, एसओसी के लिए 2250 और 480 एनएम और $CaCO_3$ के लिए 380 और 420 एनएम दर्ज की गई।

बड़े पैमाने पर भूमि संसाधन सूची से यवतमाल जिले से कुल 66 मिट्टी श्रृंखलाओं की पहचान की गई, वर्धा जिले की सेलू और समुद्रपुर तहसीलों से क्रमशः 15 और 12 की पहचान की गई। इसी तरह, अंडमान और निकोबार द्वीप समूह से 18 श्रृंखलाएं, कटिहार जिले से 18 श्रृंखलाएं, बोलांगीर जिले से 24 श्रृंखलाएं और हजारीबाग जिले से एक श्रृंखला को मान्यता दी गई। पूर्वोत्तर क्षेत्र के लिए अरुणाचल प्रदेश की ग्यारह मिट्टी श्रृंखलाओं की पहचान की गई। दक्षिणी क्षेत्र में 42 मृदा श्रृंखलाओं का दस्तावेजीकरण एवं मानचित्रण किया गया। इसके अतिरिक्त, पश्चिमी क्षेत्र में, 35 मृदा श्रृंखलाओं की पहचान की गई। रिपोर्टिंग वर्ष के दौरान, अरुणाचल प्रदेश राज्य का एलआरआई का कार्य जारी रखा गया। लोंगडिंग जिले की 10 मिट्टी श्रृंखला की मैपिंग का काम 16 चरणों में किया गया। टीएमयू का रेखांकन कमले (50), कुरुंगकुमे (40), लेपराडा (51), लोअर सुबनसिरी (42), अपर सुबनसिरी (56), शियोमी (17), और वेस्ट सियांग (54) जिलों के लिए चित्रित किया गया। इसी प्रकार, हिमाचल प्रदेश के मंडी जिले के लिए 49 टीएमयू को रेखांकित किया गया। असम के गोलपारा जिले के रंगजुली ब्लॉक और बास्का जिले के बास्का ब्लॉक में क्रमशः कुल 8 और 7 मिट्टी श्रृंखलाओं की पहचान की गई और उनका मानचित्रण भी किया गया। झारखंड के साहिबगंज जिले में एलआरआई का कार्य पूरा हो गया है और 31 श्रृंखलाओं और 48 चरणों में मैप किया गया। इसी तरह, पश्चिम बंगाल के मालदह जिले में 56 श्रृंखलाओं की पहचान की गई और उन्हें 59 चरणों में मैप किया गया। महाराष्ट्र के वन विकास निगम के चार प्रभागों– चंद्रपुर, यवतमाल, मारखंडा और प्राणहिता का एलआरआई का कार्य 10 रेंज और 28 कंपार्टमेंट को कवर करते हुए 1115 हेक्टेयर क्षेत्र में किया गया।

ब्यूरो द्वारा ओडिशा में एलआरआई और तकनीकी मदद से अभिनव विकास के माध्यम से कृषि लोचशीलता हेतु जलसंभरों का कायाकल्प" (रिवार्ड) परियोजना के तहत किया गया। मृदा संरक्षण और वाटरशेड विकास विभाग, ओडिशा सरकार और ओडिशा कृषि एवं प्रौद्योगिकी विश्वविद्यालय के परियोजना अधिकारियों के लिए संबलपुर में एलआरआई पर कार्यशाला–सह–प्रशिक्षण का शुभारंभ किया गया। इसी तरह कर्नाटक में भी रिवार्ड परियोजना के तहत कार्य किया जा रहा है।

महाराष्ट्र के15 जिलों में स्थित 4500 से अधिक गांवों में PoCRA परियोजना दूसरे चरण में प्रवेश कर गई है क्योंकि ब्यूरो ने इससे पूर्व डीएसएम के माध्यम से मृदा की जानकारी उत्पन्न करने के लिए 500 गांवों में पहले की जांच का विस्तार किया है। वर्ष के दौरान 1500 गांवों का एलआरआई पूरा किया गया।

मृदा –संबंधी विविधता (पेडोडायवर्सिटी) का अध्ययन करने के लिए 9 अलग–अलग कृषि पारिस्थितिक क्षेत्रों (एईआर) से कुल 442 वर्टिसोल मृदा प्रोफ़ाइल डेटा संकलित किया गया। आगे वर्टिसोल्स की गहराई उथली (37 सेमी) से लेकर बहुत गहरी (>150 सेमी) तक भिन्न पाई गई, और एईआर में औसत गहराई 133 सेमी दर्ज की गई। एईआर 6, 10 और 12 में मिट्टी की गहराई में काफी अंतर (37–160 सेमी) था, जबकि एईआर 7 और 11 के वर्टिसोल की गहराई में कोई खास अंतर नहीं पाया गया।

आर्द्र उष्णकटिबंधीय जलवायु से लेकर शुष्क जलवायु तक में मौजूद Fe-Mn नोड्यूल, पेडोजेनिक कार्बोनेट, गैर–पेडोजेनिक कार्बोनेट, रिक्त स्थान और मौसम योग्य खनिजों का अर्ध–मात्रात्मक अनुमान, सतह से उपसतह मिट्टी तक परिवर्तनशीलता का संकेत देता है। विभिन्न रूपों में लौह पिंडों ने जलवायु परिवर्तन के प्रभाव को दर्शाते हुए फेरस से फेरिक में लगभग पूर्ण परिवर्तन का संकेत दिया है। आंध्र प्रदेश में गोदावरी डेल्टा मृदा के रूपात्मक डेटा का उपयोग मैट्रिक्स और बनावटी परतों के रंग में पेडोजेनिक विविधताओं का मूल्यांकन करने के लिए किया गया था। संख्यात्मक और क्लस्टरिंग तकनीकों का उपयोग मृदा के पैटर्न की विशेषताओं की पहचान करने के लिए किया गया था जिनका उपयोग आंतरिक जल निकासी को परिभाषित करने के लिए पेडो–हाइड्रोलॉजिकल डेटासेट के वाहक के रूप में किया जा सकता है।

भारत का मृदा कार्बनिक कार्बन (एसओसी) सीक्वेस्ट्रेशन मानचित्र विभिन्न परिदृश्यों के तहत तैयार किया गया। जैसे सामान्य रूप से व्यवसाय, निम्नः सी इनपुट में 5 प्रतिशत की वृद्धि, मध्यमः सी इनपुट में 10 प्रतिशत की वृद्धि, उच्चः ग्लोबल एसओसी सीक्वेस्ट्रेशन के एक भाग के रूप में सी इनपुट में 20 प्रतिशत की वृद्धि के संभावित मानचित्र तैयार किये गए हैं।

केरल के पश्चिमी घाट के कुछ हिस्सों में, एक यादृच्छिक वन (आरएफ) प्रतिगमन एल्गोरिदम का उपयोग करके मृदा कार्बन पृथक्करण क्षमता (सीएसपी) को 150 मिट्टी के प्रोफ़ाइल डेटा के नामूनो के आधार पर, दो गहराई सीमाओं (0–30 सेमी और 0–100 सेमी) पर मैप किया गया।

वृक्षारोपण की मिट्टी (10.4 किग्रा मी^{2}) और वन भूमि उपयोग (9.5 किग्रा मी^{2}) की तुलना में वार्षिक फसलों (18.7 किग्रा मी^{2}) की मिट्टी के लिए उच्च सीएसपी देखा गया। कोलार जिले के वेमागलहोबली में 99 मृदा प्रोफाइल डेटा का उपयोग करके चार मशीन लर्निंग एल्गोरिदम, अर्थात् आरएफ, सपोर्ट वेक्टर मशीन (एसवीएम), क्यूबिस्ट और आर्टिफिशियल न्यूरल नेटवर्क (एएनएन) एसओसी स्टॉक और सीएसपी का तुल्नात्मक अध्यन्न किया गया। आरएफ मॉडल ने एसओसी स्टॉक और सीएसपी की भविष्यवाणी में क्रमशः 28–32% और 28–33% एसवीएम, क्यूबिस्ट और एएनएन से बेहतर प्रदर्शन किया।

पेंच नेशनल पार्क के चयनित पुनर्स्थापन स्थलों से नमूने एकत्र करके कुल कार्बन स्टॉक (जमीन के ऊपर बायोमास कार्बन, जमीन के नीचे बायोमास कार्बन और एसओसी) का अनुमान लगाया गया। 0–30 सेमी (बायोमास + मिट्टी) का कुल कार्बन स्टॉक 13036 किग्रा/1024 एम2 पर उच्चतम था। कर्नाटक के कोलार जिले की आम के बगीचे वाली मृदा में अनुमानित एसओसी स्टॉक और सीएसपी क्रमशः 4.0 से 18.3 किलोग्राम मी–2 और 12.8 से 34.7 किलोग्राम मी–2 तक दर्ज की गई।

वन पारिस्थितिकी तंत्र को बहाल करने के लिए उचित हस्तक्षेप की सिफारिश करने के लिए नागपुर और भंडारा जंगलों की मिट्टी की उर्वरता और उपयुक्तता का आकलन किया गया। मालदह जिले के निचले सिंधु–गंगा के मैदानों में ग्यारह ब्लॉकों के लिए मिट्टी के गुणों जैसे पीएच, ओसी, उपलब्ध नाइट्रोजन, फॉस्फोरस और पोटाश, जिंक, कैल्शियम कार्बोनेट, सतही मृदा कणाकार और कटाव के लिए विषयगत मानचित्र तैयार किए गए।

भारतीय राष्ट्रीय मृदा पुरालेख परियोजना के तहत एक ऑनलाइन एप्लिकेशन और एक एंड्रॉइड मोबाइल एप्लिकेशन बनाया गया। यह परियोजना संसाधित मृदा नमूनों को उनकी मृदा–स्थल विशेषताओं, रूपात्मक और भौतिक–रासायनिक गुणों के साथ डिजिटल रूप में इकट्ठा और संरक्षित करने का प्रयास करती है, जिसे प्रत्येक नमूना बॉक्स के लिए उत्पन्न त्वरित प्रतिक्रिया कोड के उपयोग से प्राप्त किया जा सकता है। भू–स्थानिक डेटा को तेजी से सूचीबद्ध करने, पुनर्प्राप्त करने, क्वेरी करने और विजुअलाइज़ करने के लिए BHOOMI जियोपोर्टल संस्करण 2.0 प्लेटफ़ॉर्म का उपयोग करके कई वेब ऐप्स और डैशबोर्ड बनाए गए हैं। भारत के कृषि–पारिस्थितिकी क्षेत्रों के चित्रण के लिए स्थानिक मॉडल विकसित करने के लिए संभावित वाष्पीकरण और संचित जल संभावित हानि का उपयोग करके वार्षिक जलवायु सूचकांक, अर्थात शुष्कता सूचकांक, आर्द्रता सूचकांक और नमी सूचकांक तैयार किए गए है।

पंडित जयशंकर तेलंगाना राज्य कृषि विश्वविद्यालय, हैदराबाद के सहयोग से सापेक्ष फसल उपज, सापेक्ष फसल प्रसार/क्षेत्र, विरासती मिट्टी और जलवायु डेटा के आधार पर तेलंगाना में 71 फसलों के लिए संभावित क्षेत्रों को रेखांकित किया गया। 15 राज्यों में उगाए जाने वाले अनार के मृदा उपयुक्तता मानचित्रों को आईसीएआर–राष्ट्रीय अनार अनुसंधान केंद्र, सोलापुर के सहयोग से जीआईएस–आधारित बहु–मानदंड मॉडल में संशोधित जलवायु, इलाके और मृदा के मापदंडों का उपयोग करके संशोधित किया गया है। इसी प्रकार, भारतीय सोयाबीन अनुसंधान संस्थान, इंदौर के सहयोग से देश में सोयाबीन की खेती के लिए संभावित क्षेत्रों का चित्रण शुरू किया गया। इसके अलावा, विदर्भ क्षेत्र की छह प्रमुख फसलों (चावल, सोयाबीन, मक्का, कपास, निम्बू वर्गीय फसलें और चना) के लिए उपयुक्त क्षेत्रों को एएचपी और जीआईएस के एकीकृत दृष्टिकोण का उपयोग करके सीमांकित किया गया। उपरोक्त फसलों की खेती के लिए लगभग 34.4% क्षेत्रफल (2091917 हेक्टेयर) अत्यधिक उपयुक्त है, 34.3% (2089576 हेक्टेयर) मध्यम रूप से उपयुक्त है, और 31.3% (1906244 हेक्टेयर) मामूली रूप से उपयुक्त है याउपयुक्त नहीं है। अध्ययन से पता चला कि खरीफ फसलों (चावल, मक्का, सोयाबीन और कपास) के लिए उच्च संभावित क्षेत्र 33% (2002964 हेक्टेयर) है। लगभग 23,68,264 और 21,51,418.5 हेक्टेयर भूमि क्रमशः रबी चना और नींबू की खेती के लिए उपयुक्त है।

चावल, सोयाबीन, अरहर, आम और अंगूर के लिए विभिन्न स्थानों से एकत्रित वर्षा, तापमान, मृदा गहराई, मृदा कणाकार, पीएच, जल निकासी, कटाव, ढलान, ऊंचाई और $CaCO_3$ डेटा का उपयोग करके प्रमुख फसलों के लिए मृदा उपयुक्तता मानदंड को संशोधित किया गया। मृदा गहराई, जल निकासी और मृदा कणाकार आम की उत्पादकता को प्रभावित करती है, जबकि मृदा गहराई और मृदा कणाकार अंगूर, अरहर और सोयाबीन की उत्पादकता को प्रभावित करती है। यह पाया गया कि अपलैंड धान की उत्पादकता वर्षा, मृदा गहराई और मृदा कणाकार से प्रभावित होती हैं

मथुरा जिले में मिट्टी की उपयुक्तता का मूल्यांकन किया गया और 15 प्रमुख फसलों के लिए मानचित्रण किया गया, और उपयुक्त भूमि उपयोग विकल्प सुझाए गए। इसी तरह, पश्चिम बंगाल के दार्जिलिंग और कलिम्पोंग जिलों के सिनकोना और अन्य औषधीय पौधे उगाने वाले क्षेत्रों के लिए वैकल्पिक भूमि उपयोग विकल्प सुझाए गए। इडुक्की जिले में वट्टावडा और मरयूर ग्राम पंचायतों में एक अध्ययन से संकेत मिला कि मिट्टी अम्लीय, जैविक कार्बन से भरपूर, उपलब्ध फॉस्फोरस और बोरॉन की कमी पाई गई। वट्टावाड़ा केले की खेती के लिए सबसे उपयुक्त पाया गया, और मरयूर के बड़े क्षेत्र आलू, कसावा, कॉफी, सुपारी और केले के लिए अत्यधिक उपयुक्त पाए गए। उच्च श्रेणी के पहाड़ी परिदृश्यों में टिकाऊ संसाधन उपयोग और पारिस्थितिक संसाधनों के संरक्षण के लिए एक स्थानिक फसल योजना प्रस्तावित की गई।

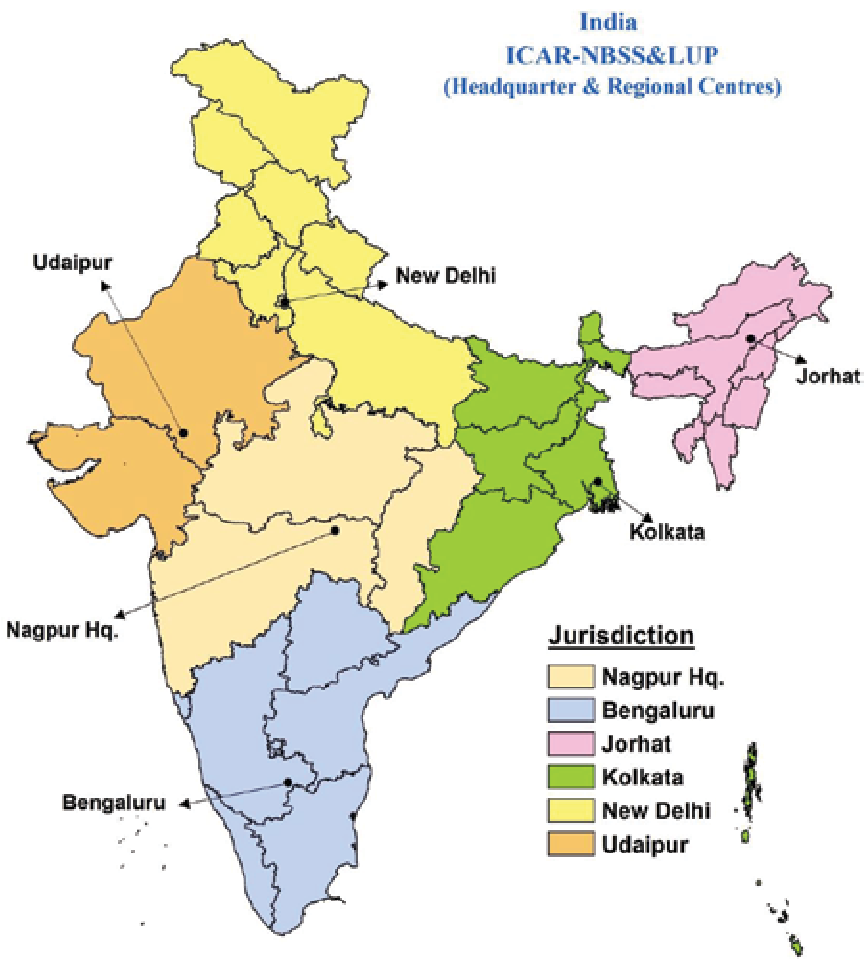
वर्ष 2022 को डिजिटल पहल का वर्ष माना जा सकता है। विदर्भ और बुलदेलखंड क्षेत्रों की डीएसएम और भूमि उपयोग योजना देश में स्थायी कृषि प्रथाओं को लागू करने के लिए हितधारकों को सुविधा प्रदान करने के लिए क्षेत्रीय और राष्ट्रीय स्तर के ज्यादा उत्पादों के लिए एक मिसाल कायम की। इसके अलावा, राष्ट्रीय मृदा संग्रह, मृदा वर्णक्रमीय पुरालेख बनाने और भूमि– जियोपोर्टल को बढ़ाने में पर्याप्त प्रगति हुई, जो कि डेटा उपलब्धता बढ़ाने में महत्वपूर्ण रही हैं।

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 are located at Bangalore, Delhi, Jorhat, Kolkata and Udaipur to address region-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 mandated tasks.

The Bureau is the country's only 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



NAGPUR (Headquarters)
Director, ICAR-NBSS&LUP,
Amravati Road, Nagpur-440 033
Tel. : 0712-2500386, 2500534
E-mail : director.nbsslup@icar.gov.in

BANGALURU
Regional Head, ICAR-NBSS&LUP
Regional Centre, Hebbal,
Bangalore-560 024
Tel. : 080-23412242, 23415683
E-mail : hd_rcb.nbsslup@icar.gov.in

JORHAT
Regional Head, ICAR-NBSS&LUP Regional Centre, Jamuguri Road, Rawriah,
Jorhat-785 004
Tel. : 0376-2311358
E-mail : hd_rcj.nbsslup@icar.gov.in

KOLKATA
Regional Head, ICAR-NBSS&LUP
Regional Centre, Sector-II, Block DK,
Salt Lake City, Kolkata-700 091
Tel. : 033-23586926, 23590727
E-mail : hd_rck.nbsslup@icar.gov.in

NEW DELHI
Regional Head, ICAR-NBSS&LUP
Regional Centre, IARI Campus, Pusa,
New Delhi-110 012
Tel. : 011-25843104, 25841624
E-mail : hd_rcd.nbsslup@icar.gov.in

UDAIPUR
Regional Head, ICAR-NBSS&LUP Regional Centre, Bohra Ganeshji Road,
University Campus, Udaipur-313 001
Tel. : 0294-2471421
E-mail : hd_rcu.nbsslup@icar.gov.in

excelled as a centre of RD&T in Soil Survey and Land Use Planning at the national and international level.

Location

The HQ is located at Nagpur. It has in its close vicinity ICAR-Central Citrus Research Institute, Ginning Training Centre a regional centre of ICAR-Central Institute for Research on Cotton Technology and Regional Remote Sensing Centre. The campus of the Bureau is also quite close to Nagpur University. The HQ, therefore, has the locational advantage which facilitates multidisciplinary studies, inter-institutional interactions and research linkages, *etc.* A map showing the location of the HQ and the five regional centres is shown on page 1.

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-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 change and growing crops out of capability domain.

Major Research Themes

- Inventorying land resources
- Remote sensing and GIS applications
- Basic pedological research
- Soil survey data interpretation and applications
- Land evaluation and land use planning
- IT enabled extension programme

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 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, 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 diffractometer
- Scanning Electron Microscope
- Inductively coupled Plasma – Atomic emission spectrophotometer
- Atomic Absorption Spectrophotometer
- Spectroradiometer
- Latest Remote Sensing and Geographic Information System (GIS) software
- CN Analyzer

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

Data Centre

The Data Centre houses the data generated over the years by 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 models. Data Centre is linked with its replicas maintained at the 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.icar.gov.in).

Bhoomi Geoportal

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

Major Achievements

1976-2022

The Bureau, through its journey over the last 4 decades, has every reason to feel proud of 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 (2767), blocks (339), villages (683) 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 Region (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-ecosystems 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, and strategies for arresting other forms of land degradation in India.
- Spectral characteristics of benchmark soils of India, mineral composition of dominant soils, organic carbon stock of Indian soils in general, and cold arid and hot arid region in particular, and Soil Spectral Library.
- 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, Nagaland, Sikkim. Tripura, Andhra Pradesh and Telangana, and mining the data for delineating areas 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 nutrient management and input-based land use planning
- Methodology 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 for land use planning.
- Development and updationof 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 System of Goa (LRIS Goa), and ii) Potential Crop Zone (PCZ) Mapper.
- Delineated sustainable areas for 17 crops in the country.
- Revised Agro-ecological Region (AER) map of the country
- Revised Agro-ecological Sub-regions (AESR) of the country
- Agricultural land use plan for 27 aspirational districts for NITI Aayog.

Salient Achievements (2022)

- Land Resource Inventory (LRI) was built for 19 districts in Arunachal Pradesh, 8 districts of Maharashtra, 4 districts in Uttar Pradesh, 3 districts each in Gujarat and Madhya Pradesh and 2 districts each in Rajasthan and A&N Islands.
- Hyperspectral characterization of soils and development of National Soil Spectral Library.
- Soil Suitability maps for pomegranate have been developed for 15 states.
- Delineation of potential crop zones for Agricultural Land Use Planning of Telangana State.
- LRI and LUP of Bundelkhand and Vidarbha

regions.

New initiatives

- LRI - Karnataka / Odisha (REWARD Program) rejuvenating watershed.
- LUP of Vidarbha region, Maharashtra
- LRI and LUP of 4500 villages under PoCRA phase II
- Evaluating and mapping soil-site suitability for major crops in Central India

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, Sterlite India Ltd., KEC International Ltd., Adani Transmission Ltd., Ahmedabad, Tata Projects Ltd., New Delhi, Govt. of Maharashtra, Neeranchal Project of DoLR, New Delhi, SAUs located in Maharashtra, Govt. of Arunachal Pradesh, Watershed Development Department, Karnataka, Odisha, Rajasthan.

Thrust areas for 2021-2026

- High resolution Land Resource Inventory
- Develop concepts and knowledge base on soil formation
- 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 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
- 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
- Generate contemporary land use plans at different levels, particularly, at village/ farmlevel

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): 2022 (Rs. in lakh)

Funds Received	:	9197.89
Funds Utilized	:	9196.80

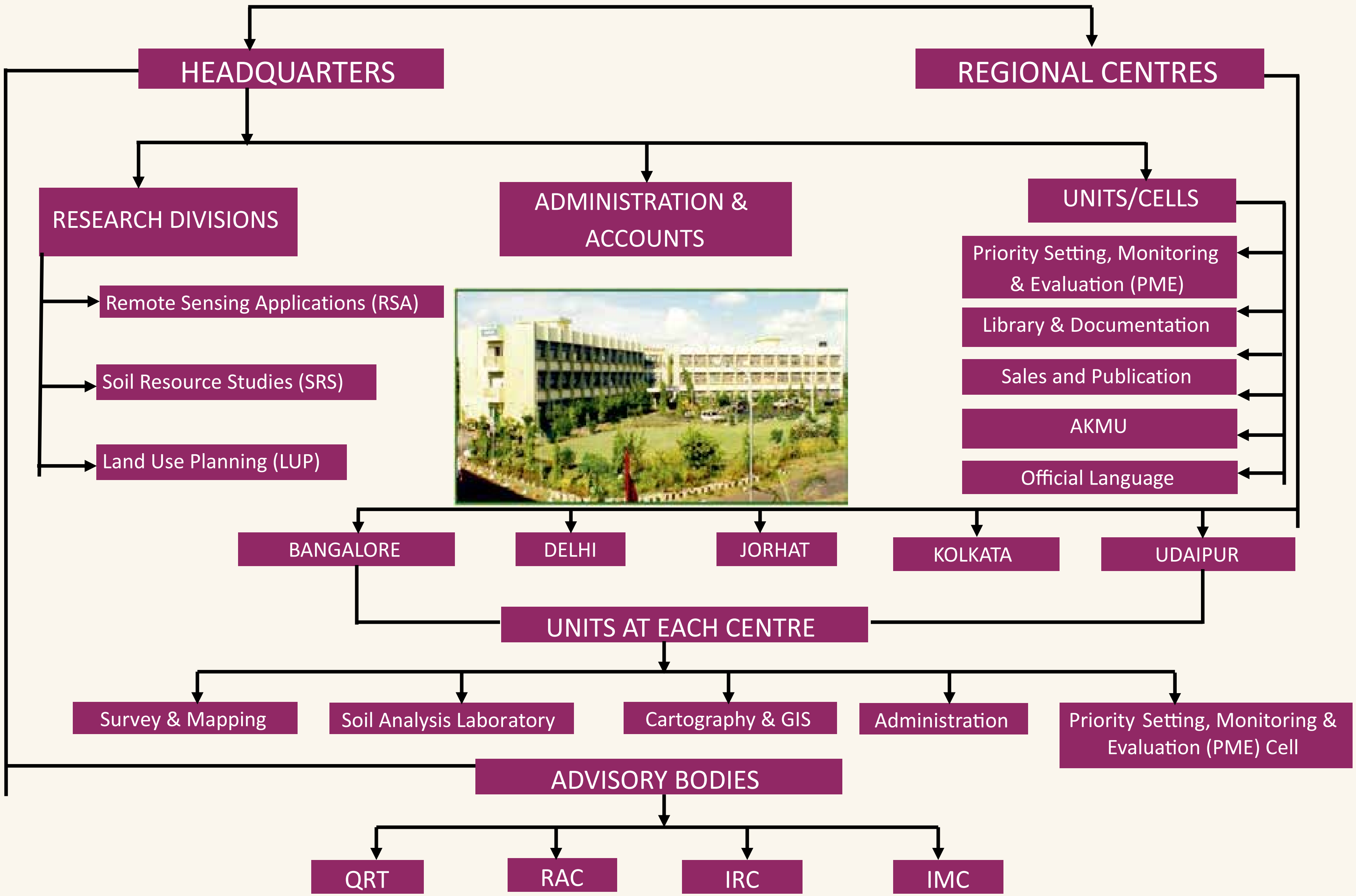
Revenue Generation: 2022 (Rs. in lakh)

Research Projects	:	331.53
Sales of publications	:	0.61
Soil analysis/testing	:	1.78
Total	**:**	**333.92**

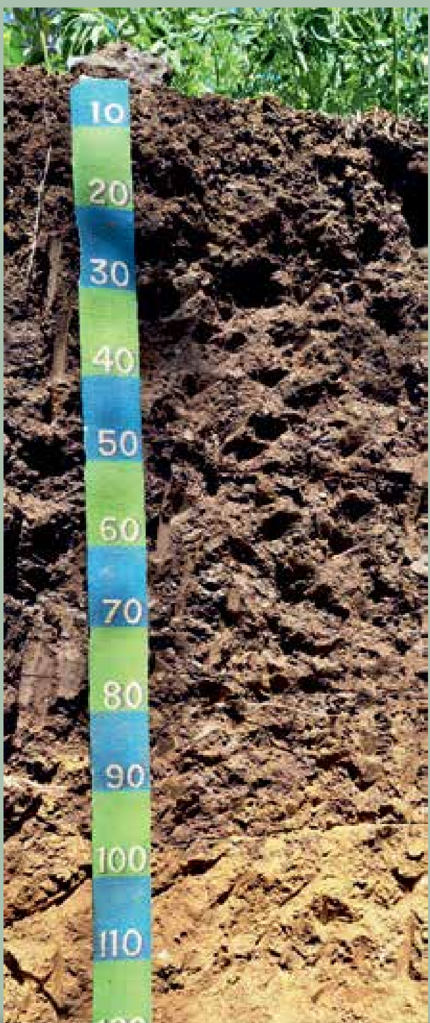
Staff Strength (as on 31.12.2022)

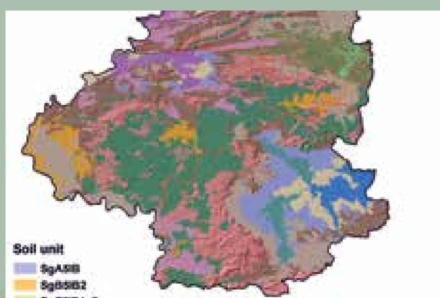
Category	Sanctioned	Filled	Vacant	%age vacancy
Research Manager Position	1	1	NIL	
Scientific	97	60	37	38
Technical	164	99	65	39.6
Administrative	72	35	37	51.4
Supporting	38	21	17	44.7
Total	**372**	**216**	**156**	**41.9**

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

Spatial Modelling for Delineation of Agro-Ecological Zones (AEZ's) of India for Smart Agricultural Planning using Earth Observation Time-series Data

Weekly, monthly and yearly rainfall datasets from 1991 to 2020 for India were extracted from the daily rainfall grid information of IMD for the same period. Similarly, the daily minimum and maximum temperature datasets were processed for the 30 year duration. Thematic maps were developed to assess the spatiotemporal variability. Potential evapotranspiration (PET) was estimated by the FAO Penman-Monteith method using weekly rainfall, minimum, maximum, mean temperature and wind speed datasets. Subsequently, weekly PET was aggregated into yearly PET, and yearly PET thematic layers were developed in GIS for the same period. Soil information on the 1:250,000 scale was used to estimate the available water-holding capacity (AWC) of Indian soils, and the AWC layer was developed in GIS. The AWC and PET data were further used to assess weekly accumulated water potential loss (APWL) and aggregated to generate a yearly APWL database in GIS. Based on PET and APWL, the water stored, actual evapotranspiration (AET), water deficit, and water surplus have been assessed and yearly climatic indices like aridity index (AI), humidity index (HI) and moisture index (MI) were generated (Fig. 2.1.1).

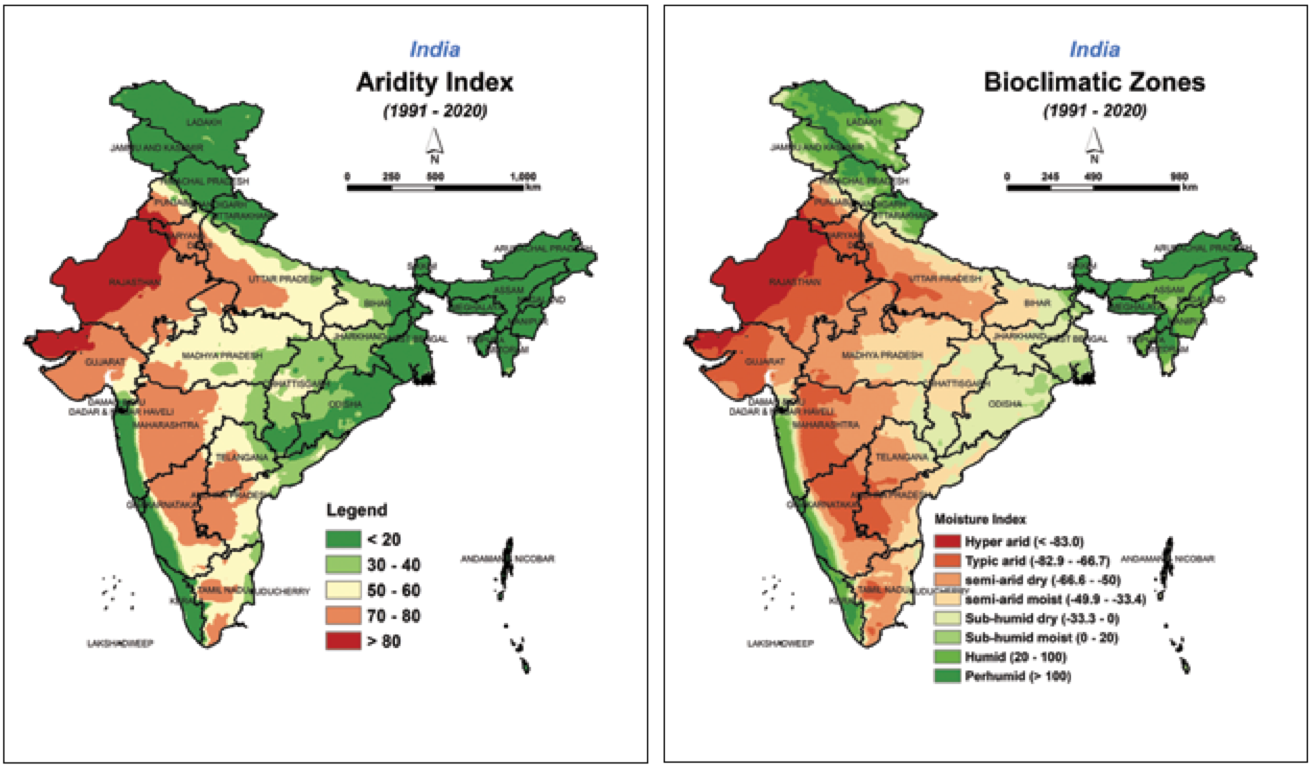
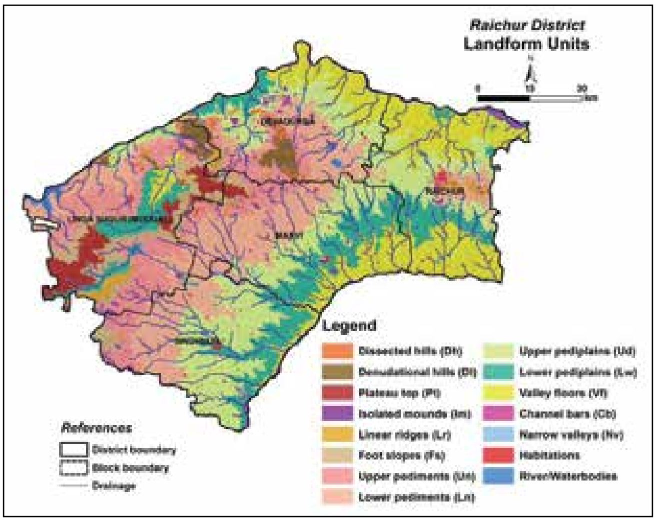


Fig. 2.1.1. Aridity index (AI) and bioclimatic zone maps of India (2020)

Landform mapping and characterization in selected aspirational districts of semi-arid tropics of India using geospatial techniques

Terrain mapping units (TMUs) of ten districts, namely Baran (Rajasthan), Barwani (Madhya Pradesh), YSR Kadapa (Andhra Pradesh), Fatehpur (Uttar Pradesh), Khammam (Telangana), Mewat (Haryana), Moga (Punjab), Osmanabad (Maharashtra), Raichur (Karnataka) and Ramanathapuram (Tamil Nadu) were revised by superimposing physiography, sub-physiography, broad landforms, landform units, slope and land use/land cover themes in GIS. Subsequently, a standardized geospatial database was developed, and thematic maps on digital terrain parameters, landform units and TMUs were generated. The developed digital database on landforms and TMUs has been submitted to the central repository of the Bureau and deployed on BHOOMI Geoportal. The delineated landforms and TMUs of Raichur district, Karnataka and their detailed description are shown in the figure 2.1.2 and Table 2.1.1.



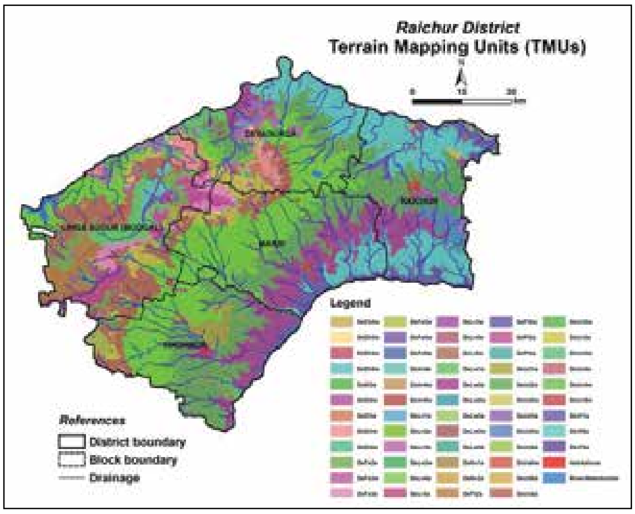


Fig. 2.1.2. Landforms and terrain mapping units (TMUs) of Raichur district, Karnataka

Table 2.1.1. Terrain mapping units (TMUs) and their description of Raichur district, Karnataka

Physiographic-region	Sub- physiographic region	Landform	Slope code	LULC code	TMU	Area (in ha.)	Area (in %)
Deccan plateau	South Deccan plateau	Channel bars	2	w	DsCb2w	3891.5	0.5
		Dissected hills	3	w	DsDh3w	809.1	0.1
		Dissected hills	4	w	DsDh4w	2497.9	0.3
		Dissected hills	5	w	DsDh5w	1208.7	0.1
		Denudational hills	2	a	DsDl2a	380.3	0.0
		Denudational hills	2	w	DsDl2w	106.8	0.0
		Denudational hills	3	a	DsDl3a	1726.9	0.2
		Denudational hills	3	w	DsDl3w	12013.5	1.4
		Denudational hills	4	w	DsDl4w	1017.8	0.1
		Foot slopes	2	a	DsFs2a	15568.3	1.9
		Foot slopes	2	w	DsFs2w	1116.6	0.1
		Foot slopes	3	a	DsFs3a	10369.4	1.2
		Foot slopes	3	w	DsFs3w	7955.8	0.9
		Foot slopes	4	w	DsFs4w	1070.7	0.1
		Foot slopes	5	w	DsFs5w	140.8	0.0
		Isolated mounds	4	a	DsIm4a	21.3	0.0
		Isolated mounds	4	w	DsIm4w	8537.2	1.0

Physiographic-region	Sub- physiographic region	Landform	Slope code	LULC code	TMU	Area (in ha.)	Area (in %)
		Isolated mounds	5	w	DsIm5w	2816.4	0.3
		Lower pediments	1	a	DsLn1a	132.0	0.0
		Lower pediments	2	a	DsLn2a	153589.8	18.3
		Lower pediments	3	a	DsLn3a	6749.9	0.8
		Lower pediments	3	w	DsLn3w	8574.6	1.0
		Lower pediments	4	a	DsLn4a	39.6	0.0
		Linear ridges	3	a	DsLr3a	5794.6	0.7
		Linear ridges	3	w	DsLr3w	4004.3	0.5
		Linear ridges	4	w	DsLr4w	1089.7	0.1
		Linear ridges	5	w	DsLr5w	572.3	0.1
		Lower pediplains	1	a	DsLw1a	20915.9	2.5
		Lower pediplains	2	a	DsLw2a	83390.7	9.9
		Lower pediplains	2	w	DsLw2w	3533.3	0.4
		Lower pediplains	3	a	DsLw3a	1966.9	0.2
		Lower pediplains	3	w	DsLw3w	189.8	0.0
		Lower pediplains	4	a	DsLw4a	114.7	0.0
		Narrow valleys	1	a	DsNv1a	5158.5	0.6
		Narrow valleys	2	a	DsNv2a	647.0	0.1
		Plateau top	2	a	DsPt2a	14868.4	1.8
		Plateau top	2	w	DsPt2w	709.7	0.1
		Plateau top	3	a	DsPt3a	10345.3	1.2
		Plateau top	4	a	DsPt4a	110.0	0.0
		Upper pediplains	1	a	DsUd1a	12276.7	1.5
		Upper pediplains	2	a	DsUd2a	146476.5	17.5
		Upper pediplains	2	w	DsUd2w	771.6	0.1
		Upper pediplains	3	a	DsUd3a	6981.3	0.8
		Upper pediplains	3	w	DsUd3w	6236.6	0.7
		Upper pediplains	4	a	DsUd4a	96.7	0.0
		Upper pediplains	4	w	DsUd4w	5.3	0.0
		Upper pediplains	5	a	DsUd5a	37.5	0.0
		Upper pediments	2	a	DsUn2a	65651.6	7.8
		Upper pediments	2	w	DsUn2w	1272.9	0.2
		Upper pediments	3	a	DsUn3a	26486.3	3.2
		Upper pediments	3	w	DsUn3w	3504.1	0.4
		Upper pediments	4	a	DsUn4a	451.9	0.1
		Upper pediments	4	w	DsUn4w	588.0	0.1
		Upper pediments	5	w	DsUn5w	178.0	0.0
		Valley floors	1	a	DsVf1a	27005.8	3.2
		Valley floors	2	a	DsVf2a	107304.4	12.8
		Valley floors	3	a	DsVf3a	535.1	0.1
River/Waterbodies						29597.6	3.5
Habitations						9096.0	1.1
Total						**838300.0**	**100.0**

Digital Terrain Analysis and Characterization of Landforms for Soil-Landscape Modelling in Maharashtra Using Remote Sensing Data, DEM and GIS

Digital terrain analysis and characterization of landforms in the Vidarbha, Marathwada, Western Maharashtra, North Maharashtra and Konkan regions of Maharashtra were carried out for soil-landscape modelling. The terrain parameters (contours, slope, drainage, aspects, hill shade, plan curvature, profile curvature and total curvature) generated from SRTM DEM (30 m) and vegetation parameters from Sentinel-2 data were integrated through GIS-based digital terrain analysis modelling to derive distinct landform units (Fig. 2.1.3) under different physiography, sub-physiography and major landforms.

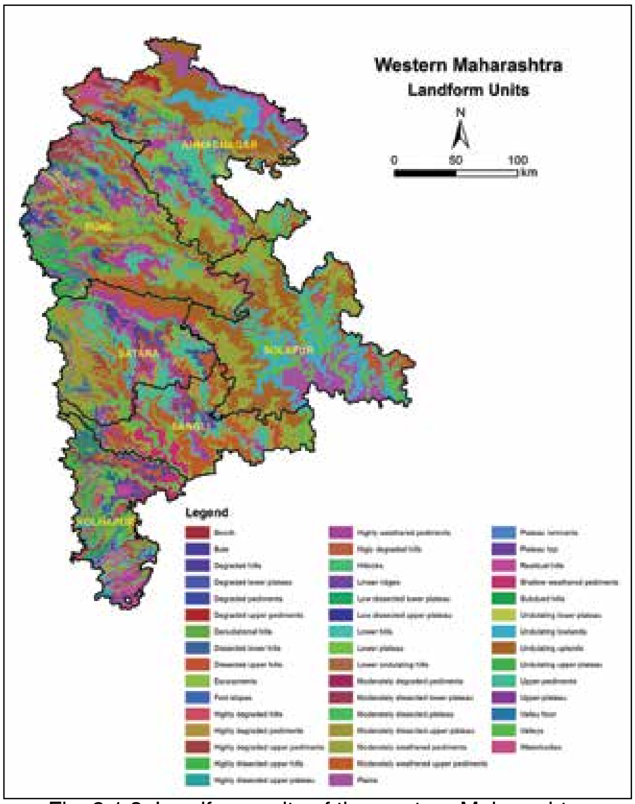


Fig. 2.1.3. Landform units of the western Maharashtra

Digital soil mapping of Western Maharashtra and North Maharashtra region

Sampling strategies for both the regions were prepared using the conditioned Latin Hypercube

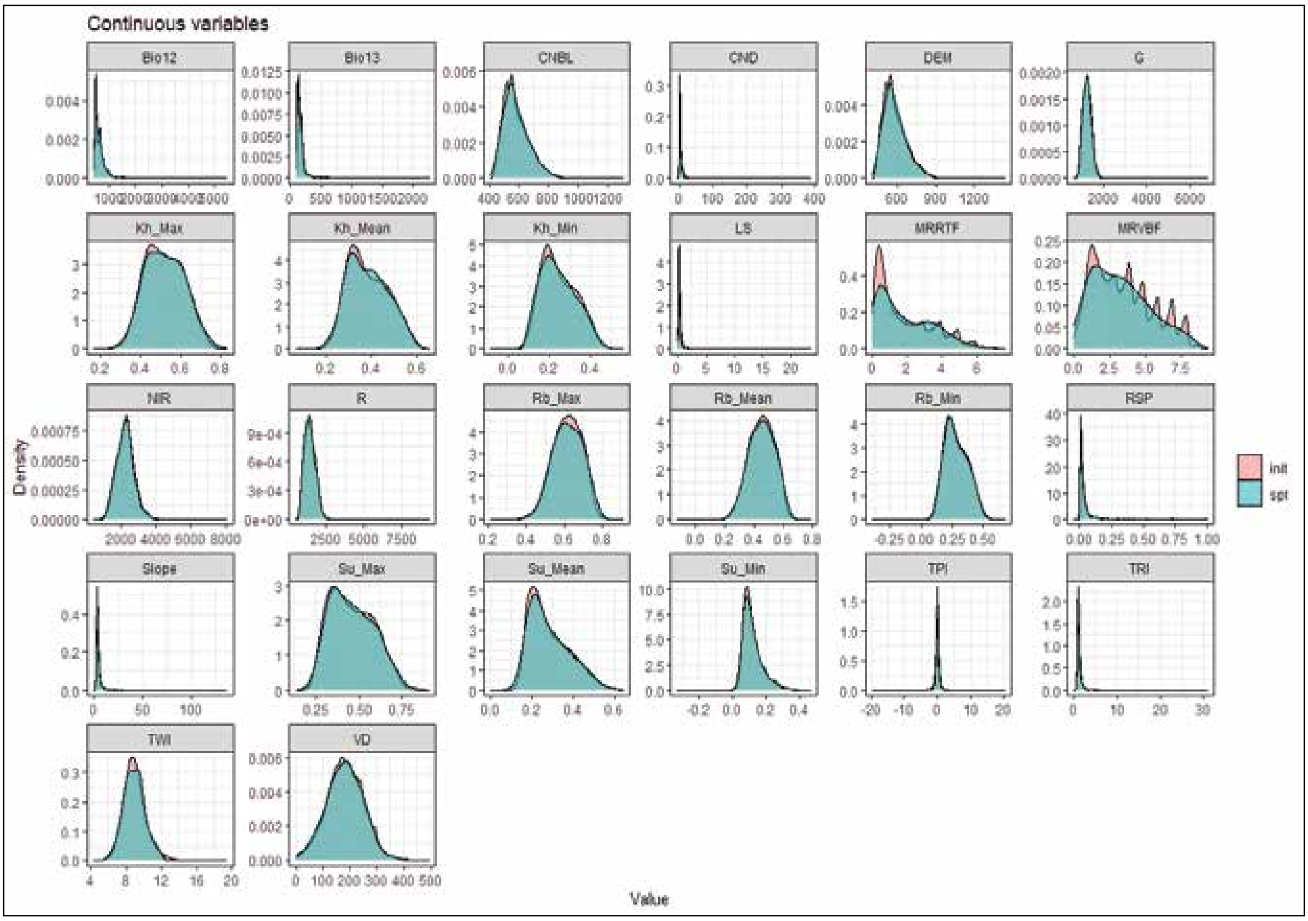


Fig. 2.1.4: Density probability plots of the population and the samples identified for the Western Maharashtra region

Sampling (cLHS) method based on terrain, climate and vegetation parameters developed from SRTM 30 m DEM, Worldclim, and Landsat 30 m data, respectively. 300 sampling points for Western Maharashtra (Fig. 2.1.4) and 250 sampling points for the North Maharashtra region (Fig. 2.1.5) could explain the entire soil variabilities in the agricultural area. The sampling point distribution developed for the two regions is shown in (Fig. 2.1.6).

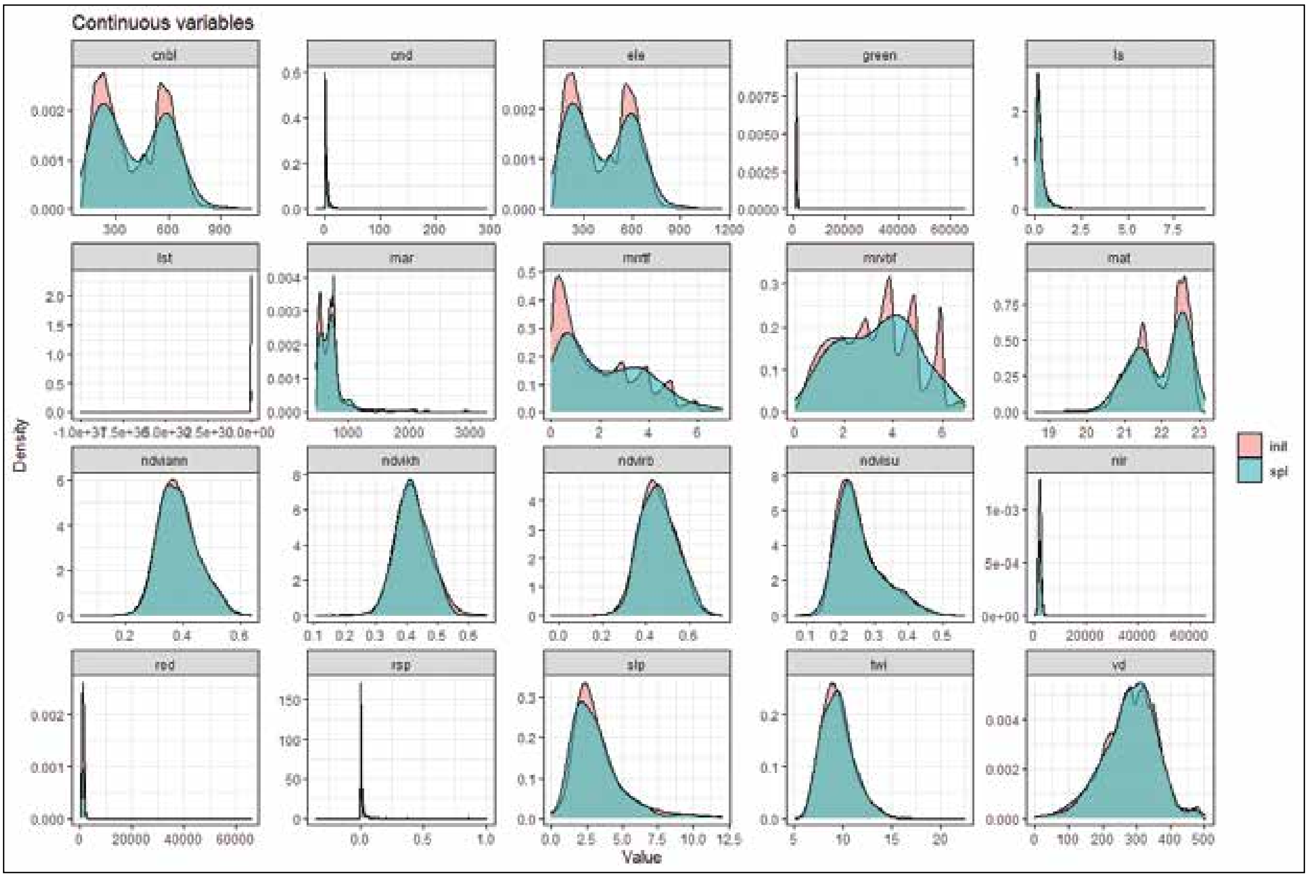


Fig. 2.1.5: Density probability plots of the population and the samples identified for the North Maharashtra region

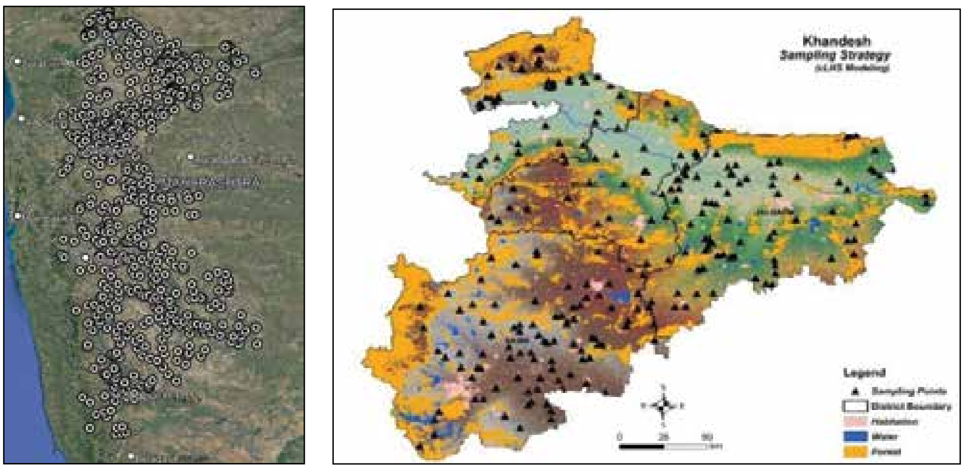


Fig. 2.1.6: Sampling strategy of western and north Maharashtra regions

Soil Sampling Strategy for Digital Mapping in Barmer district of Rajasthan

The cLHS model was run with all the input parameters to identify sampling sites in Barmer district for digital mapping of soil attributes. An optimum soil sample size of 80 profiles (cLHS model) has been identified based on the inter-quartile range matching technique (Fig. 2.1.7).

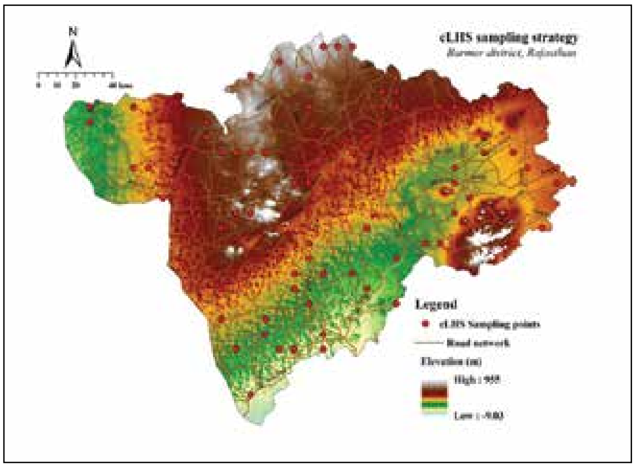


Fig. 2.1.7: Identification of sampling soil profile in Barmer district by cLHS method

Performance of model for prediction of soil organic carbon by cLHS sampling

The soil organic carbon (SOC) varied from 0.01 to 0.41% in the study region in the 0–5 cm depth (Table 2.1.2), from 0.02 to 0.40%. in the 5-15 cm depth, followed by a decrease thereafter. SOC had the higher CV, with the depths and values ranging from 53.6% for 0–15 cm to 72.9% for 100–200 cm. The SOC skewed positively with skewness values of 1.00 to 2.07 for different depths.

Table 2.1.2: Statistical description of the splined-soil organic carbon (%) at various depths in the study area of Barmer district, Rajasthan

Soil depth	Min	Max	Mean	SE	Median	SD	CV	Skewness	Kurtosis
0-5 cm	0.010	0.410	0.156	0.010	0.160	0.084	53.6	1.007	1.286
5-15 cm	0.020	0.400	0.150	0.009	0.155	0.079	52.5	0.939	1.107
15-30 cm	0.020	0.350	0.127	0.007	0.125	0.064	50.2	0.892	1.424
30-60 cm	0.010	0.240	0.099	0.006	0.100	0.052	53.0	0.523	0.081
60-100 cm	0.010	0.290	0.094	0.006	0.080	0.055	58.1	0.931	1.257
100-200 cm	0.010	0.370	0.082	0.007	0.075	0.060	72.9	2.079	7.372

Min: minimum; Max: maximum; SE: standard error of mean; SD: standard deviation; CV: coefficient of variation

The performance of the random forest (RF) algorithm was assessed using statistical measures. Table 2.1.3 provides data for the goodness of fit and errors of the prediction models used in this study. The RF model predicted SOC with R^2 values of 0.96 and 0.37 during model training and testing, respectively. Model performance was better in case of 0–5 cm depth interval as compared to the 5-15 cm depth interval, as indicted by higher R^2 values.. The concordance correlation coefficient (CCC) value varied from 0.160 (100-200 cm) to 0.418 (0-5 cm) in the validation data set, suggesting poor agreement between predicted and observed values.

Table 2.1.3: Performance of random forest model for prediction of soil organic carbon in the study area of Barmer district, Rajasthan

Soil depth	0-5 cm		5-15 cm		15-30 cm		30-60 cm		60-100 cm		100-200 cm	
	Trg	Test	Trg	Test	Trg	Test	Trg	Test	Trg	Test	Trg	Test
R^2	0.961	0.368	0.947	0.165	0.931	0.215	0.934	0.200	0.954	0.112	0.937	0.150
CCC	0.820	0.418	0.824	0.211	0.844	0.232	0.846	0.220	0.833	0.129	0.839	0.160
MSE	0.001	0.011	0.001	0.010	0.001	0.007	0.000	0.004	0.001	0.004	0.001	0.002
RMSE	0.038	0.106	0.035	0.101	0.026	0.085	0.022	0.062	0.023	0.064	0.028	0.049
ME	0.003	0.035	0.003	0.033	0.002	0.018	0.001	0.009	0.001	0.001	0.002	0.024

R^2: coefficient of determination; CCC: concordance correlation coefficient; MSE: Mean square error; RMSE: root mean square error; ME: mean error; Trg: Training.

Prediction of soil organic carbon

The spatial predictions of SOC at various depths are shown in Fig. 2.1.8. The predicted SOC varied from 0.09 to 0.29%, 0.08 to 0.28%, 0.06 to 0.24%, 0.04 to 0.17%, 0.04 to 0.16%, and 0.03 to 0.25% in soil depths of 0–5, 5–15, 15–30, 30–60, 60–100, and 100–200 cm, respectively.

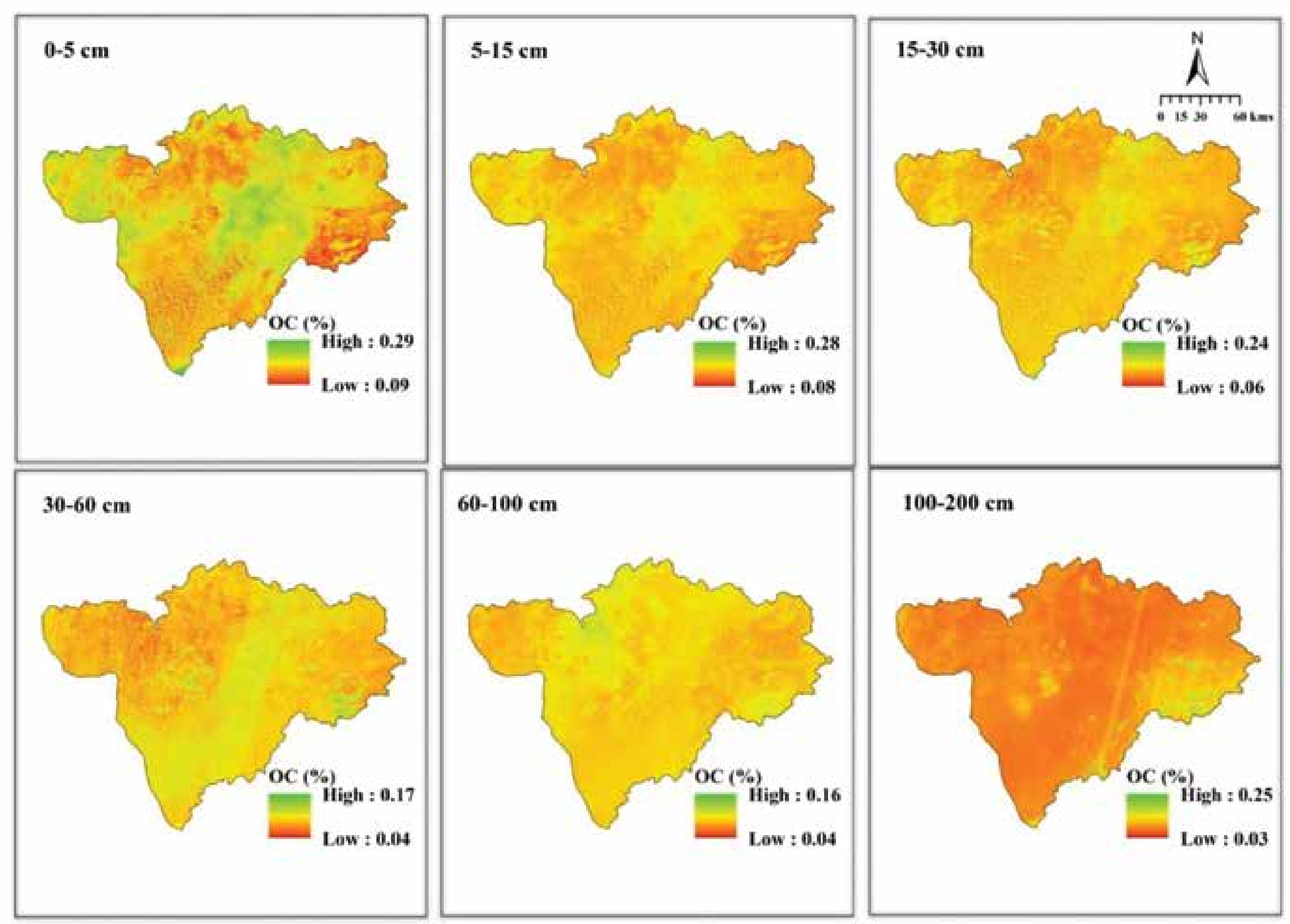


Fig. 2.1.8: Map of soil organic carbon spatial prediction by random forest model in the study area of Barmer district, Rajasthan

Soil depth Prediction through Soil-Landscape Modelling Using Machine Learning Techniques in Washim District

Spatial distribution of soil depth was investigated using machine learning algorithms in about 4.9 lakhs ha of Washim district, Maharashtra. Thirty-one environmental variables affecting soil depth were selected. Three machine learning algorithms, random forest (RF), cubist and extreme gradient boosting (XGBoost), were evaluated as individual models to predict and obtain separate soil depth distribution maps. Landsat data and terrain attributes were used as environmental variables. Among the covariates, relative slope position (RSP), channel network base level (CNBL), channel network distance (CND) and valley depth (VD) were the most influential environmental variables in predicting soil depth. Results also indicated that the RF had slightly higher prediction accuracy than XGBoost and cubist among the three selection methods (Fig. 2.1.9). The measured soil depth ranged from 5 to 165 cm with a mean of 49.52±3.03 cm. The relatively large variation (CV > 75%) in soil depth indicated high variability of soils in the district (Table 2.1.4).

Table 2.1.4: Descriptive statistics of soil depth (cm) in the study area of Washim District

Data set	n	Min	Max	Mean	SE	Median	SD	CV (%)	Skewness	Kurtosis
Calibration	120	5.0	165	49.0	3.43	36.0	37.6	76.7	1.76	2.23
Validation	30	21.0	150	51.5	6.54	36.0	35.8	69.6	1.87	2.41
Total	150	5.0	165	49.5	3.03	36.0	37.1	75.0	1.76	2.15

SD, standard deviation; SE, standard error; CV, coefficient of variation.

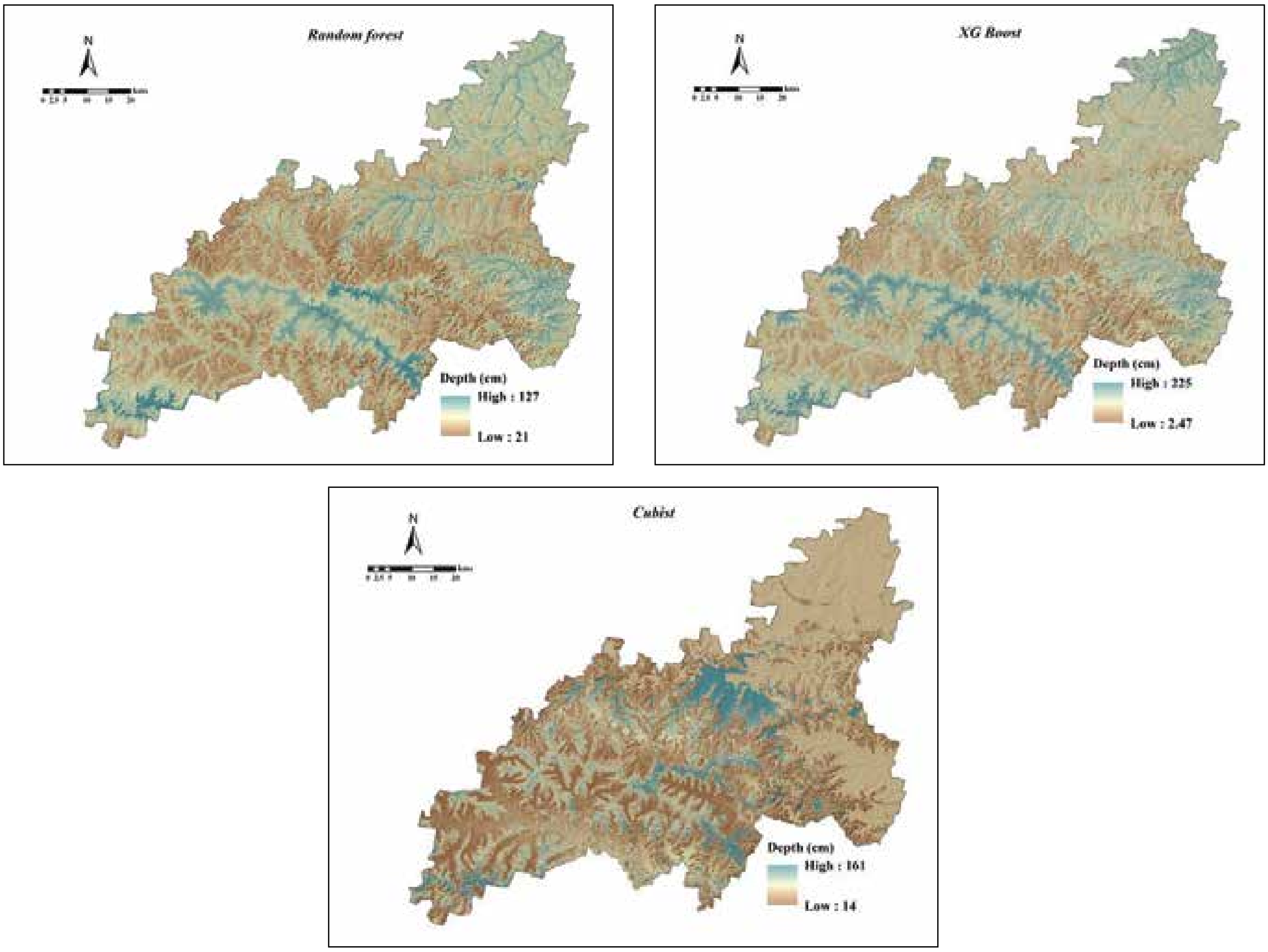


Fig. 2.1.9: Distribution of soil depth predicted by different models in the study area of Washim District

Hyperspectral characterization of soils of Central India and development of soil spectral library and models for quick assessment of soil properties

Reflectance spectra of 3691 soil samples from different districts of Maharashtra, Madhya Pradesh and Gujarat were generated. The data on soil properties (about 1500 samples collected from different districts of Maharashtra) were used to develop predictive equations with the help of the partial least square regression (PLSR) technique, and their descriptive statistics are presented in Table 2.1.5. The entire dataset was randomly divided into calibration and validation datasets. The PLSR technique was used to calibrate soil reflectance with soil parameters. Fig 2.1.10 depicts the PLSR-hyperspectral models for predicting clay, pH, soil organic carbon (SOC) and calcium carbonate content. These properties could be predicted with higher accuracy levels than the other soil properties, as indicated by higher r^2, RMSE and RPD values. The most relevant wavelengths for differentiating soil properties in the soils of the study area were found to be 560 and 1900 nm in the case of clay content, 2220 nm in the case of pH, 2250 and 480 nm in the case of SOC, and 380 and 420 nm in the case of $CaCO_3$.

Table 2.1.5. Descriptive statistics of soil properties selected for modelling.

Properties				Percentile/quartile							
	No	Min	Max	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}	Std. Deviation	Mean	CV (%)
Clay (%)	1333	2.5	86.9	20.2	33.7	50.5	62.8	69.7	18.3	48.0	38.2
pH	1333	4.5	10.0	7.1	7.8	8.1	8.3	8.6	0.6	8.0	7.7
OC (%)	1322	0.0	2.5	0.2	0.4	0.6	0.8	1.0	0.3	0.6	54.9
$CaCO_3$(%)	1298	0.2	25.9	3.4	4.5	7.5	12.0	16.5	5.4	8.9	60.9

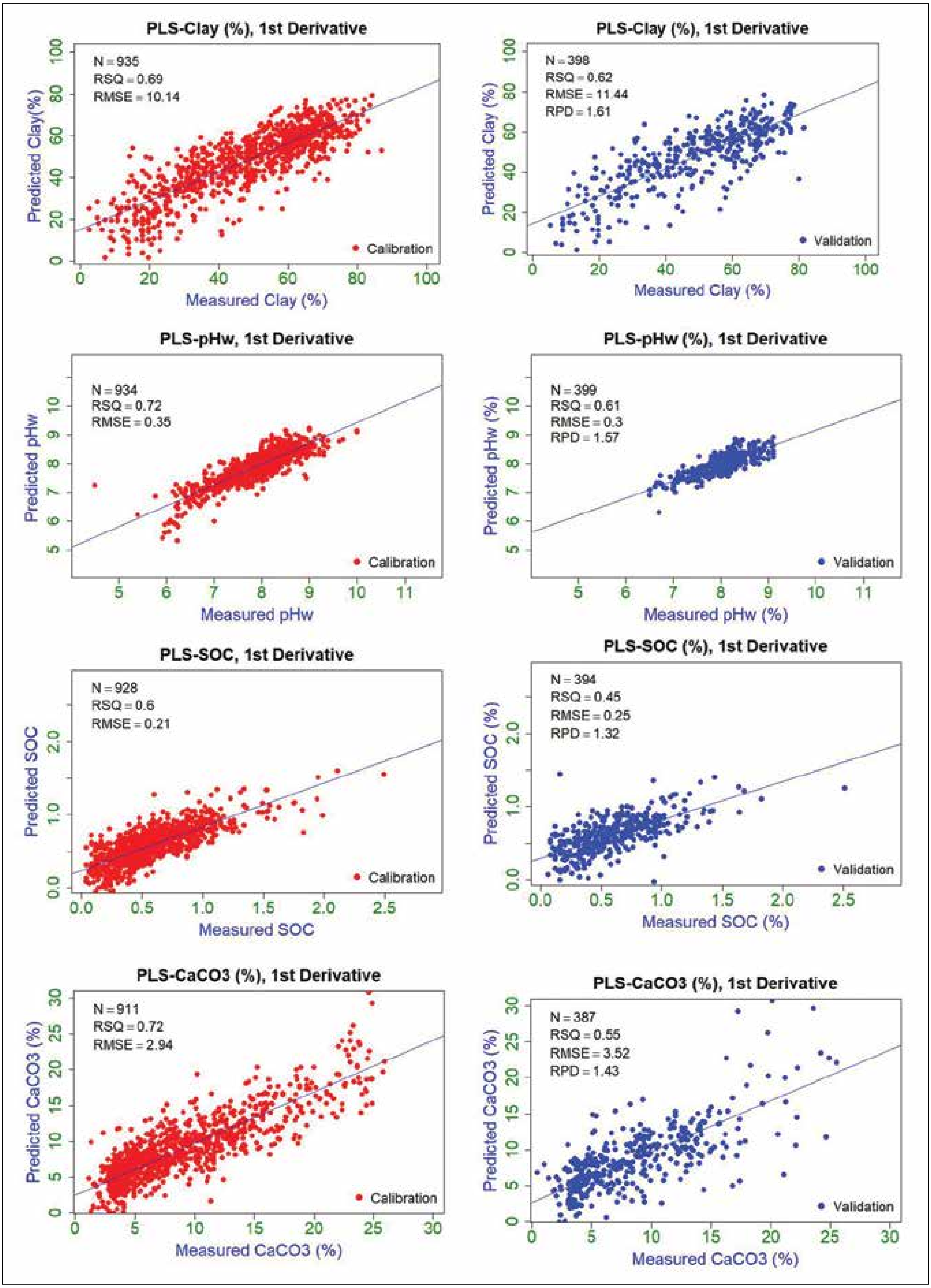


Fig. 2.1.10. Predictive models developed for selected soil properties with spectral data.

High-resolution soil attributes modelling using digital soil mapping techniques for the Marathwada region of Maharashtra

The machine learning model Quantile Random Forest (QRF) was used to develop regional level

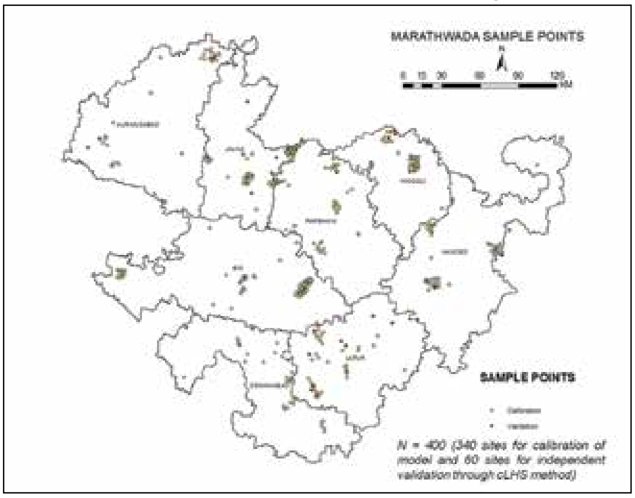


Fig. 2.1.11. Sampling sites of Marathwada region of Maharashtra state.

digital soil attribute maps for the Marathwada region of Maharashtra at 30 m resolution using legacy soil information. The sampling points along with calibration (340 soil profiles) and validation (60 soil profiles) datasets generated using the conditioned latin hypercube model is presented in Fig. 2.1.11.

Digital soil mapping models for key soil physicochemical attributes like depth, pH, SOC, sand, silt, clay and available water capacity (AWC) were developed at six standard depths (0-5, 5-15, 15-30, 30-60, 60-100 and 100-200 cm) as proposed by the world soil grid. The important environmental co-variables capturing the variability of soil properties were worked out and are shown in figure 2.1.12, along with its cross-validation results as an example concerning clay and organic carbon content (0-15cm). The predicted clay content across depths and soil depth properties map, along with uncertainty in clay content at 0-15 cm, are displayed in Fig. 2.1.13.

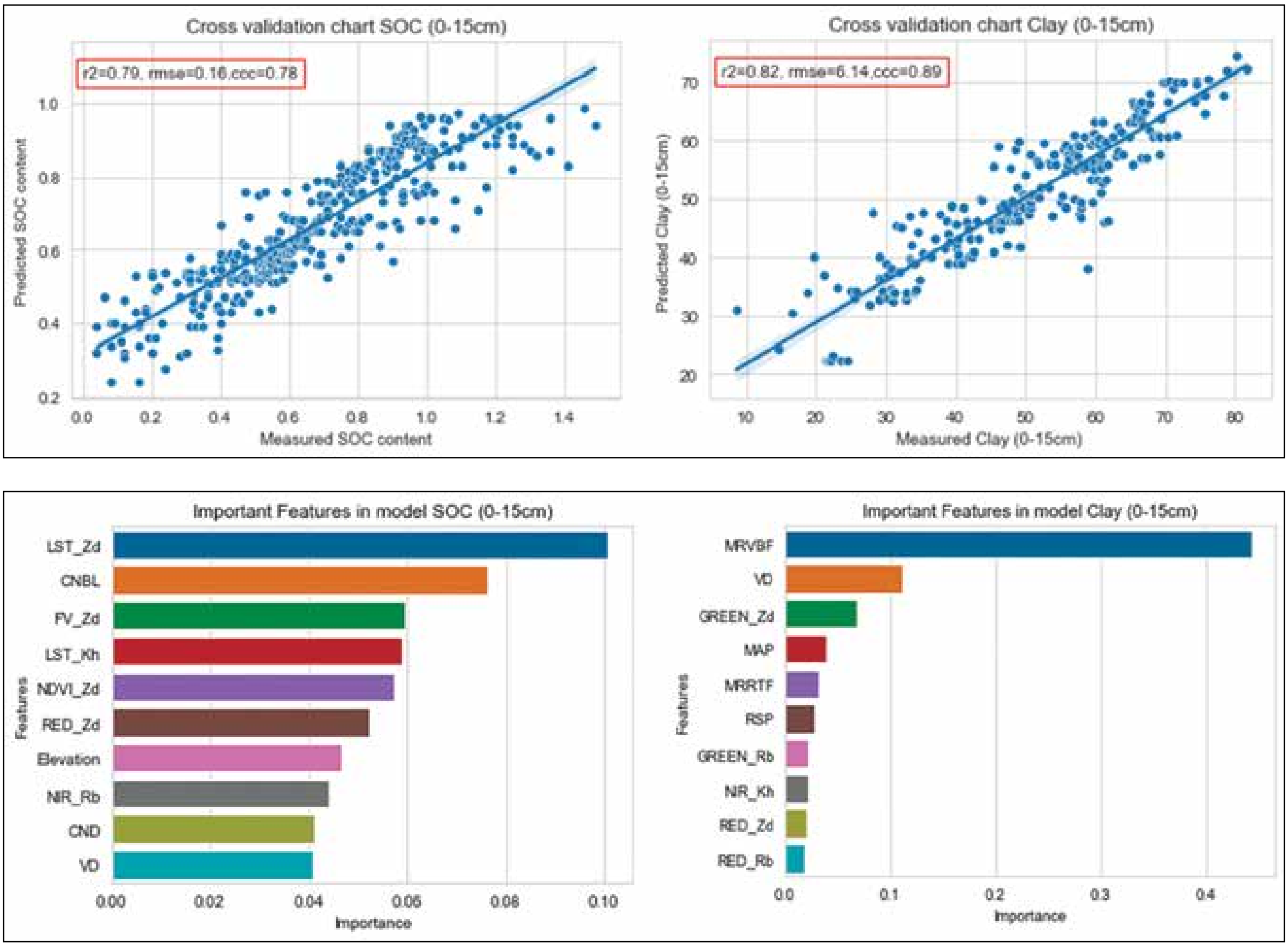


Fig. 2.1.12. soil organic carbon and clay content at 0-15cm depth in Marathwada region.

Modeled Clay content (%)

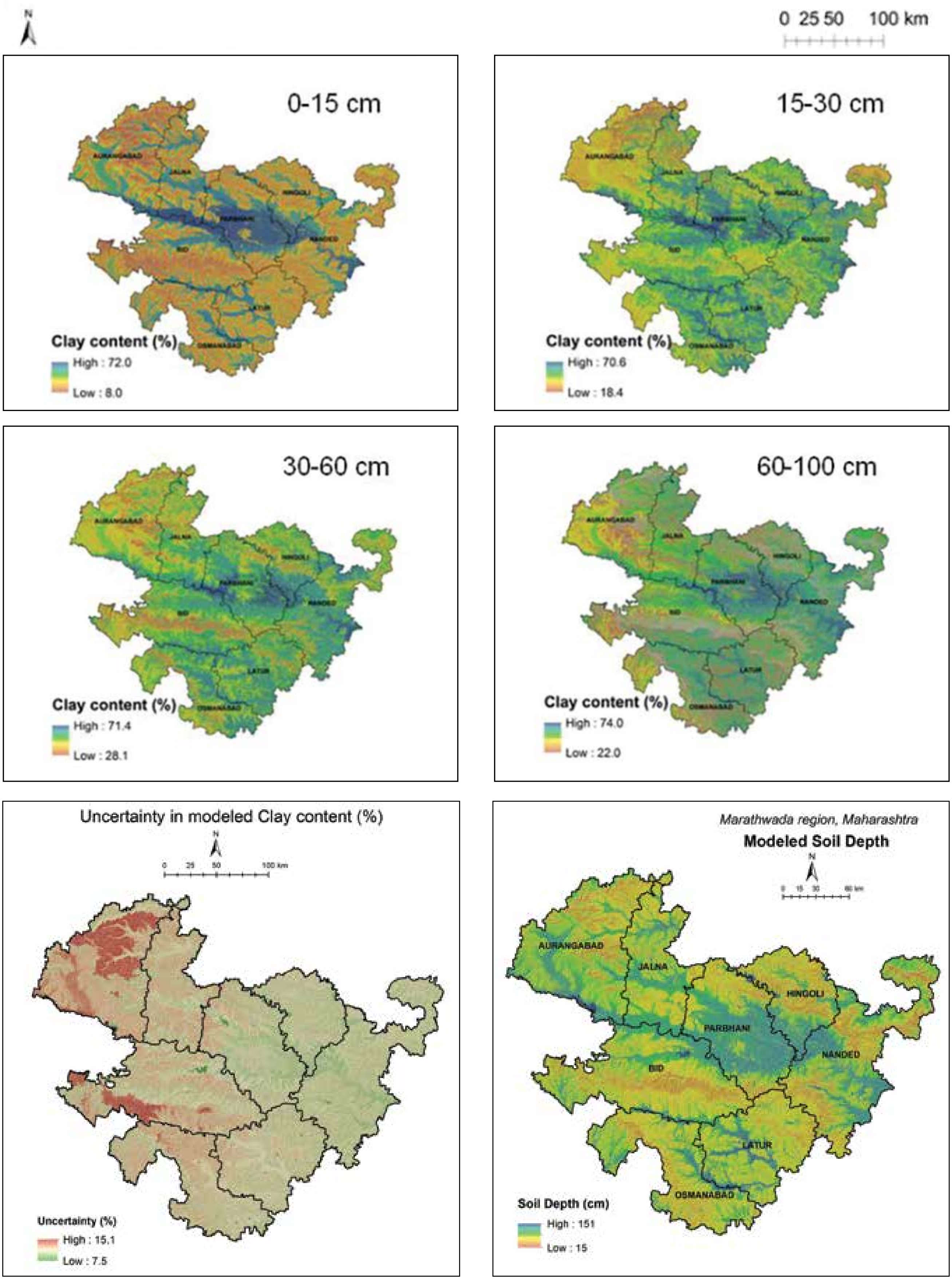


Fig. 2.1.13. Predicted clay content across depths and soil depth properties map along with uncertainty in clay content at 0-15 cm

Eastern Region

Landform identification and mapping of Aspirational districts of Eastern India

Mapping of landforms were completed for 19 aspirational districts of Jharkhand. The whole state is initially segregated into seven broad landforms: plateau top, upper plateau, lower plateau, plateau fringe, pediment, upland and plain. These are again subdivided based on their types and slope. The description of the landforms existing in few aspirational districts is given in the subsequent sections.

Ramgarh district, with an area of 1360.08 sq. km, has four broad landforms, *viz*., plateau top (1.4%), upper plateau (10.7%), lower plateau (81.2%) and plateau fringe (4.5%). These broad landforms (Fig. 2.1.14) are again sub-divided into several landform classes such as gently sloping undulating plain, moderately sloping undulating upland, gently sloping undulating upland, very gently sloping undulating plain, moderately sloping hills / dissected hill, gently sloping valley, very gently sloping undulating upland, steeply sloping hills / dissected hill, moderately sloping rock outcrops and moderately steeply sloping isolated hillock, *etc*.

Bokaro district has an area of 2702.41 sq. km and consists of undulating uplands of the Chota Nagpur Plateau, with the Damodar River cutting a valley right across. It has an elevation ranging from 178 m to 1030 m above mean sea level.

The landforms of the district are divided into five categories, *viz*., plateau top (1.9%), upper plateau (4%), lower plateau (34.5%), plateau fringe (47.9%) and pediment (5.5%) (Fig. 2.1.15). These landforms were further divided into gently sloping undulating plain, strongly sloping hills / dissected hills, moderately sloping undulating plain, moderately steeply sloping lower pediment, moderately steeply sloping mounds, very gently sloping undulating plain, very gently sloping valley, gently sloping undulating upland, moderately steeply sloping lower pediment, steeply sloping rock outcrops, moderately sloping rock outcrops, steeply sloping hills / dissected hill, moderately steeply sloping isolated hillock, *etc*.

The landforms of Ranchi district were classified into four types, *viz*., plateau fringe (18.5 %), lower plateau (15.2 %), upper plateau (31.8 %) and plateau top (29.3 %) (Fig. 2.1.16). These landforms were sub-divided into moderately sloping undulating upland, moderately steeply sloping isolated hillock, moderately steeply sloping rock outcrops, very steeply sloping rock outcrops, steeply sloping isolated hillock, moderately steeply sloping mounds.

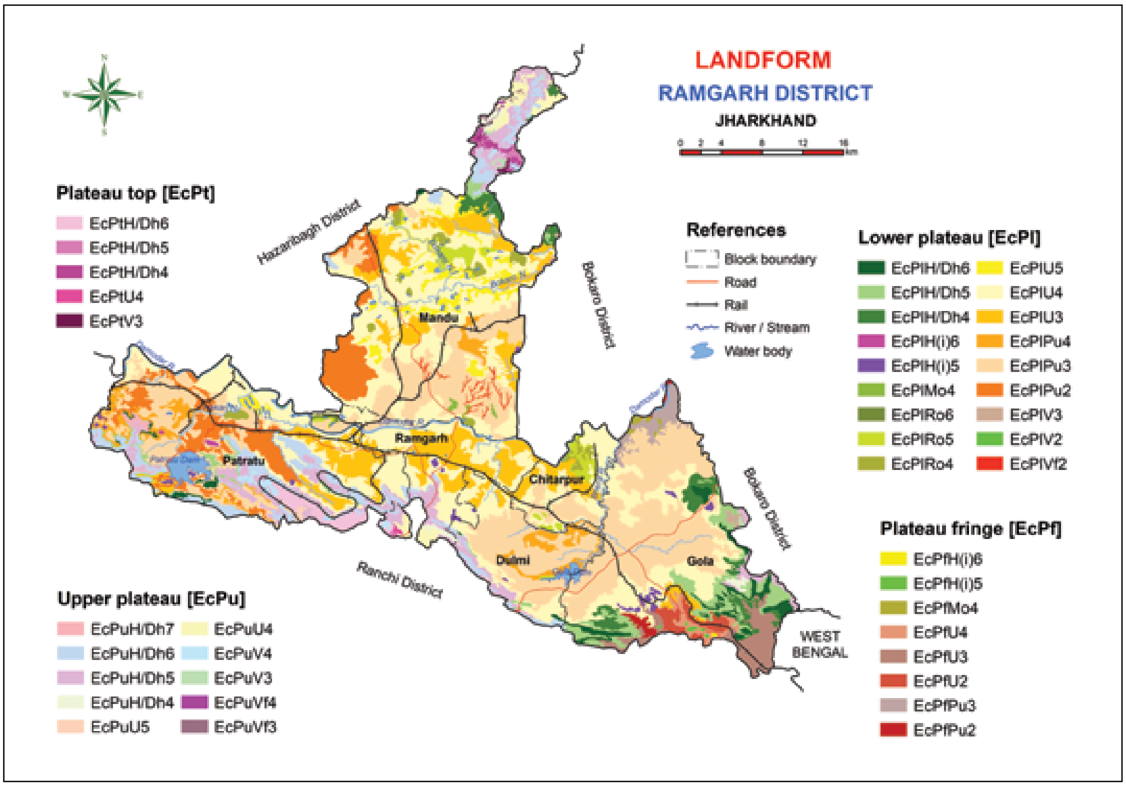


Fig. 2.1.14. Landform map of Ramgarh district, Jharkhand

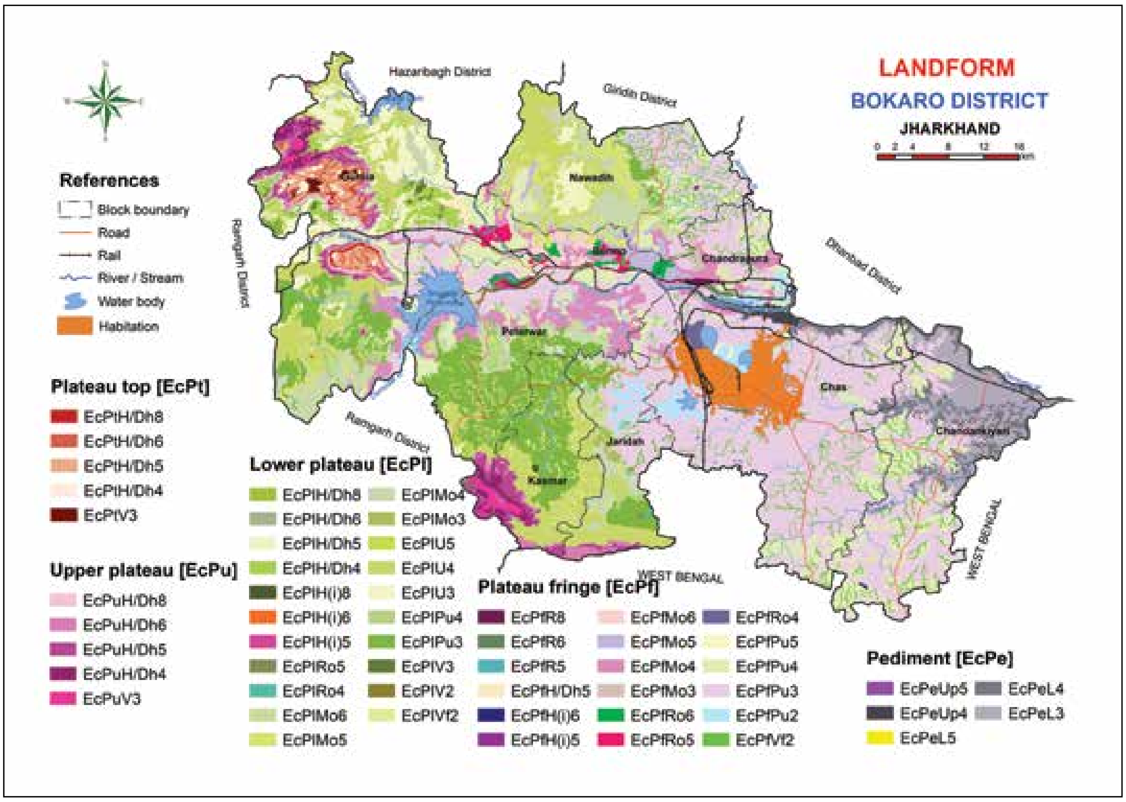


Fig. 2.1.15. Landform map of Bokaro district, Jharkhand

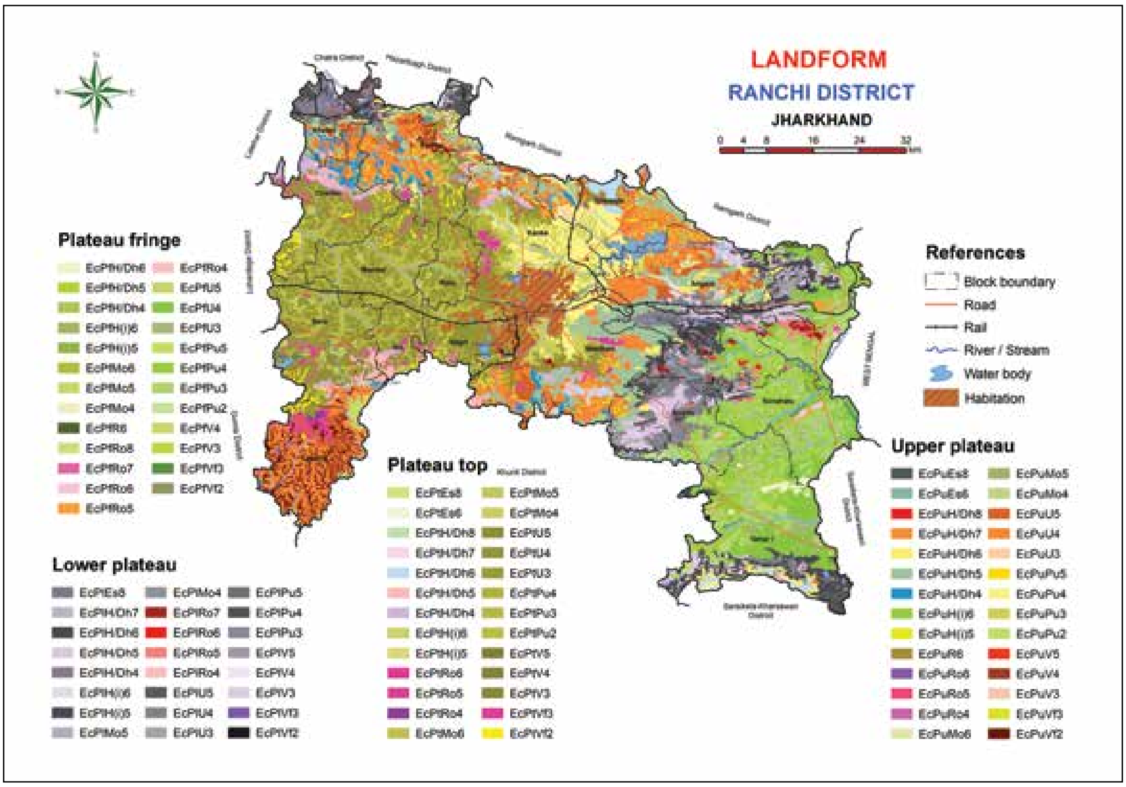


Fig. 2.1.16. Landform map of Ranchi district, Jharkhand

Giridih district, with an area of 4854 km^2, has five landforms, *viz.*, plateau top (0.5%), upper plateau (0.3%), lower plateau (63.5%), plateau fringe, pediment (1.0%). These were further divided into gently sloping undulating plain (Fig. 2.1.17), moderately sloping undulating upland, gently sloping undulating plain, and moderately steeply sloping hills / dissected hills.

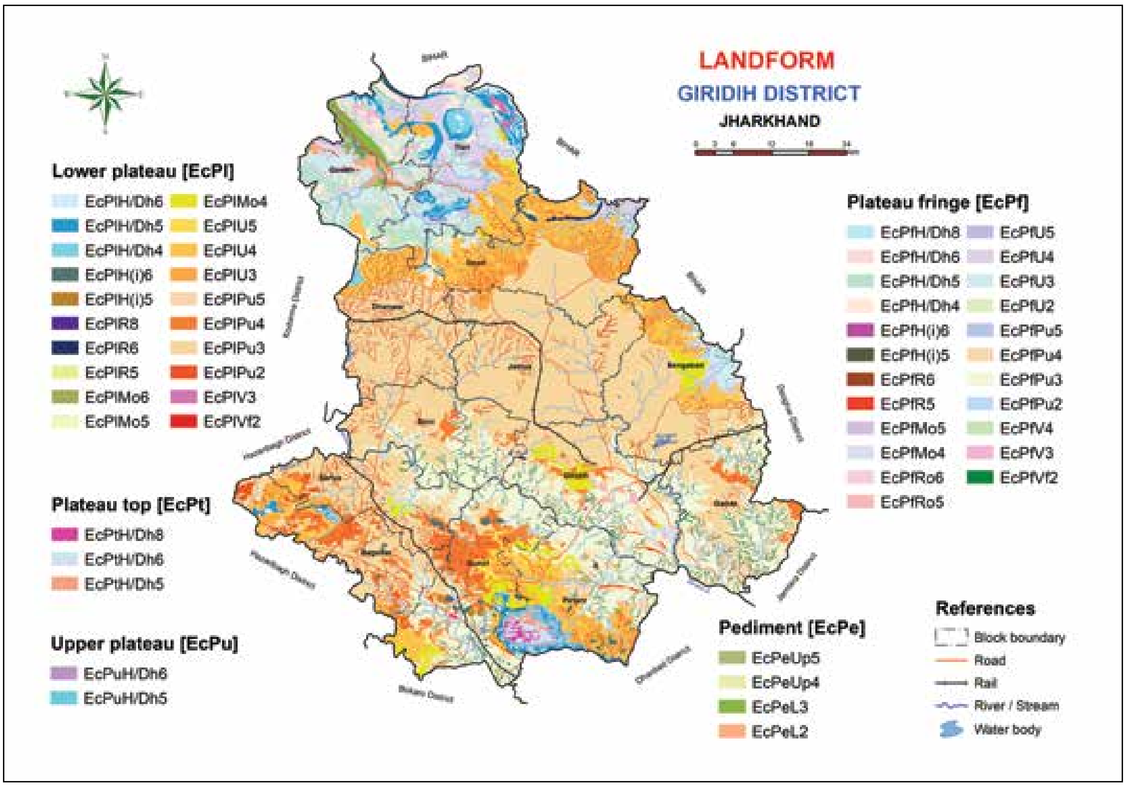


Fig. 2.1.17. Landform map of Giridih district, Jharkhand

North-Eastern Region

Land resource inventory of Arunachal Pradesh at large scale (1:10,000) for agricultural land use planning using geo-spatial technique

Tirap district, Arunachal Pradesh

Tirap district of Arunachal Pradesh state covers an area of 1,17,000 ha (PMKSY, 2020). It is situated between 26º48’ and 27º47’ N latitudes, and from 95º22’ to 96º16’ E longitudes with a cool and humid climate in lower elevations and in the valleys, representing AESR 17.1. Landscape ecological units (LEUs) as base maps for soil survey were delineated using landforms, slopes and land use/land covers.

Forest cover occupies about 79.6% of TGA of the district, whereas shifting cultivation (including old *jhum* and *jhum* under present fallow) encompasses 17.5% of TGA. Agriculture, together with plantation crops, is practised only in sporadic patches, covering 0.7% of TGA (Fig. 2.1.18).

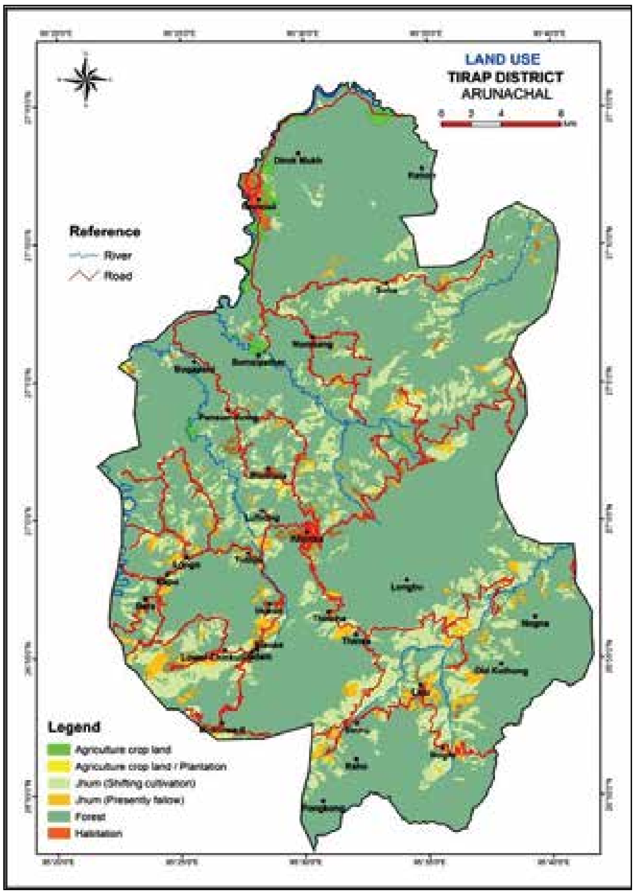


Fig. 2.1.18. Land use/Land Cover map of Tirap district, Arunachal Pradesh

The district was mapped with 11 soil series (Noglo, Dadam, Thinsa, Kheti, Moktowa, Khonsa, Borduria, Namsang, Bogapani, Deomali-II and Deomali-I) with15 phases as soil mapping units. Dadam series has the largest area occupancy (6.8% of TGA and 37.6% of total surveyed area (TSA)) occurring on very steeply sloping medium amplitudinal hills, whereas the Deomali-II series encompasses the least area (0.25% of TGA and 1.4% of TSA). The soil-landform relationship of Tirap district, Arunachal Pradesh, is presented in Fig. 2.1.19.

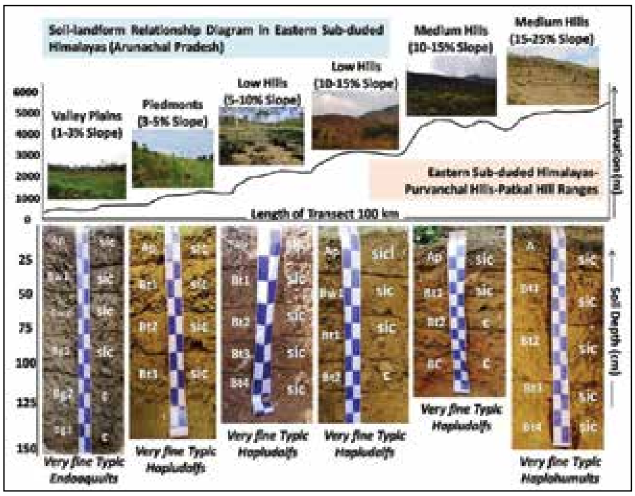


Fig. 2.1.19. Soil-Landform relationship map of Tirap district, Arunachal Pradesh

The soil samples of representative soil series were analysed for physical and chemical properties *viz.,* particle size distribution, pH, organic carbon, available N, P, K, Zn, CEC, base saturation and exchangeable cations including Ca, Mg Na and K. The soil organic carbon map of Tirap district is illustrated in Fig. 2.1.20a.

Soil suitability maps were prepared for different crops (rice, maize, pearl millet, pea, colocassia, vegetables, spices, tea, pineapple, pear and citrus). The soil site suitability (agri-horti) map of Tirap district, Arunachal Pradesh, is illustrated in Fig. 2.1.20b.

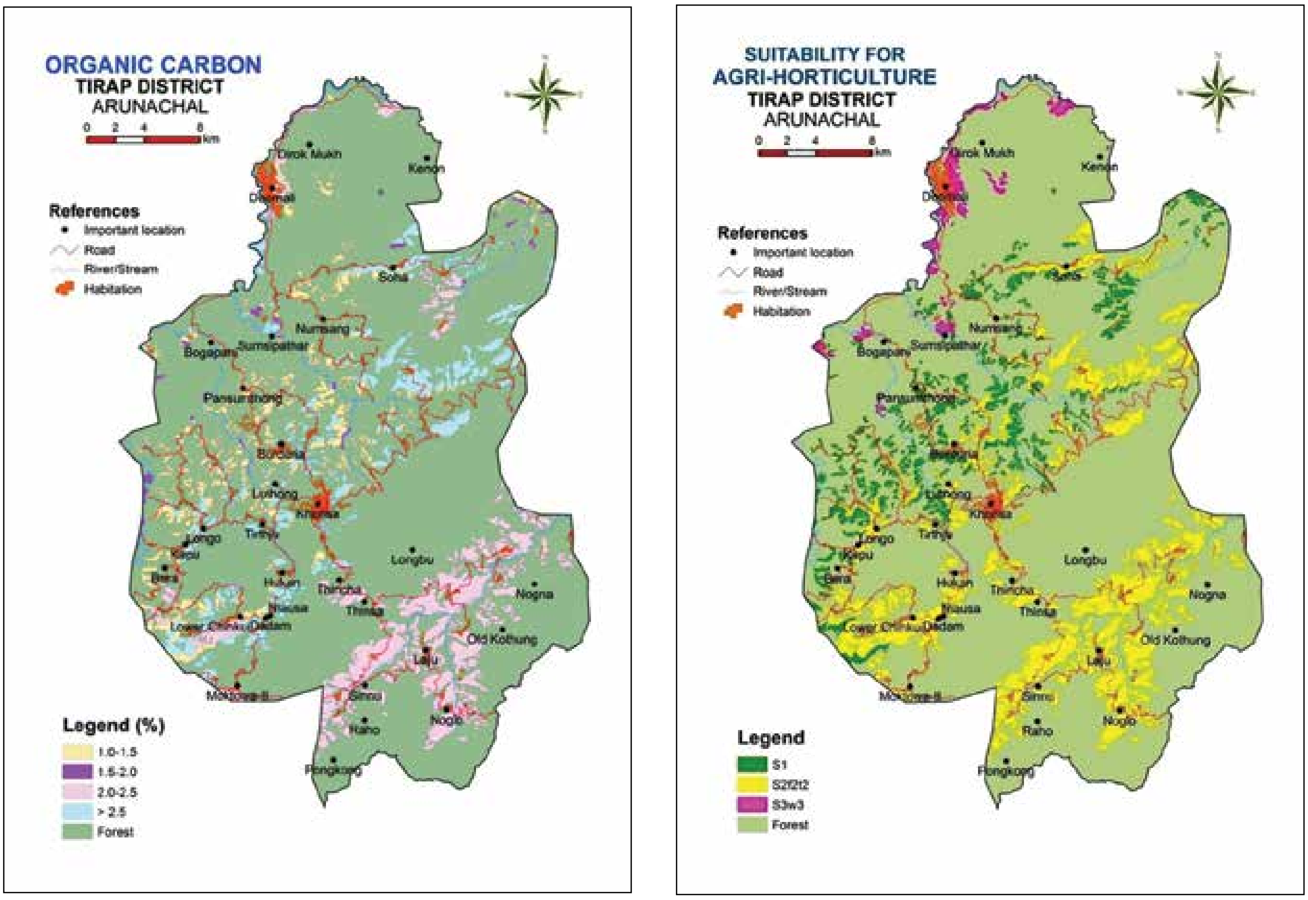


Fig. 2.1.20. a) Available soil organic carbon and b) soil site suitability (agri-horti) maps of Tirap district, Arunachal Pradesh

Kamle District, Arunachal Pradesh

The Kamle district covers an area of 1,60,048 ha. The physiography of this district comprises landforms of denudational hills, dissected hills, narrow valleys, subdued hills, sandbars and valley floors. The denudational hills are the most dominant landform (60.8% of TGA). The study area can be divided into seven land use/land cover classes and is mostly covered by forest area (95.3% of TGA). Based on landform, slope and LULC, 50 terrain mapping units (TMU) were delineated. The landform, LULC and TMU maps of the district are presented in Fig. 2.1.21 (a,b,c).

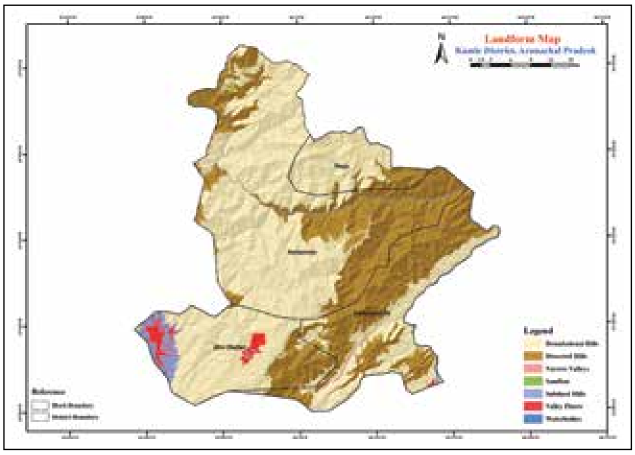


Fig. 2.1.21a. Landform Map of Kamle District, Arunachal Pradesh

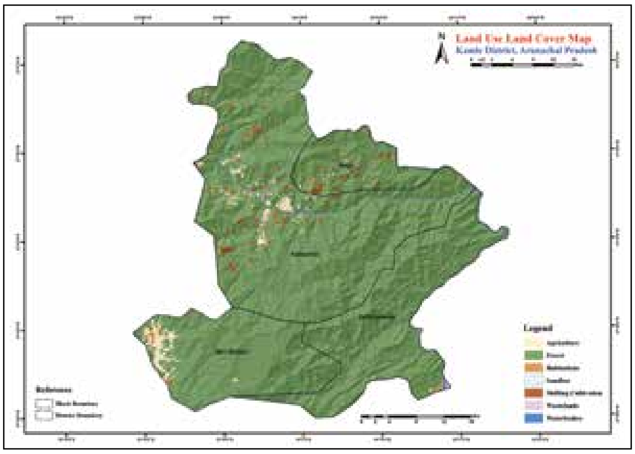


Fig. 2.1.21b. LULC Map of Kamle District, Arunachal Pradesh

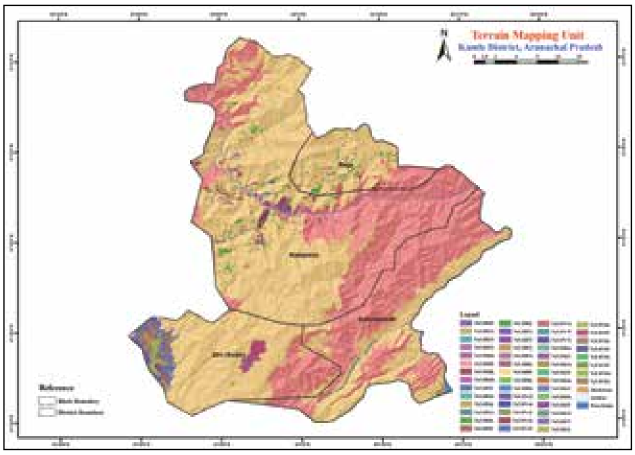


Fig. 2.1.21c. TMU Map of Kamle District, Arunachal Pradesh

Kurung Kumey District, Arunachal Pradesh

The Kurung Kumey district covers an area of 4,29,704 ha and has landforms of denudational hills, dissected hills, narrow valleys, sandbars and valley floors. Denudational hills are the most dominant landform (54% of TGA). The district has been divided into 7 LULC classes and is mostly covered by forest area (99% of TGA). The district was divided into 40 terrain mapping units (TMU) based on landform, slope and LULC. The landform, LULC and TMU maps of the district are presented in Fig. 2.1.22 (a,b,c).

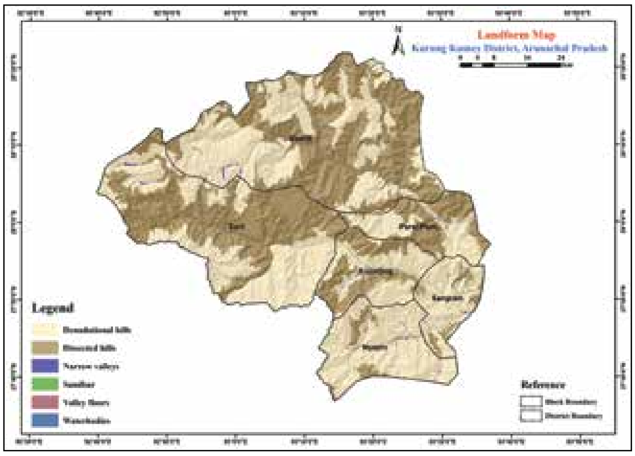


Fig. 2.1.22a. Landform Map of Kurung Kumey District, Arunachal Pradesh

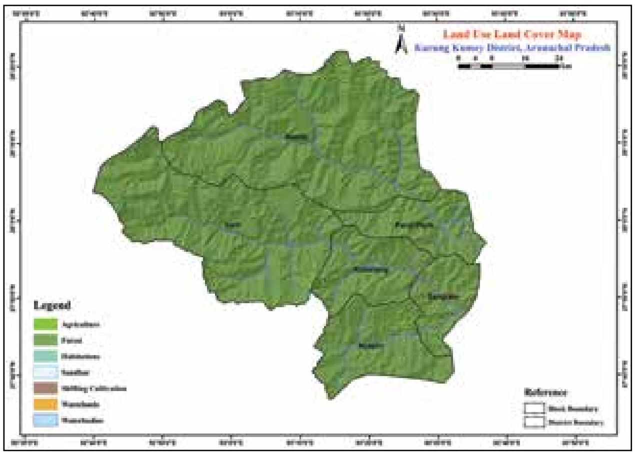


Fig. 2.1.22b. LULC Map of Kurung Kumey District, Arunachal Pradesh

Leparada District

The dominant landform of Leparada district (83,713 ha) is denudational hills (53% of TGA). The other landforms are dissected hills, valley floors, narrow valleys, sandbars and subdued hills. The district is covered by six different LULC classes, dominated by forest cover (90% of TGA). Based on landform, slope and LULC, 51 terrain mapping units (TMU) were delineated. TMU map of the district is illustrated in Fig. 2.1.23.

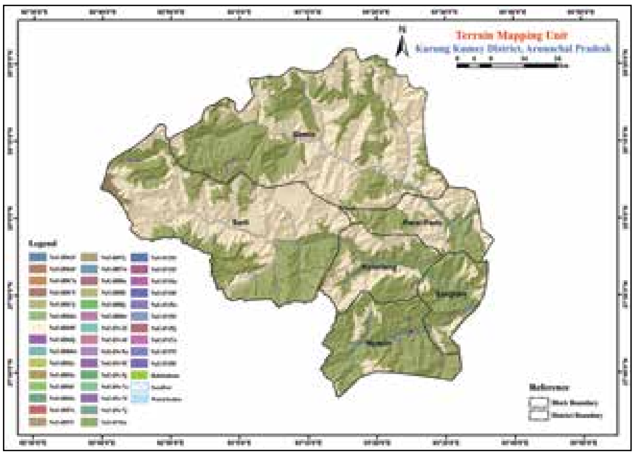


Fig. 2.1.22c. TMU Map of Kurung Kumey District, Arunachal Pradesh

Lower Subansiri District, Arunachal Pradesh

Lower Subansiri district covers an area of 1.16 lakh ha. The physiography of the district is composed of different landforms such as denudational hills, dissected hills, narrow valleys, subdued hills, sandbars and valley floors. Denudational hills are the most dominant landform (61% of TGA). The study area was divided into 5 LULC classes and is mostly covered by forest area (88.3% of TGA). Based on landform, slope

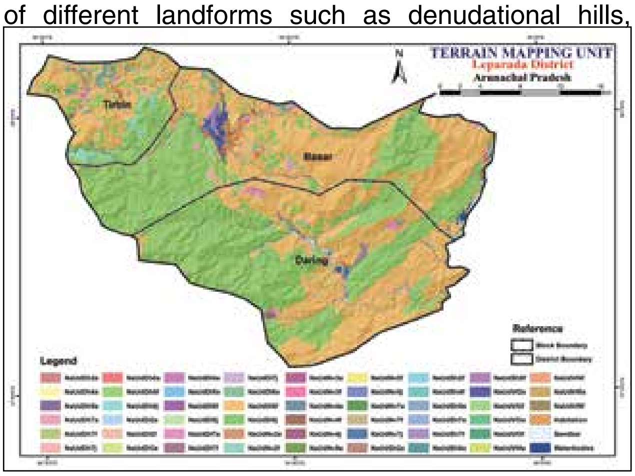


Fig. 2.1.23. TMU Map of Leparada District, Arunachal Pradesh

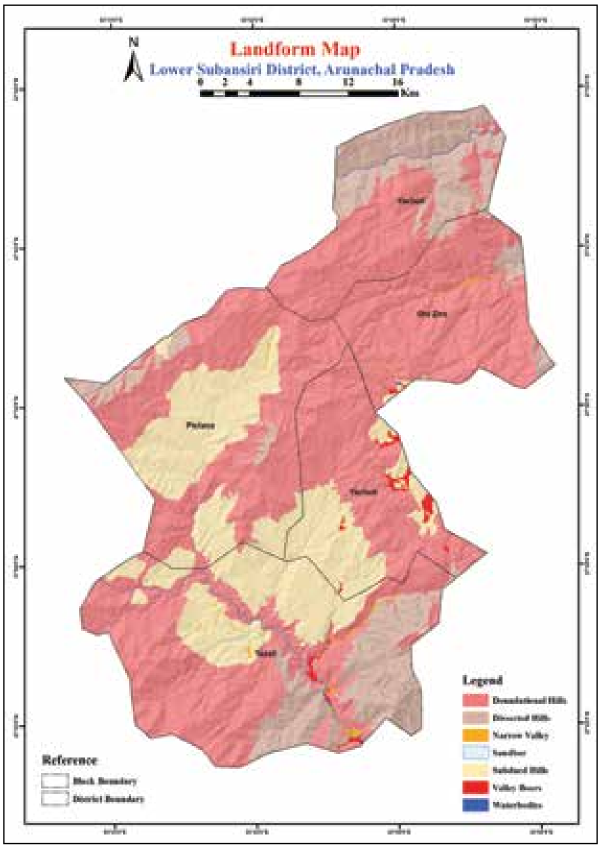


Fig. 2.1.24a. Landform Map of Lower Subasnsiri District, Arunachal Pradesh

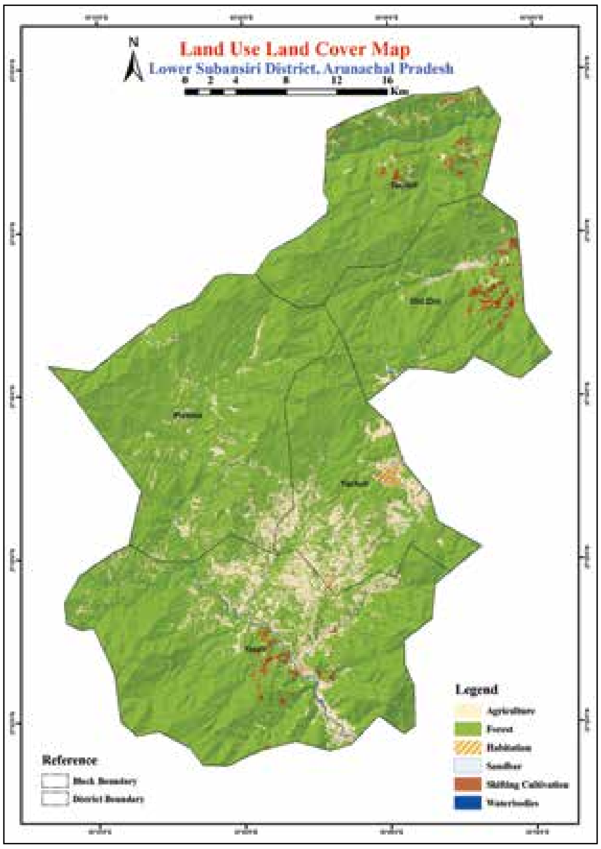


Fig. 2.1.24b. LULC Map of Lower Subansiri District, Arunachal Pradesh

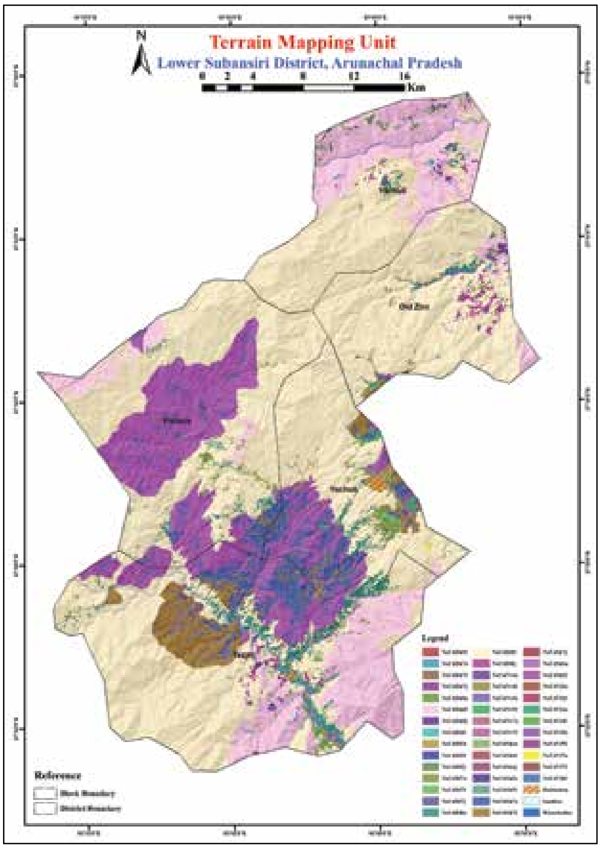


Fig. 2.1.24c. TMU Map of Lower Subansiri District, Arunachal Pradesh

and LULC in the area, 42 terrain mapping units (TMU) were delineated. The landform, LULC and TMU maps of the district are presented in Fig. 2.1.24 (a,b,c).

Upper Subansiri District, Arunachal Pradesh

Upper Subansiri District covers an area of 6,39,912 ha. The major landforms covering 56% of the total area of the district are dissected hills, denudational hills, subdued hills, narrow valleys, valley floors, sandbars and Charland and dissected hills cover. The dominant LULC class of the district is forest cover and shifting cultivation, while agriculture constitute only 0.5% of TGA. TMU map of the district is given in Fig. 2.1.25.

Shiyomi District, Arunachal Pradesh

The physiography of Shiyomi District is mainly covered by hills of the Himalayan mountain range with dominant landforms of denudational hills (50% of TGA). The district is mainly covered by forest (98% of TGA), followed by agriculture (1.42% of TGA). The district was divided into 17 terrain mapping units (TMU), forming the basis for the soil sampling strategy and classification.

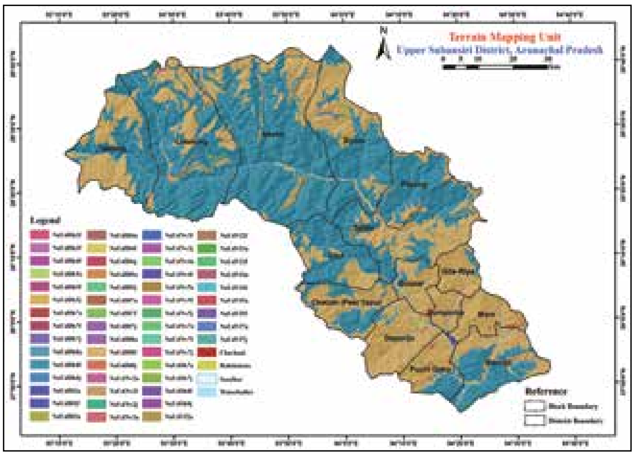


Fig. 2.1.25. TMU Map of Upper Subansiri District, Arunachal Pradesh

West Siang District, Arunachal Pradesh

The physiography of West Siang District, covering an area of 1.66 lakh ha, comprises different landforms such as denudational hills, dissected hills, narrow valleys, subdued hills, charland, sandbars and valley floors. Denudational hills are the dominant landform (80.8% of TGA). The district was divided into 7 LULC classes and is mainly covered by forest area (87.8 % of TGA). Based on landform, slope and LULC, the district was classified into 54 terrain mapping units (TMU). The landform, LULC and TMU maps of the district are illustrated in Fig. 2.1.26 (a,b,c).

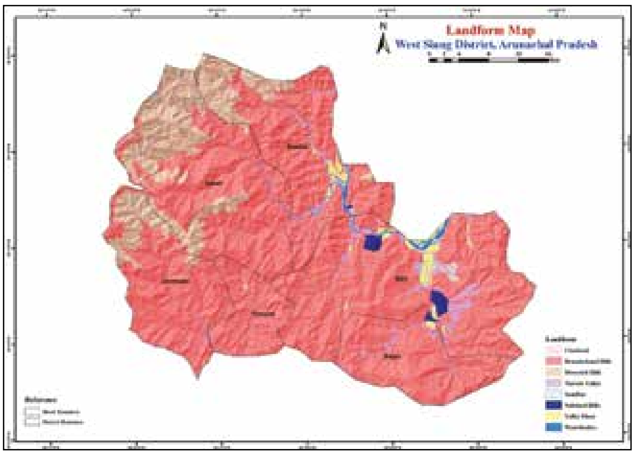


Fig. 2.1.26a. Landform Map of West Siang District, Arunachal Pradesh

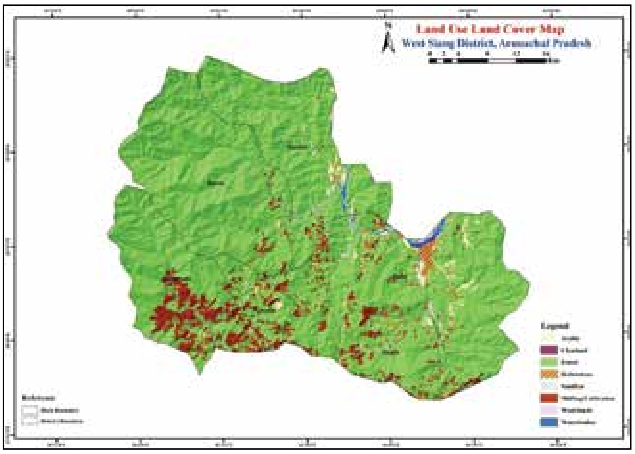


Fig. 2.1.26b. LULC Map of West Siang District of Arunachal Pradesh

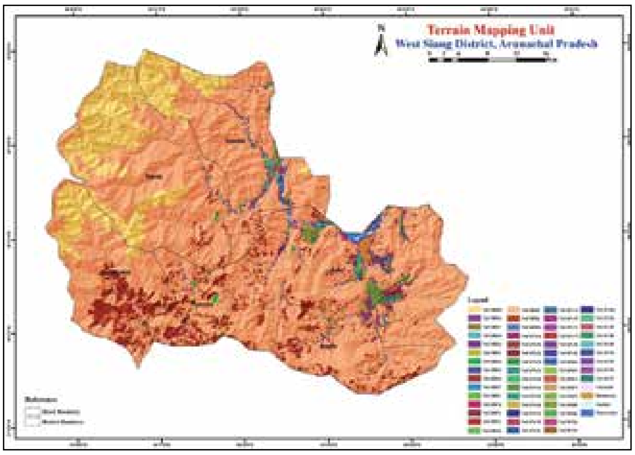


Fig. 2.1.26c. TMU Map of West Siang District of Arunachal Pradesh

Northern-Region

LULC and Landform map of Mandi district of Himachal Pradesh

Mandi district of Himachal Pradesh (HP), covering an area of 3950 km^2, is situated in Western Himalayas between 31°13'20" and 32°04'30" N latitude, and from 76°37'20" to 77°23'15" E longitude. Most of the district has a slope in excess of 33%. Major landforms occurring in the district are alluvial plains, side slopes, ridge top, valleys, and active flood plain. Paddy, maize, ginger, wheat, potato, apple and citrus fruits are the major crops (Fig. 2.1.27 & Table 2.1.6). Delineation of landform and land use/land cover (LULC) was carried out using satellite data (ALOS PALSAR DEM and Sentinel-2 & Fig. 2.1.28). Terrain mapping units (TMUs) were delineated through digital terrain analysis (Table 2.1.7 & Fig. 2.1.29).

Table 2.1.6 Landform-wise land use/land cover (LULC) in Mandi district, Himachal Pradesh

Landform	Arable	Forest	Wasteland	Others	Total
Alluvial plain	37708.79 (9.60)	-	-	360.72 (0.10)	38069.51 (9.71)
Active flood plain	136.22 (0.03)	8.35 (0.02)	11.75 (0.02)	-	156.32 (0.04)
Piedmont plain	16002.52 (4.10)	335.64 (0.08)	-	-	16338.16 (4.16)
Ridge top	3572.48 (0.91)	24989.50 (6.36)	-	-	28561.98 (7.27)
Side slope	192019.84 (48.86)	64158.02 (16.36)	3637.49 (0.93)	72.90 (0.02)	259888.25 (66.13)
Valley	35395.47 (9.01)	7214.79 (1.84)	155.83 (0.04)	72.09 (0.02)	42838.18 (10.90)
River				3928.91 (0.99)	3928.91 (0.99)
Habitation	-			3213.26 (0.82)	3213.26 (0.82)
Total	284835.30 (72.48)	96706.30 (24.61)	3805.07 (0.97)	7647.88 (1.94)	392994.60 (100)

Table 2.1.7 Description of Terrain Mapping Units (TMU) in Mandi district, Himachal Pradesh

Physiographic Region (Level-1)	Physiographic Sub-region (Level- 2)	Landform Type (Level-3)	Landform unit (Level-4)	TMU	Description
Himalayas / Mountain Ranges	Lesser Himalayas	Alluvial origin	Active flood plain	MIAfp2a	Very gently sloping active flood plain with arable land
				MIAfp3a	Gently sloping active floodplain with arable land
				MIAfp6a	Steeply sloping active floodplain with arable land
				MIAfp6w	Steeply sloping active floodplain with waste land
				MIAfp7f	Very steeply sloping active flood plain with forest land
				MIAfp7w	Very steeply sloping active flood plain with waste land
				MIAfp8a	Strongly sloping active flood plain with arable land
				MIAfp9a	Very strongly sloping active flood plain with arable land
			Alluvial plain	MIAp1a	Level to nearly level alluvial plain with arable land
				MIAp5a	Moderately steeply sloping alluvial plain with arable land
				MIAp6a	Steeply sloping alluvial plain with arable land
				MIAp7a	Very steeply sloping alluvial plain with arable land
				MIAp8a	Strongly sloping alluvial plain with arable land
				MIAp9a	Very strongly sloping alluvial plain with arable land
		Piedmont and Side slope	Piedmont plain	MIPp1a	Level to nearly level piedmont plain with arable land
				MIPp6a	Steeply sloping piedmont plain with arable land
				MIPp8a	Strongly sloping piedmont plain with arable land
				MIPp9a	Very strongly sloping piedmont plain with arable land
				MIPp9f	Very strongly sloping piedmont plain with forest land
			Side/ reposed slopes	MISs1a	Level to nearly level side slope with arable land
				MISs5a	Moderately steeply sloping side slope with arable land
				MISs5f	Moderately steeply sloping side slope with arable land
				MISs6a	Steeply sloping side slope with arable land
				MISs6f	Steeply sloping side slope with forest land
				MISs6w	Steeply sloping side slope with waste land
				MISs7a	Very steeply sloping side slope with arable land
				MISs7f	Very steeply sloping side slope with forest land
				MISs8a	Strongly sloping side slope with arable land
				MISs8f	Strongly sloping side slope with forestland
				MISs8w	Strongly sloping side slope with wasteland
				MISs9a	Very strongly sloping side slope with arable land
				MISs9f	Very strongly sloping side slope with forestland
				MISs9w	Very strongly sloping side slope with wasteland

Physiographic Region (Level-1)	Physiographic Sub-region (Level- 2)	Landform Type (Level-3)	Landform unit (Level-4)	TMU	Description
		Ridge/ Valley	Ridge top	MIRt1f	Level to nearly level ridge top with forest land
				MIRt6f	Steeply sloping ridge top with forest land
				MIRt7f	Very steeply sloping ridge top with forest land
				MIRt8a	Strongly sloping ridge top with arable land
				MIRt8f	Strongly sloping ridge top with forest land
				MIRt9a	Very strongly sloping ridge top with arable land
				MIRt9f	Very strongly sloping ridge top with forest land
			Fluvial valley	MIV1a	Level to nearly level fluvial valley with arable land
				MIV6a	Steeply sloping fluvial valley with arable land
				MIV6f	Steeply sloping fluvial valley with forest land
				MIV8a	Strongly sloping fluvial valley with arable land
				MIV8f	Strongly sloping fluvial valley with forest land
				MIV8w	Strongly sloping fluvial valley with waste land
				MIV9a	Very strongly sloping fluvial valley with arable land
				MIV9f	Very strongly sloping fluvial valley with forest land
				MIV9w	Very strongly sloping fluvial valley with waste land

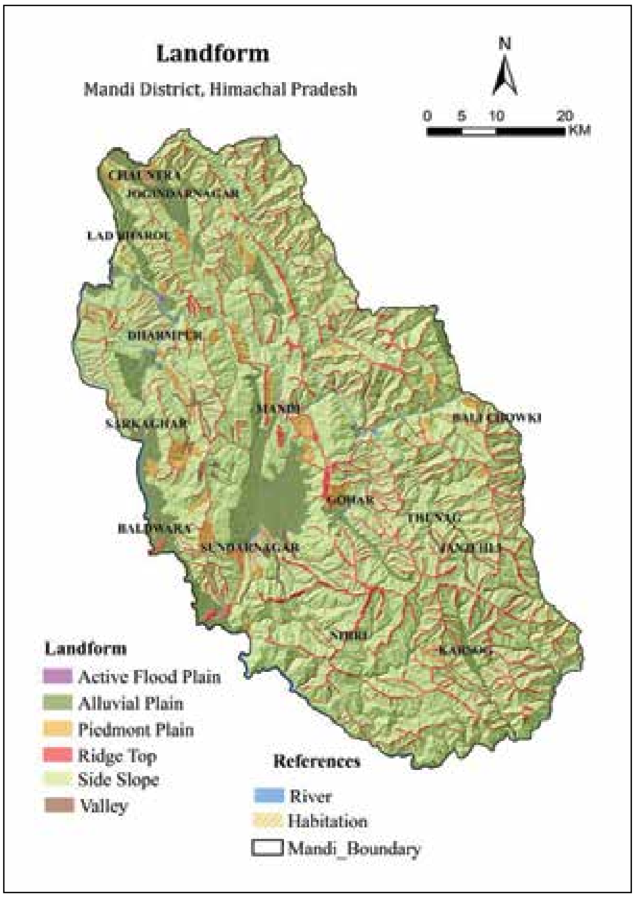


Fig. 2.1.27 Landform of Mandi district, HP

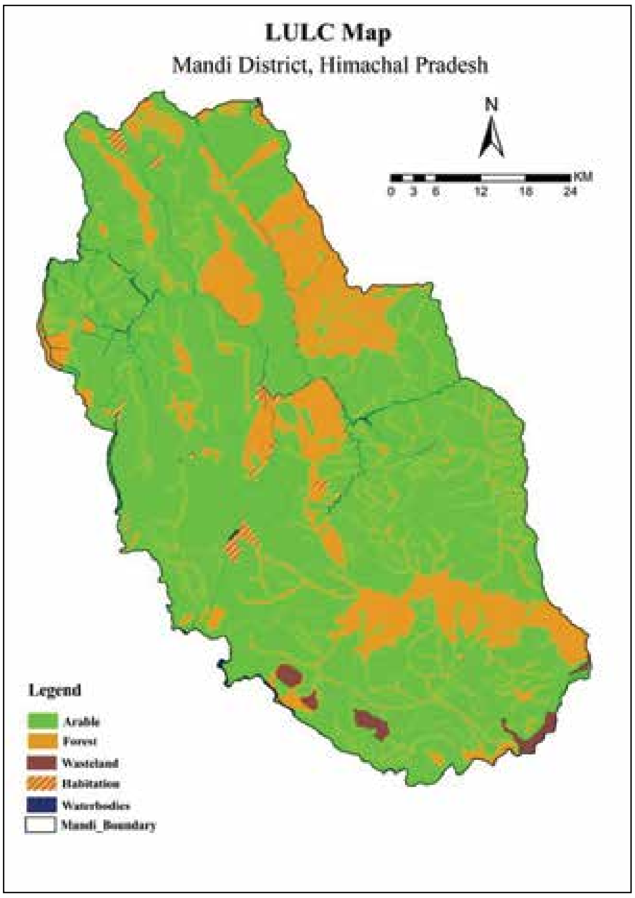


Fig. 2.1.28 LULC of Mandi district, HP

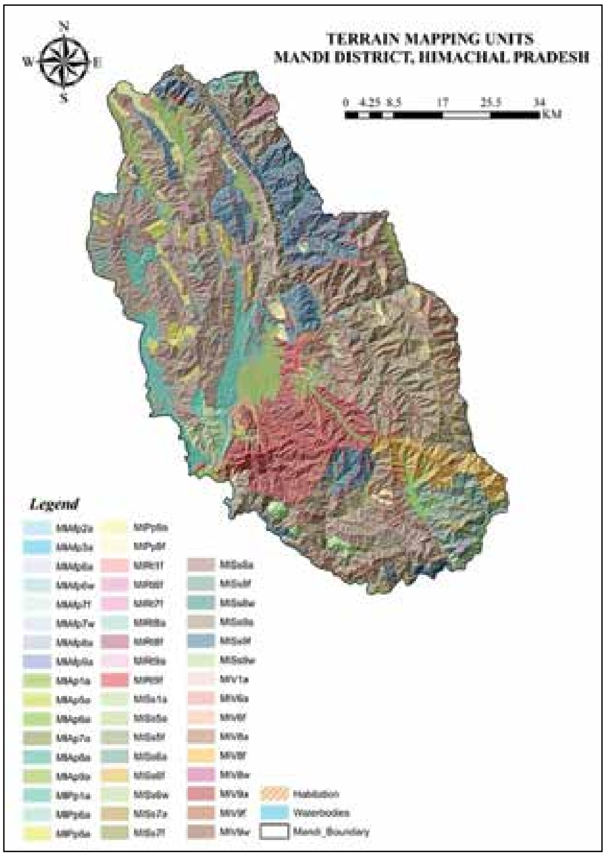


Fig 2.1.29 Terrain Mapping Units (TMU) in Mandi district, Himachal Pradesh

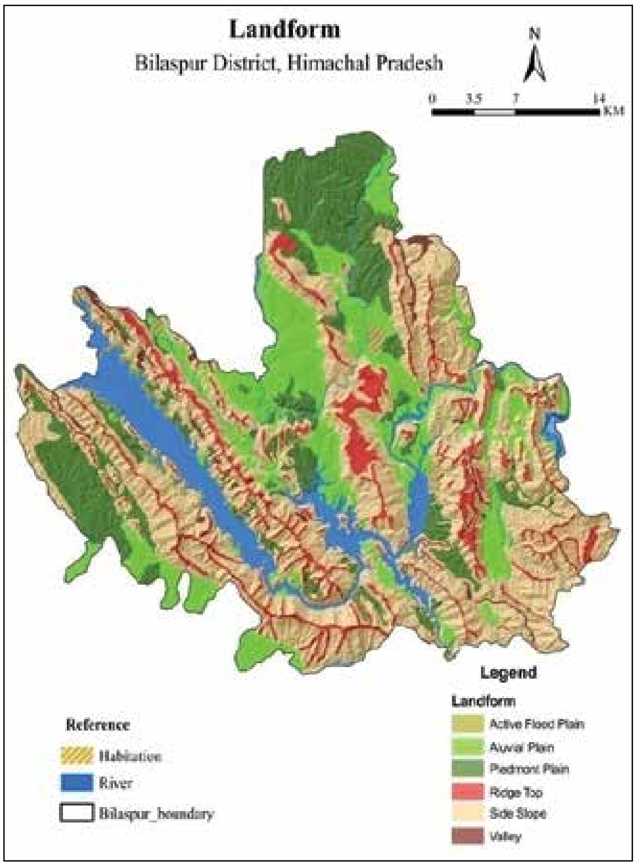


Fig. 2.1.30 Landform map of Bilaspur

Landform map of Bilaspur District of Himachal Pradesh

The Bilaspur district of Himachal Pradesh is a part of the outer hills (Shivalik) of the Himalayas with a geographical area of 1167 km^2 and lies between 31°12'30''–31°35'45''N latitudes and 76°23'45''–76°55'40''E longitudes. The climate of the area is temperate to subtropical, with an annual average rainfall of 1106 mm and temperature varying from 1.3 to 40.7° C. Maize is the principal *kharif* season crop, while wheat is predominantly sown in the *rabi* season. Besides, agriculture, horticulture, agro-forestry, and livestock are other agricultural practices in the area.

Satellite data (ALOS PALSAR DEM and Sentinel-2) were analyzed for the delineation of landform units, and terrain parameters such as DEM, slope, aspect, hill shade, and landform map (Fig. 2.1.30) generated under RS & GIS environment.

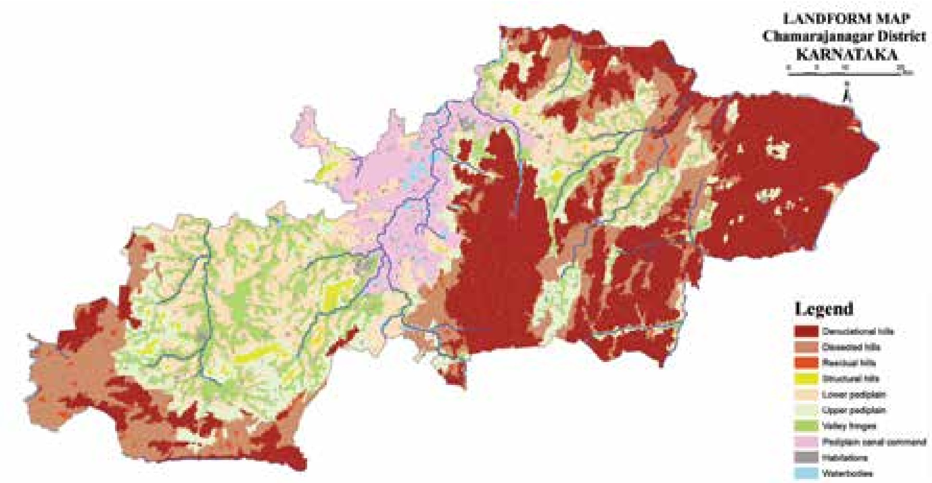


Fig 2.1.31. Landform map of Chamrajanagar district.

Southern Region

Chamarajnagar district, Karnataka

Chamarajnagar district of Karnataka covers an area of 5,64,775 ha in AESR 8.2. Eight landform units, *viz*., denudational hills, dissected hills, residual hills, structural hills, upper pediplain, lower pediplain, valley fringes, and pediplain, were delineated following the standard operating protocol (SOP) (Fig. 2.1.31).

Koppal district, Karnataka

Koppal district of Karnataka covers an area of 5,52,495 ha in AESR 8.2 and represents Deccan plateau physiography and South Deccan plateau sub-physiography. Granite-gneiss (Gn), Dharwar schist (Sc) and Kaladgi sedimentary (Sd) are the main geological formations. The district was divided into fourteen landform units, *viz*., denudational hills, dissected plateau, residual hills, escarpments, inselbergs, linear ridges, upper pediplain, lower pediplain, undulating uplands, undulating lowlands, pediments, plateau top, recent alluvial plains and valleys (Fig. 2.1.32).

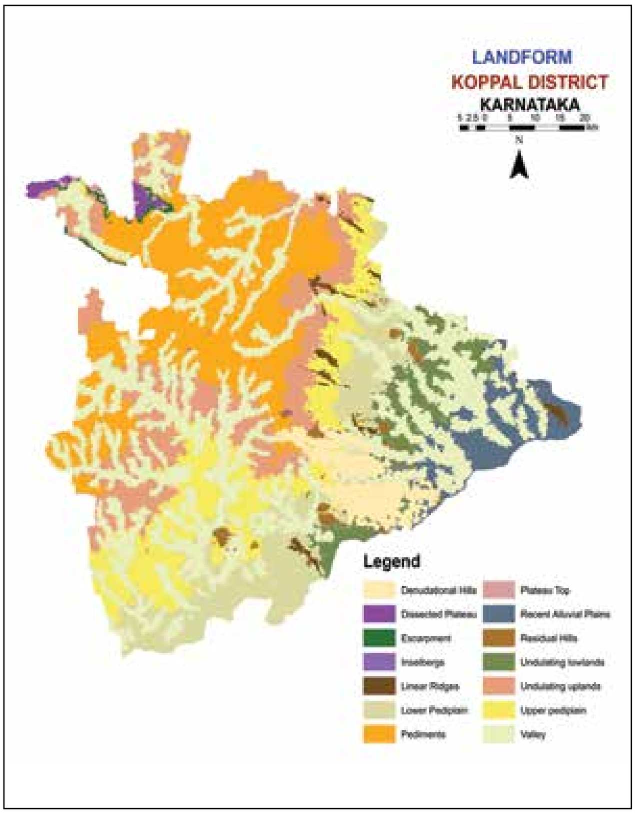


Fig 2.1.32. Landform map of Koppal district.

2.2 INVENTORYING NATURAL RESOURCES

Land Resource Inventory of Vidarbha Region for Sustainable Land Use Planning

A high-resolution digital land resource inventory (LRI) of Vidarbha region was generated, using which land use plans, including cropping/farming systems and soil and water conservation plans, were suggested. In the first step, the legacy soil data were collated, digitized, and georeferenced to locate 'blind spaces' for which no information was available. After that, the sampling strategy of seven districts (for which limited or no data was available), namely Chandrapur, Gadchiroli, Bhandara, Gondia, Washim, Akola and Buldhana was generated through the cLHS approach and a soil survey was carried out in 233 sites across the seven districts. 861 soil samples collected from the identified sites were analysed for nine key soil properties, and the digital soil mapping technique was used to generate the spatial distribution map of the soil properties, *viz*. depth, pH, EC, SOC, sand, silt, clay, available water capacity (AWC), and $CaCO_3$ content across six standard depths as per Global Soil Map specifications at high resolution (30 m). Maps depicting clay content and SOC content are illustrated in Fig. 2.2.1. Around 0.1 M ha in different pockets of Akola, Amravati and Buldhana districts require soil salinity management (EC > 4 dS m^{-1}). Nearly 9% of the Vidarbha soils have poor SOC content. Chandrapur and Gadchiroli districts have low (< 0.5%) SOC in 27% and 20% of their cultivated area, respectively. Soils of Bhandara (50% of cultivated) and Nagpur (21%) are more prone to moisture stress as compared to those of the other nine districts of the region, as indicated by low available water capacity (< 12%).

Land suitability evaluation was done for twenty major crops grown in the region using a Analytical Hierarchical Process (AHP) in the GIS environment, and crop suitability maps were generated by integrating different information layers to prepare proposed agricultural land use plans. The crop suitability analysis is in agreement with the prevailing ground reality that cotton, soybean, rice and citrus are not only the farmers' choice but also the most suited crops in different parts of the Vidarbha region (Fig. 2.2.2). Low water-requiring crops such as coarse millets and pulses have been suggested during *kharif* and *rabi*, especially, in marginal soils having shallow depth and low water holding capacity. Wheat/chickpea/linseed are advocated during *rabi* season under assured irrigation. The list of recommendations includes a combination of 14 soil and water conservation measures for arable and non-arable land. Livelihood-related activities such as fisheries in farm ponds, goat rearing, sericulture, and backyard poultry are also recommended.

Land Resource Inventory of Ahmednagar District (Northern Part), Maharashtra on a 1:10000 scale using geospatial technique for agricultural land use planning

Soils in the Akole tehsil of Ahmednagar district occur on high hills, pediments, foot slopes and valley positions. The soils of the Mutkel series are slightly acidic (6-6.5). Soils representing pediment, foot slope and valley landforms are moderately alkaline in reaction (8.1-8.6). Soil pH increases with depth in all landforms except valley. The $CaCO_3$ content ranged from 1 to 2% in the control section of high hill soils (Fig 2.2.3). The pediment soils contain 6-21 % $CaCO_3$ throughout the soil depth. Soils in the foot slope contain 3-8 % $CaCO_3$ up to 90 cm and increased up to 32 % in the BC horizon at 90-130 cm depth. Clay increase of more than 1.2 times in subsurface horizons (>15 cm thickness) indicated that clay illuviation was dominant in soils of high hills, upper pediments and foothills.

Land resource inventory and land use planning of Osmanabad district, Maharashtra using geospatial techniques

Soils from 8 Landform Units (LU) were characterized to establish the soil-landform relationship. Terrain Mapping Units (TMU) under different LUs were modified/correlated and merged based on similar soil characters, and finally, 19 TMUs were chosen for soil mapping. Soils of the area are grouped into Entisols, Inceptisols and Vertisols. Soil pH, EC, bulk density (BD), organic carbon content (OC), and exchangeable Na, and K of the soils were analyzed. Soils are moderately to strongly alkaline and non-

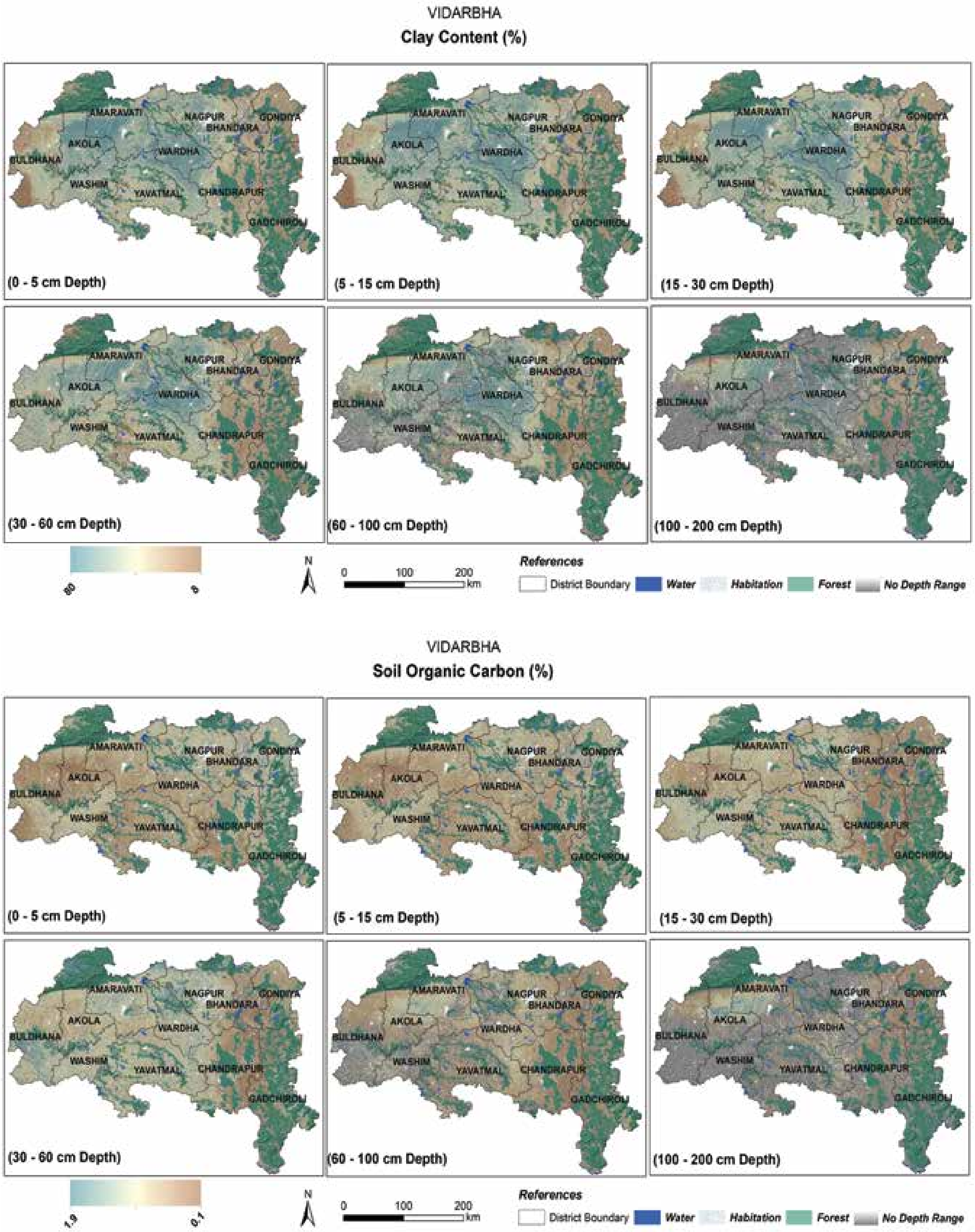


Fig. 2.2.1. Depth-wise soil organic carbon and clay content in Vidarbha region,

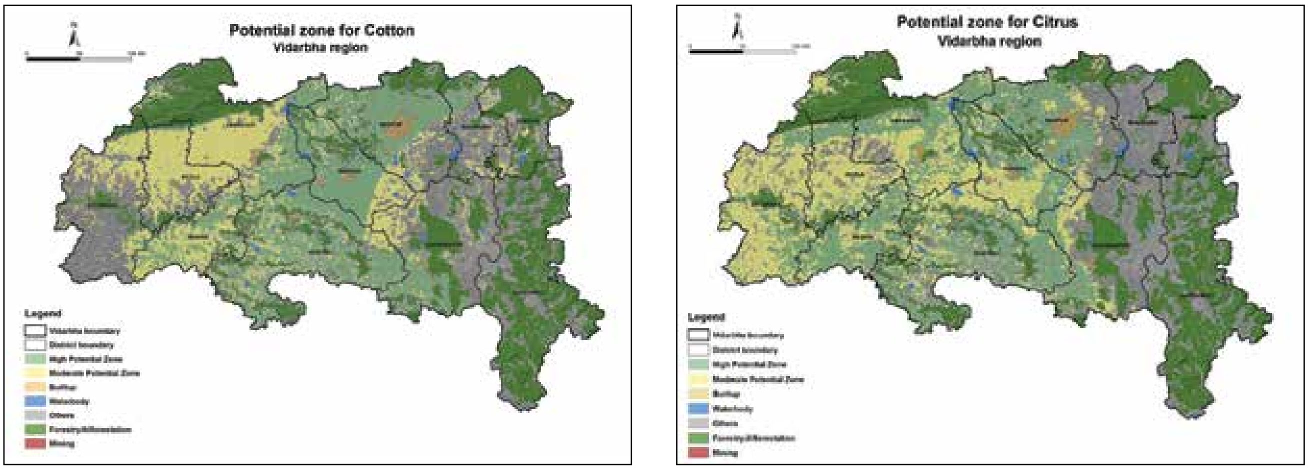


Fig. 2.2.2. Potential zones for cotton and citrus in Vidarbha region, Maharashtra

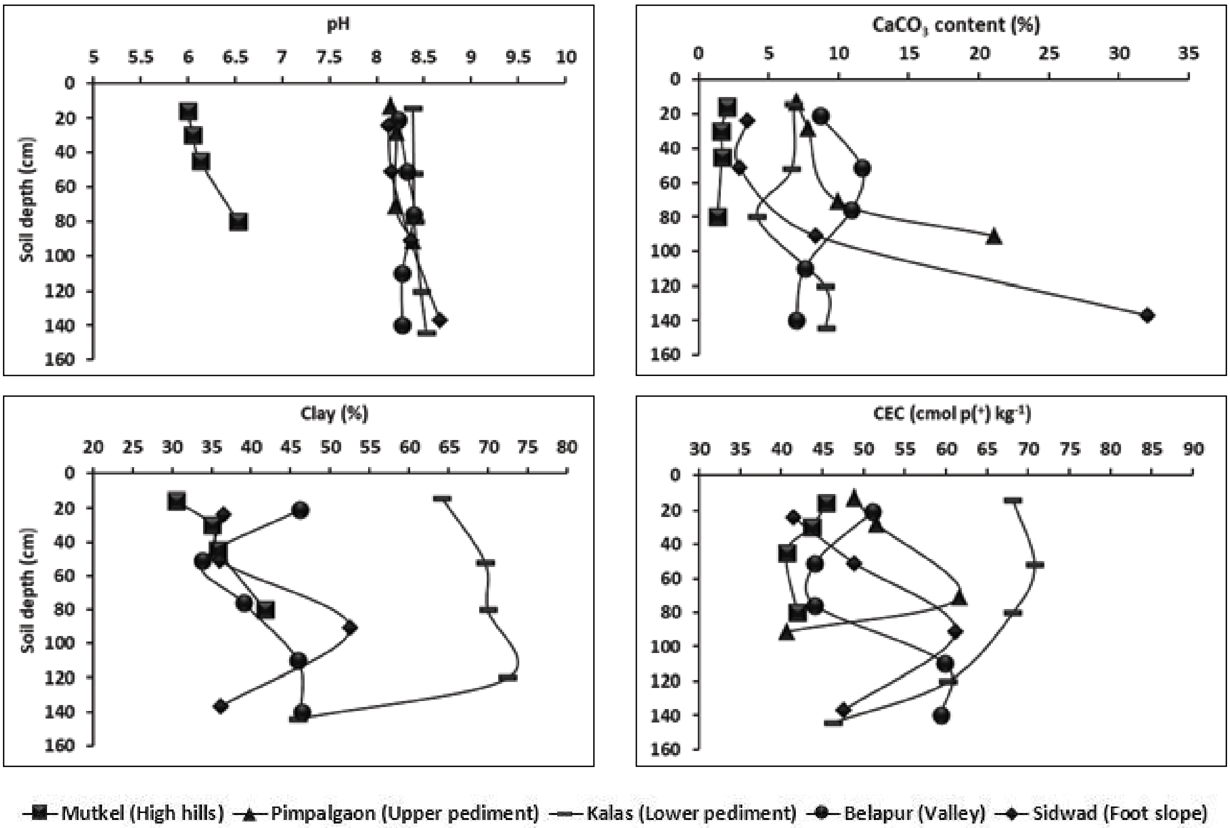


Fig 2.2.3. Depth-wise distribution of pH, clay (%) content and CEC in soils occurring at different landforms of Akole tehsil (Dist. Ahmednagar).

saline, whereas BD varies from 1.28-1.50 Mg m^{-3}. Soils developed over a subdued plateau, linear rides, scarp slopes and piedmonts are dominantly very shallow to shallow and moderately alkaline, whereas soils developed on undulating uplands, undulating lowlands, valley floors, and narrow valleys are deep to very deep and are alkaline.

Land Resource Inventory of Rahuri Taluka of Ahmednagar District, Maharashtra State on 1:10000 Scale for optimal Agricultural Land Use Planning Using Geo-spatial Techniques.

Land Management Units (LMUs) are the grouping of soil series based on the necessary management to obtain the best possible production by minimizing the influence of constraints in a given set of conditions. Eight LMUs were delineated in Rahuri taluka of Ahmednagar district. In LMU 1-4, the problem of severe soil erosion exists and needs immediate management interventions. The problems of soil salinity, sodicity, calcareousness, and poor drainage were found in the soils of LMU 4-8. LMU-wise interpretative groupings are presented in Table 2.2.1.

Table 2.2.1: Land Management Units: Interpretative grouping of soils in Rahuri taluka, Ahmednagar district

LMUs	Landforms	Description	Phases of soil series	% to TGA
1	DnBaS^m	Very shallow, well drained, gravelly clay loam soils on gently to moderately sloping summits with sever erosion.	VarfC3g1, VarfD3g1, VarfD3g2	10.2
2	DnBaS^m	Shallow, well drained, gravelly clay soils on gently sloping summits with gravely clay loam to gravelly clay surface and moderate erosion.	TahfC2g1, TahmC2g1	2.2
3	DnBaE^s/ DnBaU^p	Very shallow, well drained, slight to strong effervescence, gravelly clay loam soils on gently to moderately sloping escarpments and upper pediments and occasionally on moderately steeply sloping escarpments with moderate to severe and occasionally very severe erosion.	GunfD3g1, GunfD3g2, GunfD4g2, GunfE3g1, GunfE4g1, GunmD3g1 KanfC2g1, KanfC3g1, KanmC2g1	16.94
4	DnBaL^p	Shallow to moderately shallow, well drained, slight to strong effervescence, clay loam to clayey soils on very gently to gently sloping lower pediments with clay loam to clayey surface and moderate erosion.	VamfB2, VamfC2, VamfD3, VammB2, VammC2 DigfC2, DigmB2, DigmC2	25.17
5	DnBaU^l	Deep, moderately well drained, strong to violent effervescence, clayey soils on very gently sloping undulating lands with clayey surface, moderate erosion and slight sodicity.	DhamB2n1	0.9
6	DnBaU^l	Deep, moderately well drained, strong to violent effervescence, clayey soils on very gently to gently sloping undulating lands with clay loam to clayey surface and moderate erosion.	MalfC2, MalmB2, MalmC2	7.5
7	DnBaU^l&DnBaP^l	Very deep, moderately well to imperfectly drained, violent effervescence, clayey soils on very gently sloping undulating lands and plains with clayey surface, slight erosion and slight to moderate sodicity.	DevmB1n1 KenmB1n1, PatmB1n1 KolmB1n2	24.4
8	DnBaV^a	Very deep, well drained, violent effervescence, clayey soils on nearly level to very gently sloping valley with clayey surface, slight erosion and slight sodicity.	PipmA1n1, PipmB1n1	6.8

Land Resource Inventory of Seloo and Samudrapur *tehsils* of Wardha district using Geo-spatial Techniques

Soils of Seloo tehsil

Seloo taluka, Wardha district, Maharashtra, lies between 20°41'22.9" and 21°02'10.0" N latitudes, and from 78°31'27" to 78°55'38"E longitudes, covering an area of 76574 ha. The landform map of Seloo taluka was generated using ALOS DEM (12.5) and Sentinel-2 satellite data and revised after the field visit. Ten landforms, *viz.*, upper plateau, lower plateau, dissected plateau, pediment, escarpment, upland, lowland, narrow valley and mesa, were delineated. After a detailed soil survey, 15 soil series have been tentatively identified (Fig. 2.2.4).

Soils of Samudrapur tehsil

Samudrapur taluka, Wardha district, Maharashtra, lies between 20°25'38" to 20°47'45" N latitude and 78°48'3" to 79°13'22"E longitude covering an area of 96602 ha. A landform map of the taluka was generated by delineating seven landforms, *viz.,* plateau, pediment, upland, lowland, alluvial plain and mesa**.** Tentatively 12 soil series have been identified after the soil survey and correlation (Fig. 2.2.5).

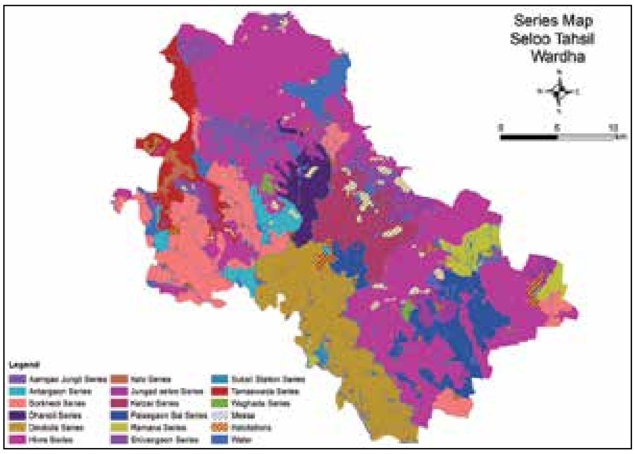


Fig. 2.2.4. Soil series map of Seloo *tehsil*

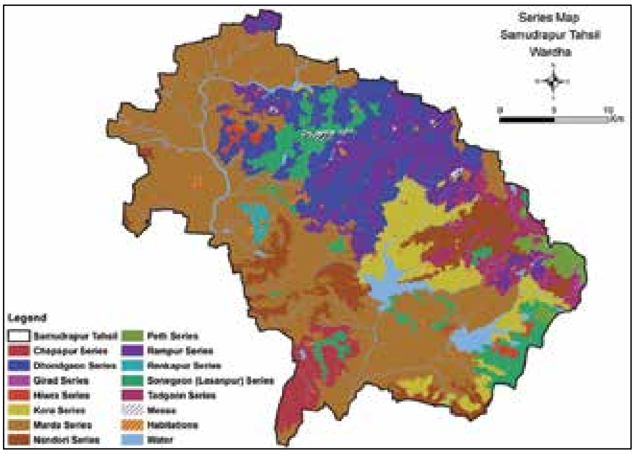


Fig. 2.2.5. Soil series map of Samudrapur *tehsil*

Land Resource Inventory of Gadchiroli district of Maharashtra on a 1:10000 scale for optimal agricultural land use planning

The Gadchiroli district, covering an area of 14042.98 km^2, is located between 18°08' and 20°50' N latitudes, and from 79°45' to 80°54' E longitudes. The landform map of the district was prepared using ALOS DEM and Sentinel-2 satellite data. Seven landforms (hills & ridges, undulating pediplain, alluvial plain, undulating uplands, undulating lowlands, undulating pediments and isolated hillocks) were delineated (Fig. 2.2.6). Hills & ridges constitute 36% of the total geographical area (TGA) of the district followed by undulating pediplains (26.1% TGA). Approximately 40% TGA of the district is under agricultural activity, and the remaining 60% area is under forest cover.

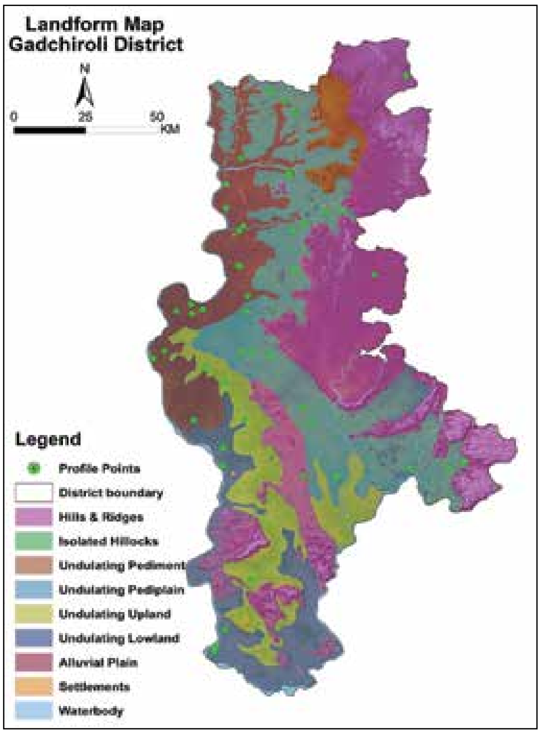


Fig. 2.2.6. Landform map of Gadchiroli district, Maharashtra with profile locations.

Land Resource Inventory of FDCM Divisions Using High-Resolution Geospatial Technique

The project was undertaken to generate the baseline data on soil fertility and soil suitability for teak plantation of the forest sites under the Forest Development Corporation of Maharashtra (FDCM) divisions of the state and to suggest the appropriate interventions to restore the forest ecosystem through the afforestation of the degraded forest areas. Four divisions, namely Chandrapur, Yavatmal, Markhanda and Pranhita, covering 10 ranges and 28 compartments, were surveyed (Table 2.2.2), and the soils were analysed for pH, EC, organic carbon, exchangeable bases, particle size distribution, bulk density, available macro and micronutrients.

Table 2.2.2: Division wise area surveyed in the second phase of FDCM

S. N	Division	Range	Compartments	Area (Ha)
1	Chandrapur	Mamla	395	25.8
			411	17.7
		Tohogaon	26	20.0
		Zaran	4	1.0
2	Yavatmal	Metikheda	233	21.5
			232	27.0
			216	30.0
			232	20.0
			278	28.0
		Ghatanji	239	20.0
			240	30.0
			242	30.0
			228	15.9
			228	14.1
3	Markhanda	Konsari	207	90.0
			181	100.0
		Markhanda	275	100.0
			278	78.8
			527	50.0
			545	67.0
			546	36.0
			181	50.0
		Tondel	93	40.0
4	Pranhita	Jimalgatta	78	36.7
			84	37.6
			55B	40.0
		Aheri	47	43.0
			45	35.0
			Total	**1115.10**

Eastern Region

Land resource inventory of Sahibganj district, Jharkhand, on a 1:10000 scale using geospatial techniques

Sahibganj district covers an area of 2,06,300 ha and is located between 24°42'49" and 25°21'16" N latitude and from 87°27'02" to 87°57'54" E longitude in the Agro-eco subregion-13.1 (Eastern Plain, Hot Sub humid (moist)). It has nine blocks *viz.* Sahibganj, Mundro, Rajmahal, Boreo, Udhwa, Taljhari, Barheit, Barharwa and Pathna. 31 soil series have been identified and mapped into 48 soil mapping units at the phase level (Fig. 2.2.7). Soils belong to Entisols, Inceptisols, Alfisols and Vertisols. Soils of the district are shallow to moderately deep in the hilly regions of Sahibganj, Borio and Mundro blocks, and very deep in the valley, foothills, pediment and alluvial plains. Soil texture vaties from silty loam to silty clay loam. Soils in parts of Rajmahal, Udhwa and Taljhari blocks are heavy textured (45-55% clay content). Most of the soils in the district are neutral (pH 7.1) to slightly alkaline (pH 7.8) in reaction, medium to high in CEC (22.8-31.3 (p^+) kg^{-1}), and high in base saturation (84-86%).

Land resource inventory of Maldah district, West Bengal, on a 1:10000 scale using geospatial techniques

Soil survey of Maldah district of West Bengal, covering an area of 373300 hectares, was completed on a 1:10000 scale. 56 soil series were identified and mapped into 59 soil mapping units at phase level (Fig. 2.2.8). The area is dominated by Alfisols, Inceptisols and Entisols soil orders. Among the different sub-orders, Endoaquepts with Vertic intergrade occupies the highest area (30.4% of TGA). The Sadhail soil series covers the maximum area (7.5% of the TGA), followed by the Satbaria soil series (5.3% of TGA). The soils of the entire area of the district formed by alluvium deposited by the Ganga River exhibit moderate (5-10%) to high (>10 %) calcium carbonate ($CaCO_3$) content as compared to the soils developed by alluvium deposition of other rivers like Mahananda and Tangon. Around 68.6%, 16.0% and 7.7% of the district were found to contain low/nil (<5%), moderate (5-10%) and high (>10%) $CaCO_3$ content, respectively.

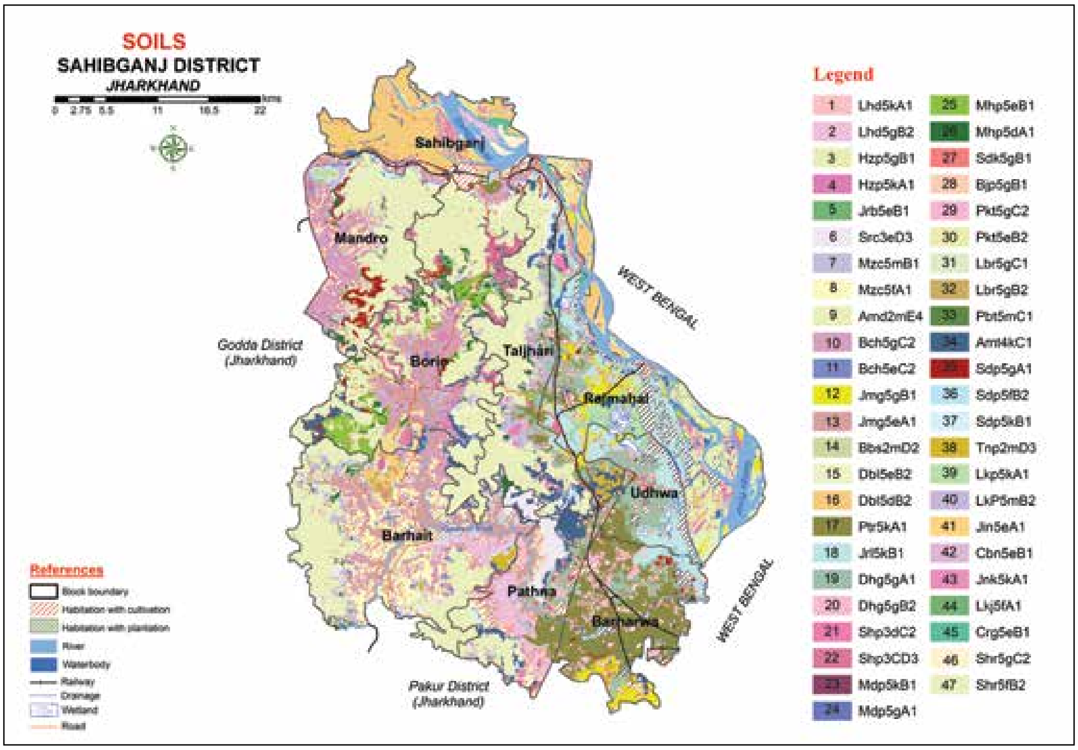


Fig. 2.2.7. Soil Map of Sahibganj District

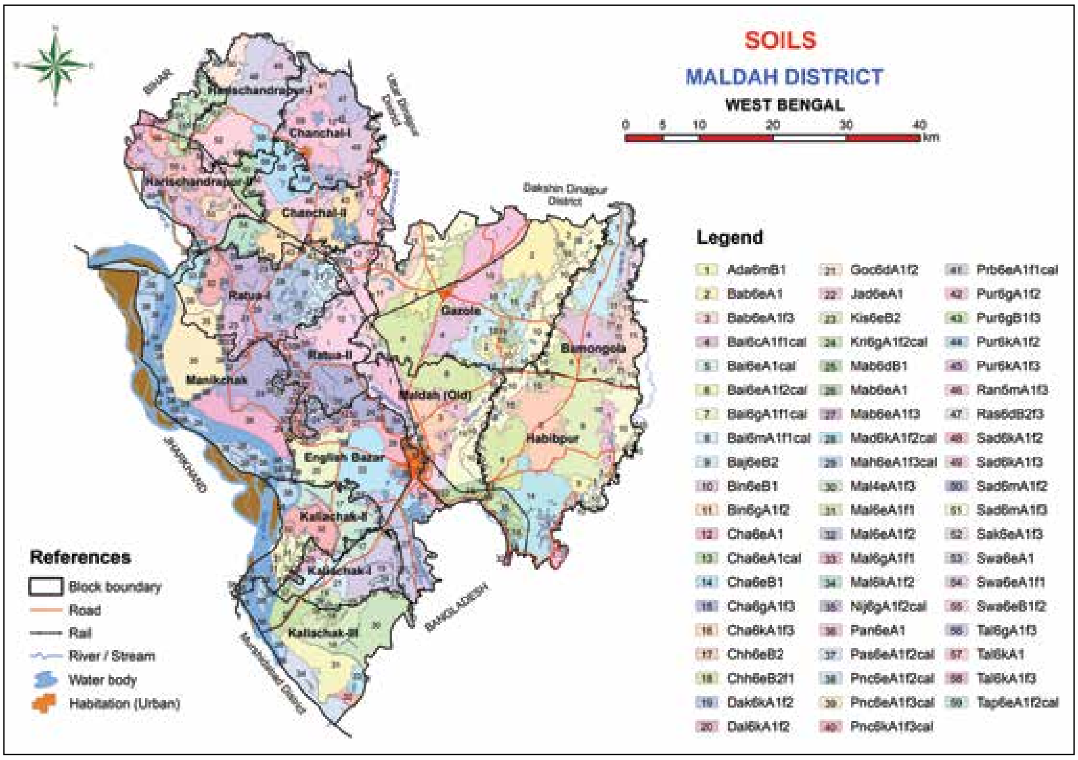


Fig. 2.2.8. Soil map of Maldah district, West Bengal

Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD) Odisha Project

A launching Workshop cum Training on LRI was conducted during November 04-07, 2022 at Sambalpur, Odisha. The manuals of Field Guide & Handbook of LRI have been released & about 50 copies of both were distributed to all OUAT partners & officials of DSC&WD & other line departments. Base map of Musakani micro watershed (MWS) was prepared and 38 soil profiles were studied, correlated and 15 profiles were selected for soil analysis (Table 2.2.3). A total of 31 soil profiles were studied in Pabliguda-Pokulpada model MWS of Koraput district, correlated (Table 2.2.4).

Table 2.2.3. Soil morphological properties of Jamloi-Musakani Model MWS, Sambalpur, Odisha

Geology	Landform	Land use	Base map legend	Soil drainage (Run-off)	Soil depth (cm)	Soil colour	Soil horizon	Soil texture	Coarse fragments	Soil Taxonomy
Quartzite	Strongly sloping side slope of hills	Dense forest	Q128fd	Excessively well (V. Rapid)	Moderately shallow to shallow	2.5 YR-5YR	A-AC-2Cr	Sandy loam – sandy clay loam	50-80% fine gravels 35-50% coarse gravels	*Lithic/ Typic Ustorthents*
	Moderately steeply sloping foot hills	Open forest	Q135fo	Well/ Somewhat excessive (Rapid)	Moderately deep to deep	2.5 YR-5YR	A-Bt-BC-CB	Loam-Sandy clay loam	35-50% fine gravels 25-35% coarse gravels	*Typic Haplustalfs/ Typic Rhodustalfs*
Granite-gneissic	Moderately sloping uplands	Dense forest	G204fd	Well (Rapid)	Moderately deep to deep	2.5 YR	A-Bt-BC	Loam-Clay loam	15-25% fine gravels 5-10% coarse gravels	*Typic Rhodustalfs*
	Gently sloping uplands	Plantation	G203p	Moderately well (Medium)	Moderately deep to deep	2.5 YR	Ap-Bw-Bt-BC	Loam-Clay loam	10-15% fine gravels 2-5% coarse gravels	*Typic Rhodustalfs*
	Very gently sloping plains	Agriculture	G302a	Somewhat Poor/ Poor (Slow)	Moderately deep to very deep	7.5 YR-10 YR	Ap-Bw-Bt-Bg-BCg	Silt loam-Silty clay loam	5-10% fine gravels	*Typic Endoaquepts/ Endoaqualfs*
	Very gently sloping valley	Agriculture	G402a	Poor/ Very poor (V. Slow)	Moderately deep to very deep	10 YR-2.5 Y	Ap-Bg-BCg	Loamy sand–Silty clay loam	10-15% fine gravels	Typic Endoaquepts/ Endoaqualfs

Table 2.2.4. Soil morphological properties of Pabliguda-Pokulpada Model MWS, Koraput, Odisha

Geology	Landform	Land use	Base map legend	Soil drainage (Run-off)	Soil depth (cm)	Soil colour	Soil horizon	Soil texture	Coarse fragments	Soil Taxonomy
Charnockite	Moderately steeply sloping side slope of hills	Open forest	C125fo	Well (Medium)	Deep	2.5 YR-10 R	A-Bw-Bt-BC	Loam- Clay loam	5-10% fine gravels	Typic Rhodustalfs
	Moderately sloping foot hills	Plantation	C134p	Well (Medium)	Deep	2.5 YR-10 R	A-Bw-Bt-BC	Loam-Clay loam	2-5% fine gravels	Typic Rhodustalfs
	Gently sloping valleys	Agriculture	C403a	Somewhat Poor (Slow)	Very deep	2.5 YR	Ap-Bw-Bt-Bg	Sandy loam-Sandy clay	Nil	Aquic Rhodustalfs
Granite-gneissic	Moderately steeply sloping uplands	Open scrubs	G205os	Moderately well (Medium)	Very deep	2.5 YR-10 R	A-Bw-Bt	Clay loam-Clayey	Nil	RhodicPaleustalfs
	Moderately sloping uplands	Plantation	G204p	Moderately well (Medium)	Very deep	10 R	Ap-Bt/ Ap-Bw-Bt	Clay loam-Clayey	Nil	RhodicPaleustalfs
	Gently sloping uplands	Agriculture	G203a	Somewhat Poor (Slow)	Very deep	5 YR-7.5 YR	Ap-Bw-Bt-Bg	Loam-Silty clay loam	Nil	OxyaquicHaplustalfs
	Very gently sloping valleys	Agriculture	G402a	Somewhat Poor (Slow)	Very deep	7.5 YR-10 YR	Ap-Bw-Bt-Bg	Silt loam-Silty clay loam	Nil	Aquic Haplustalfs

North – Eastern Region

Land resource inventory of Longding district Arunachal Pradesh on a large scale for agricultural land use planning using geospatial techniques

Ten soil series have been identified and mapped on a 1:10000 scale with 16 soil mapping units at phase level (Fig. 2.2.9 & Table 2.2.5).

Soils of Khanu, Pumai, Wakka, and Senua series have strong acidity, low phosphorus and medium potassium content, and moderate erosion. Soils of the Dasatong series are extremely acidic, low in phosphorus and medium in potassium, besides being deficient in boron and copper.

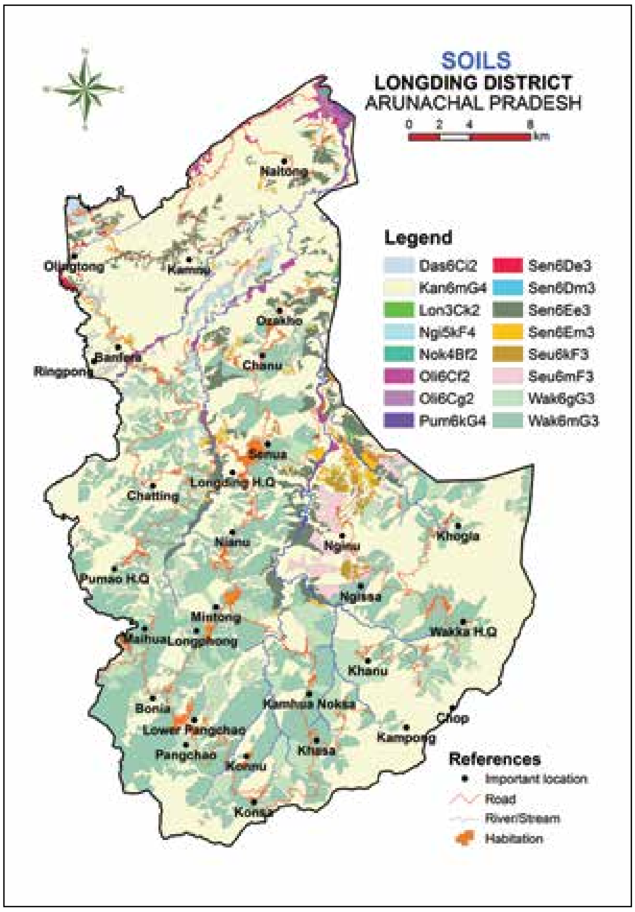


Fig. 2.2.9. Soil map of Longding district

Table 2.2.5. Soil series and phases of Longding district

Landform	LEU map unit	Soil series	Soil map unit	Mapping legend	Brief description of soil series	Area (ha)	TGA (%)
Very steeply sloping moderate hill (AHMh7)	AHMh7ag	Pumai	1	Pum6kG4	Very deep, excessive drained, dark yellowish brown to very dark greyish brown, silty clay to clay soils on very steeply sloping moderate hill having silty clay surface and very severe erosion (*Fine, mixed hyperthermic Humic Dystrudepts*).	3	0.002
	AHMh7jf	Wakka	2	Wak6mG3	Very deep, well drained, yellowish brown to very dark brown, silty clay loam to clay soils on very steeply sloping moderate hill having clay surface and severe erosion (*Fine, mixed hyperthermic Humic Eutrudepts*).	23070	21.70
	AHMh7j		3	Wak6gG3	Same as Wakkawith silty clay loam surface texture.	8612	8.10
Steeply sloping moderate hill (AHMh6)	AHMh6j	Senua	4	Seu6mF3	Very deep, well drained, brown toverydark grayish brown, silty clay to clay soils on steeply sloping moderate hill havingclay surface texture and severe erosion (*Fine mixed hyperthermic Typic Humudepts*).	1226	1.15
	AHMh6jf		5	Seu6kF3	Same as Senua with silty clay surface texture.	452	0.43

Landform	LEU map unit	Soil series	Soil map unit	Mapping legend	Brief description of soil series	Area (ha)	TGA (%)
Very steeply sloping low hill (AHLh7) and steeply sloping low hill (AHLh6)	AHLh7jf, AHLh6j	Nginu	6	Ngi5kF4	Deep, excessive drained, dark yellowish brown, sandy silty clay soils on steeply sloping low hill having silty clay surface and very severe erosion (*Fine, mixed hyperthermic Typic Haplohumults*).	904	0.85
Moderately steeply sloping low hill (AHLh5), moderately sloping low hill (AHLh4)	AHLh5j, AHLh5ag	Senua Naksa	7	Sen6eE3	Very deep, excessive drained, dark brown to very dark gray, silt loam to clay soils on moderately steeply sloping low hill having silt loam surface texture and severe erosion (*Fine mixed hyperthermic Typic Palehumults*).	4467	4.20
	AHLh5jf		8	Sen6mE3	Same as Senua Naksa developed on moderately steeply sloping low hill with clay surface texture.	1036	0.98
	AHLh4j		9	Sen6eD3	Same as Senua Naksa developed on moderately sloping low hill with silt loam surface texture.	183	0.17
	AHLh4jf		10	Sen6mD3	Same as Senua Naksa developed on moderately sloping low hill with clay surface texture.	8	0.007
Moderately sloping piedmont plain (amplitudinal hill) (AHP4) and gently sloping piedmont plain (amplitudinal hill) (AHP3)	AHP4j, AHP3j, BVf	Olingtong	11	Oli6fC2	Very deep, somewhat excessive drained, yellow to dark yellowish brown, loam to clay loam soils on gently sloping having clay loam surface and moderate erosion (*Fine mixed hyperthermic Typic Dystrudepts*).	964	0.90
Gently sloping valley (amplitudinal hill) (AHV3)	AHV3j, BVV2ag/p	Longkai	12	Lon3kC2	Moderately shallow, somewhat excessive drained, dark gray to dark olive gray, sandy clay loam to sandy clay soils on very gently sloping young alluvial plain having silty clay surface and moderate erosion (*Fine mixed hyperthermic Typic Udifluvents*).	153	0.14
Gently sloping piedmont plain (Brahmaputra valley) (BVP3)	BVP3	Olingtong	13	Oli6gC2	Same as Olingtong with silty clay loam surface texture.	135	0.13
Very gently sloping valley (Brahmaputra valley) (BVV2)	BVV2ag/p	Nokfan	14	Nok4fB2	Moderately deep, somewhat excessive drained, dark yellowish brown, loam to sandy clay soils on gently sloping piedmont plain having clay loam surface and moderate erosion (*Fine mixed hyperthermic Typic Fluvaquents*).	37	0.03
Very gently sloping young alluvial plain (Brahmaputra flood plain) (BFpY2)	BFpY2ag, BFpY2ag/p	Dasatong	15	Das6iC2	Very deep, well drained, yellow to dark yellowish brown, sandy clay loam to sandy clay soils on Very gently sloping young alluvial plain having sandy clay surface and moderate erosion (*Fine-loamy mixed hyperthermic Fluvaquentic Dystrudepts*).	294	0.28

Landform	LEU map unit	Soil series	Soil map unit	Mapping legend	Brief description of soil series	Area (ha)	TGA (%)
Very steeply to steeply sloping amplitudinal hill (AHR)	AHR6f / AHR5f	Khanu	16	Kan6mG4	Very deep, excessively drained, yellowish brown to dark yellowish brown, clay soils on very steeply sloping amplitudinal hill having clay surface and very severe erosion *(Fine mixed hyperthermic Eutric Humudepts)*.	61946	58.28
Miscellaneous (habitation / river / water body)						2810	2.65
Total area						**106300**	**100.00**

Lohit district of Arunachal Pradesh

The morphological study of the soils of the district showed a high variation in the soil properties. The soil depth varied from very shallow (0-60 cm) in the side slopes of the hills of Wakro block to deep (>100 cm) in the alluvial plains of Sunpura block. The soil profiles were correlated, and soil samples of representative soil profiles were analyzed for physical and chemical properties. The base saturation was higher in alluvial plains compared to hills and varied from 26 to 93%. Clay CEC varied from as low as 7 to as high as 73 c mol $p^{(+)}$ /kg clay. In some profiles, the OC (%) was as high as 3.4%. Lithological discontinuity was noted in almost all profiles of the alluvial plains. The active alluvial plain showed a horizon sequence of A1-AC and Ap-AC; the younger alluvial plain has Ap-Bw, whereas the A1-Bw-BC sequence was observed in the piedmont alluvial plain.

LRI of Rangjuli block, Goalpara district, Assam on a 1: 10,000, for optimal agricultural land use planning using geospatial technique

Eight soil series were identified and named as Ambari (Fluvaquentic Endoaquepts), Kahibari (Typic Kandiaqualfs), Madong (Fluvaquentic Endoaqepts), Kamarpota (Oxyaqic Kandiudalfs), Simlitola (Inceptic Hapludalfs), Sildubi (Typic Hapludalfs), Athiabari (Typic Plaeudults), Ambuk (Typic Kandiudults). The soils of Ambari occur in the active, younger and older alluvial plains, nearer to the river streams, with 0-1 % slope. Madong soils (0-1% slope) occur on the banks of the Ildek River, originating from the Meghalaya plateau. Sildubi soils occur in the inselbergs (8-15% slope) and foot hills of inselbergs (3-8% slope). Lithological discontinuity was noted in some pedons of Ambari, Kahibari and Madong series. The soil reaction of all the series was found to be moderately to strongly acidic and varied from 4.52 (Kamarpota) to 5.13 (Sildubi) in surface horizons. The exchangeable cations followed the order: $Ca^{2+}>Mg^{2+}>Na^{+}>K^{+}$. Organic carbon in surface soils varied from 0.53 (Kahibari) to 1.98% (Madong).

Land resource inventory of Baska block, Baksa district, Assam on a 1:10000 scale for optimal agricultural land use planning using geo-spatial techniques

Baska block of Baksa district, covering an area of 29,047 ha, extends from 26°33’35.7” N to 26°47’20.16” N latitude and 91°14’0.39” E to 91°25’32.83” E longitude in the lower Brahmaputra valley zone of Assam. The soils of the block are highly influenced by the fluvial activity due to the northern tributaries of Brahmaputra. Abrupt changes in the soil texture down the profiles are common, and soils were little developed and mostly cambic horizon sequence was

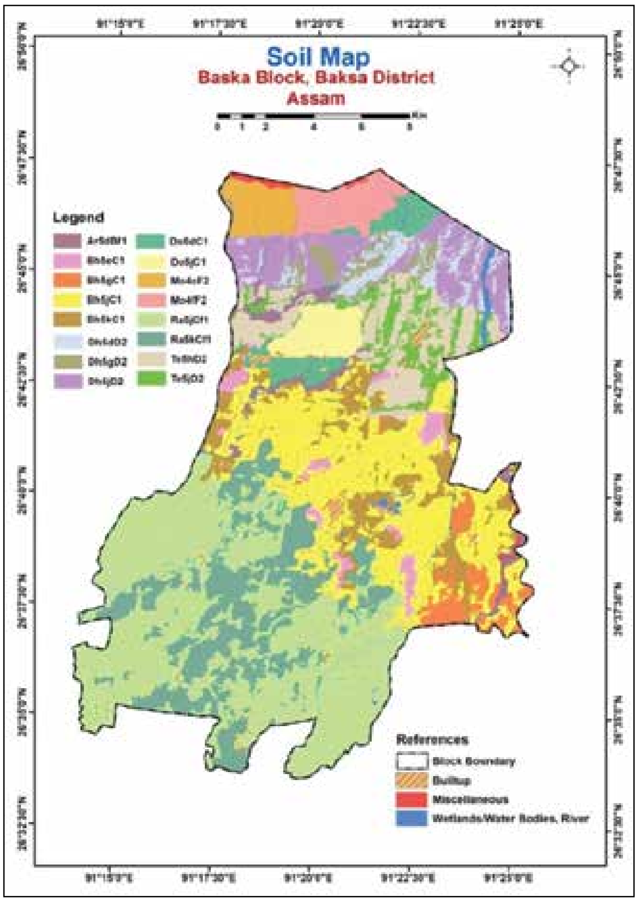


Fig. 2.2.10. Soil map of Baska block, Baksa district, Assam

observed in alluvial plains and uplands. Soils are deep to very deep, strongly acidic to neutral in reaction, low in CEC, and belong to Inceptisols, Entisols, and Alfisols. Seven soil series were identified and mapped into 16 soil mapping units at the soil phase level (Fig. 2.2.10).

Northern Region

LRI of Bundelkhand Region

A high-resolution digital land resource inventory of the Bundelkhand region, covering 14 districts of Uttar Pradesh (Jhansi, Jaluan, Hamirpur, Banda, Chattrakut, Mahoba, Lalitpur) and Madhya Pradesh (Tikamgarh, Niwari, Datia, Panna, Sagar, Damohand of Chhatarpur), was generated to provide district-level information on soil resource variabilities, extent and magnitude of land degradation, agricultural productivity potential, soil and water conservation plans. The information will help in combating drought, watershed development and to suggest conservation structures for harvesting rainwater, crop plans for optimal utilization of natural resources, and crop diversification for livelihood security of farmers.

Land degradation assessment of Bundelkhand region

Land degradation assessment was carried out for 14 districts of Bundelkhand region using a modified *GLADA* method based on time series analysis considering twenty years 16 days composite of NDVI derived from MODISterradata (Table 2.2.6 & Fig 2.2.11 a and b). The region suffers from various forms of land degradation due to hilly and rocky terrain and soil erosion. Nearly 53% of the area is degraded due to sheets/rills/gullies/ravines erosion. Further, 95% of the ravines area exists in UP Bundelkhand region, mainly in the adjoining areas of Jhansi, Jalaun and Banda districts. The districts, *viz.*, Chitrakoot (44.0%) in UP, Damoh (43.7%) and Niwari (40.6%) in MP, have the highest share of degraded land to their TGA.

Table 2.2.6. District-wise status of land degradation in 14 districts of Bundelkhand region.

District	Barren rocky/ stony waste	Gullies	Sheet erosion	Ravines	Mining	Rills	Riverine Sands	Salt Affected	Waterlogging/ surface ponding	Total
Uttar Pradesh										
Banda	2235	60891	25719	31912	57	42	14			121353
Chitrakoot	22008	45862	69639	2891	115				1084	141599
Hamirpur	52	38287	44384	24190		1052			6	107971
Jalaun		32903	16076	57982		412			469	107842
Jhansi	25946	39270	94391	18875	447	647	188		152	179916
Lalitpur	66913	581	99749		326					167569
Mahoba	13678	11634	34646	2870	172					63000
Madhya Pradesh										
Chattrapur	105152	6139	127742	1299						240332
Damoh	289511	1855	27623							318989
Datia	11177	6206	10981	6074				2246		36684
Niwari	30312	579	16648	8						47547
Panna	222608	520	53032	58						276218
Sagar	178461	2083	176613					56		357213
Tikamgarh	113354	513	40136							154003
Total	1081507	247323	837379	146159	1117	2536	202	2302	1711	2320236

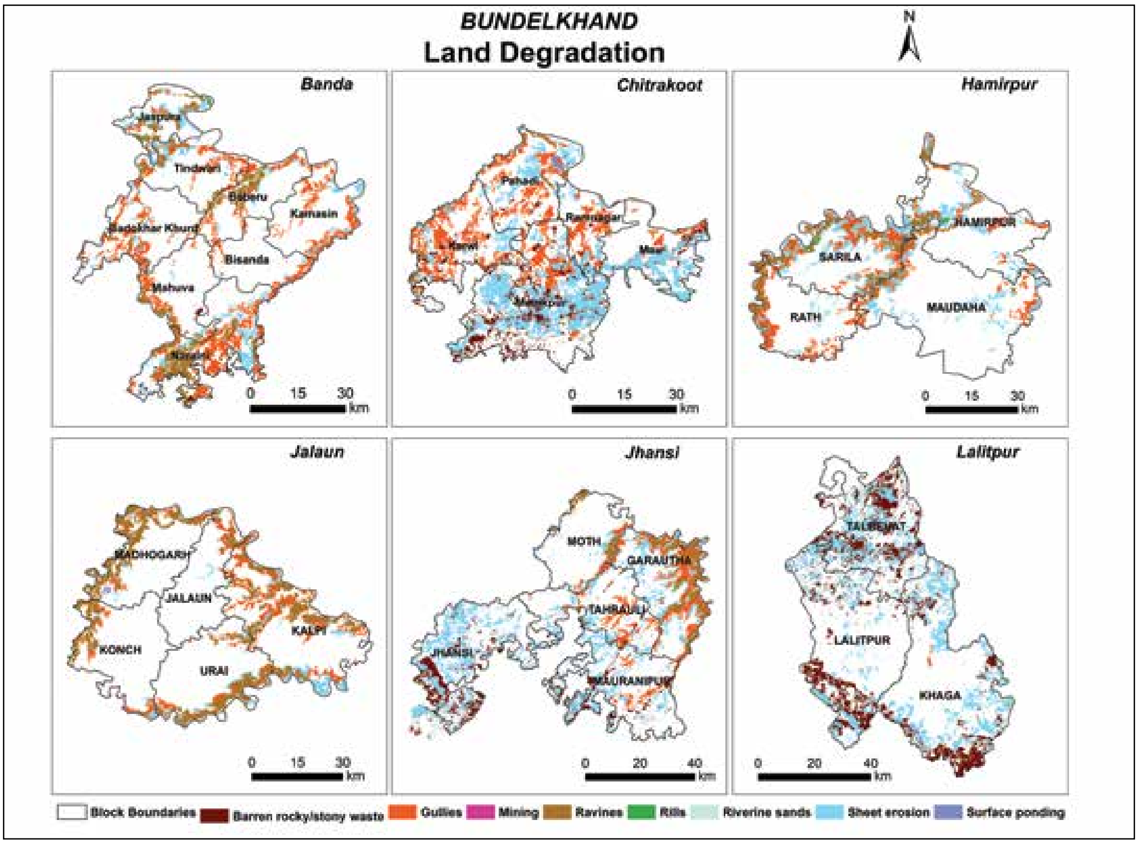


Fig 2.2.11 (a) Land degradation status of Banda, Chitrakoot, Hamirpur, Jalaun, Jhansi, Latitpur Districts of UP Bundelkhand

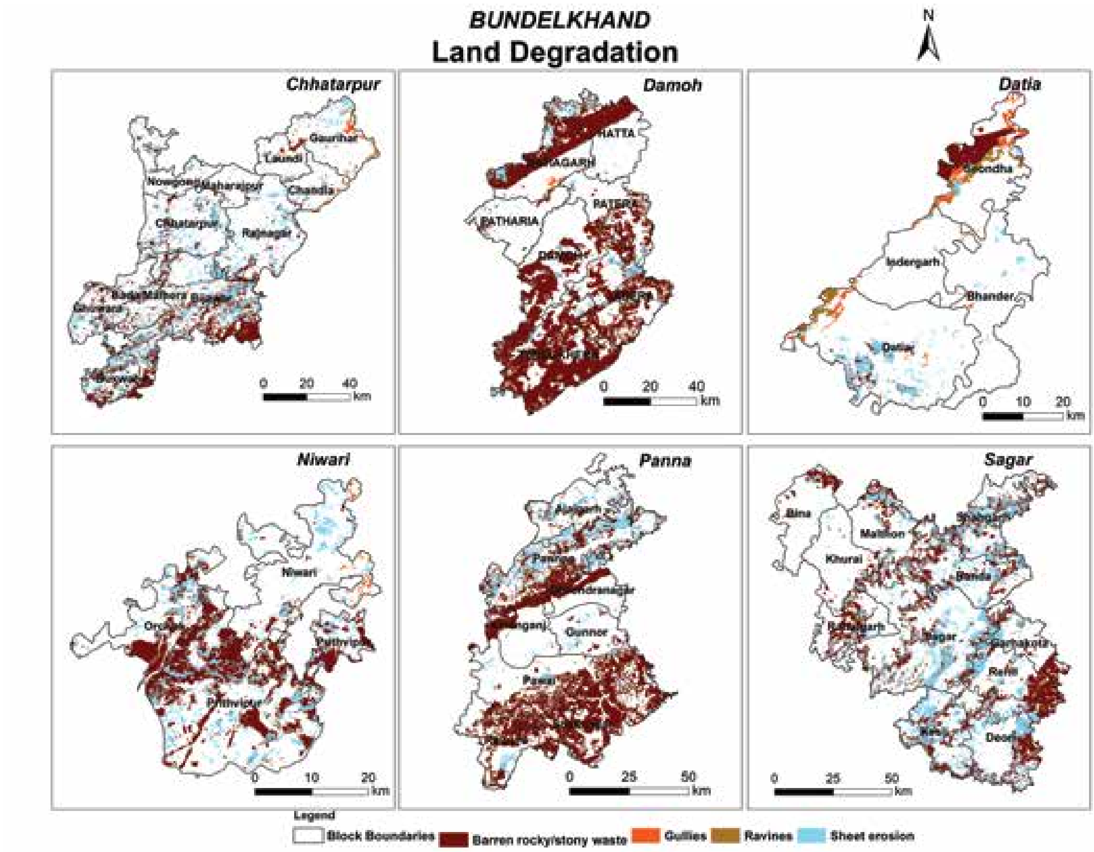


Fig 2.2.11 (b) Land degradation status of Chhatarpur, Damoh, Datia, Niwari, Panna, Sagar districts of MP Bundelkhand

LRI Odhan block, Sirsa district, Haryana, on a 1:10000 scale

Five landform units *viz.*, old alluvial plain, old alluvial plain with depression/low-lying area, aeofluvial plain, aeofluvial plain with reclaimed sand dunes, aeolian plain with occasional sand dunes were identified in the block. Seven dominant soil series were identified and mapped into 11 phase-level soil mapping units (Fig 2.2.12). The majority of soils of the block belong to the Aridisols and distributed throughout the block (85.49%), while Entisols cover about 9.34% area. The soils of old alluvial plains are well-drained, sandy loam, and calcareous with lime nodules on 0-1% slopes. The soils of the old alluvial plains with depression are very deep, well to moderately well-drained, sandy loam to loam, and calcareous and represented by the *Takhtmal* (coarse loamy over fine loamy *Ustic Haplocambids*) and *Odhan* (coarse loamy, *Ustic Haplocalcids*) soil series. The soils of *Anandgarh* (coarse loamy, *Ustic Haplocambids*) occur in the aeolian plain, which is very deep, well-drained, calcareous, loamy sand to sandy loam. The soils of the aeolian plain with occasional sand dunes are very deep, excessively drained, loamy sand to sand and represented by *Nuhiyanwali* (Sandy, *Torripsamments*) soil series. A soil-landform relationship for the dominant soils of the block is illustrated in Fig. 2.2.13.

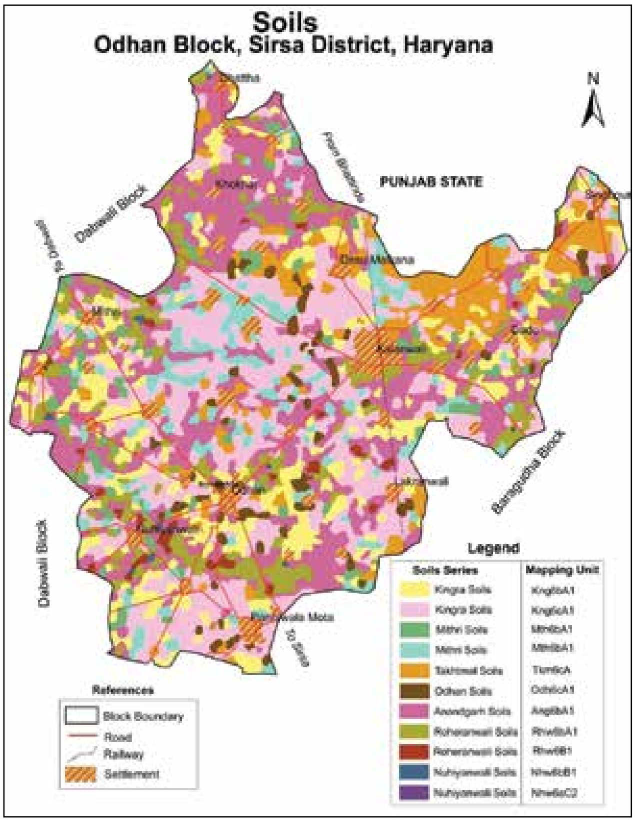


Fig.2.2.12 Soil map of Odhan block

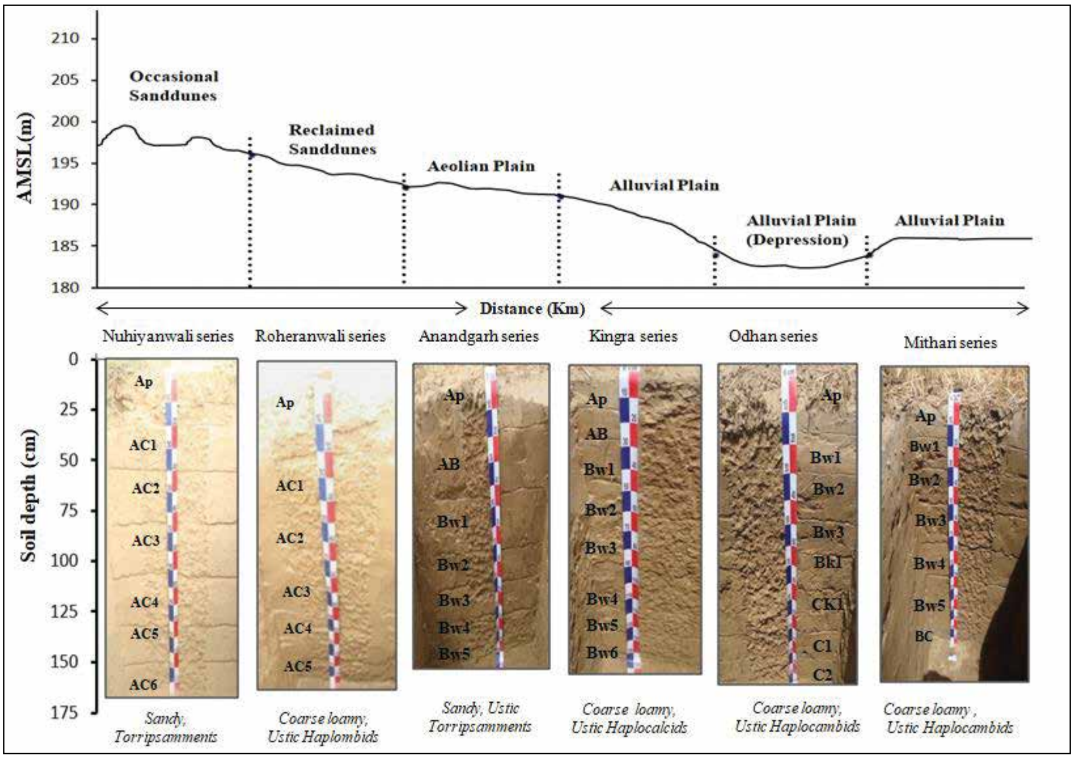


Fig 2.2.13. Soil-landform relationship in Odhan block

LRI Chamba block, Tehri Garhwal, Uttarakhand

Chamba Block of Tehri Garhwal district, covering an area of about 16,256 ha, spans from 30°8'52" to 30°24'32" N latitudes and 78°15'22" to 78°36'21" E longitudes. Nine soil series, namely Gunogi, Jaledi, Birogi, Nakot, Arakot, Hadam, Kot, Nagni, Lamkot were identified and mapped into 17 soil mapping units (phases of soil series). The soils belong to Entisols (75%) and Inceptisols (19%). Soils are mostly sandy loam (84.8%) and loam (14.8%) in texture (Fig. 2.2.14). Major area of the block is high in organic carbon (80%), medium in available nitrogen (69.1%). Lands of land capability class (LCC) III occupy 85.5% area, while 7.54 % of lands are under LCC IV and 0.82 % of lands are placed under LCC II.

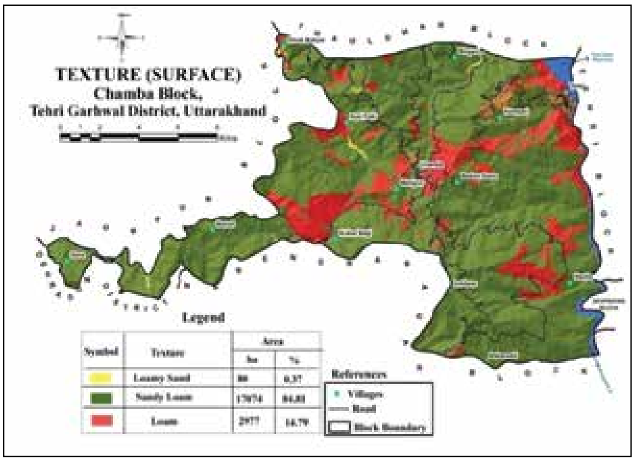


Fig.2.2.14 Texture map Chamba block

Soil-landform relationship in Patiala district, Punjab

Soils from five landforms were characterised to establish the soil-landform relationship (Fig.2.2.15). The soils developed in the old flood plain of Ghaghar and recent flood plains are very deep, brown to dark brown, neutral to moderately alkaline, sandy loam, low to high in organic carbon and classified as *Typic Ustifluvents*. Soils developed on undulating old alluvial plain on gently slopping lands are very deep, somewhat excessively drained, brown to light yellowish brown, sandy loam to loamy sand, calcareous, slightly eroded soils and classified as *Typic Ustipsamments*. Soil developed on the old alluvial plain with concave relief are very deep, poorly drained, dark greyish brown to olive brown, loam to silty clay loam, calcareous, Fe-Mn nodules, sodic found on 0-1% slopes and classified as *Aeric Halaquepts*.

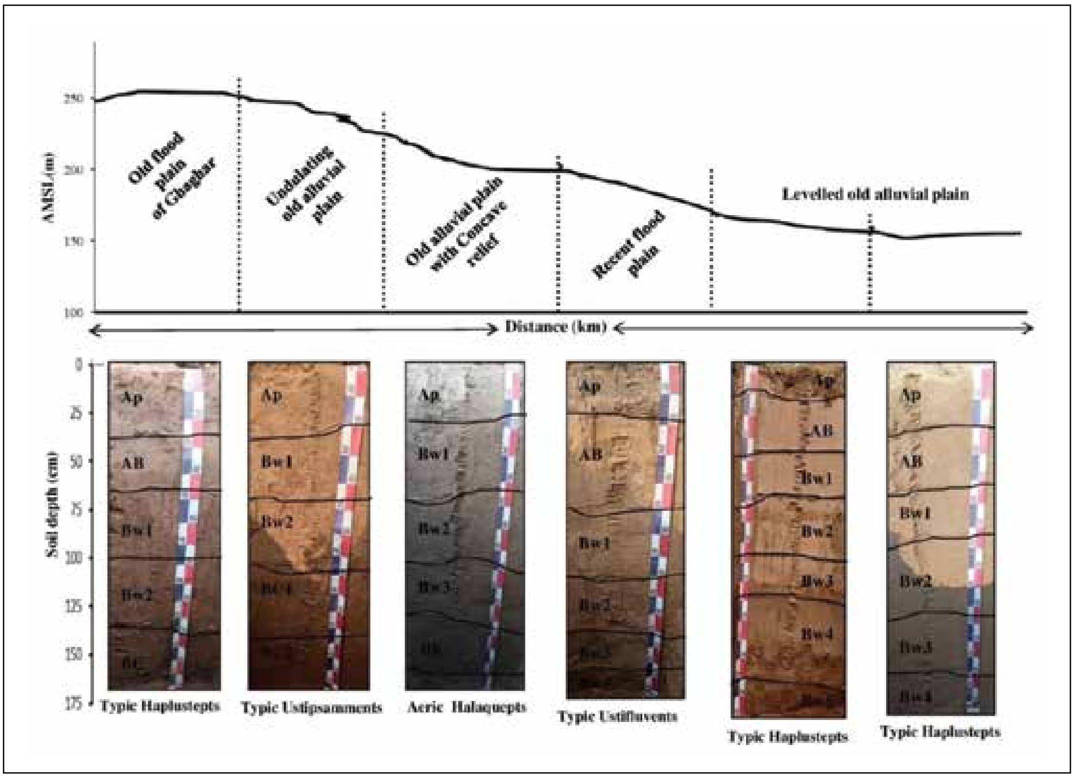


Fig. 2.2.15: Soil-landform relationship in Patiala district, Punjab

Southern Region

LRI of Mandapam block, Ramanathapuram District, Tamil Nadu

Soils of Mandapam block representing coastal regions of Tamil Nadu were mapped using sentinel 2 and ALOS DEM data combined with a field survey. The major land use in the Mandapam block is fallow lands (41% of the study area), followed by plantations (22% of TGA). Nine landscape ecological units (LEUs) were delineated based on landform, slope and land use. Eight soil series with fifteen phases were identified (Tables 2.2.7 and Figs. 2.2.16 & 2.2.17). Out of this, four soil series were identified in riverine alluvium landforms, three series were identified in sandy coastal plains, and one in sand dunes.

Soils of about 43.2% area are highly alkaline (pH 8.4–9.0), followed by very strongly alkaline (pH >9, 22.2%) and moderately alkaline (pH 7.8–8.4, 7.6%). About 29.7% of the area has high soil organic carbon content (>0.75 %).

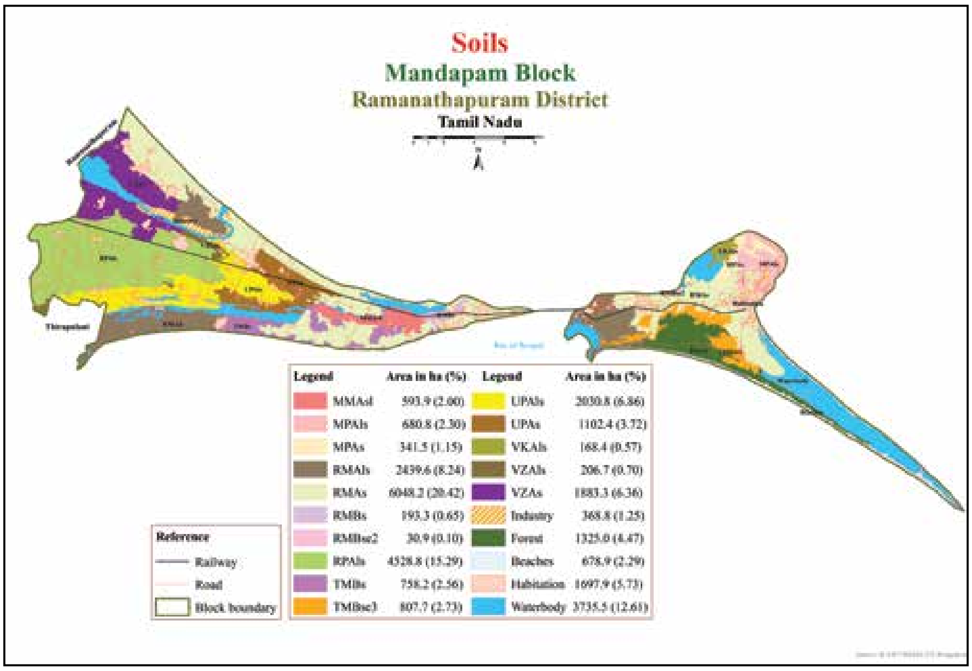


Fig. 2.2.16 Distribution of soil phases or management units in Mandapam block

Thankatchimadam series

Mandapam Series

Ragunathapuram series

Fig. 2.2.17 Major soils of Mandapam block, Ramanadahapuram district

Table. 2.2.7 Description of Soils in Mandapam block, Ramanathapuram district, Tamil Nadu

LEU	Soil series	Area (ha)	%age of TGA	Classification	Soil phases	Description of soil characteristics
DsGnH5f	Ragunathapuram	4528	15.3	Coarse loamy, mixed isohyperthermic ustic Fluvents	RPAls	Very deep, well-drained, fine loamy soils on nearly level plains with loamy sand surface
DsGnH5sc	Uchipuli (UP)	3133	10.5	Sandy over coarse loamy, mixed isohyperthermic aeric Endoaquepts.	UPAls	Very deep, moderately well-drained, fine loamy soils on nearly level plains with loamy sand surface
DsGnD2sc					UPAs	Very deep, moderately well-drained, coarse loamy soils on nearly level plains with sandy surface
	Mandapam (MM)	593	2.0	Sandy over coarse loamy, mixed isohyperthermic (cal) aquic Calciustepts	MMAsl	Very deep, well-drained, coarse loamy soils on nearly level plains with loamy sand surface
DsGnD3sc	Vazhuthur (VZ)	2059	7.1	Coarse loamy, mixed isohyperthermicaer-icHaloaquepts.	VZAls	Very deep, moderately well-drained, fine loamy soils on nearly level plains with loamy sand surface
DsGnD5sc					VZAs	Very deep, moderately well-drained, fine loamy soils on nearly level plains with sandy surface
DsGnP1d	Rameshwaram (RM)	8712	29.4	Sandy, mixed isohyperthermic ustic Quartzipsamments.	RMAs	Very deep, excessively well-drained, sandy soils on nearly level coastal plains with sandy surface
DsGnP1s					RMAls	Very deep, excessively drained, coarse loamy soils on nearly level coastal plains with loamy sand surface
					RMBs	Very deep, excessively drained, sandy soils on very gently sloping coastal plains with sandy surface
DsGnP2d					RMB-se2	Very deep, excessively drained, sandy soils on very gently sloping coastal plains with sandy surface and moderate erosion
	Vadakadu (VK)	168	0.6	Sandy, mixed isohyperthermic ustic Quartzipsamments	VKAls	Very deep, somewhat excessively drained, sandy soils on nearly level coastal plain and beaches with loamy sand surface
	Meyyampuli (MP)	1022	3.5	Sandy over coarse loamy, mixed isohyperthermic ustic Quartzipsamments	MPAls	Very deep, well-drained, coarse loamy soils on nearly level coastal plains and beaches with loamy sand surface
DsGnP2f					MPAs	Very deep, well-drained, coarse loamy soils on nearly level coastal plains and beaches with sandy surface
	Thankatchim-adam (TM)	1565	5.3	Sandy, mixed isohyperthermic ustic Torripsamments	TMBs	Very deep, Excessively drained, sandy soils on very gently sloping sand dunes with sandy surface
					TMBse3	Very deep, Excessively drained, sandy soils on very gently sloping sand dunes with sandy surface and severe erosion

Land resource inventory under REWARD, Karnataka (externally funded project from Watershed Development Department, Government of Karnataka)

The REWARD project is taken up in Karnataka (2021-2026) to provide site-specific farm-level soil, water, land use, weather, socio-economic and other information to enable planning, implementation and monitoring of watershed management.. Base maps and some important soil properties maps were prepared for Gummalpally subwatershed of Bagepalli taluk, Chikkballapur district, Karnataka (Figs 2.2.18 a&b), selected for saturation treatment.

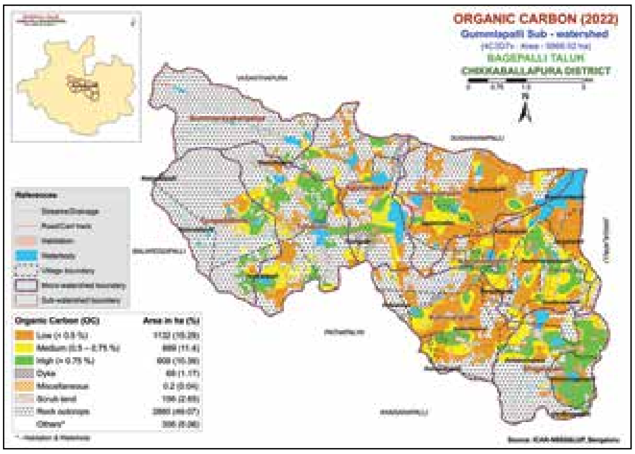


Fig. 2.2.18 (a). Soil organic carbon status of Bagepalli taluk, Chikkaballapur disrict

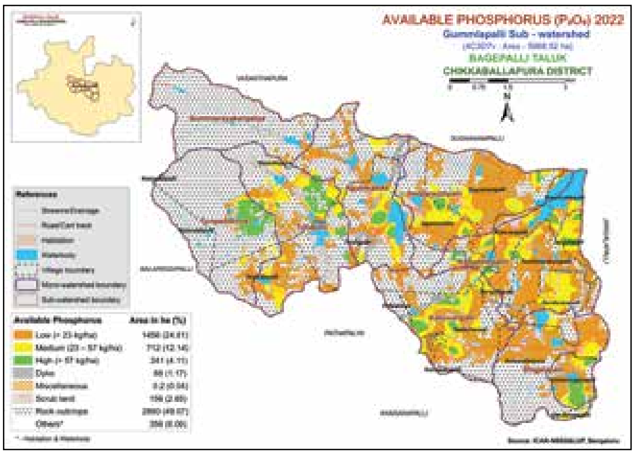


Fig. 2.2.18 (b). Available soil phosphorus status of Bagepalli taluk, Chikkaballapur disrict

Land Resource Inventory of Nuggihalli block (part) of Channarayapatna Taluk, Hassan district, Karnataka on 1:10000 scale for optimal agricultural land use planning using geo-spatial techniques.

Land Resource Inventory (1:10000 scale) was carried out in Nuggihalli block, Hassan district of Karnataka, representing the agroecological subregion (AESR) 8.2. Major soils are moderately shallow to very deep, moderately well to well drained with varying colours

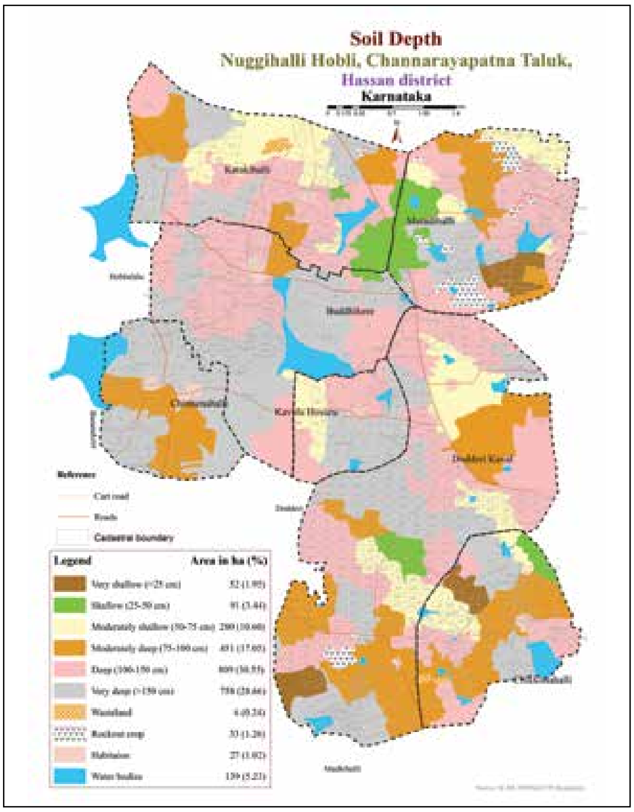


Fig.2.2.19 Soil Depth of Nuggihalli (part) block

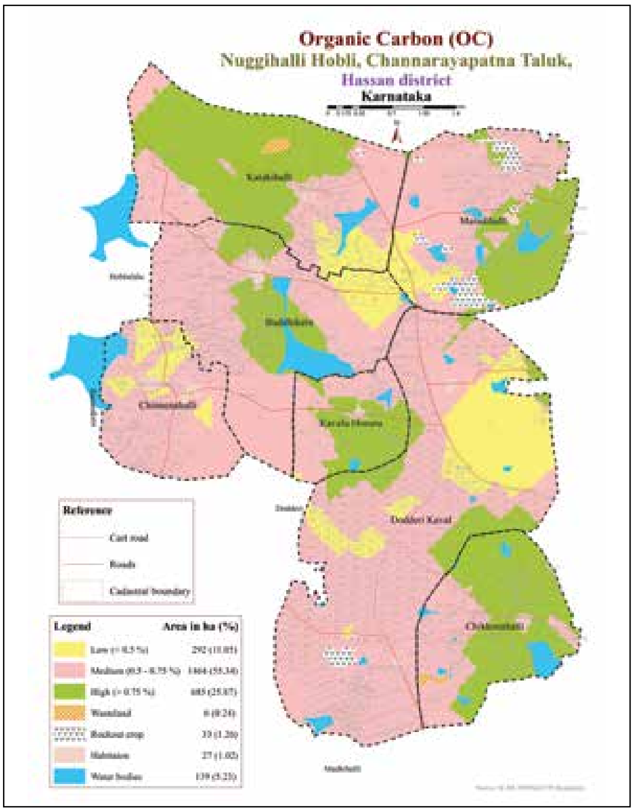


Fig. 2.2.20 Soil OC of Nuggihalli (part) block

from brown to dark reddish. Different thematic maps related to crop suitability evaluation were generated for major crops (Figs 2.2.19-2.2.22).

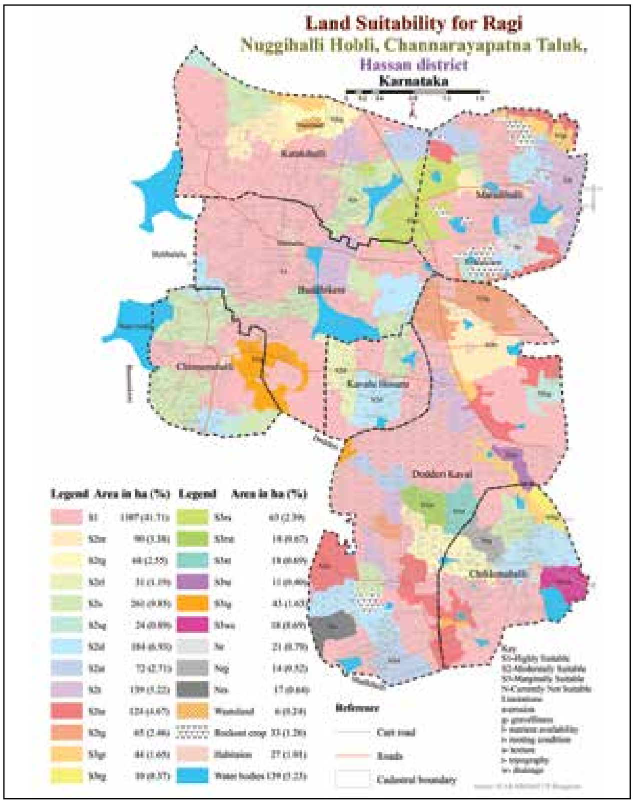


Fig.2.2.21 Ragi crop suitability evaluation of Nuggihalli (part) block

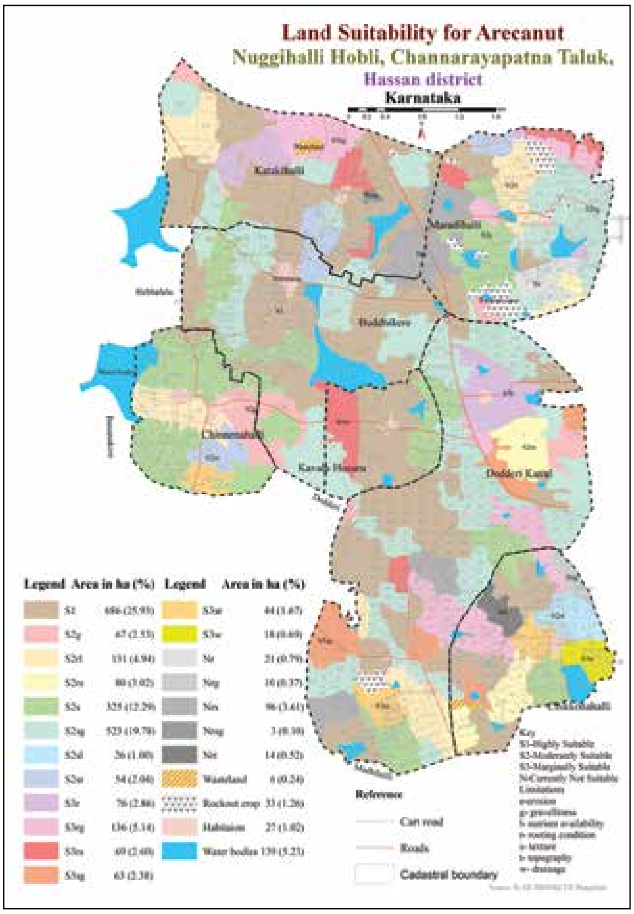


Fig.2.2.22 Arecanut crop suitability evaluation of Nuggihalli (part) block

Western Region

Land resource inventory of Pokhran and Jaisalmer tehsil of Jaisalmer district (Rajasthan) on a 1:10000 scale using geospatial techniques for optimal agricultural land use planning

Pokhran (9,56,207 ha) and Jaisalmer tehsils (24,46,200 ha) are part of Jaisalmer district of Rajasthan. Four soil series each were identified in Pokhran (Kerawa, Rathora, Away and Bhekhorai Jooni) and Jaisalmer (Sonu, Delasar, Mokla and Ashutar) (Tables 2.2.8 & 2.2.9) tehsils. The soils of the area are sandy, sandy loam, sandy clay loam and loamy sand in texture. The soils of dunes and interdunes are coarser in texture, and soils of sandy arid plains are fine textured. The soils are moderately to strongly alkaline (pH 7.74 to 9.09), non-saline, low in OC (0.02 to 0.37 g kg^{-1}), and slightly to strongly calcareous ($CaCO_3$: 4.39-19.41 g kg^{-1}). The soils are low in available nitrogen, low to medium in phosphorus and sufficient in available potassium.

Table.2.2.8. Soil series identified for Pokran tehsil of Jaisalmer district of Rajasthan

Soil series	Description of soil characteristics
Kerawa (Krw)	The soils of Kerawa series are brown (7.5 YR 4/4), moderately shallow (50-75 cm), somewhat excessively drained, sandy loam surface horizon, severely eroded, slightly calcareous, and dark brown (7.5 YR 3/4), sandy clay loam B horizon, slight effervescence, no flooding, occurring on nearly level to gently sloping plains with 1 to 3 per cent slope.
Rathora (Rtr)	The soils of Rathora series are dark yellowish brown (10 YR 4/4), moderately deep (75-100 cm), somewhat excessively drained, sandy loam surface horizon, moderately eroded and dark yellowish brown (10 YR 4/4), sandy loam B horizon, strong effervescence, occurring on nearly level plains with 1to 3 per cent slope.

Soil series	Description of soil characteristics
Away (Aw)	The soils of Away series are dark yellowish brown (10 YR 4/4), deep (100-150 cm), somewhat excessively drained, loamy sand surface horizon, moderately eroded and dark yellowish brown (10 YR 4/4), loamy sand B horizon, slight effervescence, occurring on nearly level to gently sloping plains with 1 to 3 per cent slope.
Bhekhorai Jooni (Bkj)	The soils of Bhekhorai Jooni series are dark yellowish brown (10 YR 4/4), very deep (>150 cm), well drained, loamy sand surface horizon, severely eroded and dark yellowish brown sandy loam B horizon with slight effervescence. occurring on nearly level to gently sloping plains with 1 to 3 per cent slope.

Table. 2.2.9. Phases of soil series mapped for Jaisalmer tehsil of Jaisalmer district of Rajasthan

Soil Series	Phases	Description
Sonu (Sn)	Sn2bB	moderately shallow, dark yellowish-brown soil with loamy sand surface on 1 to 3 per cent slope with moderate erosion.
	Sn2cB	moderately shallow, dark yellowish-brown soil with sandy loam surface on 1 to 3 per cent slope with moderate erosion.
	Sn1cA	moderately shallow, yellowish-brown soil with sandy loam surface on 0 to 1 per cent slope with slight erosion.
	Sn3cB	moderately shallow, yellowish-brown soil with sandy loam surface on 1 to 3 per cent slope with severe erosion.
Delasar (Dsr)	Dsr2bB	moderately deep, dark yellowish-brown soil with loamy sand surface on 1 to 3 per cent slope with moderate erosion.
	Dsr3bB	moderately deep, dark yellowish-brown soil with loamy sand surface on 1 to 3 per cent slope with severe erosion.
Mokla (Mk)	Mk2bB	deep, dark yellowish-brown soil with loamy sand surface on 1 to 3 per cent slope with moderate erosion.
	Mk3bB	deep, yellowish-brown soil with loamy sand surface on 1 to 3 per cent slope with severe erosion.
	Mk2bB	deep, dark yellowish-brown soil with loamy sand surface on 1 to 3 per cent slope with moderate erosion.
Ashutar (Atr)	Atr2bB	very deep, dark yellowish-brown soil with loamy sand surface on 1 to 3 per cent slope with moderate erosion.

Land Resource Inventory of Dang District, Gujarat Using the New SOP for Optimal Agricultural Land Use Planning

Dang is the most economically distressed district in India. The district has a geographical area of 1,76,744 ha. Soil survey and field works of all three blocks, *viz*., Subir, Ahwa and Waghai, were completed. Eight soil series were identified, and the soils of the districts were mapped into 24 soil mapping units at the phase level. (Fig. 2.2.23 and Table 2.2.10).

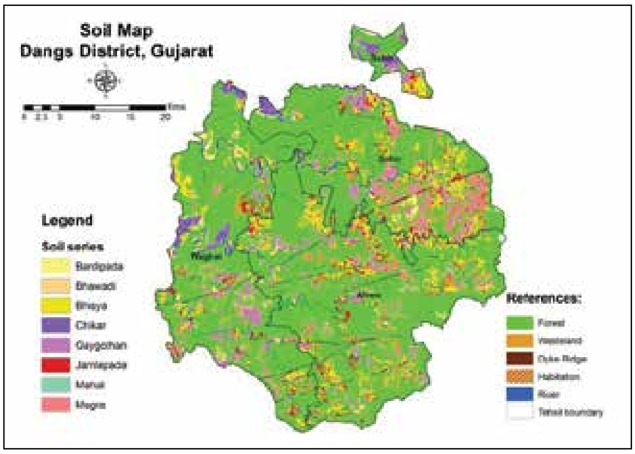


Fig. 2.2.23. Soil series map of Dang district of Gujarat.

Table 2.2.10. Brief description of soil phases of Dangs district of Gujarat

Mapping unit	landform	Series	Effective_ Depth	Soil_Phase	Soil description	Area (ha)	%TGA
1	Plateau top	Mogra	50-75	Mog-gC4g2	Moderately shallow , silty clay texture with silty clay loam surface, moderate surface stoniness occurring on gently sloping plateau top, medium well-drained, dark reddish brown (5YR 3/2 5YR 2.5/2) with very severe water erosion, non-calcareous, slightly acidic (pH 5.8) in nature,	778	0.44
2				Mog-dB4g1	Moderately shallow, silty clay texture with loamy surface, slight surface stoniness occurring on very gently sloping plateau top, medium well-drained, dark brown to dark yellowish brown (7.5 YR 3/2 to 10YR 3/4) with very severe water erosion, non-calcareous, moderately acidic (pH 5.5) in nature	1988	1.12
3	Highly dissected hills	Gaygothan	25-50	Gay-fD4g2	Shallow , clay loam texture with clay loam surface, moderate surface stoniness occurring on moderate sloping highly dissected hills, medium well-drained, very dark brown to dark brown (7.5 YR 2.5/2 to to 7.5YR 3/3) with very severe water erosion, non-calcareous, moderately acidic (pH 5.4) in nature	8356	4.73
4				Gay-fC4g2	Shallow , clay loam texture with clay loam surface, moderate surface stoniness occurring on gently sloping highly dissected hills, medium well-drained, dark brown to dark greyish brown (7.5 YR 3/2 to 10YR 4/2) with very severe water erosion, non-calcareous, slightly acidic (pH 5.8) in nature	6505	3.68
5				Gay-ff4g3	Shallow , clay loam texture with clay loam surface, strong surface stoniness occurring on steeply sloping highly dissected hills, medium well-drained, dark brown (7.5 YR 3/2) with very severe water erosion, non-calcareous, slightly acidic (pH 6.1) in nature	2027	1.15
6	Intermontane valley	Bardipada	75-100	Bar-mD4g2	Moderately deep, clay loam to sandy loamy texture with clay surface, moderate surface stoniness occurring on moderately sloping intermontane valley, medium well-drained, very dark grey to dark brown (7.5 YR 3/1 to 7.5YR 3/2) with very severe water erosion, non-calcareous, slightly acidic (pH 6.0) in nature	946	0.54
7				Bar-mC3g0	Moderately deep, clay loam to sandy loamy texture with clay surface, nil-slight surface stoniness occurring on gently sloping intermontane valley, medium well-drained, dark brown to very dark grey (7.5 YR 3/2 to 7.5YR 3/1) with severe water erosion, slightly calcareous, slightly acidic (pH 5.9) in nature	638	0.36

Mapping unit	landform	Series	Effective_ Depth	Soil_Phase	Soil description	Area (ha)	%TGA
8				Bar-gC4g0	Moderately deep, clay loam to sandy loamy texture with silty clay loam surface, nil-slight surface stoniness occurring on gently sloping intermontane valley, medium well-drained, black to very dark grey (7.5 YR 2.5/1 to 7.5YR 3/1) with very severe water erosion, non-calcareous, slightly acidic (pH 6.1) in nature	91.6	0.05
9				Bar-fC4g2	Moderately deep, clay loam to sandy loamy texture with clay loam surface, moderate surface stoniness occurring on gently sloping intermontane valley, medium well-drained, very dark brown to dark brown (7.5 YR 2.5/3 to 7.5YR 3/2) with very severe water erosion, non-calcareous, slightly acidic (pH 5.7) in nature	2028	1.15
10				Bar-fE4g1	Moderately deep, clay loam to sandy loamy texture with clay loam surface, slight surface stoniness occurring on moderately steep sloping intermontane valley, medium well-drained, brown (7.5 YR 4/3) with very severe water erosion, non-calcareous, slightly acidic (pH 6.0) in nature	22.2	0.01
11				Bar-mE4g2	Moderately deep, clay loam to sandy loamy texture with clay surface, moderate surface stoniness occurring on moderately steep sloping intermontane valley, medium well-drained, very dark grey to dark brown (7.5 YR 3/1 to 7.5YR 3/2) with very severe water erosion, non-calcareous, slightly acidic (pH 5.9) in nature	86.4	0.05
12	Low dissected hills	Jamlapada	50-75	Jam-fc4g1	Moderately shallow, clay loam texture with clay loam surface, slight surface stoniness occurring on gently sloping low dissected hills, medium well-drained, dark brown (7.5 YR 3/3) with very severe water erosion, non-calcareous, slightly acidic (pH 5.6) in nature	5167	2.92
13				Jam-fd4g2	Moderately shallow, clay loam texture with clay loam surface, moderate surface stoniness occurring on moderately sloping low dissected hills, medium well-drained, dark brown to dark reddish brown (7.5 YR 3/3 to 5YR 3/4) with very severe water erosion, non-calcareous, slightly acidic (pH 5.8) in nature	371	0.21
14		Bhisya	100-150	Bhi-fC4g2	Deep, clay to sandy loam texture with clay loam surface, moderate surface stoniness occurring on gently sloping low dissected hills, medium well-drained, dark reddish brown to brown (5YR 3/3 to 7.5YR 4/4) with very severe water erosion, non-calcareous, slightly acidic (pH 5.6) in nature	1259	0.71

Mapping unit	landform	Series	Effective_ Depth	Soil_Phase	Soil description	Area (ha)	%TGA
15				Bhi-fC3g0	Deep, clay to sandy loam texture with clay loam surface, nil-slight surface stoniness occurring on gently sloping low dissected hills, medium well-drained, dark reddish brown (5YR 3/3) with severe water erosion, non-calcareous, moderately acidic (pH 5.5) in nature	14678	8.30
16				Bhi-mE4g2	Deep, clay to sandy loam texture with clay surface, moderate surface stoniness occurring on moderately steep sloping low dissected hills, medium well-drained, dark reddish brown (5YR 3/2) with very severe water erosion, non-calcareous, slightly acidic (pH 5.6) in nature	161	0.09
17				Bhi-iD4g2	Deep, clay to sandy loam texture with sandy clay surface, moderate surface stoniness occurring on moderately sloping low dissected hills, medium well-drained, dark reddish brown to brown (5YR 2.5/2 to 7.5YR 4/4) with very severe water erosion, non-calcareous, slightly acidic (pH 6.2) in nature	18.9	0.01
18		Mahal	50-75	Mah-cC4	Moderately shallow, sandy loam texture with sandy loam surface occurring on gently sloping low dissected hills, medium well-drained, brown to dark brown (7.5YR 4/3 to 7.5YR 3/3) with severe water erosion, non-calcareous, slightly acidic (pH 6.2) in nature	85.8	0.05
19				Mah-dD4	Moderately shallow, sandy loam texture with loamy surface occurring on moderately steep sloping low dissected hills, medium well-drained, dark brown (7.5YR 3/2) with very severe water erosion, non-calcareous, Moderately acidic (pH 5.4) in nature	29.4	0.02
20	Alluvial plain	Chikar	50-75	Chi-kC3	Moderately shallow, silty clay to silty clay loam texture with silty clay surface occurring on gently sloping alluvial plains, well drained, very dark greyish brown to dark greyish brown (10YR 3/2 to 10YR4/1) with severe water erosion, moderately calcareous, slightly alkaline (pH 7.6) in nature	545	0.31
21				Chi-eC2	Moderately shallow, silty clay to silty clay loam texture with silty loamy surface occurring on gently sloping alluvial plains, well-drained, very dark greyish brown to very dark grey (10YR 3/2 to 10YR3/1) with moderate water erosion, slight calcareous, neutral (pH 6.9) in nature	2095	1.19

Mapping unit	landform	Series	Effective_ Depth	Soil_Phase	Soil description	Area (ha)	%TGA
22	Moderately dissected hills	Bhawadi	50-75	Bha-fd4g0	Moderately shallow, clay loam texture with clay loamy surface, nil-slight surface stoniness occurring on moderately steep sloping moderately dissected hills, well-drained, very dark greyish brown to dark brown (10YR 3/2 to 7.5YR3/3) with very severe water erosion, non-calcareous, moderately acidic (pH 5.5) in nature	747	0.42
23				Bha-md4g0	Moderately shallow, clay loam texture with clay surface, nil-slight surface stoniness occurring on moderately steep sloping moderately dissected hills, well-drained, very dark greyish brown to dark brown (10YR 3/2 to 7.5YR3/3) with very severe water erosion, non-calcareous, slightly acidic (pH 6.1) in nature	1043	0.59
24				Bha-dc4	Moderately shallow, clay loam texture with loamy surface occurring on moderately steep sloping moderately dissected hills, well-drained, dark reddish brown to dark brown (5YR 3/2 to 7.5YR3/2) with very severe water erosion, non-calcareous, slightly acidic (pH 6.0) in nature	113	0.06

Land resource inventory (1:10000 scale) of Dahod district, Gujarat, for optimal agricultural land use planning using geospatial techniques.

Dahod district is situated in the AESR 5.2, Central Highlands, Malwa, Gujarat Plain, with an area of 3.60 lakh ha. It is divided into seven broad landforms and 39 TMUs. The district's soil has been mapped tentatively into 20 soil series and 38 mapping units. The soil series of the district are Baroda, Chobariya, Dasla, Garbada, Jambusar, Kakarkhila, Kalapeepal, Kanjer, Karmadi, Kuni, Lakhanpur, Limdi, Malekpur, Medharal, Piplod, Salara, Sampoi, Sanjeli, Sevaniya and Vanjariya. Medharal soil series occupy the highest area (23.10%) and is moderately deep, 7.5YR4/3 to 7.5YR3/4 in colour, loam to sandy loam in texture, non-calcareous followed by Jambusar (20.72%) which is moderately shallow, 10YR4/3 to 10YR5/3 in colour, clay loam texture, and calcareous and Kuni (9.32%) series which is very shallow, 7.5YR3/3 to 7.5YR3/3 in colour, clay loam in texture, and non-calcareous.

Land resource inventory (1:10000 scale) of Narmada district, Gujarat, for optimal agricultural land use planning using geospatial techniques.

Narmada district is situated in the AESR 5.2, Central Highlands, Malwa, Gujarat Plain. The geographical area of the district is 2,82,046 ha, divided into seven broad landforms *viz;* dissected plateau (35.9%), fluvial plain (26.8%), pediplain (23.3%), residual hills (0.3%), dissected hills and valleys (2.0%), pediment (0.6%), and rolling plain (4.5%). The major land uses of the district are agriculture (41.8%) and forest cover (47.0 %). Narmada district is divided into 39 TMUs based on the variability of landform, land use and slope. Soils of the district have been tentatively mapped into 23 soil series *viz.*, Chimbapani, Chulli, Dhanikhod, Gader, Jesalpur, Khabaj, Khocharvada, Kokam, Kunwarpura, Mathasar, Movi, Namariya, Nandpara, Nani Singoti, Patlamau, Pichipura, Sagai, Savli, Tilakwada, Uman, Waviala, Wadva and Kanbudi. The soils are shallow to very deep, loamy to clay, and calcareous to non-calcareous. Kanbudi series covers maximum area (1,14,639 ha) with a soil depth of 55 cm, loamy to clay texture, non-calcareous. The Kokam soil series (22,646 ha) has a soil depth of 45 cm, loamy texture, and non-calcareous. Khocharwada soil series covers an area of 38, 364 ha with a soil depth of 72 cm, loamy to clay loam texture, and non-calcareous. Chully, Patlamau, and Uman soil series cover an area of 18,387, 10,189 and 1,172 ha, respectively. The minimum area (218 ha) is covered by Movi soil series with a soil depth of 90 cm, clay texture, severe calcareous, and 5YR 2.5/2, 3/2, 3/3 and 4/3 colour combination.

Land Resource Inventory of Tapi District, Gujarat for Optimal Agricultural Land Use Planning.

Tapi district covers 3,13,900 ha area accounting for 1.6 % area of the Gujarat state. The district is located between 20°48'48" and 21°33'04" N latitudes and from 73°11'53" to 74°19'56"E longitudes in the southern part of the Gujarat state. The district is characterized by central (Malva) highlands, Gujarat plains and the Kathiawar peninsula ecoregion (AESR 5.2). It is divided into 58 TMUs (Figure 2.2.24), dominated by gently sloping old alluvial plains (GpAlOu3a) with arable land (22,244 ha), followed by very gently sloping old alluvial plains (GpAlOu2a) with arable land (22,130 ha).

Land Resource Inventory of Vadodara District, Gujarat for Optimal Agricultural Land Use Planning

Vadodara District, with an area of 4110 km² area extends from 21°49'19" to 22°48'48" N latitudes and 72°51'05" to 73°33'55" E longitudes. The agro-ecological sub-region of the district is Central (Malwa) Highlands. The district is divided into 48 TMUs (Table 2.2.11 & Figure 2.2.25), dominated by very gently sloping coastal plains (GpAlCp2a) with arable land (837 km²) followed by very gently sloping pediplains (GpAlPp2a) with arable land (662 km²).

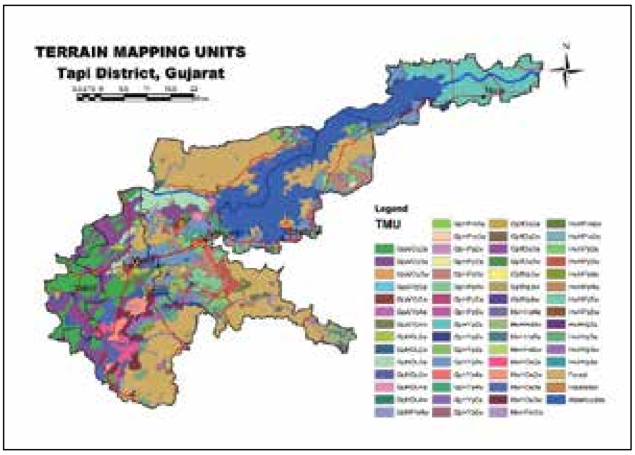


Fig. 2.2.24. Terrain Mapping Units map of Tapi district, Gujarat

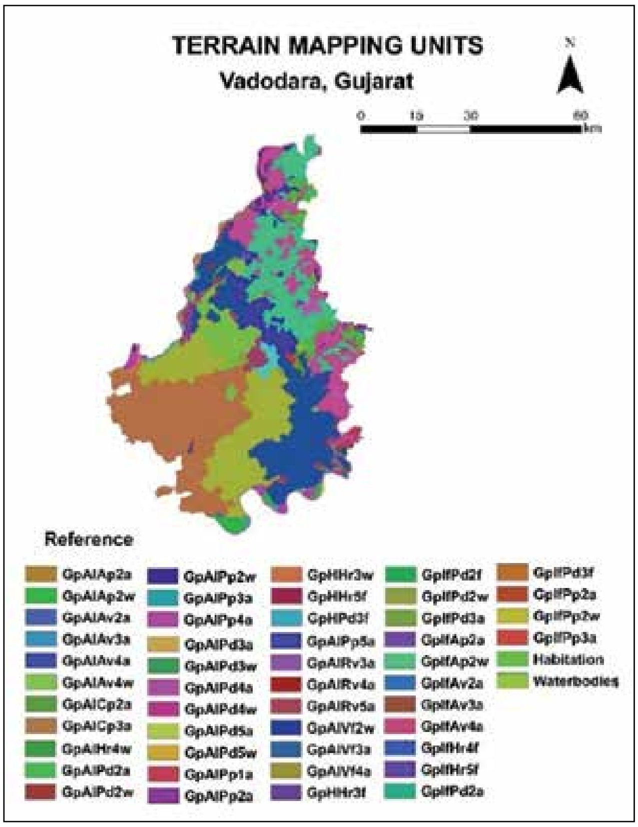


Fig. 2.2.25. Terrain Mapping Units map of Vadodara district, Gujarat

Table. 2.2.11: Terrain mapping unit area of Vadodara district

S. No.	TMU	Description	Area (km²)	% of TGA
1	GpAlAp2a	Very gently sloping alluvial plains with arable land	645	15.90
2	GpAlAp2w	Very gently sloping alluvial plains with waste land	33	0.82
3	GpAlAv2a	Very gently sloping active flood plain with arable land	30	0.75
4	GpAlAv3a	Gently sloping active flood plain with arable land	10	0.25
5	GpAlAv4a	Moderately sloping active flood plain with arable land	6	0.16
6	GpAlAv4w	Moderately sloping active flood plain with waste land	2	0.04
7	GpAlCp2a	Very gently sloping coastal plains with arable land	837	20.65
8	GpAlCp3a	Gently sloping coastal plain with arable land	3	0.08
9	GpAlHr4w	Moderately sloping hill ridges with waste land	1	0.03
10	GpAlPd2a	Very gently sloping piedmont with arable land	392	9.67
11	GpAlPd2w	Very gently sloping piedmont with waste land	491	12.11

S. No.	TMU	Description	Area (km²)	% of TGA
12	GpAlPd3a	Gently sloping piedmont with arable land	33	0.80
13	GpAlPd3w	Gently sloping piedmont with waste land	47	1.15
14	GpAlPd4a	Moderately sloping piedmont with arable land	11	0.28
15	GpAlPd4w	Moderately sloping piedmont with waste land	6	0.16
16	GpAlPd5a	Moderately steeply sloping pidmont with arable land	1	0.02
17	GpAlPd5w	Moderately steeply sloping pidmont with waste land	1	0.03
18	GpAlPp1a	Level to nearly level pediplain with arable land	2	0.06
19	GpAlPp2a	Very gently sloping pediplain with arable land	662	16.34
20	GpAlPp2w	Very gently sloping pediplain with waste land	146	3.60
21	GpAlPp3a	Gently sloping pediplain with arable land	64	1.58
22	GpAlPp4a	Moderately sloping pediplain with arable land	18	0.44
23	GpAlPp5a	Moderately steeply sloping pidmont with arable land	0	0.01
24	GpAlRv3a	Gently sloping ravines with arable land	22	0.55
25	GpAlRv4a	Moderately sloping ravines with arable land	26	0.65
26	GpAlRv5a	Moderately steeply sloping pidmont with arable land	3	0.07
27	GpAlVf2w	Very gently sloping vally fills with waste land	3	0.08
28	GpAlVf3a	Gently sloping vally fills with arable land	8	0.21
29	GpAlVf4a	Moderately sloping vally fills with arable land	4	0.11
30	GpHHr3f	Gently sloping hill ridges with forest	1	0.03
31	GpHHr3w	Gently sloping hill ridges with waste land	1	0.03
32	GpHHr5f	Moderately steeply sloping pidmont with forest	4	0.09
33	GpHPd3f	Gently sloping piedmont with forest	2	0.05
34	GpIfAp2a	Very gently sloping piedmont with arable land	12	0.29
35	GpIfAp2w	Very gently sloping alluvial plains with waste land	33	0.81
36	GpIfAv2a	Very gently sloping active flood plain with arable land	33	0.82
37	GpIfAv3a	Gently sloping active flood plain with arable land	8	0.19
38	GpIfAv4a	Moderately sloping active flood plain with arable land	2	0.04
39	GpIfHr4f	Moderately sloping hill ridges with forest	2	0.04
40	GpIfHr5f	Moderately steeply sloping pidmont with forest	1	0.03
41	GpIfPd2a	Very gently sloping piedmont with arable land	71	1.74
42	GpIfPd2f	Very gently sloping piedmont with forest	4	0.10
43	GpIfPd2w	Very gently sloping piedmont with waste land	18	0.45
44	GpIfPd3a	Gently sloping piedmont with arable land	2	0.04
45	GpIfPd3f	Gently sloping piedmont with forest	4	0.10
46	GpIfPp2a	Very gently sloping pediplain with arable land	14	0.35
47	GpIfPp2w	Very gently sloping pediplain with waste land	6	0.14
48	GpIfPp3a	Gently sloping pediplain with arable land	8	0.20
49	Habitation		204	5.04
50	Waterbodies		115	2.84

Land Resource Inventory of Anand District, Gujarat for Optimal Agricultural Land Use Planning

Anand district covers an area of 3486 km^2 and situated between north latitudes 22°15' & 23°15' and east longitudes 72°45' & 73°15'. The district falls within Gujarat Plain & Hills region. There are 8 talukas (Anand, Anklav, Borsad, Khambhat, Petlad, Sojitra, Tarapur and Umreth). The district is divided into 26 TMUs (Table 2.2.12 & Figure 2.2.26), the major being Gently sloping piedmont with arable land-GpAlPd3a (83,627 ha) followed by Gently sloping alluvial plains with arable land-GpAlAp3a (60,898 ha).

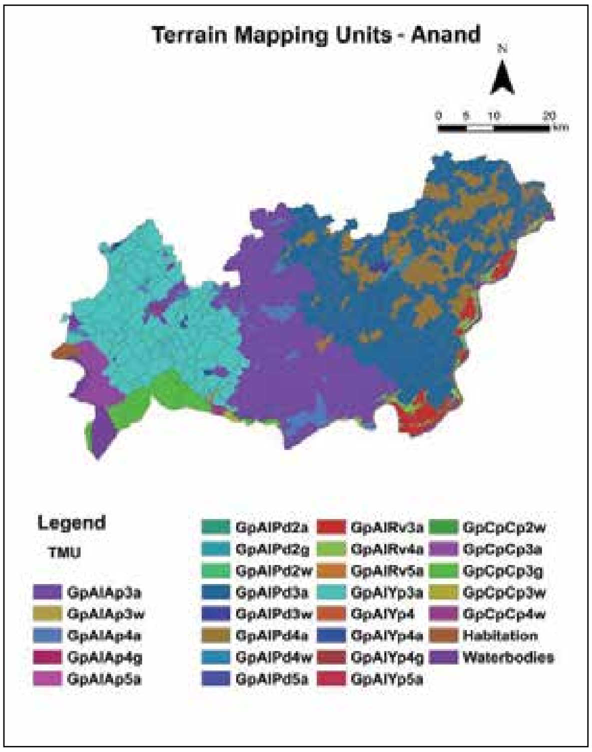


Fig. 2.2.26. Terrain Mapping Units map of Anand district, Gujarat

Table. 2.2.12 Terrain Mapping Unit area of Anand district of Gujarat

S.No.	TMU	Descriptions	Area in ha.	% of TGA
1	GpAlAp5a	Moderately steeply sloping alluvial plains with arable land	11	0.004
2	GpAlPd5a	Moderately steeply sloping piedmont with arable land	13	0.005
3	GpAlPd2w	Very gently sloping piedmont with wasteland	16	0.006
4	GpAlPd2a	Very gently sloping piedmont with arable land	44	0.016
5	GpAlYp4g	Moderately sloping younger alluvial plains with grass land	75	0.027
6	GpAlRv5a	Moderately steeply sloping ravineous with arable land	78	0.028
7	GpCpCp2w	Very gently sloping coastal plains with wasteland	81	0.029
8	GpAlYp5a	Moderately steeply sloping younger alluvial plains with arable land	113	0.041
9	GpAlAp3w	Gently sloping alluvial plains with wasteland	193	0.070
10	GpAlAp4g	Moderately sloping alluvial plains with grass land	229	0.083
11	GpCpCp3w	Gently sloping coastal plains with wasteland	342	0.123
12	GpCpCp4w	Moderately sloping coastal plains with wasteland	453	0.164
13	GpAlPd3w	Gently sloping piedmont with wasteland	619	0.224
14	GpAlYp4a	Moderately sloping younger alluvial plains with arable land	910	0.329
15	GpAlPd4w	Moderately sloping piedmont with wasteland	1213	0.439
16	GpAlRv4a	Moderately sloping ravineous with arable land	4161	1.504
17	GpCpCp3a	Gently sloping coastal plains with arable land	5488	1.984
18	GpAlRv3a	Gently sloping ravineous with arable land	5832	2.109
19	GpAlAp4a	Moderately sloping alluvial plains with arable land	7242	2.618
20	GpCpCp3g	Gently sloping coastal plains with grass land	9400	3.399
21	GpAlPd4a	Moderately sloping piedmont with arable land	27911	10.091
22	GpAlYp3a	Gently sloping younger alluvial plains with arable land	57603	20.825
23	GpAlAp3a	Gently sloping alluvial plains with arable land	60898	22.016
24	GpAlPd3a	Gently sloping piedmont with arable land	83627	30.234
	Habitation		2446	0.884
	Waterbodies		7605	2.749

2.3 BASIC PEDOLOGICAL RESEARCH

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

Transformation of nano-size clay minerals in associated red and black soils of Western Ghats, India

Pedogenic processes are influenced by clay minerals that undergo alteration and transformation depending on the environmental conditions. Nanosize clays (< 0.1 μ) are the most reactive part of soil clays. A study was undertaken on three spatially associated clay enriched soils *viz*., (a) Vertisols (*Typic Haplustert*, P1), Alfisols (*Typic Haplustalf*, P2) and Mollisols (*Vertic Argiustoll*, P3), developed from weathered Deccan basalt of Western Ghats under humid tropical climate. The clays of Mollisol are dominated by kaolin followed by mica and smectite, whereas nanoclays have similar mineral composition except they contain a very smaller amount of mica (Table 2.3.1). Higher CEC in Vertisols (53-70 cmol p^+ kg^{-1}) compared to the Mollisols (30-46 cmol p^+ kg^{-1}) and Alfisols (18-20 cmol p^+ kg^{-1}) indicates lower weathering of Vertisol than the other two soils. The extent of hydroxy interlayering was more in the nano size (< 0.1 μ) Vertisol clays than coarser clays (< 2 μ). The presence of hydroxy interlayered smectite and kaolin in Vertisol nanoclays indicates the probable transformation of smectite to interstratified kaolin (Sm/K). The dominant minerals in the clays and nanoclays of Mollisol and Alfisol are kaolin, which is not 0.7 nm discrete kaolinite but are interstratified with Sm/K. It indicates that small amount of hydroxy interlayered smectite within the kaolin is responsible for maintaining a pedo-environment for the accumulation of organic matter and has made the formation of mollic epipedon possible even in the humid tropical climate. Clay mineralogical investigation indicated that Sm/K is dominant in red soil nanoclays (Alfisol and Mollisol), whereas smectite is dominant in black soil nanoclays (Vertisols). The Sm/K is formed by the transformation of montmorillonite, the first weathering product of Deccan basalts in a humid tropical climate.

Table 2.3.1. Mineral quantification within clays and nano-clays

Pedon	Depth (cm)	Horizon	Sm		Mica		Kaolin	
			Clay (<2 μ)	Nano-clay (<0.1 μ)	Clay (<2 μ)	Nano-clay (<0.1 μ)	Clay (<2 μ)	Nano-clay (<0.1 μ)
P1	0-14	Ap	D	D	+	A	+	+
	14-30	Bw1	D	D	+	A	+	+
	30-46	Bss1	+++	D	++	A	+	+
	46-81	Bss2	D	D	+	A	+	-
	81-97	Bw2	D	D	+	A	+	+
	97-110	BC	D	D	-	A	+	-
P-2	0-12	A	A	A	+	+	D	D
	12-32	Bt1	A	A	+	+	D	D
	32-42	Bt2	A	A	+	+	D	D
	42-59	Bt3	A	A	+	++	D	D
	59-70	BC	A	A	+	++	D	D

Pedon	Depth (cm)	Horizon	Sm		Mica		Kaolin	
			Clay (<2 μ)	Nano-clay (<0.1 μ)	Clay (<2 μ)	Nano-clay (<0.1 μ)	Clay (<2 μ)	Nano-clay (<0.1 μ)
P-3	0-14	A	+	++	+	+	D	+++
	14-39	Bw1	+	++	++	+	++	+++
	39-78	Bw2	+	++	+	+	D	+++
	78-102	Bt	+	++	++	+	D	+++
	102-133	BC	+	++	++	+	+++	+++

Sm = Smectite, Quantification = D (> 70%); +++ (50-70%); ++ (20-50%); + (5-20); – (1-5%); A (Absent)

Pedodiversity of Vertisols in different Agro Ecological regions of India

This study was initiated to understand the variability of Vertisols with respect to AER characteristics, cropping systems, and level of management. A total of 442 Vertisol soil profiles data was compiled from 9 different AERs (Fig. 2.3.1). The majority of profiles occur in AERs 4, 6, 10, 11, 12, and 19. The depth of the Vertisols varied from shallow (37 cm) to very deep (>150 cm) with a mean depth of 133 cm across the AERs. The soil depth varied considerably (37-160 cm) in AER 6, 10 and 12, whereas the Vertisols of AERs 7 and 11 did not vary significantly in depth.

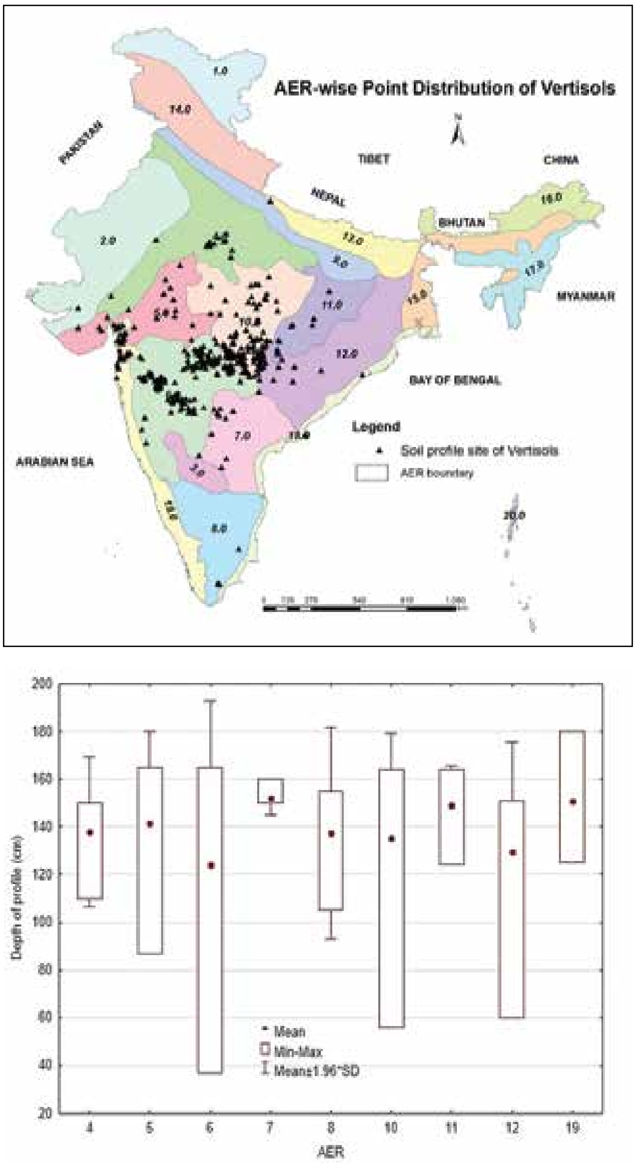


Fig. 2.3.1. Distribution of Vertisols in different Agro Ecological Regions (AERs) of India and the variability in their depth across the AERs

Quantification of micromorphological features of soils for its implication in climate change research

Semi-quantitative estimation of Fe-Mn nodules, pedogenic carbonate (PC), non-pedogenic carbonate (NPC), voids, and weatherable minerals present in humid tropical to dry arid climate indicated variability from surface to subsurface soils (Fig. 2.3.2, a-i). Study showed that iron nodules are in different forms, *i.e.* rounded to sub-rounded with concentric rings having an inner core ferrous and outer core ferric. Semi-quantitative data on iron nodules indicated that, in most cases, there is a near-complete transformation from ferrous to ferric, showing an impact of climate change. Similarly, PC and other minerals, and the presence of voids were also quantified.

Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD) Odisha Project

LRI was carried out in two model watersheds in Sambalpur and Koraput districts, Odisha, using World View 2.0 data 5m Cartosat-3 DEM. The soil-landform relationship was established in physiographic confluence of Eastern Ghats and Mahanadi Basin in Sambalpur and Eastern Ghats Highlands in Koraput (Fig 2.3.3).

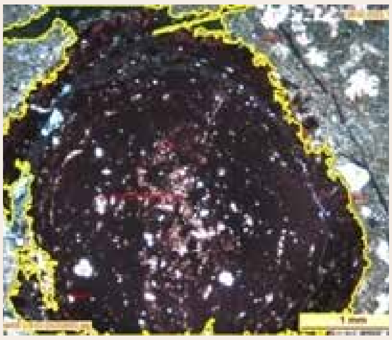
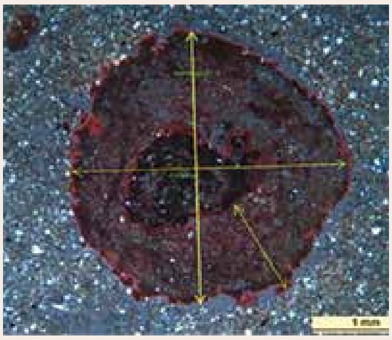
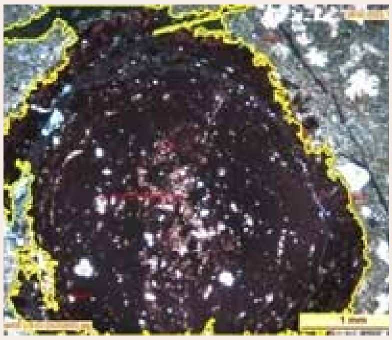
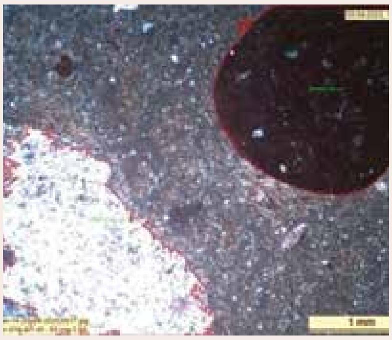
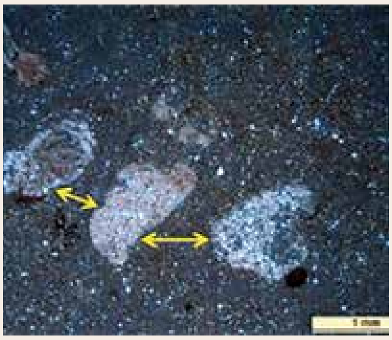
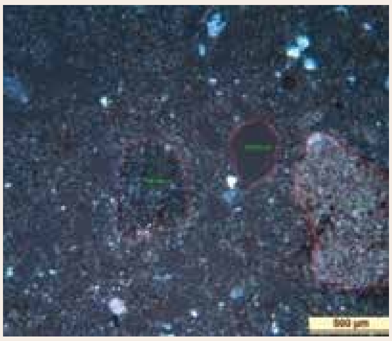
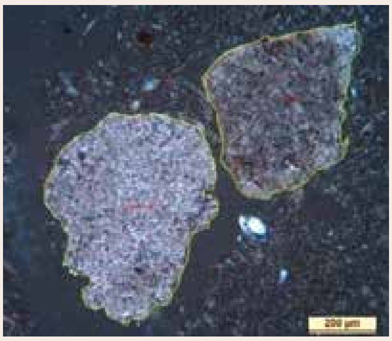
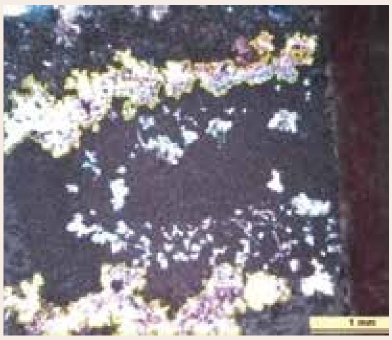
		
(a) Concentric iron nodules with dissolution features in the soils of Lakholi Kanhar, Raipur. XPL, 2.5x, 3 -18cm (472/1). (Area:8410498.973 μm2)	(b) Conversion of ferrous to ferric iron from inner to outer ring, an indicator of climate change in Lakholi Kanhar, Raipur,. XPL, 2.5x, 41-63cm, (474), (total area of the concretion is 4945763.280 μm2, inner core 5741.904 μm2, transformed area 4940021.38 μm2	(c) Dissolution of iron nodules in the soils of Lakholi Kanhar, Raipur. XPL, 2.5x, 41-63cm (474).
		
(d) Pedogenic carbonate as well as iron nodules occurring together in a soil matrix of Lakholi Kanhar, Raipur. XPL, 2.5x, 41-63cm, (474)	(e) Three PC grains in different stage of weathering indicating the impact of climate change in the soils of Lakholi Kanhar, Raipur. XPL, 2.5x, 41-63cm, (474).	(f) Curved plainer voids in the soils of Lakholi Kanhar, Raipur. XPL, 2.5x, 41-63cm (474)
		
(g) Pyroxene (Hypersthene) along with quartz in different stage of weathering in the soils of Joldarsi, Bellary. 10x, xpl, 0 -17 cm (353)	(h) Dolomite in the soils of Joldarsi, Bellary. XPL, 10x, 0 -17 cm (353).	(i) Pyroxene (Aegirine-Augite) in different stage of weathering in the soils of Joldarsi, Bellary. XPL, 10x, 0 -17 cm. (353).

Fig. 2.3.2 (a-i) Representative photomicrographs of Fe-Mn nodules, pedogenic carbonate (PC), non-pedogenic carbonate (NPC), voids and weatherable minerals in soils under cross-polarized light

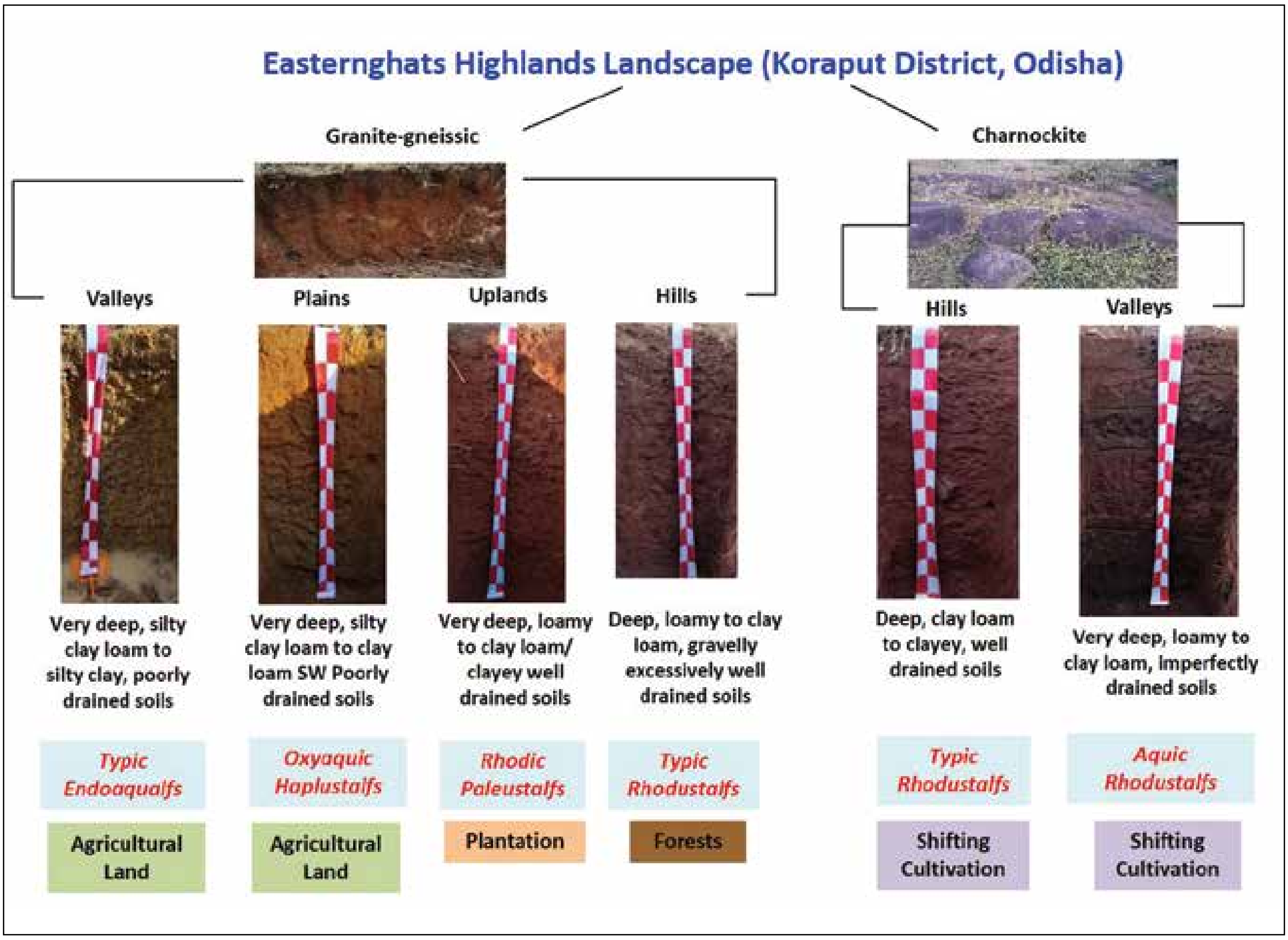


Fig. 2.3.3. Soil-landform relationship in two varying landscapes of Eastern Ghats of Odisha

Land Resource Inventory of Cinchona and other medicinal plant growing areas of Darjeeling and Kalimpong districts, West Bengal

The descriptive statistics (Table 2.3.2) indicated that the mean values of sand, silt, clay, exch. Ca, exch. Mg, exch. Na, exch. K, base saturation (BS) and cation exchange capacity (CEC) were 45.2%, 32.6%, 22.2%, 4.6 cmol (p^+) kg^{-1}, 0.74 6 cmol (p^+) kg^{-1}, 0.156 cmol (p^+) kg^{-1}, 0.10 cmol (p^+) kg^{-1}, 58.6% and 9.7 cmol (p^+) kg^{-1}, respectively. The soils are light to medium texture with high BS and CEC and the exchange complex is dominated by Ca followed by Mg, Na and K. The soils are well drained and good for cultivation.

Table 2.3.2. Descriptive statistics of soil physical and chemical parameters

Parameters	Sand	Silt	Clay	Ca	Mg	Na	K	BS (%)	CEC cmol (p+) kg^{-1}
	%			cmol (p+) kg^{-1}					
Minimum	8.0	5.7	5.2	1.2	0.20	0.10	0.10	50.0	3.10
Maximum	80.8	68.7	47.6	14.7	2.8	0.80	0.50	71.0	28.4
Mean	45.2	32.6	22.2	4.6	0.74	0.22	0.20	58.6	9.7
SD	15.6	14.6	8.2	2.0	0.45	0.15	0.10	4.2	3.8
CV (%)	34.5	44.8	36.9	43.5	60.8	68.2	50.0	7.2	39.2

2.4 INTERPRETATION OF SOIL SURVEY DATA

Soil Organic Carbon Sequestration Potential Map of India

ICAR-NBSS&LUP has developed the soil organic carbon sequestration map of India as a part of the Global Soil Organic Carbon Sequestration Potential Map initiative of FAO. The maps were prepared under four different scenarios, *viz.*, Business as Usual, Low (SSM1): 5 percent increase in C input, Medium (SSM2): 10 percent increase in C inputs, and High (SSM3): 20 percent increase in C inputs. Maps of relative sequestration rates (expressed as the annual average sequestration rates compared to BAU management) were also prepared. Uncertainty maps of initial SOC stocks, final SOC stocks under business-as-usual scenario and final SOC stocks under sustainable SSM 3 were generated (Fig.2.4.1).

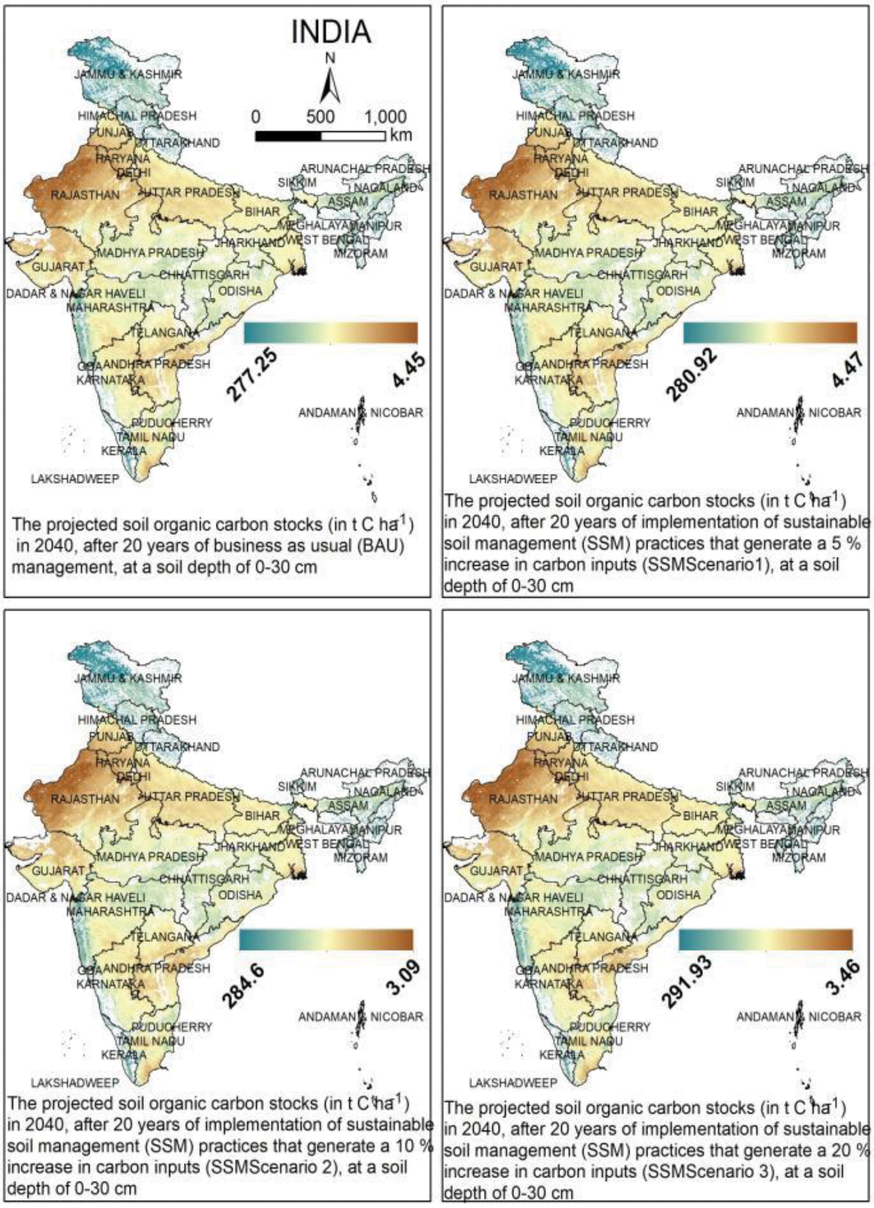


Fig.2.4.1: Soil organic carbon sequestration potential at four scenarios

Eco-Restoration of the Pench National Park

The objective of the project is to generate baseline soil information to rehabilitate the human-induced degraded sites in Pench National Park. The data will be used to develop an appropriate land use plan to restore the forest ecosystem. Soil physical, chemical, and biological parameters were studied. Microbial biomass carbon, soil basal respiration, metabolic quotient (qCO_2), and soil dehydrogenase activity (Table 2.4.1) were determined from the 27 selected sites to assess the microbial activity, representing the living SOC. The data indicate that soil microbial parameters (SMBC, SBR, SMBC/SC, qCO_2) are key soil health and fertility indicators, and they are influenced by land use/cover changes.

Table 2.4.1: Baseline date of soil biological properties before the treatment

Code	Microbial biomass carbon (mg kg^{-1} soil)	Soil basal respiration (µg CO_2-C g^{-1} soil hr^{-1})	Metabolic quotient (qCo_2) (µg CO^2 mg^{-1} C mic h^{-1})	Soil dehydrogenase (µg TPF released g^{-1} d^{-1})
C -1	741.93	66.00	0.089	13.29
C -2	767.20	64.11	0.084	11.32
C -3	729.30	73.13	0.100	14.98
C -4	787.06	60.23	0.077	42.53
C -5	781.65	85.95	0.110	25.00
C -6	778.04	90.18	0.116	22.72
C -7	767.20	44.70	0.058	21.82
C -8	723.88	50.89	0.070	13.80
C -9	738.32	64.14	0.087	21.58
C -10	740.13	25.63	0.035	13.72
C -11	767.20	38.08	0.050	12.54
C -12	736.52	41.24	0.056	23.35
C -13	774.43	28.42	0.037	50.63
C -14	750.96	90.94	0.121	10.69
C -15	765.40	63.38	0.083	24.25
C -16	839.41	59.87	0.071	20.44
C -17	769.01	93.70	0.122	48.00
C -18	812.33	68.69	0.085	23.78
C -19	830.39	59.73	0.072	20.95
C -20	817.75	94.40	0.115	10.89
C -21	788.87	50.61	0.064	10.46
C -22	785.26	97.20	0.124	17.69
C -23	859.27	28.69	0.033	11.64
C -24	866.49	60.75	0.070	17.30
C -25	844.83	41.15	0.049	19.89
C -26	00.00	00.00	00.00	00.00
C -27	00.00	00.00	00.00	00.00
C-26 and C-27 has full of broken cemented rubbles so it has been considered as no soil carbon				

Northern Region

Depth-wise Distribution of Soil Properties

The depth-wise distribution of some soil properties of Patiala district, Punjab is presented in Fig. 2.4.2. The soils of the Patiala district are neutral to strongly alkaline and the pH of the soils increases with depth. The soils are very low to high in OC content in surface layers (0.02 to 0.83%) and it decreased with depth. Similar was the case with CEC. The clay content was higher in soils of old flood plain of Ghaghar landform, varying from 4.5 to 56.8%. It decreased with depth.

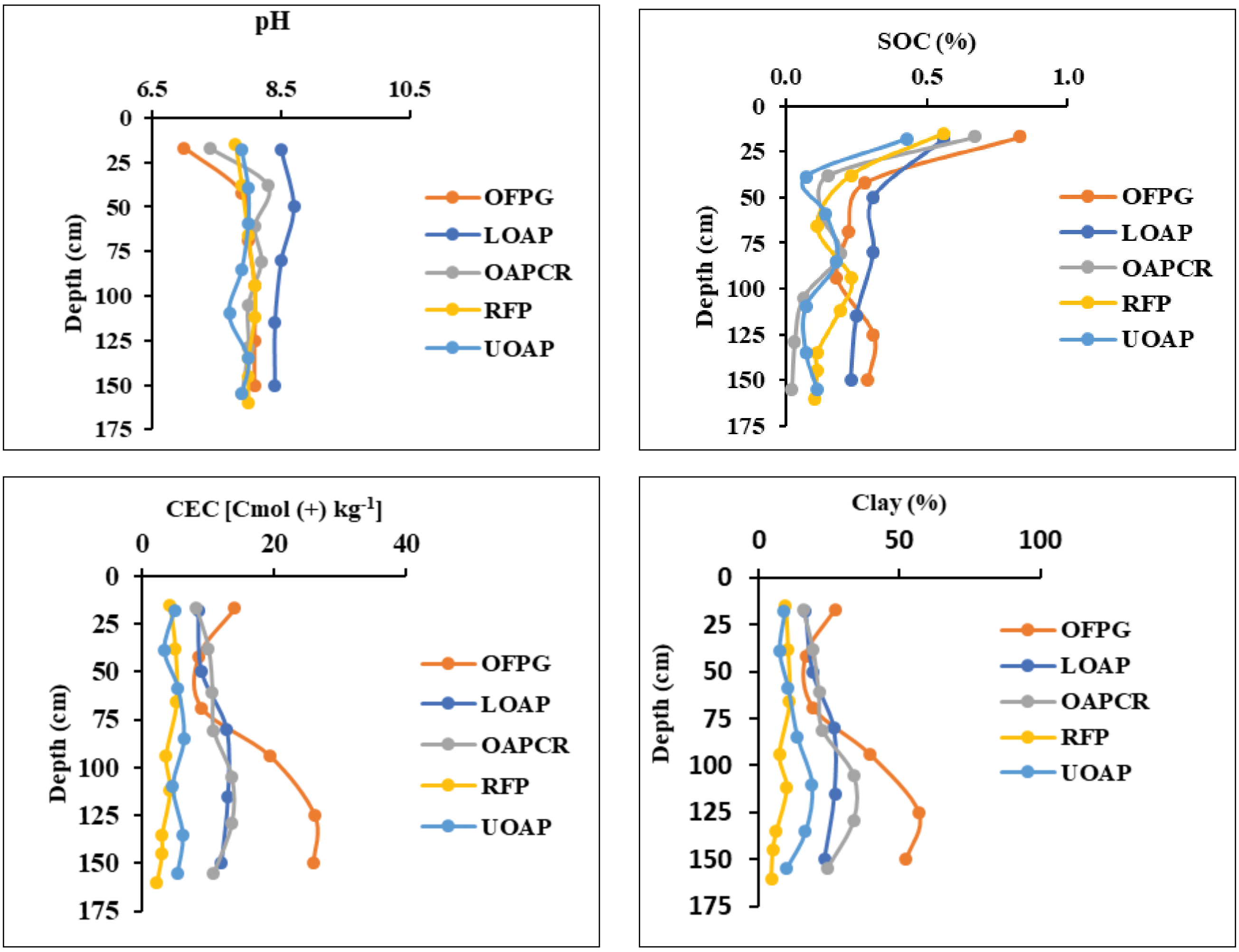


Figure 2.4.2: Soil Properties in different landforms (OFPG- old flood plain of Ghaghar); levelled old alluvial plain (LOAP); old alluvial plain with concave relif (OAPCR); recent flood plains (RFP); undulating old alluvial plain (UOAP)

Depth-wise Distribution of Soil Properties in Shahid Bhagat Singh Nagar district, Punjab

The soils of the district are neutral to strongly alkaline in reaction (pH: 7.3 to 8.7), low to high in SOC content in surface layers (0.17 to 0.8%), and it decreased with depth except in soils of active flood plains. Clay content varied from 6.8 to 22% in surface soils.The depth-wise distribution of soil organic carbon and clay content in Shiwalik hills, piedmont plains, old alluvial plains, recent alluvial plains and active flood plains of Shahid Bhagat Singh Nagar district of Punjab are shown in Fig 2.4.3 to 2.4.4.

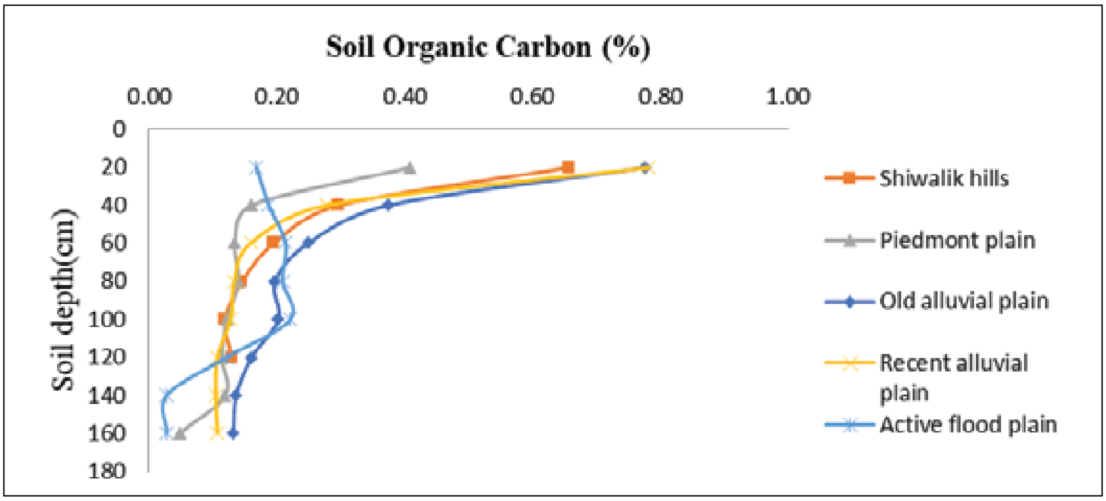


Fig. 2.4.3: Depth-wise distribution of soil organic carbon in different landforms of Shahid Bhagat Singh Nagar district of Punjab

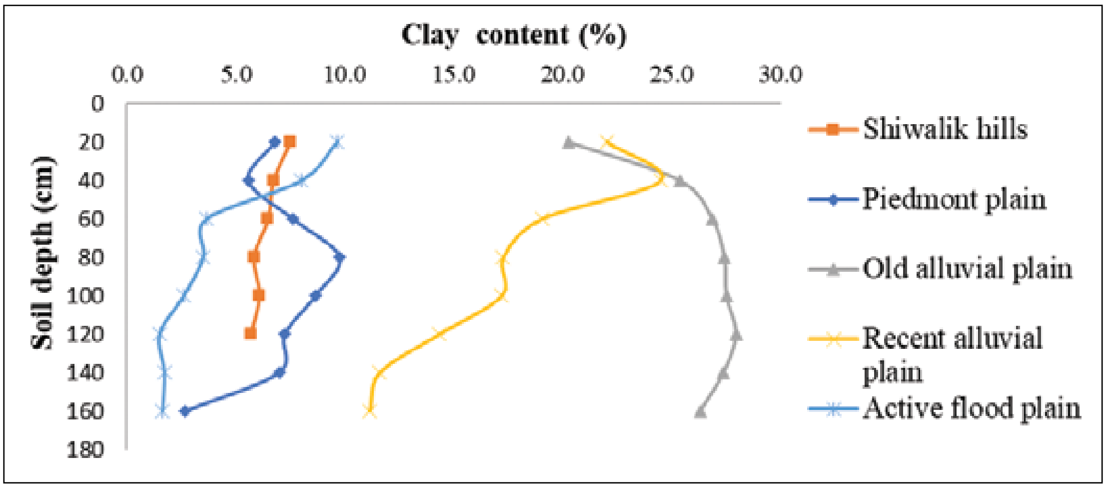


Fig.2.4.4: Depth-wise distribution of clay content in different landforms of Shahid Bhagat Singh Nagar district of Punjab

Soil properties estimation from Vis-NIR spectral data

Visible and near-infrared (Vis-NIR, 350-2500 nm) spectroscopy is used for soil properties estimations. However, the performance of such estimations may be dependent on pedological and spectral similarities between calibration and validation datasets. In this study, models were calibrated and validated from both regional database (regional model) and its subsets stratified by soil order (soil-order model). The regional database contained 482 soil samples belonging to four soil orders (Alfisols, Vertisols, Inceptisols and Entisols) and analyzed for six soil properties namely, OC, sand, silt, clay, CEC and pH as well as Vis-NIR spectroscopy. Estimates were produced using Random Forest multivariate models.

The sand content was positively correlated with the average reflectance along the Vis-NIR spectral range, while the clay content was negatively correlated with the average reflectance along the Vis-NIR spectral range (Fig. 2.4.5). The CEC and silt content also followed correlation patterns similar to clay. The mean spectra measured for Entisols and Alfisols presented the highest absorption band centred at 2207 nm (Fig. 2.4.6). Vertisols recorded relatively lower reflectance irrespective of the bandwidth. This work showed that

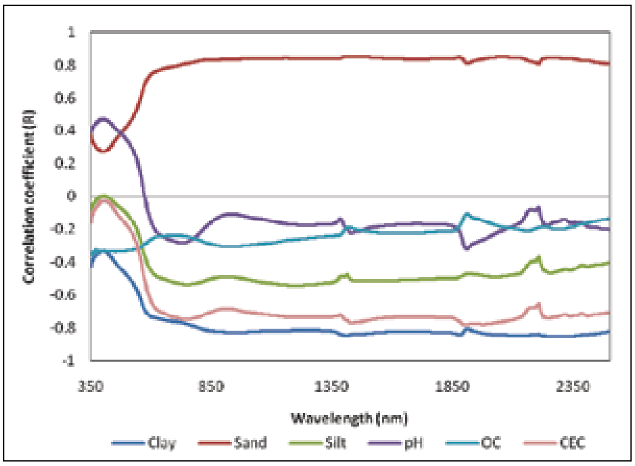


Fig.2.4.5 Correlation coefficient *(R)* between soil properties and mean reflectance

models based on a regional database for calibration can be considered as providing i) high accuracy of some soil properties estimations when considering the regional strategy in validation step (Fig. 2.4.7) (e.g., R^2_{val} of 0.74, 0.76 and 0.74 for clay, CEC and sand, respectively, but ii) modest accuracy of these same soil properties when considering subsets stratified by soil order validation step (e.g., R^2_{val} of 0.48, 0.58 and 0.38 over Vertisol for clay, CEC and sand, respectively). The study also highlighted the benefit of soil-order based model compared to a regional model for calibration depends on both soil property and soil order.

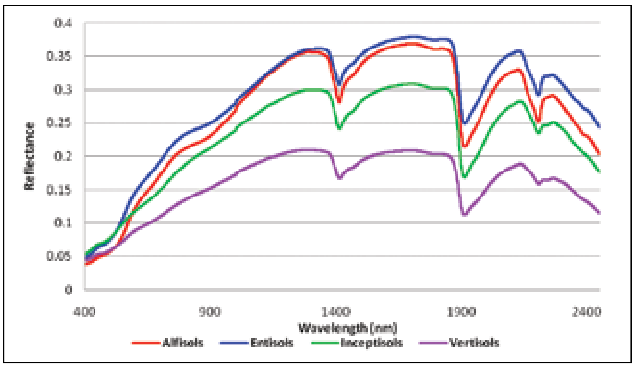


Fig.2.4.6. Mean spectral reflectance of soil samples stratified per soil order

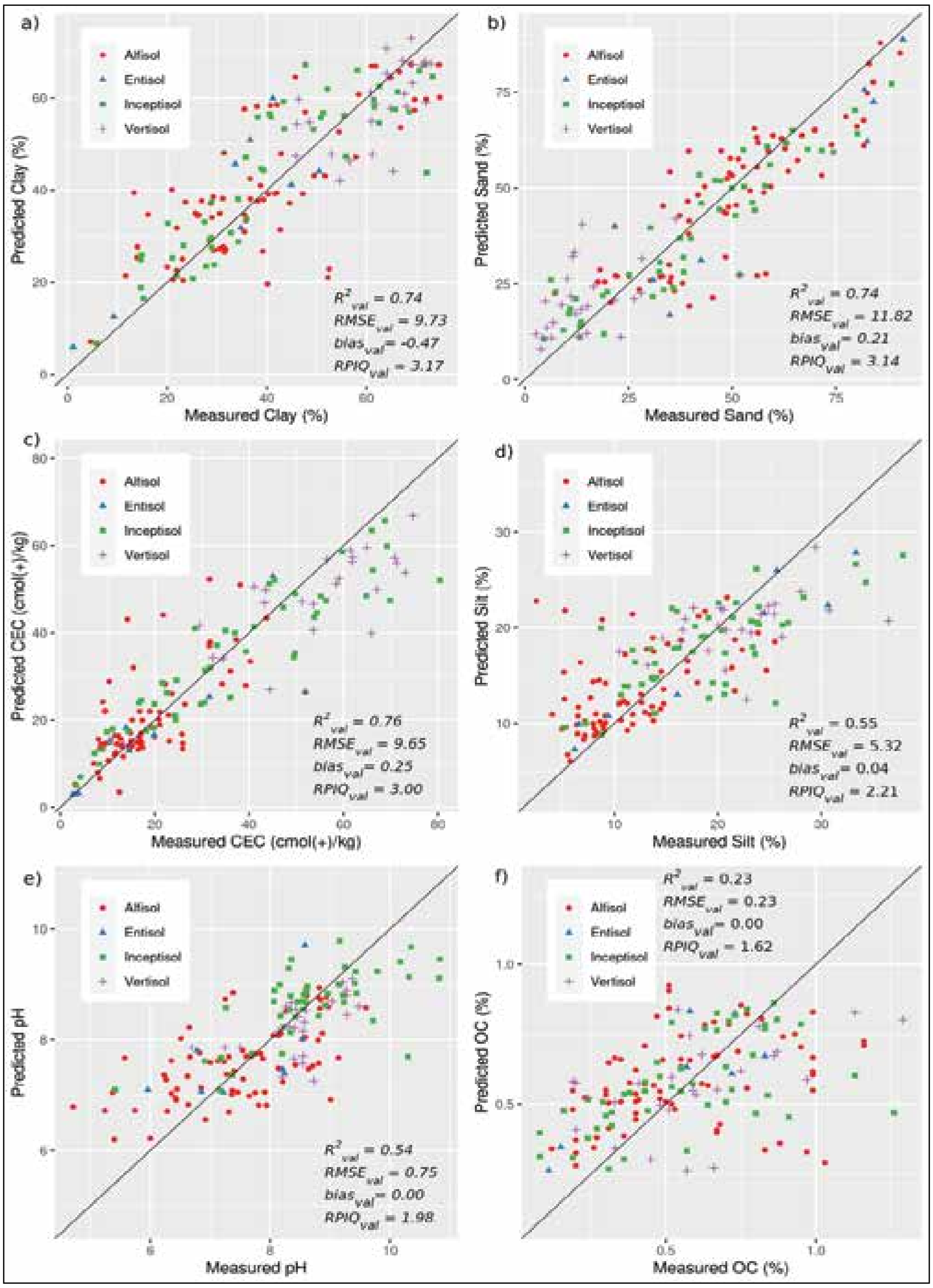


Fig. 2.4.7 Scatter plots of predicted versus observed soil properties obtained for the BD_*Val_Regional datasets*.

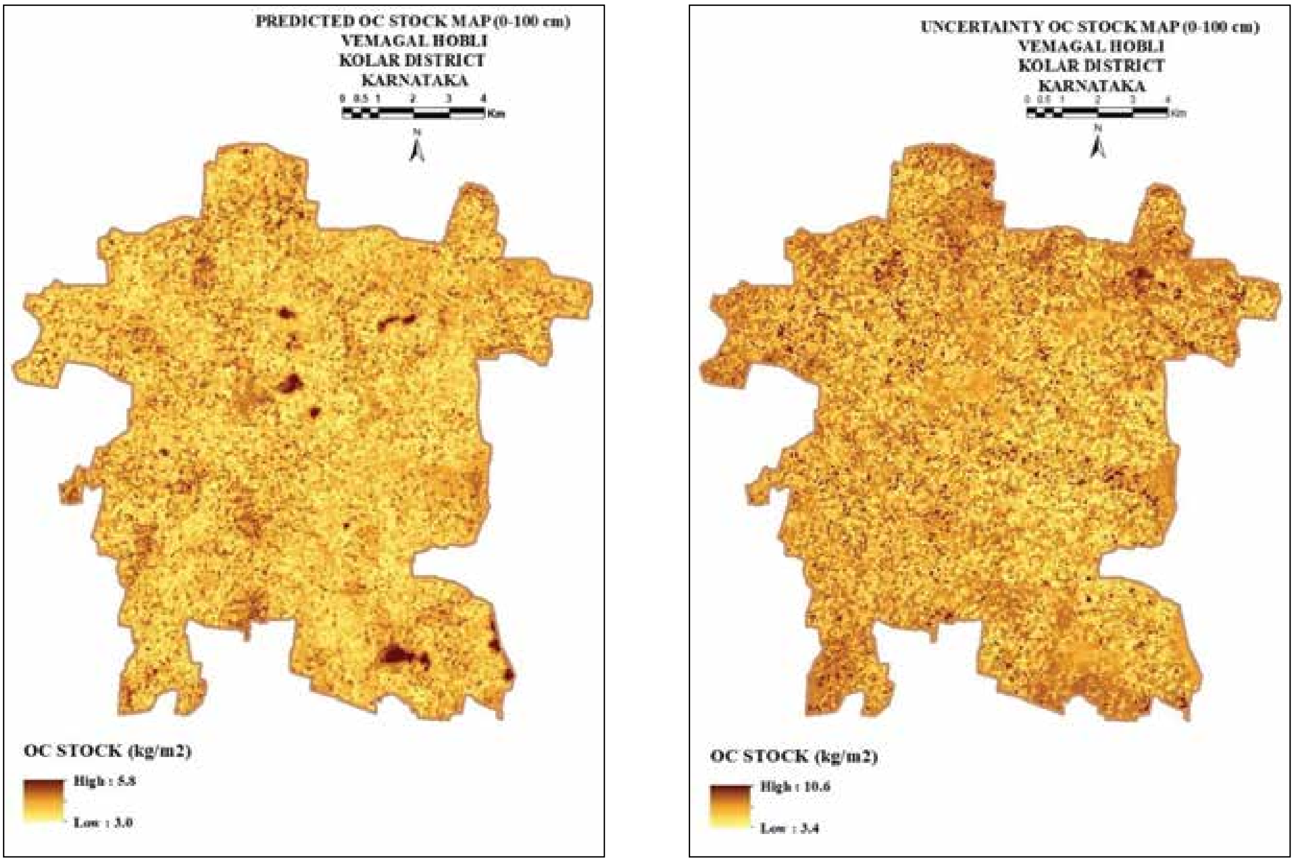


Fig. 2.4.8. Predicted & uncertainty maps of organic carbon stock (0-100 cm)

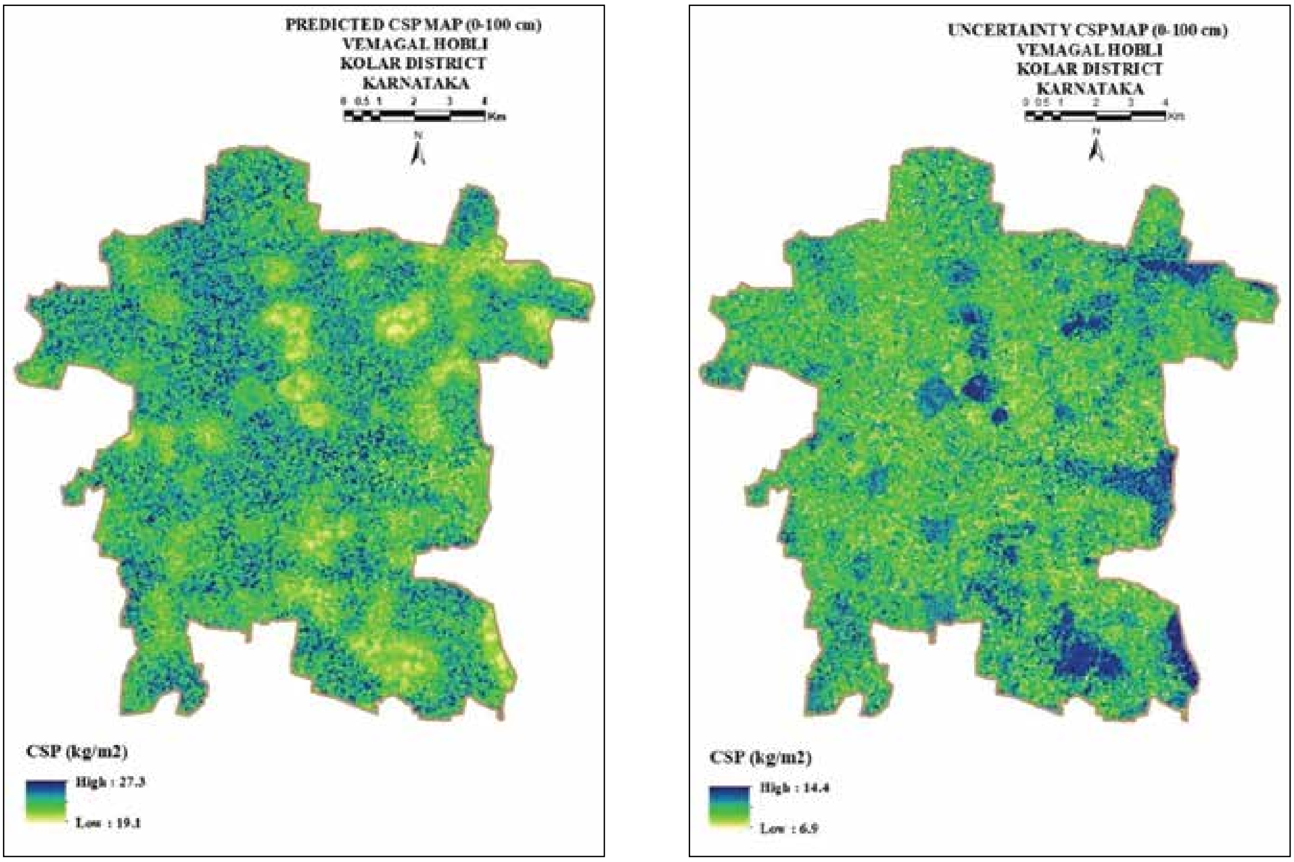


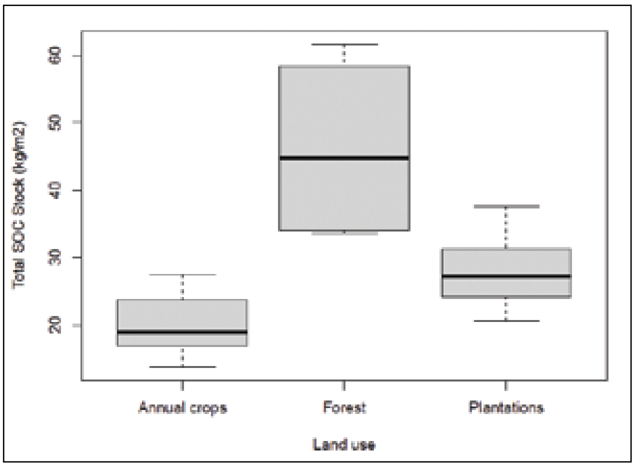
Fig. 2.4.9. Predicted & uncertainty maps of CSP (0-100 cm)

Mapping of Soil Organic Carbon Stock and Carbon Sequestration Potential

Four machine learning algorithms (Random Forest (RF), Support Vector Machine (SVM), Cubist and Artificial Neural Network (ANN)) were compared for prediction of SOC stock and CSP using 99 soil profiles data collected in Vemagal Hobli, Kolar district. RF model performed better than SVM, Cubist and ANN by explaining variability of 28-32% and 28-33% in prediction of SOC stock and CSP, respectively. The predicted SOC stock and CSP were 3.0-5.8 and 19.1-27.3 kg m^{-2}, respectively, and were mapped at 30 m resolution along with uncertainty for 100 cm depth for understanding their spatial distribution (Fig. 2.4.8 & 2.4.9).

Quantification of Carbon Sequestration Potential of soils

In this study, soil carbon sequestration potential (CSP) in parts of Western Ghats, Kerala is mapped using RF algorithm over two depth ranges (0-30 cm and 0-100 cm) using 150 soil profiles. Relatively higher CSP was observed for soils under annual crops (18.7 kg m^{-2}) compared to those under plantation (10.4 kg m^{-2}) and forest land use (9.5 kg m^{-2}) (Fig. 2.4.10). The correlation between fine particles and current OC concentration in the top 30 cm soil depth shows that only 6 samples have over-saturated (Fig. 2.4.11). The RF model yielded better prediction for actual SOC stock (R^2 = 0.52-0.55) compared to CSP (R^2 = 0.21-0.36). Enhanced vegetation index (EVI) is the most important variable in the prediction of SOC stock followed by NDVI (Fig. 2.4.12). About 256 Tg and 1089 Tg CO_2-equivalents could theoretically be stored in the top 30 cm and 100 cm of study area, respectively through best management practices that has added advantages of high agricultural productivity (Fig. 2.4.13).



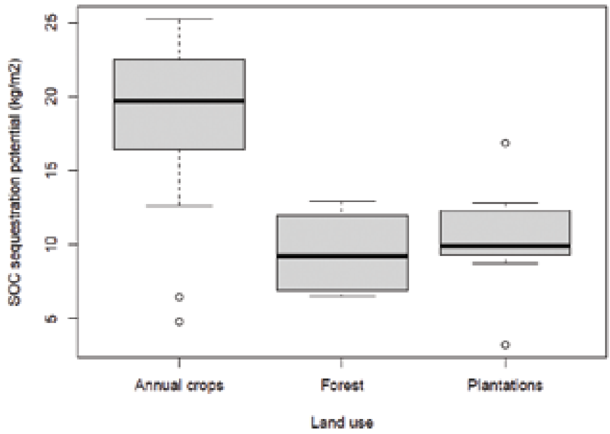


Fig. 2.4.10. SOC stock and CSP for 100 cm depth for different land use

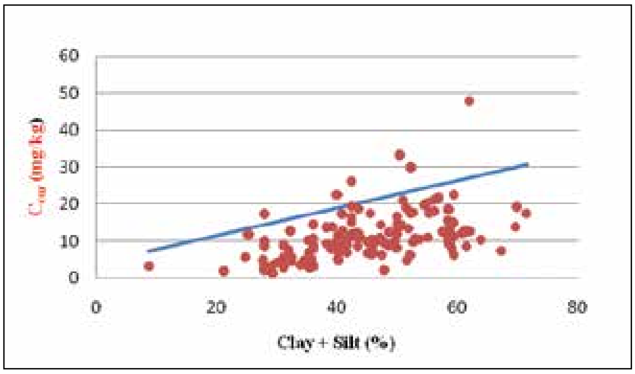


Fig. 2.4.11. Correlation between proportion of silt+clay and SOC stock in the top soil
(The blue line indicates the C saturation (Csat) according to Hassink 1997)

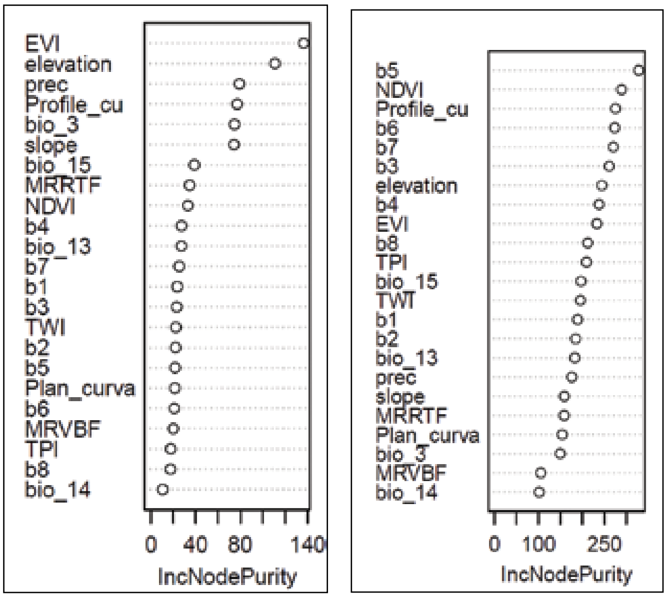


Fig. 2.4.12. Variable importance ranking of SOC stock and carbon sequestration potential

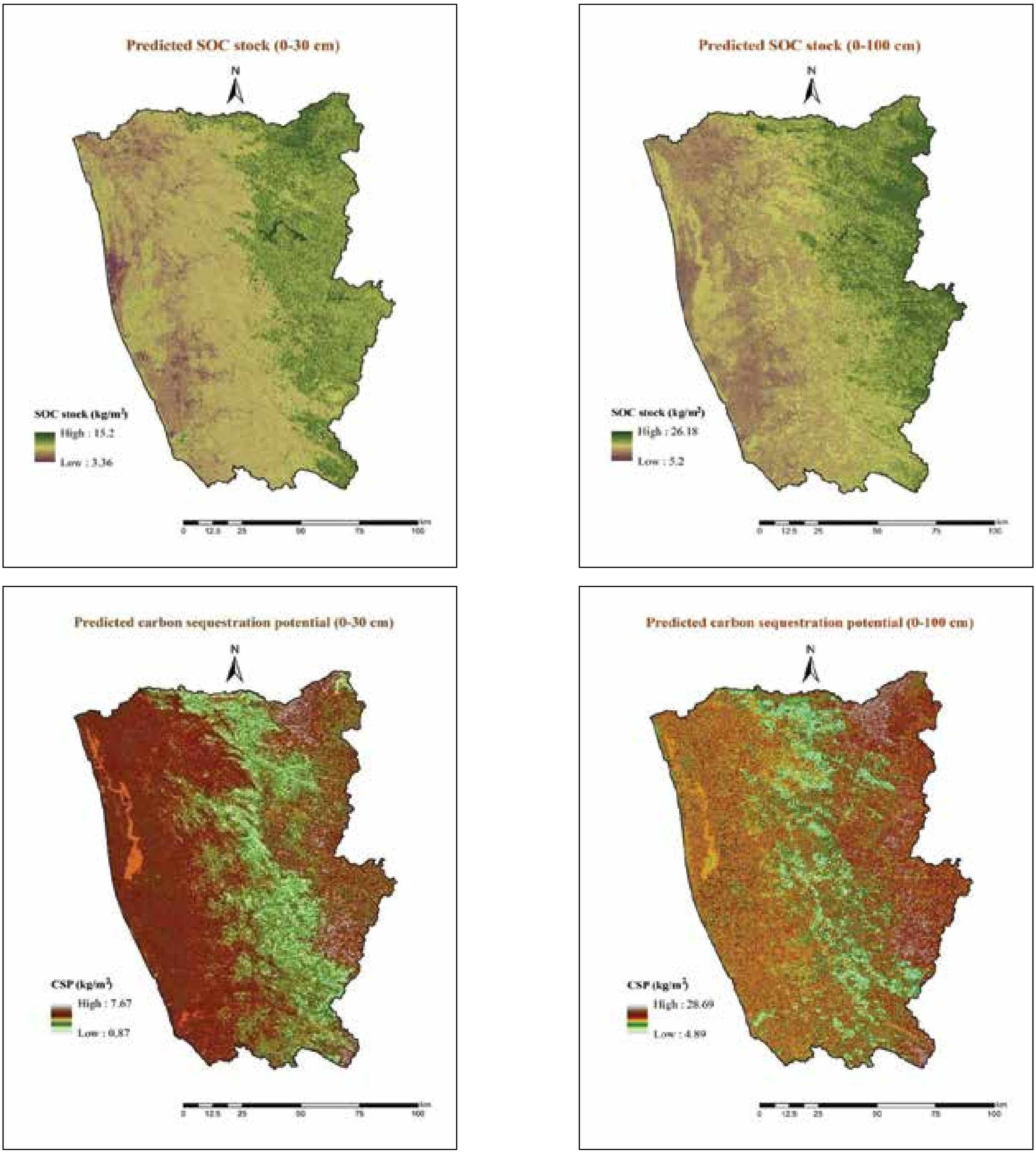


Fig.2.4.13. Predicted SOC stock and CSP in two different depths

Assessing Soil Nutrients Variability and Adequacy for the Cultivation of Mango, Kolar District of Karnataka

This study evaluated soil nutrient status in selected mango gardens of Kolar district, Karnataka and identified variations and their suitability for mango. A total of 163 surface soil samples were analysed for pH, organic carbon, available nitrogen, available phosphorus, available potassium, sulphur, boron, iron, manganese, copper and zinc. The soils were deficient in available nitrogen and phosphorus (Fig. 2.4.14). The available sulphur was medium and zinc content was low in 22 -30 per cent of the soils.

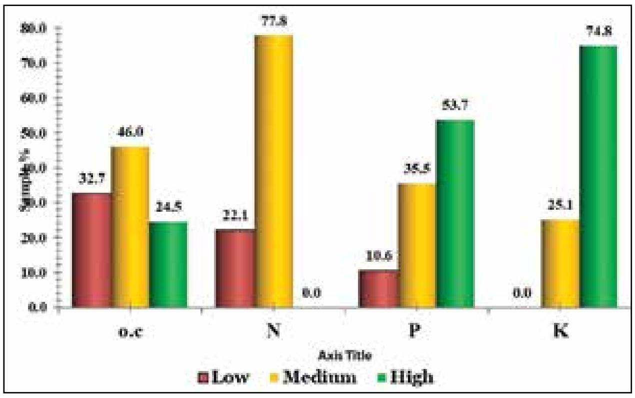


Fig. 2.4.14. Fertility status of soil samples in selected mango gardens

Water quality assessment of Nuggihalli Hobli, Channarayapatna Taluk, Hassan district, Karnataka

A total of 67 water samples collected from different sources *i.e.*, tank, well, and bore wells were analyzed for different water quality parameters (Table.2.4.2 & Fig. 2.4.15 and 2.4.16) and spatial maps for selected parameters were prepared.

Soil carbon sequestration potential of mango growing orchards, Kolar district Karnataka

A study was undertaken to characterize and classify the mango growing soils and to assess the organic carbon sequestration potential in rainfed ecosystem of Kolar, Karnataka. The soils were deep (100 cm) to very deep (>150 cm), well drained, with sandy clay to clay sub-surface texture. These soils were classified as Alfisols and Inceptisols. The estimated SOC stock and CSP in the mango orchard ranged from 4.0 to 18.3 kg m^{-2} and 12.8 to 34.6 kg m^{-2}, respectively. In total, about 9.27 Tg and 30.40 Tg CO_2-equivalents, respectively could theoretically be stored in the 100 cm of study area.

Table 2.4.2. Water quality status in Nuggihalli Hobli, Channarayapatna Taluk, Hassan district

Water quality	pH	EC (dS/m)	CO3	HCO3	Cl	SO4	Ca	Mg	K	Na
			<-----------------------meq/lit--------------------------->							
Minimum	7.4	0.17	0	0.96	0.08	0.25	0.1	0.1	0.1	0.3
Maximum	9.5	1.72	4.4	9.46	4.64	3.2	5.3	9.1	1.6	7.4
Average	8.19	1.006	1.39	5.567	1.52	1.48	1.5	3.4	0.3	3.9
Safe for irrigation	6.5-8.4	2.25	<0.1	0-10	0-30	0-20	0-20	0-5	0-2	0-40
Not safe for irrigation		5	>0.1	>10	>30	>20	>20	>5	>2	>40

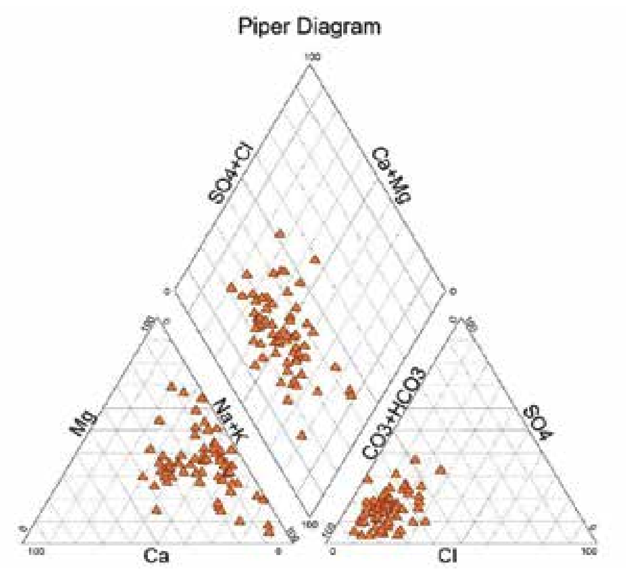


Fig.2.4.15 Water quality piper diagram for Nuggihalli block

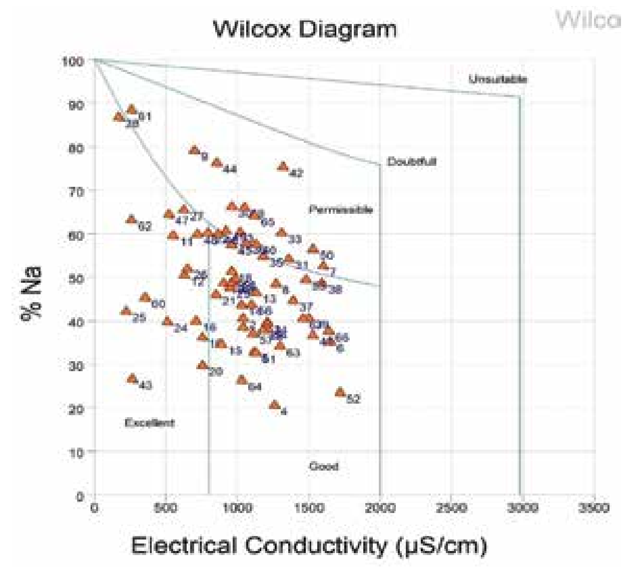


Fig. 2.4.16 Water quality Wilcox diagram for Nuggihalli block

2.5 LAND EVALUATION AND LAND USE PLANNING

Identification of suitable areas for pomegranate cultivation in India (Collaboration with ICAR-NRCP, Solapur)

Suitability maps for pomegranate for 15 states have been revised by the Bureau, with the help of the revised climate, terrain and soil parameters in the GIS-based multi-criteria model. The maps were finalized and validated by ICAR-NRCP, Solapur. Subsequently, state and district-wise area analyses have been carried out based on the thematic maps. State-wise thematic maps on various input parameters were generated. The revised soil suitability maps of Karnataka and Telangana for pomegranate are shown in Fig. 2.5.1.

Delineation of potential areas for soybean cultivation in all states of India using GIS modelling techniques (Collaboration with ICAR-IISR, Indore)

The inter-institutional project has been initiated by ICAR-Indian Institute of Soybean Research (ICAR-IISR), Indore, along with the partner institutes, *i.e.*, ICAR- National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS&LUP), Nagpur and SOLIDARIDAD, Bhopal to delineate the potential areas for soybean cultivation in India. Initially, the climate and soil-based input parameters were generated for 15 states for their integration to identify the potential areas. The GIS-based draft modelling criteria and weights for various input parameters were developed.

Land Resource Inventory of Yavatmal district of Maharashtra on 1:10000 scale using remote sensing and GIS technique

Soil Depth map of Yavatmal District- Yavatmal district covers 13582 km^2 (4.41 % of the state) area in the eastern part of the Maharashtra state. A detailed soil survey of the Yavatmal district was undertaken on a 1: 10000 scale and soil site suitability for cotton was evaluated (Fig. 2.5.2). The study showed that 30% area is highly suitable, 37% area was moderate to marginally suitable, and 27% not suitable for cotton crop. The most limiting factor for cotton cultivation is shallow soil depth and steeply sloping land.

Soil and water conservation plans and suggested

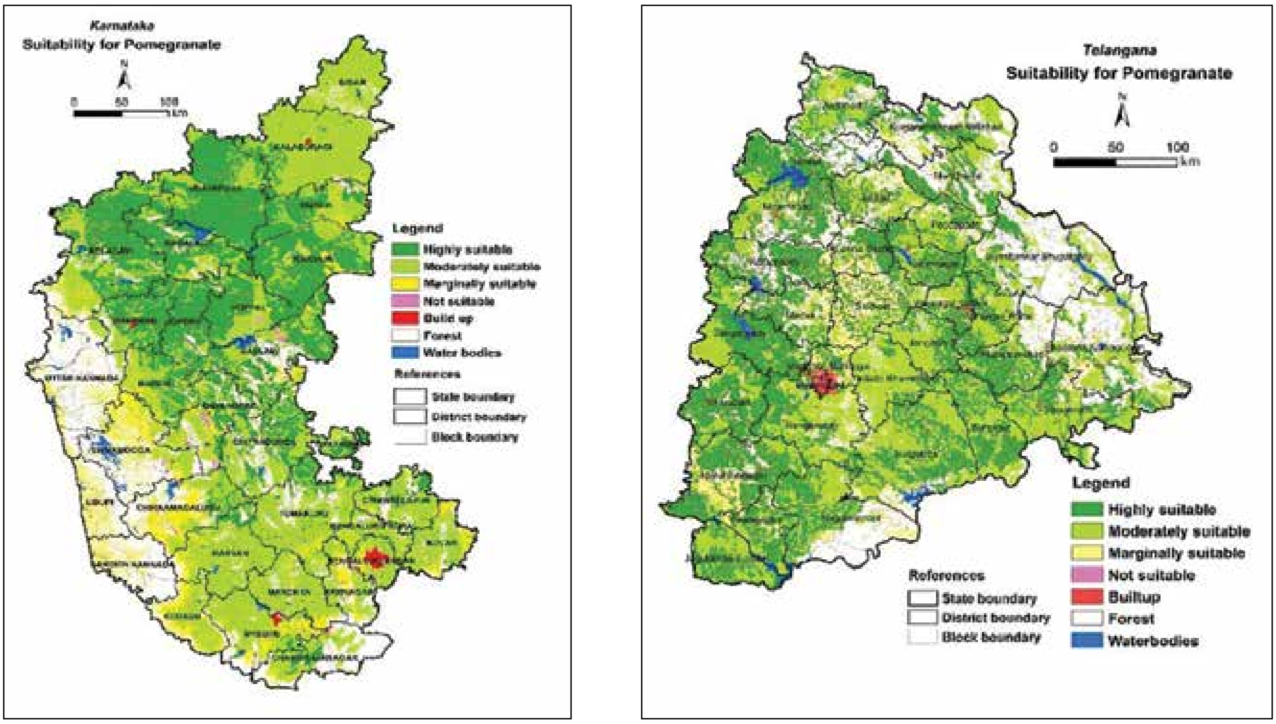


Fig. 2.5.1. Suitability maps for pomegranate in Karnataka and Telangana states

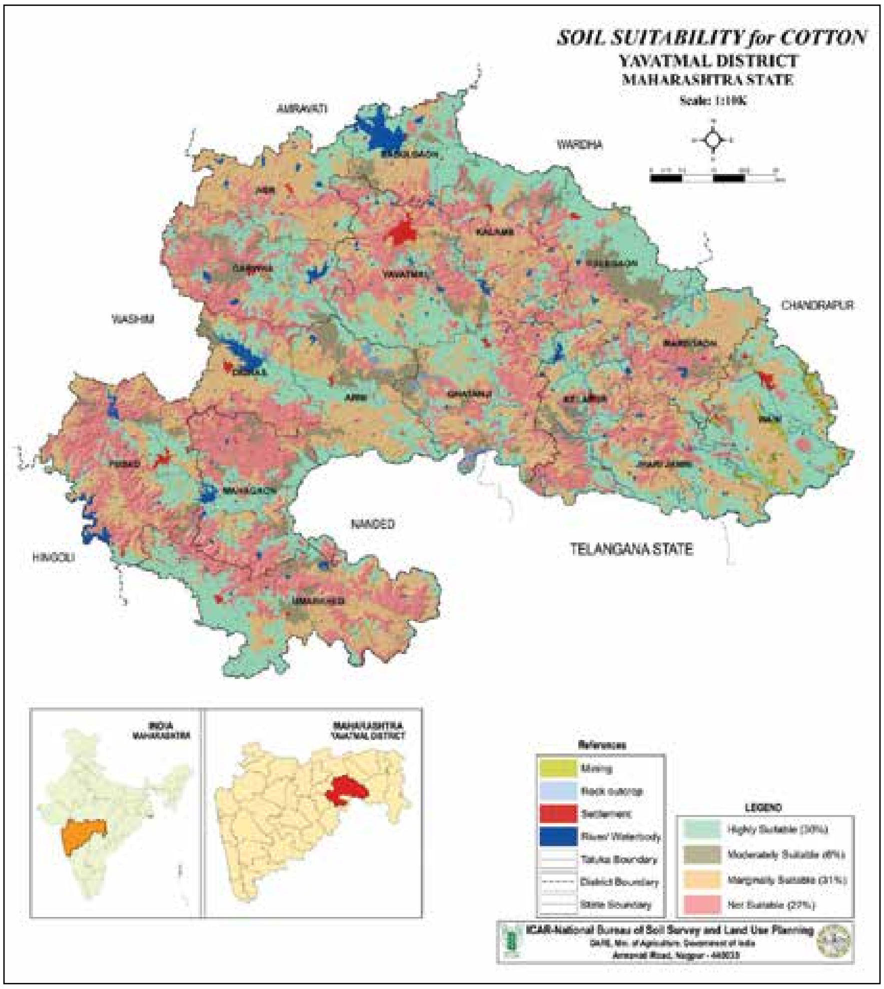


Fig. 2.5.2. Soil suitability map for cotton, Yavatmal district, Maharashtra

Land use options for Rahuri tehsil

Soil erosion is one of the major constraints for agriculture in the upper part of the landscape, including the summit, escarpment, and upper and lower pediment, whereas the lower part of the landscape covering undulating plain, and valley was severely affected by salinity, sodicity and poor drainage. The land management units, suggested sustainable land-use plan consisting of appropriate soil and water conservation techniques, agriculture, and horticulture is presented in Table 2.5.1 and Fig. 2.5.3 (a) and (b).

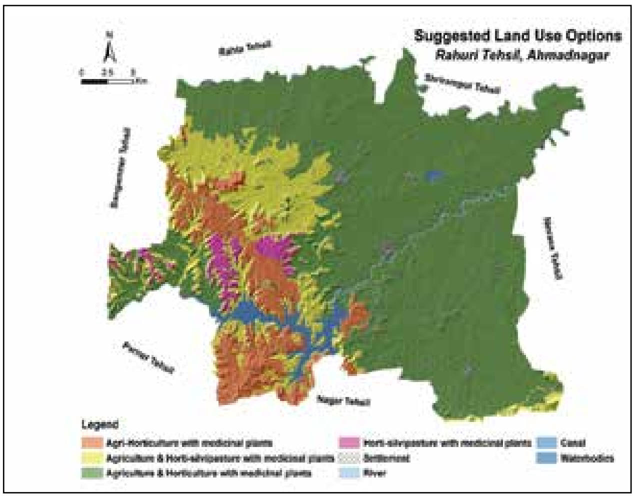


Fig. 2.5.3 (a) Land Management Units in Rahuri *tehsil*, Ahmednagar

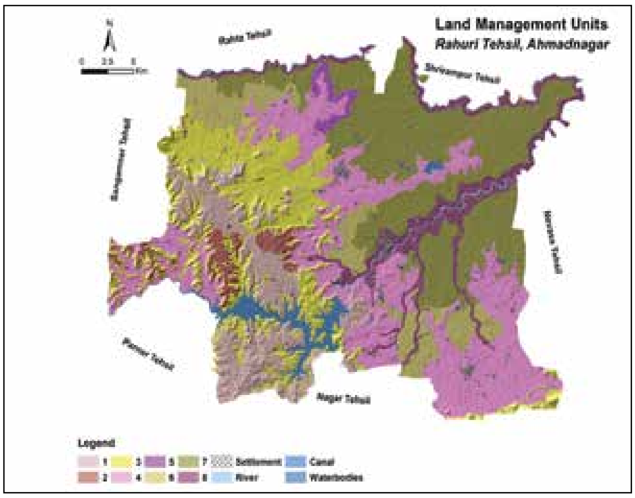


Fig. 2.5.3 (b) Suggested land use options for Rahuri *tehsil*, Ahmednagar

Table 2.5.1: LMU-wise soil & water conservation plan and suggested land use options for Rahuri tehsil

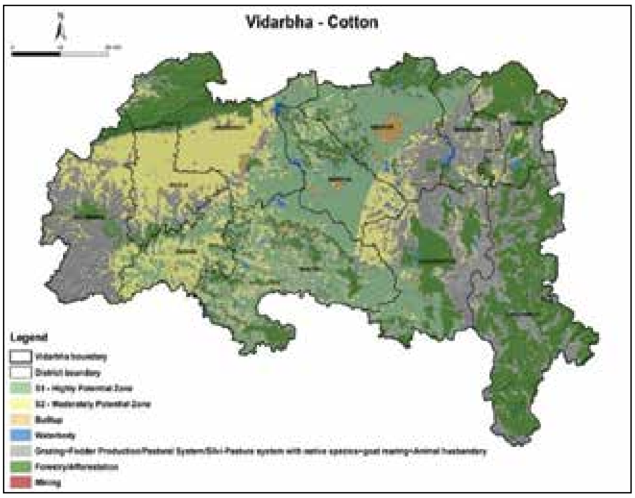
LMUs	Present land use	Slope (%)	Soil and water conservation measures	Suggested land use options	Area (ha)
1	Pigeon pea, Cotton	3-5	**Cropland:** Contour bunding**/** field bunding with stone pitching and vegetative barrier **Plantation:** In-situ moisture conservation measures **Organic farming**: Apply organic sources *Viz.* FYM, Vermicomposting, Green Manuring, Crop residues mulching	**Agri-Horticulture** (Custard apple, Ber, Pomegranate, Bamboo) **Medicinal plant-**Indian winter cherry (Ashwagandha), Lemongrass	10086.1
2	Cotton, Sugarcane	1-3	**Cropland:** Field bunding with stone pitching and vegetative barrier **Plantation: I**n-situ moisture conservation measures **Organic farming**: Apply organic sources *Viz.* FYM, Vermicomposting, Green Manuring, Crop residues mulching	**Horti-Silvopasture** (Custard apple, Ber, Aonla, Pomegranate, Bamboo, Neem, Subabul, Fodder grass) **Medicinal plant**- Ashwagandha, Lemongrass	2207.2
3	Pigeon pea, Cotton	5-10	**Cropland:** Contour bunding /Field bunding with stone pitching and vegetative barrier **Plantation:** In-situ moisture conservation measures **Organic farming**: Apply organic sources *Viz.* FYM, Vermicomposting, Green Manuring, Crop residues mulching	**Agriculture** (*kharif* sorghum, pearl millet, soybean, vegetables, mixed cropping, fodder sorghum) **Horti-silvipasture** (Custard apple, Ber, Bamboo, acacia spp.,Neem, Subabhul, Fodder grass) **Medicinal plant**- Ashwagandha, Lemongrass	16726.54
4	Pigeon pea, Sugarcane	3-5	**Cropland:** Contour bunding /Field bunding with stone pitching and vegetative barrier **Plantation:** In-situ moisture conservation measures **Organic farming**: Apply organic sources *Viz.* FYM, Vermicomposting, Green Manuring, Crop residues mulching	**Agriculture** (Sorghum, Pearl millet, pigeonpea, Sunflower, Safflower, Maize, Vegetable, Intercropping, Fodder Sorghum, Suru Sugarcane with drip irrigation) **Horticulture** (Pomegranate, Ber) **Medicinal plant**- Ashwagandha, Lemongrass	24872.1
5	Sugarcane	1-3	**Cropland:** Surface/subsurface drainage system. **Chemical amendments:** Apply Gypsum/ Sulphur and soil test-based RDF **Organic farming**: Apply organic sources *Viz.* FYM, Vermicomposting, Green Manuring, Crop residues mulching	**Agriculture** (Sorghum, Pearl millet, Pigeonpea, Sunflower, Safflower, Maize, Vegetable, Intercropping, Fodder sorghum, Suru Sugarcane with drip irrigation) **Horticulture** (Banana, Sapota) **Medicinal plant**- Ashwagandha, Lemongrass	868.4
6	Sugarcane	1-3	**Cropland:** Surface/subsurface drainage system. **Organic farming**: Apply organic sources *Viz.* FYM, Vermicomposting, Green Manuring	**Agriculture** (Sorghum, Pearl millet, Pigeonpea, Sunflower, Safflower, Maize, Vegetable, Intercropping, Fodder sorghum, Suru Sugarcane with drip irrigation) **Horticulture** (Banana) **Medicinal plan**t- Ashwagandha, Lemongrass	7388.5

LMUs	Present land use	Slope (%)	Soil and water conservation measures	Suggested land use options	Area (ha)
7	Sugarcane	1-3	**Cropland:** Surface/subsurface drainage system. **Chemical amendments:** Apply Gypsum **Organic farming**: Apply organic sources *Viz.* FYM, Vermicomposting, Green Manuring, Crop residues mulching	**Agriculture** (Sorghum, Pearl millet, Pigeonpea, Sunflower, Safflower, Maize, Vegetable, Intercropping, Fodder Sorghum, Suru Sugarcane with drip irrigation) **Horticulture** (Banana) **Medicinal plant**- Ashwagandha, Lemongrass	24171.1
8	Sugarcane	0-1	**Cropland:** Surface/subsurface drainage system. **Chemical amendments:** Apply Gypsum **Organic farming**: Apply organic sources *Viz.* FYM, Vermicomposting, Green Manuring, Crop residues mulching	**Agriculture** (Sorghum, Pearl millet, Pigeonpea, Sunflower, Safflower, Maize, Vegetable, Intercropping, Fodder Sorghum, Suru Sugarcane with drip irrigation) **Horticulture** (Banana) **Medicinal plant**- Ashwagandha, Lemongrass	6686.4

Evaluating and mapping soil-site suitability for major crops in Central India using GIS-based multi-criteria decision analysis

Soil-site suitability analysis for six major crops (*i.e.*, rice, soybean, maize, cotton, citrus and gram) of the Vidarbha region was carried out using an integrated approach of AHP and GIS. Nine suitability parameters of soil and climate (soil depth, texture, drainage, organic carbon, pH, slope, elevation and rainfall pattern) were assigned weights. To demonstrate the integration of AHP and GIS-based approach and the relative importance of parameters in the pair-wise comparison matrix of AHP was determined by considering the opinion of a team of experts from the ICAR-NBSS&LUP, ICAR-CICR and ICAR-CCRI by organizing consultation meetings. Fuzzy sets were used with AHP to eliminate the uncertainties in assessing soil-site suitability analysis.

The evaluation shows that approximately 34.4% of the area is highly suitable, 34.3% is moderately suitable, and 31.3% is marginally or not suitable for cultivating the selected crops. The method was consistent with ground reality. The gap analysis between the suitable areas derived from the study and the actual mean growing area during 2020-21 revealed that out of actual growing areas, only 47 and 49 % of the area is suitable for cotton and soybean cultivation, while the rest of area is either moderately or not suitable for cotton, thereby productivity is less than the average. Land suitability maps were developed for the major crops (Fig. 2.5.4).



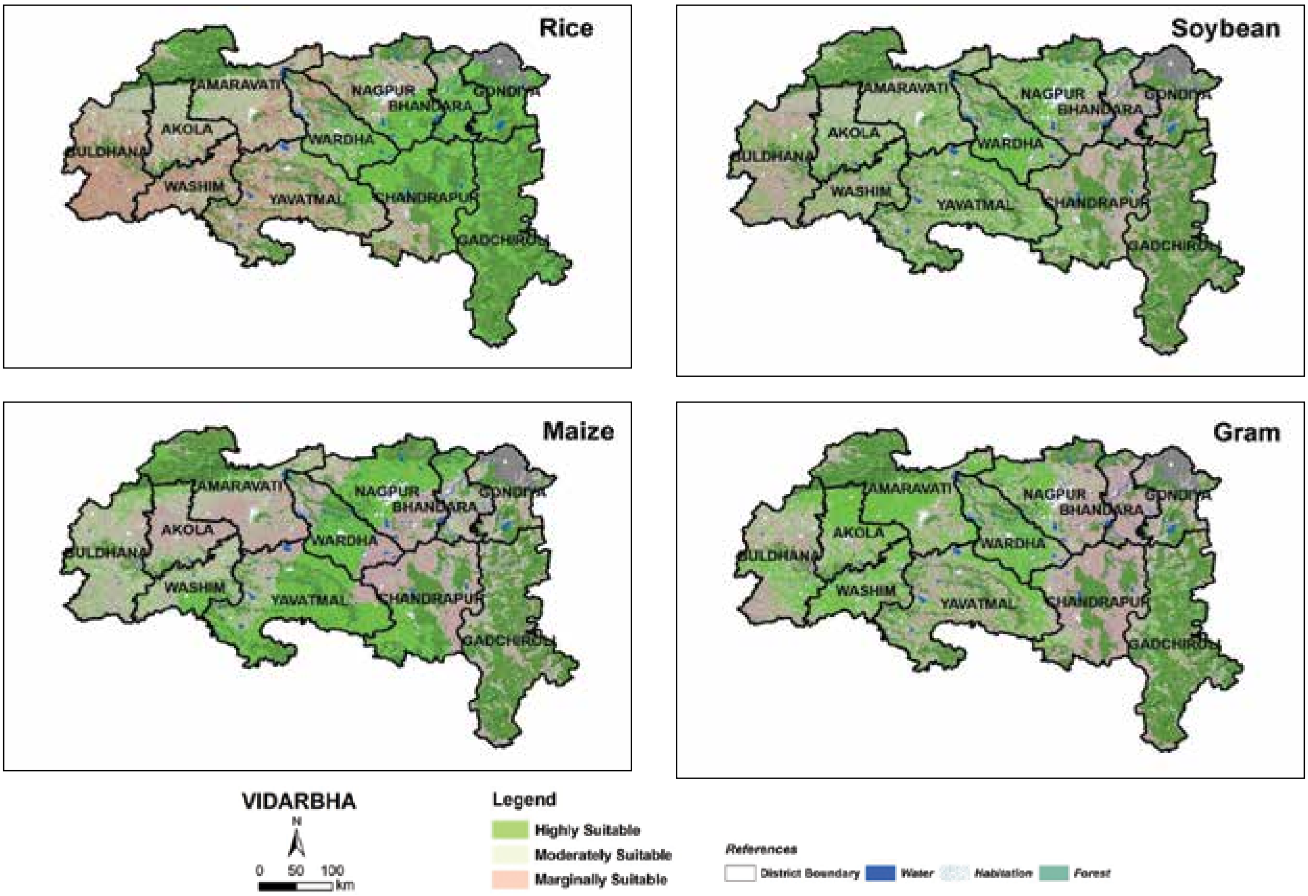


Fig. 2.5.4: Land suitability map of crops

Heavy metal contamination and ecological-health risk evaluation in peri-urban wastewater-irrigated soils of Nagpur city

Twelve hotspot sites were selected in the Nag river watershed to study soil heavy metal contamination in peri-urban areas of Nagpur city. The DTPA extractable heavy metals represented in the rotated component matrix, the first principal component (PC) (PC1, variance of 56.9%) included iron (Fe), copper (Cu), nickel (Ni), zinc (Zn) and cadmium (Cd) whereas the second PC (PC2, variance of 17.9%) was constituted by chromium (Cr), manganese (Mn) and cobalt (Co) which caused lesser pollution than other heavy metals (Fig. 2.5.5).

The S3, S7 and S9 locations were considered the most contaminated and S4, S8 and S12 were moderately contaminated. The S2, S5, S6, S10, and S11 are the least contaminated sites for DTPA extractable heavy

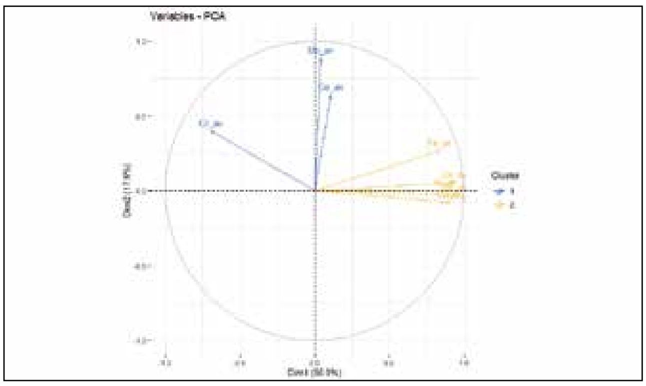


Figure 2.5.5: Principal component analysis (PCA) represents the contribution of DTPA extractable heavy metals on PC1 and PC2.

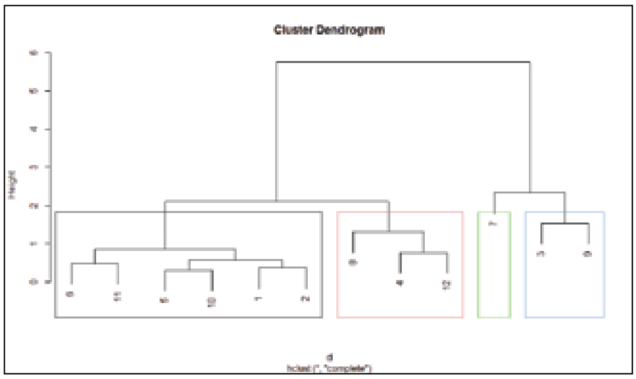


Figure 2.5.6: Dendrogram obtained by hierarchical cluster analysis (HCA) of different sites using principal component analysis (PCA) for DTPA extractable heavy metal contents in different sites.

metals, as indicated in the dendrogram obtained from the cluster analysis (Fig. 2.5.6).

Eastern Region

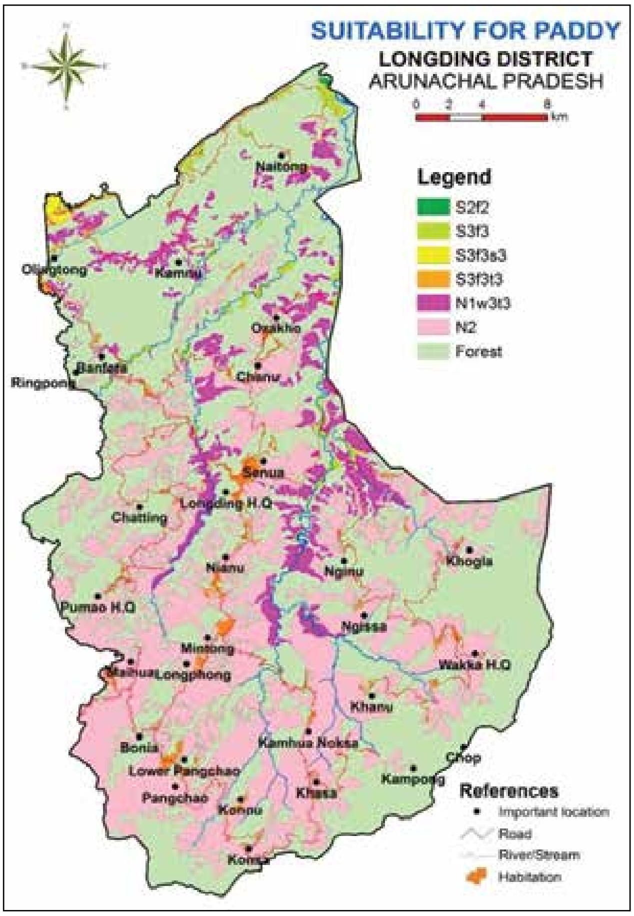
Land resource inventory of Longding district Arunachal Pradesh on a large scale for agricultural land use planning using geospatial techniques

The soils of the district were evaluated for paddy, maize, pearl millets and spices. The results showed that 1.3% of TGA of the district is marginally suitable for paddy due to fertility, soil and topography limitations, whereas 37.47% of TGA is not suitable due to topographic position from steeply sloping to moderately sloping land and high KCl-Al (>5 cmol(p+) kg^{-1}) (Fig. 2.5.7 a)

The soil suitability analysis shows that 1.33% of TGA of the district is moderately suitable for maize due to fertility and soil limitations, 5.2% of TGA is marginally suitable due to fertility and soil condition. About 32.2% area of the district is not suitable for pearl millet cultivation. The results of land evaluation indicate that 38.7% of TGA of the district is moderately suitable for spices due to fertility and topography limitations, whereas 0.03% of TGA is marginally suitable due to fertility and drainage condition (Fig. 2.5.7 b).

Land Resource Inventory of Cinchona and other medicinal plant growing areas of Darjeeling and Kalimpong districts, West Bengal

Considering the land resource information and land evaluation, a land use model was suggested for the study area (Figure 2.5.8). Soil resources on mountain peaks and high hills are marginally suitable for cinchona and other medicinal plants. However, these soils are best suited for forest (pine, pipli, *etc.*) and kiwi, which require well-drained, sandy loam soils with a soil pH of less than 6.5 and a minimum winter temperature of 7°C. Hence, it is proposed that, mountain peaks and high hills of the study area (elevation 2029-1500 m) be kept for the forest as a buffer zone, with a portion used for kiwi cultivation as a pilot study because these landforms experience slightly lower temperatures than others areas and the soils also have requisite parameters suitable for kiwi cultivation. The best elevation for cinchona cultivation ranges from 2000–1000 m, while the average temperature of 20 °C is conducive for ite growth.



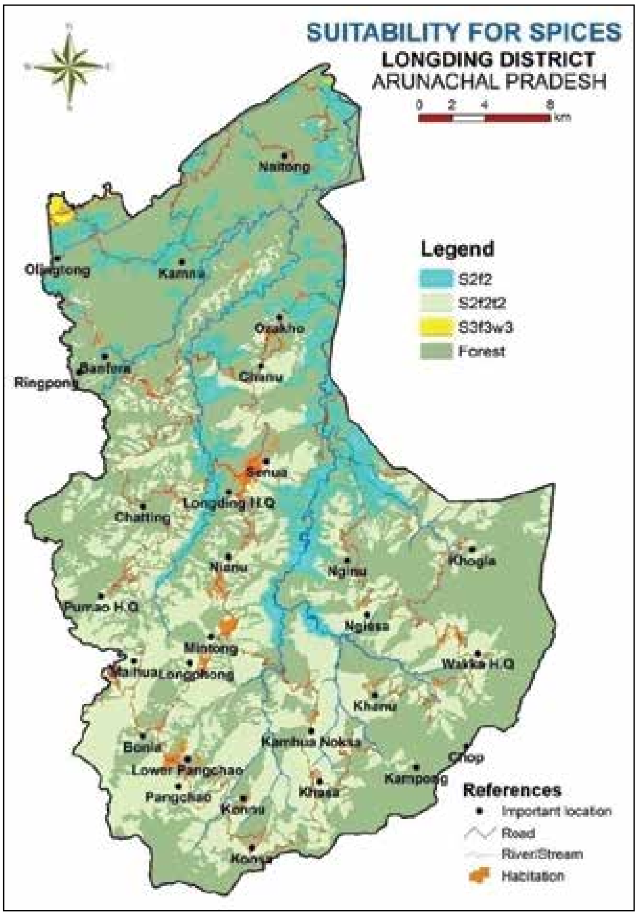


Fig. 2.5.7 (a) and (b) Soil-site suitability maps of paddy and spices for the Longding district

Cinchona prefers porous, well-drained, fertile soils with a thick cover of organic matter and a pH range of 4.5 to 6.5. Currently, cinchona is cultivated in all the landforms in the study area. However, based on soil resource information of the area, cinchona cultivation may be limited to medium hills with very steep to steep side slopes (1800–800 m elevation). These soils are very deep, medium textured and high in organic matter content. The findings of this study also indicate that the horticultural crops, namely, coffee, bamboo *etc.*, are suitable in low hills as coffee requires high temperatures, steep slopes, well-drained and a warm, humid climate. In the present land use model, it is suggested that coffee may be grown in the elevation range of 1000–600 m in very steeply sloping low hills since water stagnation harms coffee and the area also experiences a warm and humid climate. Moderately sloping valley soils are very deep, well-drained, and loamy, have slightly higher pH than other landforms, and are suitable for orange and rubber cultivation.

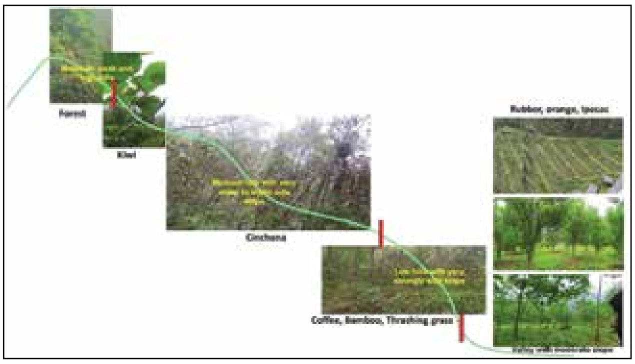


Figure 2.5.8. Proposed land use model in different landforms

Land evaluation and land use planning of Rangjuli Block, Goalpara district, Assam

- Soil site suitability analysis for major crops of the study area revealed that the Ambari and Kahibari series soils were moderately suitable for paddy, with the major soil limitations being very strong soil acidity and poor drainage. Rubber is highly suitable in Madong, Athiabari and Ambuk and moderately suitable for Sildubi. Kamarpota and Similitola are moderately suitable for rubber due to imperfect drainage. Banana is marginally suitable for all soils due to very strong to strongly acidic pH. The soil reaction of the study area was noted as the major suitability limitation.
- Capability-Index (Ci) for irrigation revealed that Ambari soils are almost unsuitable (N1). Kahibari soils are marginally suitable with drainage limitation (IIId). Kamarpota, Simlitola, Athiabari, Madong and Ambuk are moderately suitable (S2). Sildubi soils of inselbergs are marginally suitable due to topography limitations (S3t). The study results were integrated to formulate a holistic agricultural land use plan for each series (Table 2.5.2).

Northern Region

LUP of Pangi block, Chamba district, Himachal Pradesh

Land resource database of Pangi block was evaluated for soil-site suitability in respect of wheat, barley, finger millet, proso millet, cabbage and potato (Fig 2.5.9 (a) and (b)). The analysis indicates that about 1.3, 0.9 and 0.8% areas are moderately suitable for proso millet, cabbage and potato, respectively. Marginal suitability exists in about 7.5% of the area for finger millet, 7.4% for wheat and barley, 7.3% for potato and cabbage, and 6.8% for proso millet. The major limitations for crop cultivation and suitability are cold climate, steep topography, excessive drainage, soil texture, soil depth, gravelliness and stoniness.

Table 2.5.2: Integrated agricultural land use planning at a series level for the Rangjuli block

Series	Nutrient limitation	Existing cropping system	Alternate Land Use Plan	Suggested management
Ambari	K, P, B, Zn	Paddy-fallow/ paddy-paddy	Paddy – pulse in residual soil moisture, Paddy – Paddy	Slow-release fertilizers, a split dose of N, nitrification inhibitors, split K, Zn foliar spray, and micronutrient management.
Kamarpota	N, K, B, Zn	Arecanut, rubber, mono banana crops, small scale	Arecanut + Pepper + Pineapple vertical cropping	Assured irrigation during dry period, INM, and regular incorporation of organic matter.
Kahibari	N, K, P, B, Zn	Paddy-fallow/ fallow	Paddy – pulse in residual soil moisture, Paddy – Paddy	Similar to Ambari soils, special attention to maintenance of high O.C. Band placement of K and P nutrients. Foliar spray of Zn and B micronutrients are crucial.

Series	Nutrient limitation	Existing cropping system	Alternate Land Use Plan	Suggested management
Simlitola	N,K, B, Zn, P	Tea	Tea	Regular split doses of N, P and K fertilizers and foliar spray of Zn and B micronutrients.
Madong	K, P, B, S	Paddy, banana, potato, pea and other vegetable crops	Arecanut + pepper + pineapple Potato - pea, vegetable-ground nut	Band placement of K and P nutrients, Foliar spray of B. Lift irrigation from Ildek river for assured irrigation. Adequate liming Flood irrigation should be avoided, micro-irrigation
Sildubi	N, B, Zn, P	Rubber, forest, arecanut, barren	Rubber with intercrops of cover crops such as lemon grass, or pasture crops, Tea, Rubber-tea intercropping	Micro-irrigation, regular liming if intercropped with grasses.
Athiabari Ambuk	P, Zn, B K, P, Zn, B	Arecanut, Banana, rubber	Rubber – pasture in 5-8 % slopes, Arecanut + pepper+ pineapple in 3-5 % slope	Regular incorporation of organic manures, application of N, K and P fertilizers at regular intervals and foliar sprays of Zn and B micronutrients.

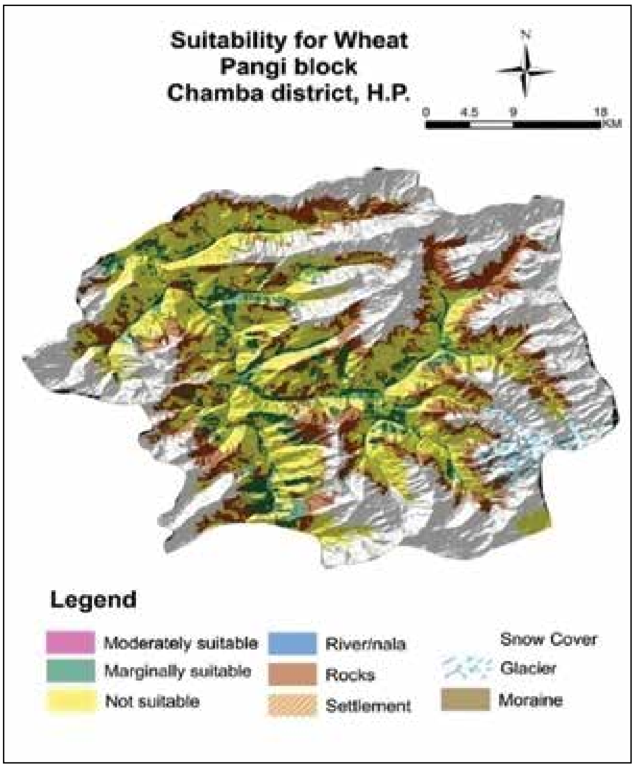


Fig.2.5.9 (a) Soil suitability for wheat in Pangi block, Chamba district, H.P.

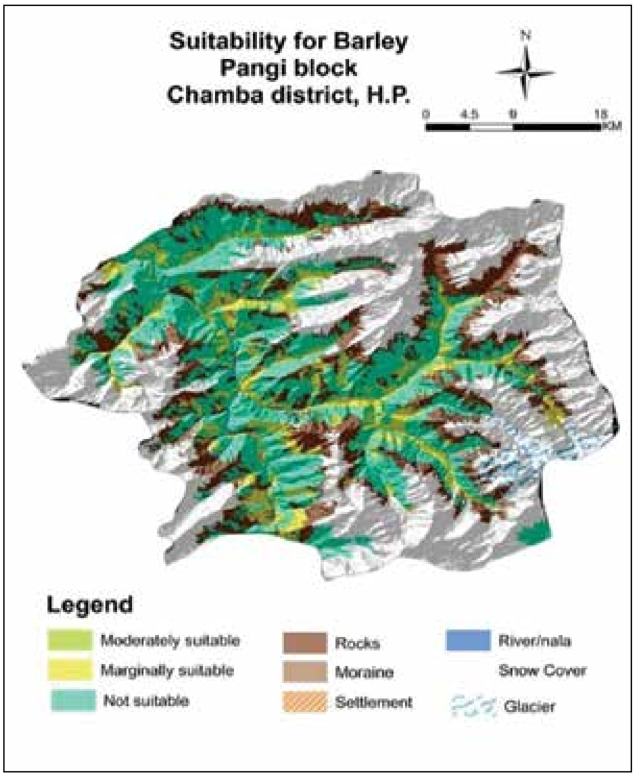


Fig.2.5.9 (b) Soil suitability for barley in Pangi block, Chamba district, H.P.

Land Use Planning of Mathura District

The soil resources of the study area have been evaluated for the site suitability of various crops (Fig. 2.5.10 (a) & (b)). Soil suitability maps were prepared for major crops *viz.*, cereals (rice, wheat, barley) including the coarse cereals (sorghum, maize) and millets (pearl millet, barnyard millet), oilseeds (sesame, mustard), cash crops (sugarcane, cotton), pulses (pigeon pea, cluster bean and gram), and commodity vegetable crop (potato) to suggest alternate land use options. The evaluation indicates that the maximum area is moderately suitable (S2) for rice.

Soil suitability analysis for major crops in Odhan block, Sirsa district, Harayana

Soil suitability evaluation for major crops (cash crops / pulses/ oilseeds/) was carried considering climatic, soil, site and socio-economic condition and

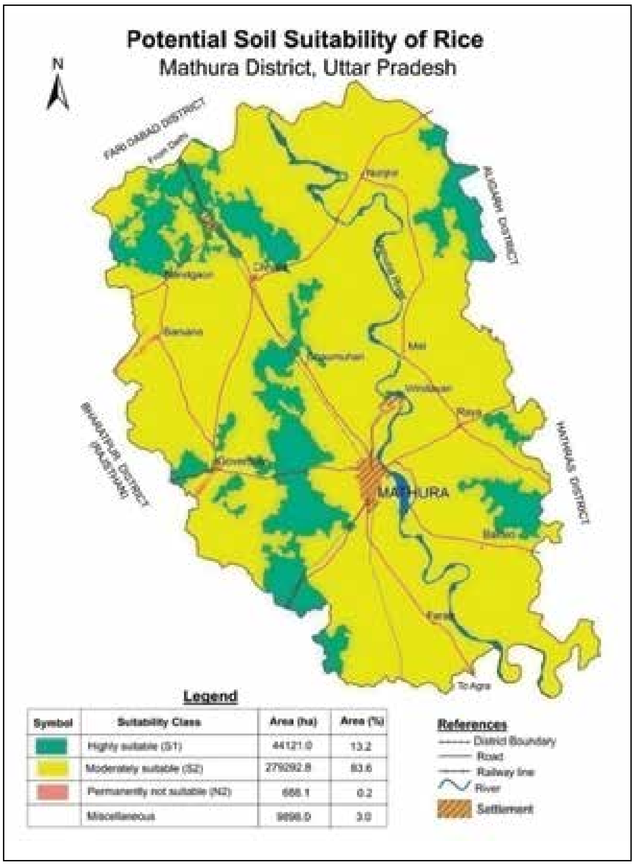


Fig. 2.5.10 (a) Potential soil suitability of rice

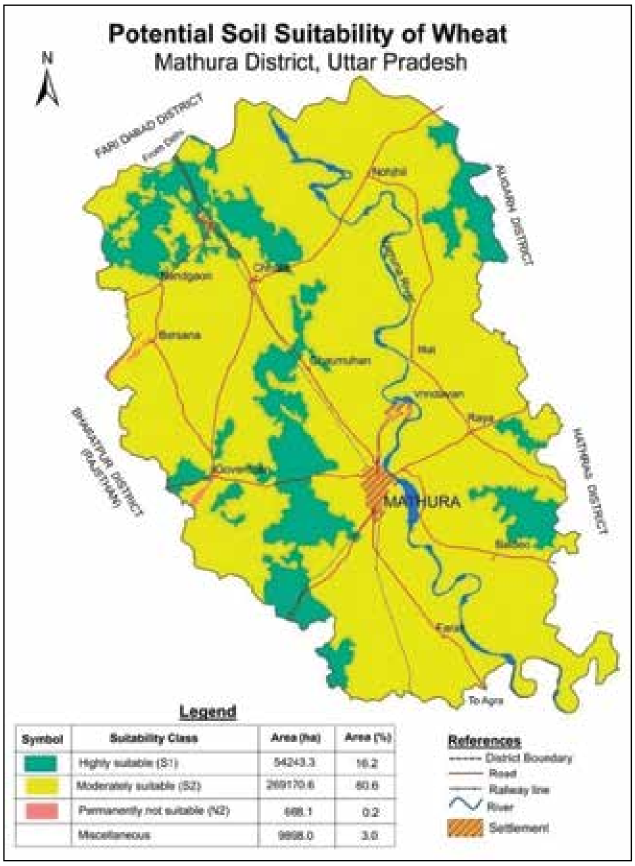


Fig.2.5.10 (b) Potential soil suitability of wheat

market facilities for the region specific agricultural development. The climatic conditions of the block are characterized by its dryness, extremes of temperature and scanty rainfall. The annual rainfall varies between 100 and 500 mm. Majority of the area is irrigated (36831hectare) by canal (Bhakhra Canal System) and tube-wells and only 18% area is unirrigated. Comprehensive land use/crop options with management interventios are suggested for different land management units (LMUs) (Table 2.5.3).

Table 2.5.3. Land management units for suggested land use options and management interventions

LMU	Soil series	Constraints	Recommendations	Suggested cropping system (Crop rotation in preference)	
Soils of old alluvial plains					
1, 2	*Takhtmal* *Kingra and Mithri*	• Poor physical conditions • Low to medium permeability. • Nutrient deficiencies • Saline/sodic groundwater • Groundwater depletion	• Site-specific integrated plant nutrient management to maintain productivity and soil health • Improvement of soil permeability and physical conditions by adding fertilizers and FYM • Balanced fertilization • Application of N in splits • Judicious use of irrigation water	All climatically adapted crops-cotton-wheat, paddy-wheat, cotton-mustard, Paddy-mustard, Cluster beans-wheat, sorghum-wheat with inclusion of legumes in the crop rotations. Mix cropping may be encouraged Kinnow orchard.	28790.69 (58.03)
3	*Odhan (depres-sional lnds)*	• Low infiltration rate • Poor physical conditions • Nutrients deficiencies • Saline/sodic groundwater • Depletion of groundwater	• Addition of FYM and green manure to improve physical conditions and permeability • If possible, use canal water for irrigation or alternate irrigation by canal water and groundwater	Cotton-wheat, paddy-wheat, cotton-mustard, Paddy-mustard, sorghum-wheat with the inclusion of legumes in the crop rotations	1362.90 (2.75)
soils of Aeolian plane					
4	*Anandgarh*	• Rapid permeability • Poor physical conditions • Leaching of • nutrients • Nutrients deficiencies • Saline/sodic groundwater • Depletion of groundwater	• Improvement of soil permeability and physical conditions by adding fertilizers and FYM • Balanced fertilization • Application of N in splits • Field bunding • If possible, use canal water for irrigation or alternate irrigation by canal water groundwater • Mix cropping may be encouraged.	Cotton-wheat, cotton-mustard, cluster beans-wheat, with inclusion of legumes in the crop rotations, Kinnow orchard	12257.04 (24.71)
Soils of Aeolian plane with reclaimed sand dunes					

LMU	Soil series	Constraints	Recommendations	Suggested cropping system (Crop rotation in preference)	
5	Roheranwali	• Light soil texture • Very low water and nutrient retentivity, Poor permeability • Slumping of sand in furrowed fields, • Loss of water and nutrients through percolation / leaching • Slight wind erosion	• Addition of FYM and crop residues to improve organic matter • Site specific integrated plant nutrient management to maintain productivity and soil health • Application of N in splits • Frequent and light irrigation • Soil compaction to reduce permeability • Drip and sprinkler irrigation for water economy • Leveling, bunding and anti-erosion measures	With adaptation of soil and water conservation measures: Cluster beans-wheat, cluster beans-mustard, cotton-mustard, potato- wheat and short duration crops like barley, green gram, groundnut, sesame vegetables crops and Taramira (Aarugula - *Eruca sativa*)etc.	3989.25 (8.04)
		• Poor soil structure • Saline/sodic groundwater • Depletion of groundwater	• Selection of crops that use moisture and nutrients from lower layers • Tree plantation on field boundaries to protect the soils from erosion as well as for additional income. • If possible use canal water for irrigation or alternate irrigation by canal water and ground water		
Soils of Aeolian plane with occasional sand dunes					
6	Nuhiyanwali	• Light soil texture • Very low water and nutrient retentivity • Slight to moderate undulation, Slumping of sand in furrowed fields, • Loss of water and nutrients through percolation / leaching • Slight to moderate wind erosion • Poor soil structure • Saline/sodic groundwater • Depletion of groundwater	• Addition of FYM and crop residues to improve organic matter • Site specific integrated plant nutrient management to maintain productivity and soil health • Application of N in splits • Frequent and light irrigation • Soil compaction to reduce permeability • Drip and sprinkler irrigation for water economy • Leveling, bunding and anti-erosion measures • Selection of crops that use moisture and nutrients from lower layers • Use of mulches • If possible use canal water for irrigation or alternate irrigation by canal water and ground water	• With adaptation of soil and water conservation measures: Cluster beans-mustard; cluster beans-wheat; potato- wheat and short duration crops like barley, taramira, green gram, groundnut, sesame and vegetables crops etc. • Social forestry –Tree plantation / shrubs on field boundaries to protect the soils from erosion as well as for additional income	**645.23** **(1.30)**

Land evaluation for sustainable land use planning for Jhansi district of Bundelkhand region

For Jhansi district of the Bundelkhand region, rice/maize/soybean during the *kharif* season and wheat/potato/onion/lentil/linseed/vegetables/floriculture during the *rabi* season are the most suitable crops recommended in plains and adjoining landscapes. Low water-requiring crops such as coarse millets and pulses are suggested during *kharif* for gently to moderately sloping areas having AWC. In contrast, wheat/gram/vegetables/floriculture are advocated during the *rabi* season, assuming the availability of at least one life-saving irrigation. Coarse millets, pulses, vegetables, and floriculture in arable land are suggested as potential substitutes with assured income in case of crop failure. Non-arable lands can be utilized for fodder production. Further, planting suitable species of shrubs and trees with adequate SWC measures, such as trenching, is proposed to reduce unabated soil erosion along the higher slopes. Livelihood-related activities such as fisheries in farm ponds, goat rearing, sericulture, and backyard poultry are also recommended at appropriate places (Fig. 2.5.11).

Land evaluation for land use planning of Dhanpatganj Block, Sultanpur, UP

The land resources database of the Dhanpatganj block of Sultanpur District was evaluated for sorghum, barnyard millet, gram, groundnut, mango and guava (Fig. 2.5.12 a to d). Nearly 16% of the area is highly suitable for cultivation of barnyard millet. The moderately suitable area is about 52% for mango, 47% for barnyard millet and guava, 37% for sorghum and gram, and 26% for groundnut cultivation. About 56%, 55%, 48%, 35%, 30% and 24%, 52% and 47% area is marginally suitable for cultivating sorghum, gram, groundnut, guava, barnyard millet and mango, respectively. About 12%, 17% and 18% of the area are unsuitable for cultivating guava, mango and groundnut. The major limitations for crop cultivation are soil pH, sodicity, soil texture, soil fertility and drainage.

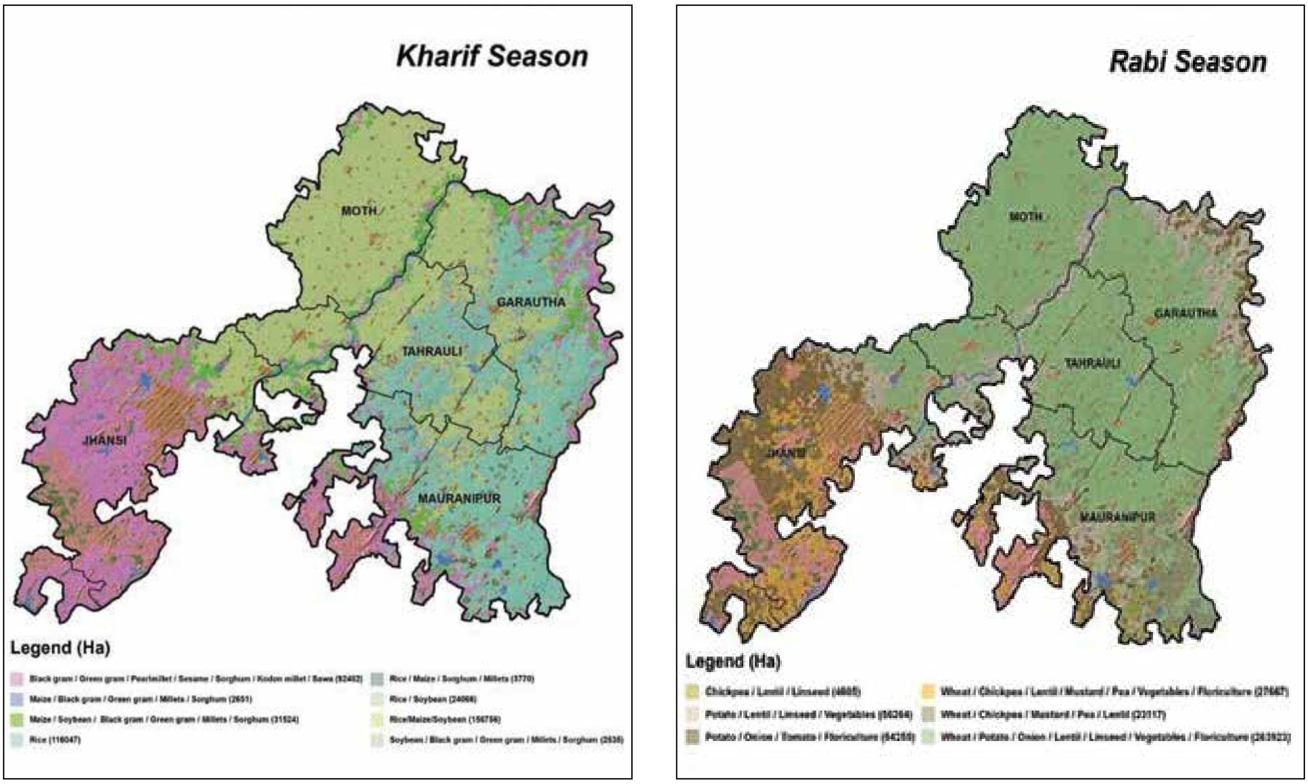


Fig. 2.5.11. Alternate land use plan for Jhansi district

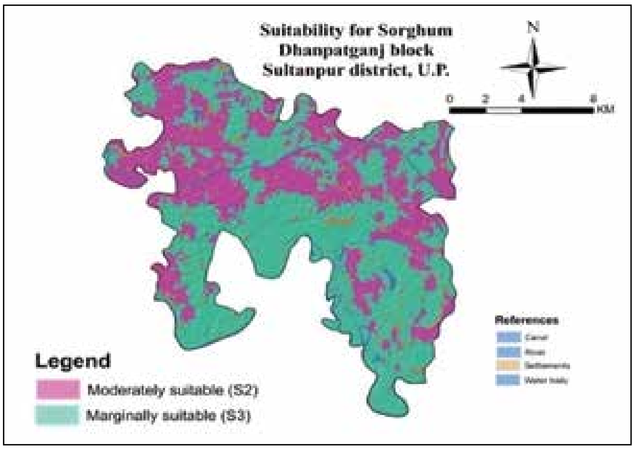


Fig. 2.5.12 (a): Soil suitability for Sorghum in Dhanpatganj block

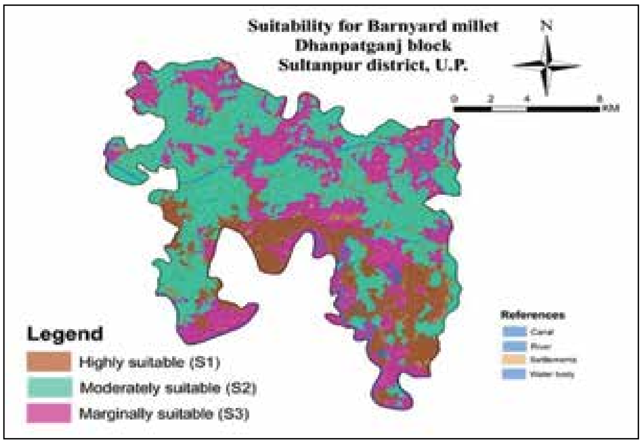


Fig. 2.5.12 (b): Soil suitability for Barnyard millet in Dhanpatganj block

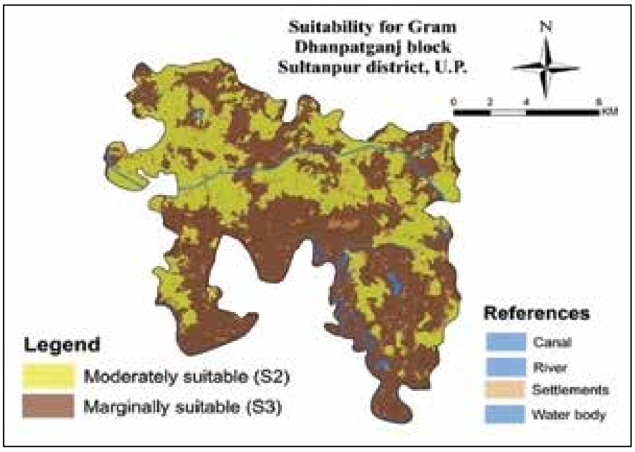


Fig. 2.5.12 (c): Soil suitability for Gram in Dhanpatganj block

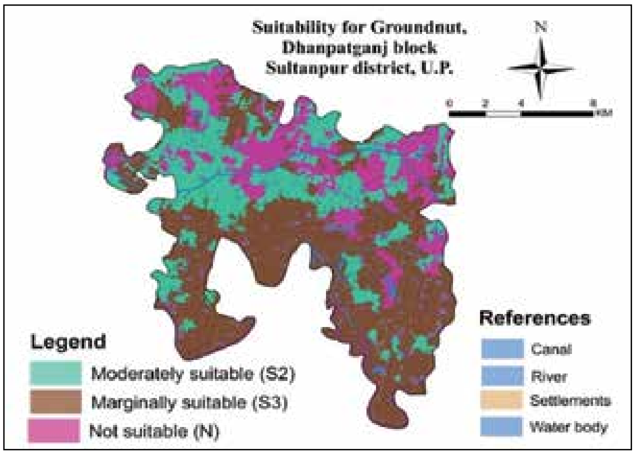


Fig. 2.5.12 (d): Soil suitability for groundnut in Dhanpatganj block

Revision of Soil-site suitability criteria of major crops

Datasets related to rainfall, temperature, soil depth, soil texture, soil pH, drainage, erosion, slope, elevation and soil $CaCO_3$ were collected from different locations for rice, soybean, red gram, mango and grapes. Soil depth, drainage and texture were found to influence the productivity of mango, whereas soil depth and texture influence productivity of grapes, red gram and soybean. Rainfall, soil depth and consistency were vital for rice productivity in upland conditions, system of rice intensification and aerobic situations.

Revised soil-site criteria for Rice

Rice yield data and soil-site parameters were collected from 75 locations across the country, and data were analyzed using principal component analysis. The revised soil-site criteria for rice irrigated/flooded and Rice (direct seeded) is presented in Tables 2.5.4 and 2.5.5.

Table 2.5.4: Soil-site suitability criteria for Rice (irrigated)

Land use requirement			**Rating**			
Soil-site characteristics						
		Unit	Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Not suitable N
Climatic regime	The mean temperature in growing season	°C	24-34 14-17	35–38 18-23	39–40 24-26	>40 <14

Land use requirement			Rating			
Soil-site characteristics						
			Land quality			
Oxygen availability to roots	Soil drainage	Class	Imperfect	Moderately well	Well; Somewhat excessive	Excessive
Nutrient availability	Texture	Class	c, sic	sicl, cl, sil, l, scl	sc, sl, ls, fs	s, cs
	pH	1:2.5	5.5-6.5	6.6-8.5 4.5-5.4	8.5-9.0 2.8-4.4	>9.0 <2.8
	$CaCO_3$ in root zone	%	<5	6-15	16-25	>25
Rooting conditions	Effective soil depth	cm	>75	51 to 75	25 to 50	<25
Soil toxicity	Salinity (E.C. saturation extract)	dS/m	<3	3 to 6	6 to 10	>10
	Sodicity (ESP)	%	<15	15 to 30	30 to 40	>40
Erosion hazard	Slope	%	< 1	1-2	3-5	>5

Table 2.5.5: Soil-site suitability criteria for Rice (Direct seeded)

Land use requirement			Rating			
Soil-site characteristics						
		Unit	Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Not suitable N
Climatic regime	Mean temperature in growing season	°C	24-34 14-17	35–38 18-23	39–40 24-26	>40 <14
	Total rainfall	mm	900-1000	750-900	500-750	<500
	LGP	days	>120	105-120	90-105	<90
			Land quality			
Oxygen availability to roots	Soil drainage	Class	Poorly to moderately well drained	Well to very poorly drained	Somewhat excessive	Excessive
Nutrient availability	Texture	Class	hc, c, sic	sc, sicl, cl, sil, l, scl	sl, ls, fs	s, cs
	pH	1:2.5	5.5-6.5	6.6-8.5 4.5-5.4	8.5-9.0 2.8-4.4	>9.0 <2.8
	$CaCO_3$ in root zone	%	<5	6-15	16-25	>25
Rooting conditions	Effective soil depth	cm	>90	50 to 90	25 to 50	<25
Soil toxicity	Salinity (E.C. saturation extract)	dS/m	<3	3 to 6	6 to 10	>10
	Sodicity (ESP)	%	<15	15 to 30	30 to 40	>40
Erosion hazard	Slope	%	< 1	1-2	3-5	>5

Revised soil-site criteria for Red gram

India ranks first among the major countries growing pigeonpea, with about 70 per cent of world production. The revised soil site suitability criteria are presented in Table 2.5.6.

Table 2.5.6: Soil-site suitability criteria for Pigeon pea

Land use requirement			Rating			
Soil-site characteristics						
		Unit	Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Not suitable N
Climatic regime	Mean temperature in growing season	°C	25-28	22-24	20-21	<20
	Total rainfall	mm	800-1000	600-800	400-600	<400
Land quality						
Moisture availability	Length of growing period for short duration	Days	>120	100–120	80–100	<80
	Length of growing period for long duration	Days	>180	150–180	120–150	<120
Oxygen availability to roots	Soil drainage	Class	Well	Moderately well; Imperfect	Poor; Excessive	Very poor
Nutrient availability	Texture	Class	fl, sl, sil, cl, scl, sicl, l	sic, ls, c	Fs, s	Cs, c(ss)
	pH	1:2.5	6.0–7.5	7.6–8.0; 5.5–5.9	8.1–9.0; 4.5–5.4	>9.0
Rooting conditions	Effective soil depth	cm	>100	85–100	40–85	<40
	Coarse fragments	Vol %	<15	15–35	35-55	>55
Soil toxicity	Salinity (E.C. saturation extract)	dS/m	<4.0	4-8	8-10	>10
	Sodicity (ESP)	%	<5	5-10	10-15	>15
Erosion hazard	Slope	%	<3	3–5	5–10	

Land suitability analysis of Mango orchards

Multi-criteria-based land suitability analysis (MCLS) was used to assess the soils of mango orchards for their suitability in Kolar district of Karnataka. In MCLS, land quality indices such as physical, chemical and fertility indices were given equal weightage to assess the land suitability. Based on physical quality indices, and three locations (SVP2, MUL3 & 6) are marginally suitable for mango cultivation due to high clay texture and drainage. Based on climatic quality index, SVP2, MUL3 & 6 are marginally suitable for mango. Fertility quality index is moderately to highly favourable in most of the study area for mango cultivation. The results of land suitability analysis indicate that very deep (>150cm) and well-drained soils, having sandy clay texture with a neutral (6.0-7.0) pH are highly suitable for mango cultivation. The overall physical suitability of soil was adopted from the most limiting (worst) land quality indicator. Soil constraints such as high pH, low OC, depth and nutrient availability are responsible for moderate to marginal suitability for mango cultivation. Overall, Kolar is high to moderately suitable for mango production.

Spatial crop planning for sustainable resource use

This work envisaged the development of a spatial crop plan for sustainable resource use and conservation of ecological resources in the high-range mountain landscapes of Kerala under the Indian High Range Mountain Landscape Project by the United Nations Development Programme.The Anchunadu and adjoining areas have been witnessing increased occurrence of landslides in the major agricultural lands that has drawn attention towards the development of a spatial crop plan by evolving comprehensive and sustained cultivation practices to ensure sustainable use of resources, preservation and conservation of the biodiversity of the landscape.

Detailed soil survey and mapping were carried out using the cadastral map as a base in Vattavada and Marayoor Gram Panchayats and selected landslide-prone areas in Adimali panchayat for spatial crop planning. The major soils in Vattavada belonged to the orders *Inceptisols* and *Ultisols,* and in Marayoor, besides *Inceptisols, Ultisols, Mollisols* and *Alfisols* were also identified (Fig.2.5.13 to 2.5.18). Based on their susceptibility to landslides, the soils of Adimali were classified into three classes: high, moderate and slight. Soils under *Ultisols* were classified under highly and moderately susceptible classes, and *Inceptisols* under slightly susceptible classe. The highly and moderately susceptible soils reported decreased sand content from the surface to deeper horizons.

Surface soil fertility assessment was done following collection of surface soil samples (101 from Vattavada and 95 from Marayoor) and their analysis for soil reaction, macro, secondary and micro-nutrients. Most Vattavada soils were strongly acidic (pH: 4.4 to 6.9) (Fig. 17), non-saline and rich in OC (mean 2.18 %). The majority of the area was high in available P (198 ha), available K (134 ha), medium in available S (131 ha) and sufficient in Ca and Mg. Most of the soils of Marayoor were moderately acidic (53.9% of the area) (Fig. 18), non-saline and rich in organic carbon. The majority of the area was high in available P (64.4%), medium in available K (42.0%) and available S (67.8%) and sufficient in Ca and Mg. The entire area was deficient in B. Total SOC stock for 100 cm depth varied from 12.5-24.2 kg m^{-2} and 13.5-24.5 kg m^{-2} in Vattavada and Marayoor.

Land suitability for major crops was assessed in three-gram panchayats. In Vattavada, banana is the most suitable for cultivation among the fruit crops. Large areas in Marayoor are highly suitable for potatoes, cassava, coffee, areca nut and banana. In Adimali, large areas were found to be moderately suitable for cardamom cultivation and moderately to highly suitable for Arabica and Robusta coffee.

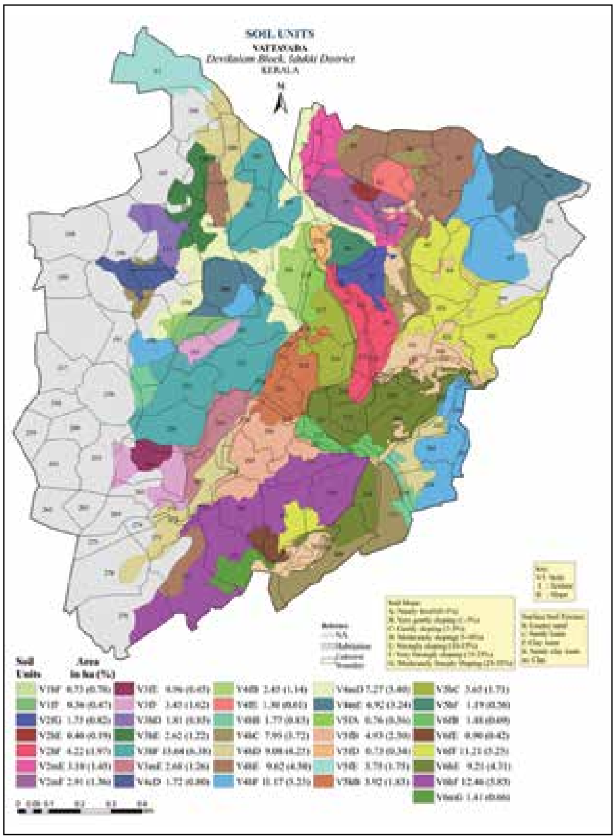


Fig. 2.5.13. Soil map of Vattavada village

Fig. 2.5.14. Dominant soils and landscape of Vattavada

Fig. 2.5.15. Depth-wise distribution of sand content in soil series identified in Vattavada Gram panchayat

Fig 2.5.16 . Landscape of Marayoor

Fig. 2.5.17. Dominant soils of Marayoor

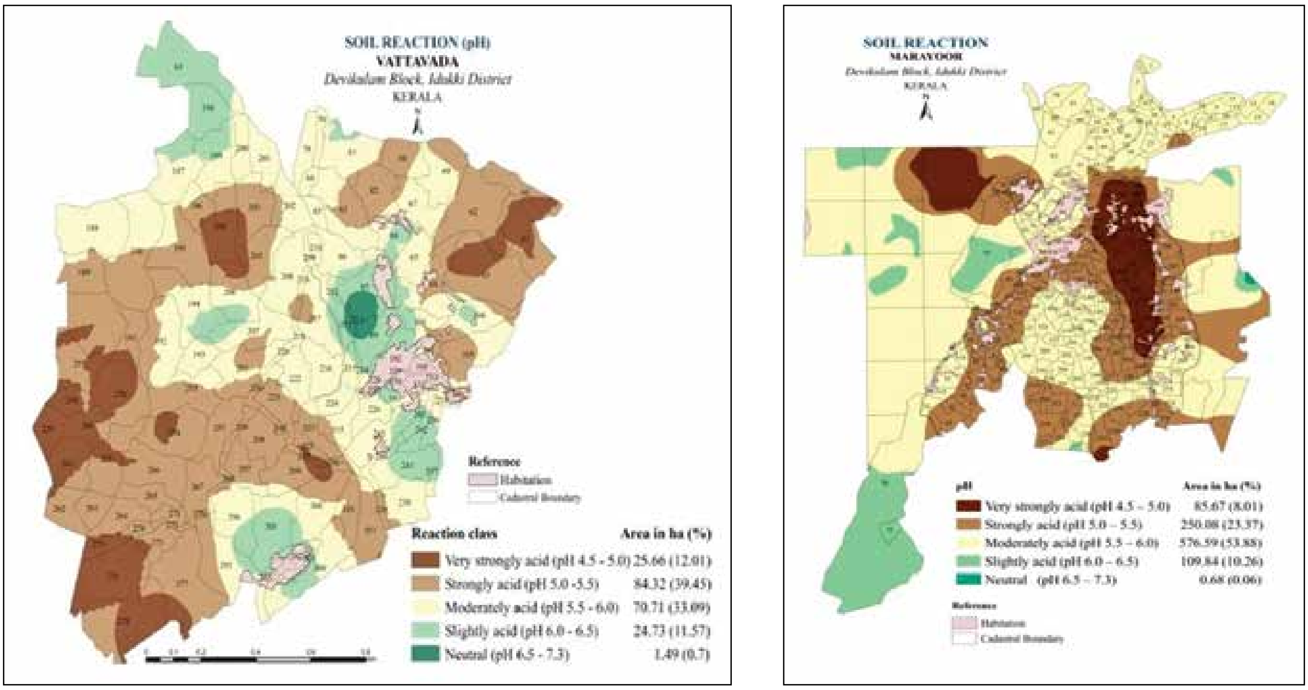


Fig. 2.5.18. Soil pH maps of Vattavada and Marayoor

Alternate land use and suggestions for these areas are included, along with preserving the cardamom hill reserve and Shola forests. In Vattavada, cultivation in classes V to VIII of the LCC calls for implementation of appropriate soil and water conservation measures. In Adimali, alternate land use should check the occurrence of landslides by choosing crops with a strong root system to hold the soils prone to landslides.

Evaluation of Effectiveness of LRI in Watershed Development and its Impact on Agro Ecosystem Services and Livelihood in Chamarajanagar district, Karnataka.

The effectiveness of the land resources inventory was evaluated using a survey questionnaire designed for an online Survey from the officers of the watershed development department, university teachers and scientists. The questionnaire covers the adequacy of training, adequacy of LRI, the utility of LRI, difficulties in using LRI, and suggestions for improvements. The questionnaire was mailed to concerned stakeholders, and 68 officers and scientists replied to the survey.

Project on Climate Resilient Agriculture

In the second phase LRI of more than 5000 villages has been taken up in 16 districts of Maharashtra. Predictive soil mapping is being done using legacy data collected during the first phase of the project i.e. LRI of selected 500 villages. During the report period, 1500 villages were covered. The final database comprises files in raster and vector formats segregated at village level. Additionally, the generated data is linked to the respective cadastral boundary layers to have a comprehensive idea about the region of interest in terms of the tangibility of the mapping units and the eventual broader perspective in decision-making based on a comparison of the variation of all the different soil properties on the single mapping unit viz. the cadastral plot. The interpretability of the soil information is demonstrated based on illustrative examples of two representative soil properties namely-Soil Depth and Available Water Capacity pertaining to the regions of interest encompassed in the already shared 10 districts viz. Aurangabad, Beed, Latur, Parbhani, Hingoli, Jalna, Nanded, Osmanabad, Jalgaon and Amravati.

1. Amravati District

The soil depth statistics of the clusters in Amravati district shown in Table 1 indicates that the shallow category soils account for 3117 ha. Thus, the extremely vulnerable area is less than 2% in the district clusters. About 25450 ha is in moderate category, implying that in a drought year, mitigations measures will be necessary in 28567 ha (25450+3117). The farmers in these areas are marked in red and yellow colour (Fig. 1). They could be alerted in advance to initiate mitigation measures and make crop choice in accordance with the low productivity soils. The crop specific advisories to these farmers could include

- Low water requirement crops like sorghum, millets, blackgram etc. should be preferred in 28567 ha area
- If farmer decides to grow other high water requiring crop like cotton, it could be impressed on him that it is a risk and the crop would require soil moisture conservation measures if a dry spell occurs during the monsoon season.
- Daryapur cluster has the maximum area (1800 ha) in shallow soils category followed by Anjangaon surji (388 ha), but in percentage terms Chikhaldara cluster has about 24% area in this category. Thus, the Daryapur and Anjangaon Surji farmers are likely to face greater stress compared to others.
- In other soils (deep and very deep category), famers in plain areas could be informed that drainage measures will help the crop growth. Proper drainage will also reduce pest and disease attack.

Table 1 Soil Depth Statistics of Amravati clusters

Cluster name	Area in ha					
	Shallow	Moderate	Deep	Very Deep	Total	% Shallow region
Achalpur	120.91	599.84	1880.70	1412.93	4014.38	3.01
Amravati	197.17	2349.44	9617.13	16327.82	28491.55	0.69
Anjangaon Surji	388.14	3726.53	13421.01	4828.18	22363.86	1.74
Bhatkuli	43.21	1881.13	18425.93	27457.15	47807.42	0.09
Chandur Bazar	38.93	1316.89	7484.16	11521.32	20361.29	0.19
Chandur Railway	0.01	0.16	0.32	0.44	0.93	1.20
Chikhaldara	139.73	233.74	165.05	53.75	592.27	23.59
Daryapur	1800.53	12215.20	47484.73	17781.58	79282.04	2.27
Dharni	143.57	586.50	765.16	144.11	1639.33	8.76
Morshi	4.49	151.00	4445.05	6034.42	10634.97	0.04
Nandgaon Khandeshwar		9.62	760.30	1715.00	2484.93	0.00
Teosa	155.55	1211.27	4454.73	1284.71	7106.26	2.19
Warud	84.45	1164.80	3740.51	1298.41	6288.17	1.34
Total	3117.45	25450.40	112653.12	89860.33	231081.29	1.35

The statistics in Table 2 shows that in Daryapur cluster, Yeoda BK is the single most vulnerable village with 214 ha in shallow, and 1005 ha area in moderate category. Interestingly, the same village has maximum area in deep soil category.

Table 2 Soil Depth Statistics of Daryapur cluster in Amravati district

Villages in Daryapur cluster					
S.No.	Village name	Area in ha			
		Shallow	Moderate	Deep	Very Deep
1	Uparai		16.52	131.00	614.86
2	Thilori	7.08	381.19	1770.22	541.69
3	Sangkud	7.08	227.77	920.51	531.07
4	Yeoda Bk.	214.79	1005.48	3055.40	518.08
5	Wadura		17.70	168.76	511.00
6	Chandikapur		18.88	309.20	469.70
7	Shingnapur		161.68	1020.83	460.26
8	Nanded Bk.		21.24	450.82	407.15
9	Khalar	7.08	71.99	312.74	380.01
10	Arala		2.36	75.53	358.76

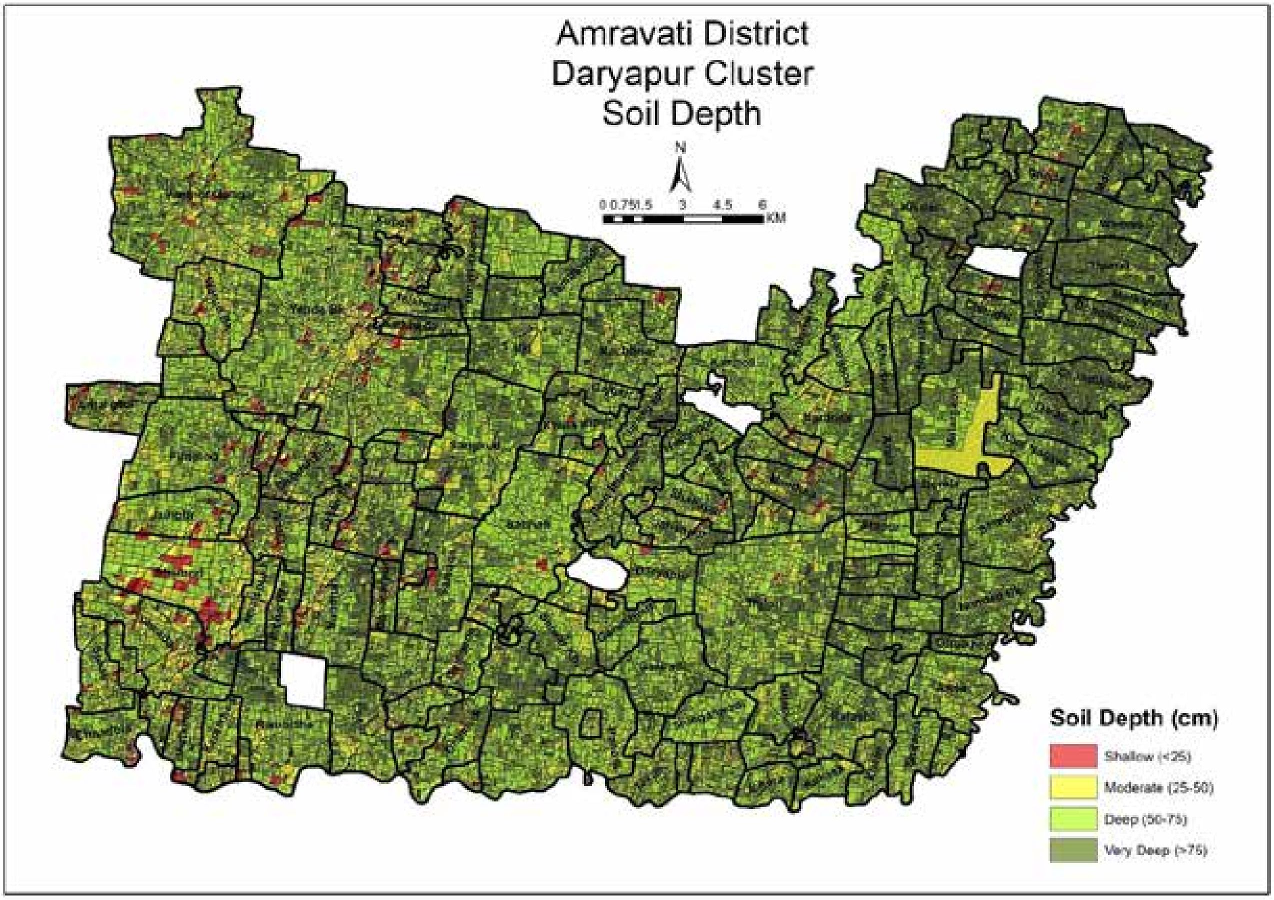


Fig. 1 Soil depth map of Daryapur cluster

The Available water capacity (AWC) statistics of the clusters in Amravati district shown in Table 3 indicates that the shallow category soils account for 2320 ha. About 94600 ha area is in moderate category, implying that nearly 10000 ha area needs to conserve soil moisture for better crop growth especially when there is a dry spell.

Table 3 Available Water Capacity Statistics of Amravati clusters

Cluster name	Area in Ha				
	Low	Moderate	High	Total	% Low region
Achalpur	513.346	1449.02	2052.02	4014.386	12.79
Akola	0.221339	1.81305		2.034389	10.88
Akot	1.16896	2.94018		4.10914	28.45
Amravati	28.7573	9116.76	19346	28491.52	0.10
Anjangaon Surji	0.672705	11083.9	11279.3	22363.87	0.00
Bhatkuli	3.90382	10056.9	37746.6	47807.4	0.01
Chandur Bazar	488.129	9300.45	10572.7	20361.28	2.40
Chandur Railway		0.716722	0.20881	0.925532	0.00
Chikhaldara	240.539	351.585	0.14408	592.2681	40.61
Daryapur	444.792	39598.1	39239.1	79281.99	0.56
Dharni	467.134	1136.27	35.9312	1639.335	28.50
Morshi	0.114814	3431.45	7203.41	10634.97	0.00
Murtijapur	3.17114	4.58412		7.75526	40.89
Nandgaon Khandeshwar		693.073	1791.86	2484.933	0.00
Teosa		4424.12	2682.14	7106.26	0.00
Warud	128.574	3949.3	2210.29	6288.164	2.04
Total	2320.524	94600.98	134159.7	231081.2	1.00

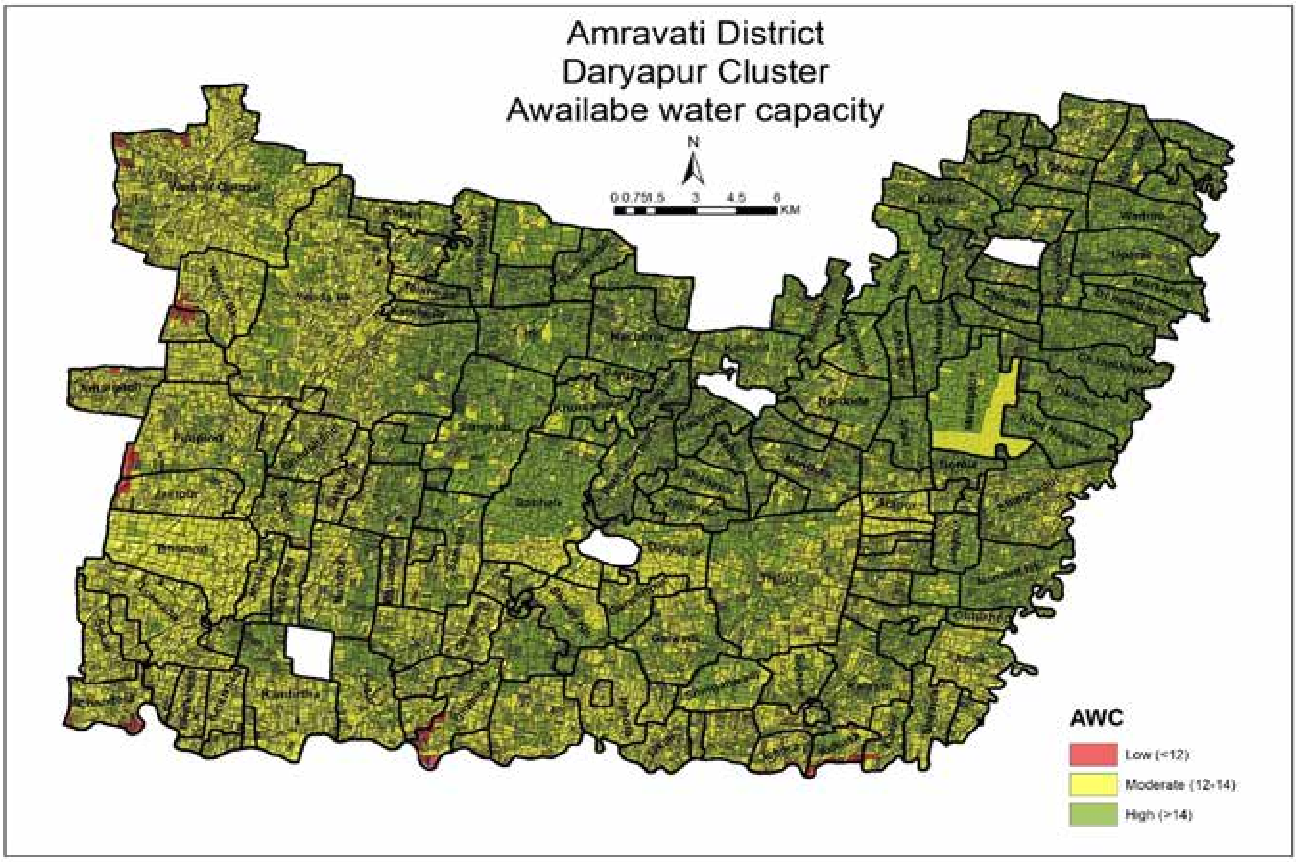


Fig. 2 AWC map of Daryapur cluster

It could be noted that Daryapur cluster has very few villages in low AWC category (Table 4). Therefore, fertilizer response will be better and crop yield would improve with nutrient management.

Table 4 AWC statistics of Daryapur cluster villages

Villages in Daryapur cluster				
S. No	Village name	Area in Ha		
		Low	Moderate	High
1	Uparai		54.55	710.67
2	Thilori		1586.57	1108.79
3	Sangkud		295.25	1388.77
4	Yeoda Bk.		3104.30	1692.70
5	Wadura		62.17	629.01
6	Chandikapur		20.59	777.06
7	Shingnapur		614.29	1041.25
8	Nanded Bk.		129.10	749.75
9	Khalar		175.65	603.65
10	Arala		2.08	435.65

Predicting soil depth and engineering properties for commercial purpose (Sterlite Technologies Ltd, KEC International Ltd and Adani Transmission Ltd)

Use of algorithms developed to predict the soil depth over the terrain based on topographic and land cover attributes was continued for the new routes depending on the needs of the sponsoring agency. Topographic attributes, derived from a digital elevation model (DEM), land use land cover information and geological information were combined with visual interpretation of Google earth images and expert knowledge. During the year, point data on soil depth and lithology for routes measuring more than 7000 Km routes (across India) were shared with the user agency which reported 80-85% accuracy of the prediction. Different railway routes, power transmission lines and solar farm areas located in different countries namely- Cameroon, Kenya, Mexicoetc. were analysed to predict engineering properties of soils. An algorithm developed to predict angle of repose, bulk density and ultimate bearing capacity of the soils at 50 m interval was used. It uses global gridded soil information maintained by ISRIC (1:500000 scale) to procure primary soil information like textural composition and other related information. Land use, land cover information is derived from Google Earth data. ASTER DEM data were used to derive terrain attributes like slope, mean elevation and contours. Visual inspection of the route to verify derives information and combined with secondary data on geology, rainfall, crops, water table information. During the report year more than 2000 Km transmission lines, plots of varied size adding to 11300 ha were analyzed.

2.6 IT ENABLED EXTENSION PROGRAMME

Enrichment of BHOOMI Geoportal platform and development of thematic services for application in agricultural land use planning

During the reporting period, BHOOMI Geoportal open-source Geoserver has been upgraded from ver. 2.14 to 2.21 with updated header information. Various functionalities were developed to easily catalogue, retrieve, query and visualize the geospatial information using programming languages like HTML, CSS, JavaScript, PHP, and JQuery. Various vector and raster layers of soil data developed for Bundelkhand and Vidarbha regions has been processed and deployed on the Geoportal to visualize and query required information at district level. Also, soil information at 1:10,000 scale for 85 blocks received from different Regional Centres has been processed and deployed. A dedicated dashboard has been developed by using JavaScript programming to easily query and assess the status of data availability at block level under different states (Fig.2.6.1). Further, user can visualize the various attributes available in the soil layer, by selecting a soil layer from the selected block. This dashboard also helps to generate the Centre-wise report on availability of soil data at 1:10,000 scale. The physiography, sub-physiography, landforms and TMUs for 10 aspirational districts have been processed and deployed on the Geoportal. The developed Google Form-based 'Soil Map Users Survey' has been deployed on BHOOMI Geoportal to get feedback from the users and stakeholders to improve the future soil survey programmes of the Bureau. Additional vector and raster data were deployed through API's from KRISHI and IIRR Geoportal to strengthen the BHOOMI Geoportal Interoperable Platform. The dedicated APIs for soil parameters of 1:1m scale have been developed and integrated with ICAR-KRISHI geoportal through an interoperability platform. The mechanism of real-time data collection through the Mobile App of Soil Survey Data Collection and Management System (SDCMS) has been integrated with BHOOMI Geoportal with more user-friendly options and to maintain a centralized soil survey data. During the reporting period, 53784 viewers visited the BHOOMI Geoportal across the globe.

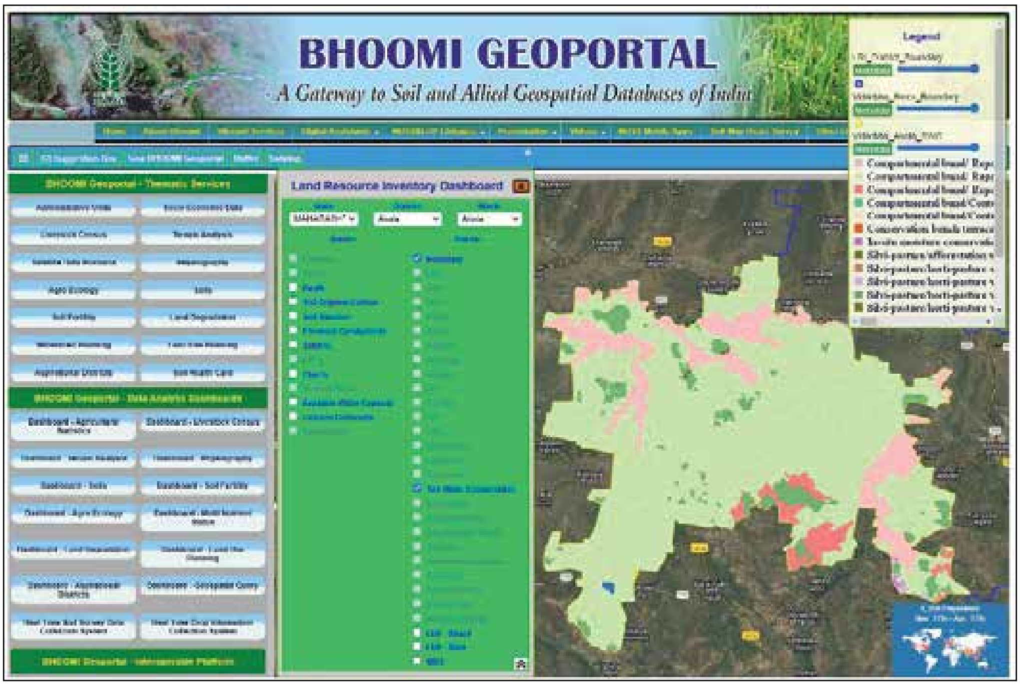


Fig.2.6.1. Dedicated Dashboard developed on BHOOMI Geoportal to visualise and query the soil information at 1:10,000 scale

ICAR Research Data Repository for Knowledge Management- Agricultural Knowledge Resources and Information System Hub for Innovations (KRISHI) (Externally funded project)

During the reporting period, the 'Geoportal Interoperable Platform' was strengthened by adding more services to visualize the selected services from ICAR-KRISHI, BHOOMI and rice portal on a single platform. The codes were created for API using programming language like JavaScript to provide WMS and deployed on the central Geoportal server to access the provided services. The robustness of the interoperable platform developed on BHOOMI Geoportal allows sharing of data in the form of service APIs instead of physical data sharing with the users. The data-providing organizations have the flexibility to decide the access protocols and the concerned institutes have the ownership of such datasets. Further, data shared in the form of service through APIs can be updated at their respective institute level as and when needed and that automatically reflects on the Geoportal of the other end. This interoperable mechanism is to be deployed on KRISHI Geoportal to fetch the services through APIs from different institutes to visualize and query by the users. The API services for various soil parameters on a 1:1m scale and grapes suitability of Maharashtra and Madhya Pradesh states were developed and deployed on ICAR-KRISHI Geoportal for dissemination to the users. The grapes suitability of Madhya Pradesh state thematic service deployed through API on ICAR-KRISHI geoportal in WMS format is shown in Fig. 2.6.2.

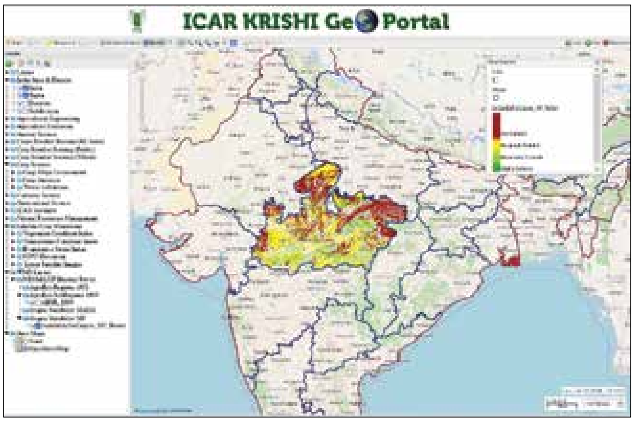


Fig. 2.6.2. Information on grapes suitability of Madhya Pradesh ICAR-KRISHI Geoportal

Development of Indian National Soil Grid

Geoportal in the line with World Soil Grid showing key soil properties of standard DSM depth ranges in 30-meter grid has been prepared for India. Both web based and Android based applications are available. User can visualize values of any property at a location, across all soil depths, in form of bar diagram. Also, the user can explore all soil properties with the depth-wise variation occurring at a particular point (Fig. 2.6.3).

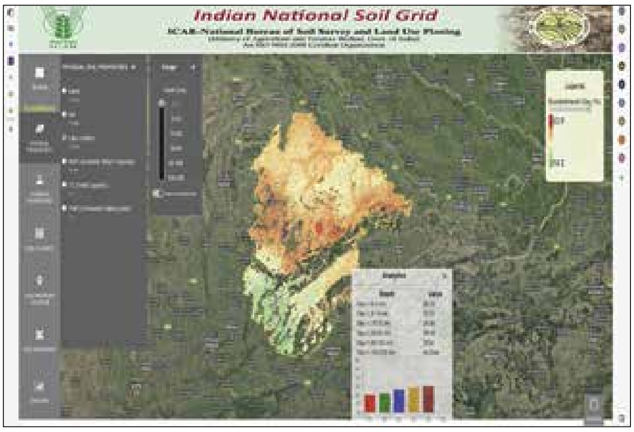


Fig.2.6.3: Digital soil map of clay content at 5-10cm with depth wise distribution in in Bundelkhand region

Design and development of MobileApp on 'Soil Survey Data Collection and Management System (SDCMS)'

User-friendly features were added to MobileApp on 'Soil Survey Data Collection and Management System (SDCMS)' to collect real-time soil survey data from the field during the soil surveys conducted by the Bureau under various projects. Once a user logs in to the MobileApp, the user has access to various menus like project registration, data collection, soil data report, soil data update, about the app and log out button. To use the MobileApp, the user has to provide details on the project name, project period, duration, project id, principal investigator name and funding source. After providing the location details, the user can fill the forms like soil site parameters, morphological, physical and chemical parameters. The user can also generate the report by using three categories like search by state, search by project id and search by date. The SDCMS Mobile App was integrated with the BHOOMI Geoportal database system to directly generate the data repository and create separate tables for different sections to maintain the records of collected soil survey data. The workflow of the MobileApp on SDCMS is shown in Fig. 2.6.4.

Development of online soil spectroscopy

An online system has been developed for the prediction of soil properties using the spectral signature of a soil sample. The system predicts soil properties using soil spectra based on hyper-spectral libraries for different types of soils (Fig. 2.6.5). This can be used operationally to reduce resources in the preparation of soil health card. Options are given for researchers to select the pre-processing and modelling techniques as they desire.

Fig. 2.6.4. Workflow of MobileApp on ‘Soil Survey Data Collection and Management System (SDCMS)

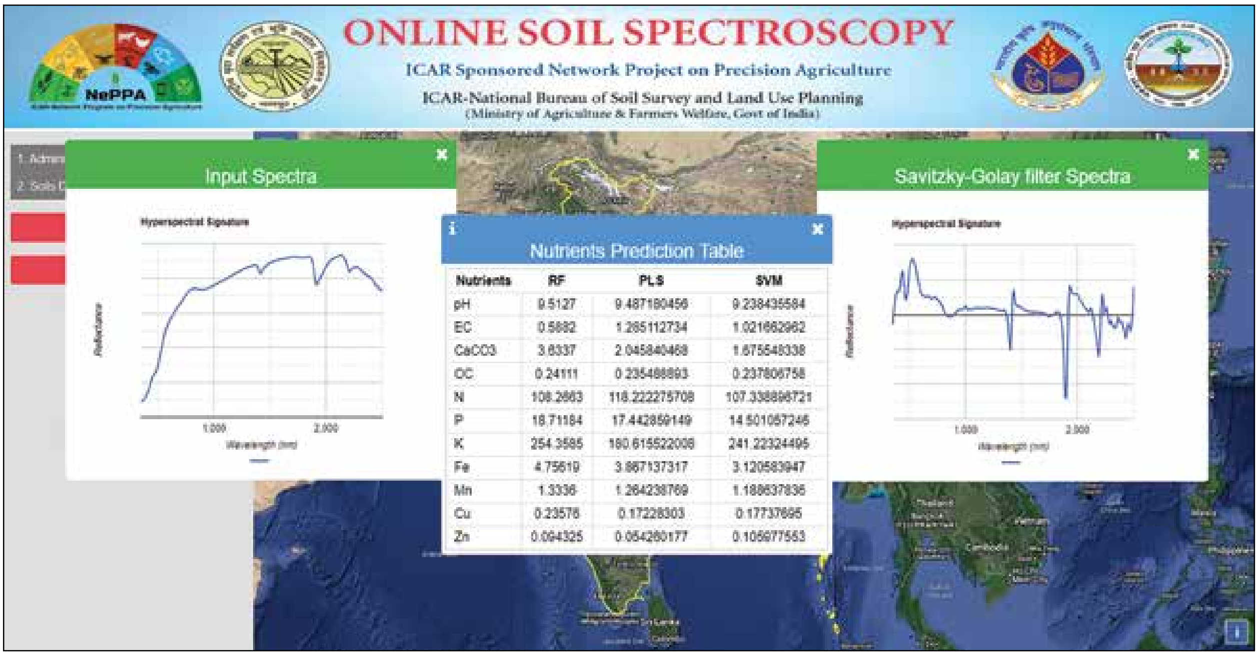


Fig. 2.6.5: Online soil spectroscopy system with prediction of sol properties with different modelling techniques

3 RESEARCH PROGRAMME

Institute Projects (Ongoing)

Inventorying Natural Resources

Land Resource Inventory (LRI)

Sr. No.	Project Title & Investigators
1.	High resolution soil mapping of Kolar district, Karnataka using digital soil mapping approach. R. Vasundhara, S.C Ramesh Kumar, V. Ramamurthy, R. Srinivasan, M. Lalitha S. Dharumarajan, Kalaiselvi. B, K.S. Karthika, S. Srinivas and Rajendra Hegde
2.	High resolution soil mapping of Chamarajanagar district, Karnataka using digital soil mapping approach. M. Lalitha and Rajendra Hegde
3.	High resolution soil mapping of Davanegere district, Karnataka using digital soil mapping approach. Sunil P. Maske, M. Lalitha, R. Srinivasan and M. Chandrakala
4.	High resolution soil mapping of Chitradurga district, Karnataka using DSM approach. M. Chandrakala, B. P. Bhaskar, R. Srinivasan, Karthika, K.S. , Lalitha, M., Sunil P. Maske, S. Srinivas, S. C. Ramesh Kumar and Rajendra Hegde.
5.	High resolution soil mapping of Tumkur district, Karnataka using digital soil mapping approach. Karthika K. S, K.S. Anil Kumar, R. Srinivasan, M. Chandrakala, B. Kalaiselvi, M. Lalitha, R. Vasundhara, S. Dharumarajan, S. Srinivas and Rajendra Hegde.
6.	High resolution soil mapping of Hassan district, Karnataka using DSM approach. R. Srinivasan and B. Kalaiselvi, M. Chandrakala, M. Lalitha, R. Vasundhara, S. Dharumarajan, S. Srinivas and Rajendra Hegde.
7.	High resolution soil mapping of Yadgir district, Karnataka using DSM approach. K. S. Anil Kumar, K.S. Karthika, R. Srinivasan, B. Kalaiselvi, M. Lalitha, M. Chandrakala, Sunil P Maske, S. Srinivas and Rajendra Hegde
8.	Land resource inventory of Birbhum district, West Bengal at 1:10000 scale using Geospatial technique. S. Gupta Choudhury, S. Mukhopadhyay, B. N. Ghosh, S.K. Reza and S. Bandyopadhyay
9.	High resolution soil mapping of Anand district, Gujarat for optimal agricultural land use planning using digital soil mapping techniques. B. L. Mina, B. Yadav, RL Meena, M. Nogiya, L.C. Malav and B.L. Mina
10.	High resolution soil mapping of Tapi district, Gujarat for optimal agricultural land use planning using digital soil mapping techniques. L.C. Malav, RL Meena, M. Nogiya, B. Yadav and B.L. Mina
11.	High resolution soil mapping of Vadodara district, Gujarat for optimal agricultural land use planning using digital soil mapping techniques. Brijesh Yadav, L.C. Malav, RL Meena, M. Nogiya and B.L. Mina
12.	Land Resource Inventory of Washim district, Maharashtra at 1:10,000 scale for optimal agricultural land use planning. P. C. Moharana and R.K. Naitam, M.S. Raghuvanshi, Amrita Daripa, H.L. Kharbikar, N.G. Patil and Nirmal Kumar

Sr. No.	Project Title & Investigators
13.	Land Resource Inventory of Mandi District, Himachal Pradesh for optimal Agricultural Land Use Planning using Geo-spatial techniques. Sunil Kumar, R.K. Meena, Jaya N. Surya and Ashok Kumar
14.	High resolution soil mapping of Koppal district, Karnataka using DSM approach. Kalaiselvi. B., S. Dharumarajan, M. Lalitha, R. Srinivasan, Vasundhara. R, K. S. Karthika, K.S. Anil Kumar, S. Srinivas and Rajendra Hegde
15.	High resolution soil mapping of Barmer district, Rajasthan for optimal agricultural land use planning using digital soil mapping techniques. P. C. Moharana, Nirmal Kumar, M. Nogiya , R.S. Meena and R.L. Meena
16.	High resolution soil mapping of Dang district, Gujarat using DSM approach. M. Nogiya, B. Yadav, R. L. Meena, R.S. Meena and B. L. Mina
17.	High resolution soil mapping of Amreli district, Gujarat for optimal agricultural land use planning using digital soil mapping techniques. M. Nogiya, Nirmal Kumar, P.C. Moharana, R.S. Meena and R.L. Meena
18.	High resolution soil mapping of Dahod district, Gujarat for optimal agricultural land use planning using digital soil mapping technique. R.L. Meena, M. Nogiya, B. Yadav, R.S. Meena and B. L. Mina
19.	High resolution soil mapping of Narmada district, Gujarat for optimal agricultural land use planning using digital soil mapping technique. R.L. Meena, M. Nogiya, B. Yadav, R.S. Meena and B. L. Mina
20.	Land Resource Inventory of Gadchiroli district of Maharashtra on 1:10000 scale using geo-informatics. R. K. Naitam, N.G. Patil, M.S. Raghuvanshi, P. C. Moharana, H.L. Kharbikar and G.P. Obi Reddy
21.	Land Resource Inventory of Patiala district, Punjab on 1:10000 scale for Agricultural Land Use Planning. Sunil Kumar, Jaya N. Surya and R.K. Meena
22.	Land Resource Inventory of SBS Nagar district, Punjab on 1:10000 scale for Agricultural Land Use Planning. R. K. Meena, Vikas and Jaya N. Surya
23.	Land Resource Inventory of Sirsa district, Haryana on 1:10000 scale for Agricultural Land Use Planning. Ashok Kumar, Prabha S. Philip, Nirmal Kumar and ShilpiVerma,
24.	Land resource inventory of Sahibganj district, Jharkhand at 1:10000 scale using geospatial techniques. T. Chattopadhyay, S. Mukhopadhyay and S. K. Reza
25.	Land resource inventory of Murshidabad district, West Bengal at 1:10,000 scale using geospatial techniques. S.K. Gangopadhyay, S. Mukhopadhyay and B. N. Ghosh
26.	Land resource inventory of Maldah district, West Bengal at 1:10,000 scale using geospatial techniques. S. Gupta Choudhury, S. Mukhopadhyay and B. N. Ghosh
27.	Land resource inventory of Nadia district, West Bengal at 1:10,000 scale using geospatial techniques. S. Gupta Choudhury, S. Bandyopadhyay and S. Mukhopadhyay
28.	Land Resource Inventory of Sri Ganganagar district (Rajasthan) on 1:10000 scale for optimal agricultural land use planning using geo-spatial techniques. R. S. Meena, Mahaveer Nogiya and R. L. Meena

Sr. No.	Project Title & Investigators
29.	Land Resource Inventory of Yavatmal district of Maharashtra on 1:10000 scale using remote sensing and GIS technique. R.K. Naitam, K. Karthikeyan, R. Paul, N. G. Patil, Nirmal Kumar, R. P. Sharma and S. Chattaraj
30.	Land Resource Inventory of Morena district, Madhya Pradesh on 1:10000 scale for optimal agricultural land use planning, using geo-spatial techniques. R. P. Sharma, Vasu D., Ranjan Paul, U.K. Maurya, L.C. Malav, Nirmal Kumar, P. Tiwary, Gopal Tiwari, B. Dash, Sonalika Sahoo and P. Chandran
31.	Land resource inventory of southern part of Ahmednagar district (Parmer, Ahmednagar, Pathardi, Shrigonda, Karjat, Jamkhed blocks), Maharashtra on 1:10000 scale for optimal agricultural land use planning, using geo-spatial techniques. R.P. Sharma and Nirmal Kumar, R. K. Naitam, D. Vasu, R. Paul and U.K. Maurya
32.	Land Resource Inventory of Wardha district of Maharashtra at 1:10000 scale using geo-spatial technique for agricultural land use planning. K. Karthikeyan, R.K. Naitam, Nirmal Kumar, Pramod Tiwary and P. Chandran
33.	Land resource inventory and land use planning of Osmanabad District of Maharashtra, having geospatial techniques. U.K. Maurya, P. Tiwary, K. Karthikeyan, RP Sharma, D Vasu, Ranjan Paul, G.P. Obi Reddy and Nirmal Kumar
34.	High resolution soil attributes modeling using digital soil mapping techniques in Western region of Maharashtra. Nirmal Kumar, MSS Nagaraju, G. P. Obi Reddy, R. K. Naitam, R. P. Sharma, S. Chattaraj, B. Dash, Sunil BH, R. Paul, D. Vasu, K. Karthikeyan and P. Tiwary
35.	High resolution soil attributes modeling using digital soil mapping techniques in Marathwada region of Maharashtra. S. Chattaraj, R. Paul, G. Tiwari, U. K. Maurya, N. G. Patil, R. K. Naitam, H. L. Kharbikar, A. Daripa, R. P. Sharma and A. Jangir.
36.	High resolution soil attributes modeling using digital soil mapping techniques in Konkan region of Maharashtra . H. Biswas, Nirmal Kumar, Sunil B.H., B. Dash, MSS Nagaraju, G.P. Obi Reddy, S. Chattara and R.K. Naitam.
37.	High resolution soil attributes modeling using digital soil mapping techniques in Khandesh region of Maharashtra. Sunil B.H., MSS Nagaraju, G.P. Obi Reddy, H. Biswas, Nirmal Kumar, S. Chattaraj and B. Dash
38.	Land Resource Inventory of Jalihal Hobli, Sindhanur taluk, Raichur district, Karnataka on 1:10,000 scale for optimal agricultural land use planning, using geo-spatial techniques. R. Vasundhara, Srinivasan, R., B. Kalaiselvi, K. S. Karthika, S. Dharumarajan, S. Srinivas and Rajendra Hedge
39.	Land Resource Inventory of Mandapam block of Ramanathapuram District, Tamil Nadu for optimal land use planning. S. Dharumarajan, M. Lalitha, R. Vasundhara,, R. Srinivasan, Kalaiselvi. B and Rajendra Hegde
40.	Land Resource Inventory of Nuggihalli block (part) of Channarayapatna Taluk, Hassan district, Karnataka on 1:10000 scale for optimal agricultural land use planning using geo-spatial techniques. R. Srinivasan, M. Lalitha, B. Kalaiselvi, M. Chandrakala, R. Vasundhara, S. Dharumarajan and Rajendra Hegde
41.	Land Resource Inventory of Bhimtal Block of Nainital district, Uttarakhand on 1:10000 scale for agricultural land use planning. Vikas, R. K. Meena, Jaya N. Surya, Prabha P. and Ashok Kumar

Sr. No.	Project Title & Investigators
42.	Land Resource Inventory of Chamba Block of Tehri Garhwal district, Uttarakhand on 1:10000 scale for agricultural land use planning. Vikas, R. K. Meena, Jaya N. Surya and Ritu Nagdev
43.	Land Resource Inventory (1:10000 scale) of Pangi Block of Chamba district, Himachal Pradesh for development of soil health cards and agricultural planning. R.K. Meena, Vikas, S.K. Mahapatra and Jaya N Surya
44.	Land Resource Inventory of Ranjuli block, Goalpara district, Assam (at 1:10000 scale) for optimal agricultural land use planning using geo-spatial techniques. Surabhi Hota, K.K. Mourya, S.K. Ray and U.S. Saikia
45.	Land Resource inventory of Pokharan and Jaisalmer tehsil of Jaisalmer district, Rajasthan at 1:10000 scale for optimal agricultural land use planning using geo-spatial technique. R. S. Meena, M. Nogiya and R.L. Meena
46.	Land resource inventory of Bemetara Block, Bemetara District, Chhattisgarh state (AESR 11) on 1:10000 scale for optimal agricultural land use planning, using geo-spatial techniques. K. Karthikeyan, P. Tiwary, G.P. Obi Reddy, R.P. Sharma, Gopal Tiwari, Abhishek Jangir and B. Dash
47.	Land Resource Inventory of Leh Block of Union Territory of Ladakh on 1:10,000 scale for Agricultural Land Use Planning. Jaya N Surya and Vikas
48.	Land resource inventory of Lohit district of Arunachal Pradesh in large scale for agricultural land use planning using geo-spatial techniques Surabhi Hota, K.K. Mourya and S.K. Ray
49.	Land resource inventory of Longding district of Arunachal Pradesh in large scale for agricultural land use planning using geo-spatial techniques S.K. Reza, K. K. Mourya, Dr. S. Mukhopadhyay, Surabhi Hota and S. Bandyopadhyay
50.	Land resource inventory of Tirap district of Arunachal Pradesh in large scale for agricultural land use planning using geo-spatial techniques. S. Bandyopadhyay, S.K. Reza, S. Mukhopadhyay, K.K. Mourya, Surabhi Hota and S.K. Ray
REMOTE SENSING AND GIS APPLICATIONS	
51.	Development of Indian National Soils Archive. Nirmal Kumar, G.P. Obi Reddy, H. Biswas, S. Chattaraj, R.K. Naitam, K. Karthikeyan, R.P. Sharma, R. Srivastava, K.K. Maurya and MSS Nagaraju
52.	Delineation of potential areas for pomegranate cultivation in India using remote sensing and GIS modeling. G.P. Obi Reddy, D.T. Meshram, Jyotsna Sharma and R.A. Marathe
53.	Spatial Modelling for delineation of Agro-Ecological Zones (AEZs) of India for smart agricultural planning using earth observation time-series data. G.P. Obi Reddy, V. Ramamurthy, S. Srinivas, Nirmal Kumar, B. Dash, H. Biswas, and M. S. Raghuvanshi
54.	Hyperspectral characterization of soils of Central India and development of soil spectral library and models for quick assessment of soil properties. H. Biswas , Nirmal Kumar, B. Dash, R. P. Sharma, K. Karthikeyan, R. K. Naitam, H. L. Kharbikar, D. Vasu, G. Tiwari, A. Jangir, R. Paul and MSS. Nagaraju
55.	Enrichment of BHOOMI Geoportal platform and development of thematic services for applications in agricultural land use planning. G.P. Obi Reddy, Nirmal Kumar, S. Chattaraj, R. Srivastava, V. Ramamurthy, S. Srinivas, S. Mukhopadhyay, P. Chandran, M.S.S. Nagaraju, Rajendra Hegde, Jaya N. Surya, Uday Saikia and B.L. Mina

Sr. No.	Project Title & Investigators
56.	Digital terrain analysis and characterization of landforms for soil-landscape Modelling in Maharashtra Using Remote Sensing Data, DEM and GIS. G.P. Obi Reddy, Nirmal Kumar, S. Chattaraj, H. Biswas, B. Dash and M.S.S. Nagaraju
57.	Revision of agro-ecological sub-regions of red soils of India for land use planning. G.P. Obi Reddy, B. Dash and Nirmal Kumar
58.	Assessment of land degradation and prime agricultural land in the country using MODIS time series NDVI and legacy data. Nirmal Kumar, G.P. Obi Reddy, R.K. Naitam, R.P. Sharma and B. Dash
59.	Digital soil mapping of India (Indian Soil Grids project). S. Dharumarajan, M. Lalitha, B. Kalaiselvi, R. Vasundhara, R. Srinivasan, R. K. Jena, Prasenjit Ray, S. Mukhopadhyay, S. K. Reza, R. K. Meena, Shilpi Verma, P.C. Moharana, Nirmal Kumar, Nisha Sahu, S. Chattaraj, Sonalika Sahoo, Amrita Daripa and Rajendra Hegde
60.	Development of GIS based digital library and data analysis for REWARD project (Sub-project of REWARD project sponsored by Govt. of Karnataka). S. Srinivas, Rajendra Hegde, B.P. Bhaskar, S. Dharumarajan, M. Lalitha, R. Vasundhara, B. Kalaiselvi, R. Srinivasan and K.S. Karthika
61.	ICAR Research Data Repository for Knowledge Management (KRISHI) G.P. Obi Reddy
LAND EVALUATION AND AGRICULTURAL LAND USE PLANNING	
62.	Agronomic evaluation of crops for their suitability in different soils of Karnataka. V. Ramamurthy, B.P. Bhaskar, S.C. Ramesh Kumar and R. Vasundhara
63.	Evaluation of effectiveness of land resources inventory in watershed development and its impact on agro ecosystem services and livelihood in Chamarajanagar district, Karnataka. S. C. Ramesh Kumar, R. Hegde, R. Vasundhara, S. Dharumarajan and S. Srinivas
64.	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. Ashok Kumar, Vikas and Ritu Nagdev
65.	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). B.N. Ghosh, S. Mukhopadhayay and S.K. Ray
66.	Socio economic impact of land use land cover change in selected districts of Eastern Vidarbha Zone in India. H. L. Kharbikar, M. S. Raghuvanshi, A. Daripa, , R. K. Naitam and N. G. Patil
67.	Assessment of heavy metal contamination in soil, water and vegetables in selected hotspots of Purna river basin, Maharashtra. Lal Chand Malav, Amrita Daripa, R.A. Marathe, M. S. Raghuvanshi, S. Chattaraj, R.K. Naitam and N .G. Patil
68.	Heavy metal contamination and ecological-health risk evaluation in peri-urban wastewater-irrigated soils of Nagpur city. Amrita Daripa, L. C. Malav, B. Dash, H. L. Kharbikar, S. Chattaraj, Savitha Santosh (ICAR-CICR) and M. S. Raghuvanshi
69.	Evaluating and mapping soil-site suitability for major crops in Central India using GIS based multi criteria decision analysis. M. S. Raghuvanshi, Nirmal Kumar, R.K. Naitam, G.P. Obi Reddy, N.G.Patil, Pramod Tiwary, Amrita Daripa and H. L. Kharbikar

Sr. No.	Project Title & Investigators
BASIC PEDOLOGICAL RESEARCH	
70.	Pedo-diversity of Vertisols and their associated soils in different agro-ecological regions of India. D. Vasu, P. Tiwary, K. Karthikeyan, R.P. Sharma and Ranjan Paul
71.	Pedo-transfer functions for water retention characterisation of major soils of Karnataka. Sunil P. Maske, M. Chandrakala, R. Srinivasan, B.P. Bhaskar and Rajendra Hegde
72.	Developing micro-morphological threshold in climate change study. U.K. Maurya, P. Tiwary, K. Karthikeyan R.P. Sharma D. Vasu and Nirmal Kumar
73.	Nature and composition of nano-clays of major soil groups of India (Vertisols, Alfisols and Ultisols) and their implications in managing nutrients. R. Paul, D. Vasu U.K. Maurya and P. Chandran
74.	Genesis and Classification of soils in Bemetara block, Bemetara district, Chhattisgarh. K. Karthikeyan, P. Chandran, S.K. Ray and P. Tiwary
INTERPRETATION OF SOIL SURVEY DATA	
75.	Morphological evaluation for soil development in delta soils of Andhra Pradesh using legacy data of SRM. B.P. Bhaskar, Sunil P. Maske and V. Ramamurthy
76.	Assessment of soil organic carbon stocks and impact on climate change and crop productivity in selected watershed in Karnataka under REWARD project S. C. Ramesh Kumar
SCSP PROGRAMME	
77.	Livelihood improvement of SC communities of selected villages of Kolar district through Integrated Land Use planning R. Vasundhara, V. Ramamurthy and S.C. Ramesh Kumar
78.	Agricultural land use planning to enhance productivity and livelihood security of farming community of Majherpara village of Canning-II block, South 24 Parganas district, West Bengal S. Bandyopadhyay, S.K. Reza, K. Das and S.K. Gangopadhyay
79.	Improving livelihood through integrated natural resource management in Cluster of Villages, Railmagra tehsil of Rajsamand district &Mavali tehsil of Udaipur district of Rajasthan R. S. Meena, R.L. Meena, Brajesh Yadav, L.C. Malav, M. Nogiya and B.L. Mina
EXTERNALLY FUNDED PROJECTS	
80.	Development of standard protocols for assessment of cropped area, crop monitoring and precision orchards management in mango R. Vasundhara, S. Dharumarajan, K. S. Anil Kumar, S.C. Ramesh Kumar, S. Srinivas, Rajendra Hegde and V. Ramamurthy
81.	Land resource inventory of Cinchona and other medicinal plants growing area of Darjeeling district on larger scale using geo-spatial techniques S.K. Reza
82.	Digital mapping of soil attributes for precision farming using imaging/non-imaging remote sensing data M.S.S. Nagaraju, Nirmal Kumar, H. Biswas, S. Chattaraj, Sunil B.H. and G.P. Obireddy
83.	Monitoring of Benchmark sites under Sujala III Exit strategy project Rajendra Hegde, Ramesh Kumar, S. Srinivas, M. Lalitha, R. Vasundhara and S. Dharumarajan
84.	Land resource inventory of horticultural farms and nurseries in Koppal district, Karnataka Rajendra Hegde

Sr. No.	Project Title & Investigators
85.	Spatial crop planning for sustainable resource use and conservation of ecological resources under GoI-GEF-UNDP IHRML project S. Dharumarajan, Dr. S.C. Ramesh Kumar, Dr. S. Srinivas, Dr. R. Srinivasan, Dr. M. Lalitha, Dr. R. Vasundhara, Dr. B. Kalaiselvi and Dr. K.S. Karthika
86.	Accompanying the adaptation of irrigated agriculture to climate change (ATCHA project) S. Dharumarajan, Rajendra Hegde, M. Lalitha, R. Vasundhara, R. Srinivasan and B. Kalaiselvi
87.	Land resource inventory of Arunachal Pradesh in large scale for agricultural land use planning using geo-spatial techniques U. S. Saikia, K.K. Mourya and Surabhi Hota
88.	Role of crystalline and non-crystalline nano-clays for carbon stabilization in pedo-genetically important soil orders of tropical India (DST funded) Ranjan Paul
89.	Development of spectral models for prediction of soil properties in soils of Maharashtra using hyperspectral remote sensing (A collaborative project with Neoperk Technologies Pvt. Ltd., Mumbai). M.S.S. Nagaraju and Nirmal Kumar
90.	Land Resource Inventory of Pench National Park for ecological restoration K. Karthikeyan, P. Tiwary and L.C. Malav
91.	Land Resource Inventory of FDCM Divisions Using High Resolution Geo-spatial Technique. R.K. Naitam, Nirmal Kumar, L.C. Malav, K. Kathikeyan, D. Vasu, H. Biswas, B. Dash, P. C. Moharana, M. Raghuvanshi, H.L. Kharbikar and N.G. Patil
92.	Development of an algorithm to predict soil depth using legacy data and terrain attributes N.G. Patil
93.	Application of soil resource database for geospatial planning of power transmission towers in India N.G. Patil
94.	An Algorithm to predict soil depth and engineering properties N.G. Patil

COMPLETED PROJECTS

FLAGSHIP PROJECTS

Sr. No	Title
1.	Land Resource Inventory of Bundelkhand Region for sustainable agricultural land use planning. NBSS&LUP Pub.No.184.
2.	Land Resource Inventory of Vidarbha region for Sustainable Land Use Planning, NBSS&LUP Pub. No. 186.

EXTERNALLY FUNDED PROJECT

Sr. No	Title
1.	Land Resource Inventory for Climate- Resilient Agricultural in selected clusters Governments Maharashtra- PoCRA, Phase II

4 PUBLICATIONS

Research Papers

1. A. Rani, Kumar, N., Sinha, N.K. and Kumar, J. 2022. Identification of salt-affected soils using remote sensing data through random forest technique: a case study from India. *Arabian Journal of Geosciences,* **15.**
2. Adyasha Priyadarshini, Naitam, R.K., Nirmal Kumar, Tedia, K., Mishra, V.N. Annu Singh, Srivastava, G.K. and Saxena, R.R. 2022. Use of Soil Health Card Data for Nutrient Mapping: A Case Study of Bemetara District, Chhattisgarh. *Agropedology,* **32 (1):**122-133; NAAS: 4.63.
3. Ashok Kumar, Mahapatra, S.K., Ramamurthy, V., Meena, R.K. and Singh. T. 2022. Soil-site suitability evaluation for diversification of rice-wheat cropping system ecology in the Indo-Gangetic Plains of India-A Case Study. *Annals of Agricultural Research New Series,* **43(4):** 396-403.
4. Ashok Kumar, Singh, Dilip and Mahapatra, S.K. 2022. Energy and carbon budgeting of the pearl millet-wheat cropping system for environmentally sustainable agricultural land use planning in the rainfed semi-arid agro-ecosystem of Aravalli foothills. *Energy,* **246**:123389. https://doi.org/10.1016/j.energy.2022.123389.
5. Bandyopadhyay, S., Gangopadhyay, S.K., Das, K., Ghosh, B.N., Mukhopadhyay, S., Gupta Choudhury, S., Sahoo, A.K., Maitra, A.K. and Haldar, A. 2022. Differential Pedogenesis of Some Pseudo-Andic and Non-Andic Soils in a Toposequence of Andaman and Nicobar Islands. *Journal of the Indian Society of Soil Science,* **70**:32-43.
6. Bhaskar, B.P., Ramamurthy, V.,Ramesh Kumar, S.C. and Maske, Sunil. 2021. Assessment of Soil Quality in Dryland Agricultural Landscapes of Pulivendula Tehsil, YSR Kadapa District, Andhra Pradesh. *Indian Journal of Plant and Soil,* **8(2).**
7. Chandrakala M., Srinivasan, R., Bhoora Prasad, Niranjana K.V, Sujatha K, Hegde, Rajendra, Chandran, P., Dwivedi, B.S. and Maske, Sunil P. 2022. Land Suitability Evaluation for Pigeon Pea in Semiarid Land, South Telangana Plateau, India, Using GIS, Remote Sensing and Detailed Survey. *Communications in Soil Science and Plant Analysis*, **53**:6, 675-687, DOI: https://doi.org/10.1080/00103624.2022.2028807
8. Chandrakala M., Anil Kumar K.S. and Sujatha K. 2022. Soil heterogeneity: A comparative assessment of soils from two different AESR, southern India. *Annals of Plant and Soil Research,* **24(1):** 29-35, https://doi.org/10.47815/apsr.2021.10119.
9. Chandrakala M., Bhoora Prasad, Niranjana, K.V., Srinivasan, R., Sujatha, K., Basavaraj, B., Maske, Sunil P., Hegde, Rajendra and Dwivedi, B.S. 2022. Paddy lands of south Telangana plateau (Rayalseema), Andhra Pradesh, India: A detailed suitability assessment. *Indian Journal of Soil Conservation,* **50(1):** 57-65.
10. Choudhari, Pushpajeet L., Prasad J., Ray S.K. and Gurav, P. 2022. Genesis and Mineralogy of Teak – Supporting Soils in Seoni District of Madhya Pradesh. *Journal of the Indian Society of Soil Science,* **70** :160-171.
11. Daripa A., Chattaraj S., Malav L.C., Ray P., Sharma R.P., Mohekar D.S., Ramamurthy V., Raghuvanshi M.S. and Patil N.G. 2022. Risk assessment of agricultural soils surrounding an iron ore mine: A field study from Western Ghat of Goa, India, *Soil and Sediment Contamination: An International Journal*, DOI: 10.1080/15320383.2022.2111403.
12. Daripa, A., Chattaraj, S., Malav, L.C., Sharma, R.P., Naitam, R.K., Mohekar, D.S. and Ramamurthy, V. 2022. Land Use Based Distribution Pattern, Fractionation forms and Health Risk Assessment of Heavy Metals in Mining-affected Soils of Western Ghat of Goa. *International Journal of Plant & Soil Science,* **34**:838-854, 2022; Article no.IJPSS.92958, ISSN: 2320-7035.
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21: 119-126.

14. Dharumarajan, S., Gomez, C., Lalitha, M., Kalaiselvi, B., Vasundhara, R. and Hegde, R. 2023. Soil order knowledge as a driver in soil properties estimation from Vis-NIR spectral data – Case study from northern Karnataka (India). *Geoderma Regional*, **32**, e00596. https://doi.org/10.1016/j.geodrs.2022.e00596
15. Dharumarajan, S., Kalaiselvi, B., Lalitha, M., Vasundhara, R., Anil Kumar, K.S. and Hegde, Rajendra. 2022. Predictive Soil Mapping of Key Soil Properties in Western Ghats, India. *Journal of the Indian Society of Soil Science*, **70(3):**266-278 (2022) DOI: 10.5958/0974-0228.2022.00032.9
16. Dharumarajan, S., Lalitha, M., Niranjana, K.V. and Hegde, R. 2022. Evaluation of digital soil mapping approach for predicting soil fertility parameters—a case study from Karnataka Plateau, India. *Arabian Journal of Geosciences,***15(5):**386.
17. Elizabeth Baby George, Cécile Gomez, D. Nagesh Kumar, Subramanian Dharumarajan and Manickam Lalitha. 2022. Impact of bare soil pixels identification on clay content mapping using airborne hyperspectral AVIRIS-NG data: spectral indices versus spectral unmixing. *Geocarto International*, DOI: 10.1080/10106049.2022.2102241
18. Gangopadhyay, S.K. and Obi Reddy, G.P. 2022. Spatial variability of soil nutrients under the rice-fallow system of eastern India using geostatistics and Geographic Information System. *Journal of Soil and Water Conservation,* **21(1):** 55-66. DOI: 10.5958/2455-7145.2022.00007.8
19. Gangopadhyay, S.K., Bandyopadhyay, S. and Maitra, A.K. 2022. Characteristics of Soils of Lower Indo-Gangetic Plains of West Bengal under Rice Cultivation*. Journal of the Indian Society of Soil Science,* **70 (1):**21-31.
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21. Hegde, Rajendra, Mahendra Kumar, M.B., Niranjana, K.V., Seema, K.V. and Dhanorkar, B.A. 2023. Spatial Distribution of Organic Carbon status in Koppal and Yadgir Taluks of Karnataka, India using GIS and Geostatistics. 2023. *Journal of Geological Society India*, 99-108. https://doi.org/10.1007/s12594-023.
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23. Hota, S., Mishra, V., Mourya, K.K., Saikia, U.S. and Ray, S.K. 2022. Fertility Capability Classification (FCC) of soils of a lower Brahmaputra valley area of Assam, India. *Environment Conservation Journal,* **23 (3)**:192-201.
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26. Karikkathil, C. Arun Kumar, Gangalakunta P. Obi Reddy, Palanisamy Masilamani and Pundoor Sandeep 2002. Indices-based assessment of vulnerability to agricultural drought in the tropical semi-arid ecosystem using time-series satellite and meteorological datasets, *Arabian Journal of Geosciences,* **15 (11):**1022*.*
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- Bandyopadhyay, Siladitya, Ghosh, B.N., Choudhury, S. Gupta, Mukhopadhyay, S.,

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- Gupta Choudhury, S, Mukhopadhyay, S., Paul, R., Tiwary, P., Mukhopadhyay, J., Haldar, A. and Basu, R. 2022. Identification and Characterization of Indo Gangetic Alluvial Soils with Vertic Properties.
- Daripa, Amrita, Chattaraj, Sudipta, Malav, Lal C., Sharma, Ramprasad, Naitam, Ravindra K., Mohekar, Deepak S, and Ramamurthy V. 2022. Heavy metals distribution pattern in various land uses and fractionation forms in iron ore mine-affected soils of Western Ghat of Goa, India.
- Das, Ruma, Kumar, Rahul, Das, Shrila, Trivedi, Ankita and Singh, Renu 2022. Stability of carbon in soils of Indo-Gangetic plains under rice and non-rice based cropping systems.
- Hota, Surabhi, 2022. Investigation of pedogenesis through clay mineralogy of the lower Brahmaputra valley of Assam at foothills of Meghalaya plateau".
- Mourya, K.K., 2022. Soil quality assessment under different land uses in North Eastern Himalaya of India

National conference on "Landscape Management for Preventing Flood and Reservoir Sedimentation" (LMPFRS-2022) during 22-24th September, 2022 held at BAU, Ranchi (Jharkhand).

- Kala, S., Mina, B.L., Kumar, Ashok, Meena1, H.R., Ali, Shakir, Rashmi, I.and Sharma, G.K.2022. Viable regreening technique for management of stone mine spoil areas in Rajasthan. 78.

6th National Conference of Indian Society of Soil Salinity and Water Quality, Karnal - 132001, Haryana, India held at Tiruchirappalli during 11-13 October 2022, Tamil Nadu.

- Srinivasan, R., Vasundhara, R., Lalitha, M., Kalaiselvi, B., Parvathy, S. and Rajendra Hegde. (2022). Climate change effect on Irrigation Water Quality- Mapping and Characterization in Southern Transition Zone of Karnataka, India. Salinity management for land degradation neutrality and livelihood security under changing climate, Abstracts, (Eds.) pp. 40-41.

86th Annual Convention of the Indian Society of Soil Science (ISSS) and National Seminar on Developments in Soil Science - 2022 held at Mahatma Phule Krishi Vidyapeeth, Rahuri-413722, Maharashtra

- Chandrakala, M and Mandal, Debashis 2022. Soil organic carbon stocks- A sustainable land quality indicator in different phases of erosion Tropical humid regions, India.

Conference/Seminar/Workshop attended

- Dr. K.K. Mourya attended the National Seminar on "Managing Soils in a Changing Climate" organized by Indian Society of Soil Survey and Land Use Planning (ISSLUP), ICAR- NBSS&LUP, Nagpur during 24-26 March, 2022.
- Dr. Arijit Barman attended the National Seminar on "Developments in Soil Science - 2022" during the 86th Annual Convention of the Indian Society of Soil Science (ISSS) held at the MPKV, Rahuri, Maharashtra during November 15-18, 2022 through online mode and presented a paper on"Characterization and Mapping of Sodic Soil in Salt-Affected Ghaghar Plains of Haryana".
- Dr. Surabhi Hota attended the 24th Annual Convention and National Conference on Application of Clay and Allied Sciences in Agriculture, Environment and Industry held during September 22-23, 2022 at ICAR-National Bureau of Soil Survey& Land Use Planning (NBSS & LUP), Regional Centre, Kolkata- 700 091 and presented a paper "Investigation of pedogenesis through clay mineralogy of the lower Brahmaputra valley of Assam at foothills of Meghalaya plateau". In the same conference Dr. K.K. Mourya made an oral presentation on topic "Soil quality assessment under different land uses in North Eastern Himalaya of India".
- Dr. K.K. Mourya attended the National Seminar on "Managing Soils in a Changing Climate" held at ICAR-NBSS&LUP, Campus, Nagpur during March 24-26, 2022 and presented poster entitled "Characterization and classification of Soils of Baska Block, Baksa District, Assam".
- Dr. U.S. Saikia attended a Technical Workshop on 14.12.2022 and Resham Krishi Mela on 15.12.2022 at RSRS, Jorhat, organized by Central Sericultural Research & Training Institute, Jorhat.
- Paul, R., Vasu, D., Tiwary, P., Sheikh, S., Chandran, P and Gaikwad, S.S. (2022). Amorphous clay minerals and soil acidity control organic carbon sequestration in humid tropical soils of India; At AIPEA-XVII International Clay Conference 2022 during 25-29 July 2022 at Hilton Maslak, Istanbul, Turkey.
- Paul, R., Vasu, D., Tiwary, P., Sheikh, S., and Chandran, P (2022) Transformation of Nano size

clay minerals in associated Red and Black soils of Western Ghats, India; At National Seminar on "Managing Soils in a Changing Climate" organized by the Indian Society of Soil Survey and Land Use Planning at ICAR-NBSS & LUP, Nagpur, Maharashtra during 24-26 March, 2022. (Best poster presentation)

- Maurya, U.K., Tiwary, P., Karthikeyan, K., Vasu, D., Paul, R. and Kumar, N. (2022). Soil micro morphological indicators of climate change and its implication in BSR and IGP soils. In: 24th Annual Convention and National Conference of CMSI 2022 organised jointly by CMSI New Delhi and ICAR-NBSS&LUP, Kolkata during 22-23 September, 2022. Abst. 76p.
- Maurya, U.K., Tiwary, P., Sharma, R.P., Karthikeyan, K., Vasu, D., Paul, R. Kumar, N. and Chandran P. (2022). Soil micromorphology in climate change study. In: Souvenir cum Abstract National Seminar on Managing Soils in Changing Climate" organised jointly by ISSLUP and ICAR-NBSS&LUP, Nagpur, during 24-26 March 2022. PS II/6, 139p.

Radio/ Television talk

- Dr. Jaya N. Surya, Pr. Scientist & Head, RC Delhi delivered radio talk on "***Vijayi Purva Mitti Ki Jyanch Kyo Avashak"and Per Drop Per Crop***" and live interaction show with farmers of India on 05-09-2022 to solve their queries/ questions on Natural Resource Management on "Krishi Evam Kalyan mantralay" Kisan ki baat programme, Prasar Bharti live show at Akashanwani Bhawan, New Delhi.
- **E-Recording** :Jaya Surya on Vishva Mrida Diwas Ka Mahtava : KISAN KI BAT- youtube released by Krishi Evam Kalyan mantralay" Kisan ki Baat programme, Prasar Bharti youtube release by Prasar Bharti.

5 MEETINGS ORGANIZED

Research Advisory Committee (RAC)

Research Advisory Committee RAC (2022) of ICAR-NBSS&LUP was held during 10-11 November 2022 at Hqrs. Nagpur under the chairmanship of Dr. P. S. Minhas, Ex-Director, NIASM, Baramati. Dr Adlul Islam, ADG (SWM), Dr. Suresh Kumar, Dr. H. K. Senapati, Dr. D. K. Sharma, Dr. Sunil D. Gorantiwar, Dr. G. S. Dasog, Dr. B.P. Bhaskar, Director, and Dr. N.G. Patil, Member Secretary also participated in the two-day meeting.

Institute Management Committee (IMC)

Institute Management Committee of ICAR-NBSS&LUP was held on 15 November 2022 at Hqrs. Nagpur under the chairmanship of Dr. B. P. Bhaskar, Director, ICAR-NBSS&LUP, Nagpur. Dr. Adlul Islam, ADG (SWM), Dr. B. L. Mina, Dr. Nayan Ahmad, Dr. R. P. Mishra, Dr. A. Murkute, Dr. R. Sable and Dr. A. P. Nagar, Member Secretary Participated in the meeting along with. The special invitees, Dr. N. G. Patil, Pr Scientist, Dr. Pramod Tiwary, Pr Scientist, Dr. Uday Saikia, Pr Scientist, Dr. B. N. Ghosh, Pr Scientist, Dr. Rajendra Hegde, Pr Scientist, and Dr. (Mrs.) J.N. Surya, Pr Scientist, Dr.G. P. Obi Reddy, Pr Scientist, Sh. Ashwani Garg Senior Finance & Account Officer, Sh. Rakesh Kumar Jatav Administrative Officer and Sh. Toran Prasad, Assitant Administrative Officer.

6 MAJOR EVENTS

ICAR-NBSS&LUP celebrated its 46th Foundation day on 27th August 2022

ICAR-National Bureau of Soil Survey and Land Use Planning celebrated its 46th Foundation Day on 27th August 2022. Dr B.S. Dwivedi, Director, ICAR-NBSS&LUP welcomed all the guests and presented Bureau's salient research achievements of 2021-2022 with new accomplishments. The Chief Guest Shri Nitin Gadkari, Hon'ble Minister for Road, Transport and Highways, Govt. of India, congratulated all the staff of the Bureau and emphasized on linking the science with new techniques for better future of Indian agriculture and enhancing the linkages and coordination of the ICAR institutes with State Agricultural Universities and State departments for the betterment of the farming communities. Chairman of the function, Dr. Himanshu Pathak, Secretary, DARE and Director General, ICAR advised the scientists to come up with new research ideas and technologies. Shri Gadkari released the research publication of the Bureau entitled "Land

Celebration of 46th Foundation Day

Resource inventory of Vidarbha region for sustainable agricultural development". Dr MSS Nagaraju, Head, Division of Remote Sensing Applications, proposed vote of thanks.

Foundation Stone Laying ceremony of New office building of ICAR-NBSS&LUP, Regional Centre Delhi, in allotted plot of IARI campus, New Delhi was undetaken by Hon'ble Sh. Kailash Choudhary, Minister of State for Agriculture & farmers welfare, Govt. of India, New Delhi on 06-06-2022, in presence of Dr S. K. Chaudhari, DDG(NRM), ICAR and Dr B. S. Diwedi, Director, NBSS&LUP. During the Various

Foundation Stone laying ceremony of New office building of ICAR-NBSS&LUP, RC Delhi by Hon'ble MoS for Ag. & FW, Sh. Kailash Choudhary.

dignitores of ICAR were also present on the occasion including staff of NRM division, IARI and RC Delhi.

Release of "LRI of Bundelkhand region for sustainable land use planning" report in 93rd Annual General Body Meeting (AGM) of ICAR, by Hon'ble Sh. Narendra Singh Tomar, Minister of Agriculture

Release of "LRI Of Bundelkhand Region for sustainable Land Use Planning" Report in AGM - 2022

Hon'ble Sh. Narendrasingh Tomar, Minister of Agriculture and Farmers Welfare, Govt of India, on 26th March 2022 release the report at NASC Complex , New Delhi

and Farmers Welfare, Govt of India, on 26th March 2022 at NASC Complex, New Delhi.

Vigilance Awareness Week (VAW-2022)

The ICAR-National Bureau of Soil Survey and Land Use Planning celebrated Vigilance Awareness Week (VAW-2022) from 31st October to 6th November, 2022. The program began with an integrity pledge on 31st October, 2022 at ICAR-NBSS & LUP Nagpur and its Regional Centres for promoting honesty and integrity towards achieving self-reliance in all spheres of life. With a focus on *"Corruption-free India for a Developed Nation",* various events like Webinar ("*Transparency in Public Procurement*") /Seminar ("Preventive Vigilance" and "Conduct Rules"), meetings in Gram Panchayat under 'Awareness Gram Sabhas' debate competitions on *"Is Integrity Responsible for Self-Reliance in India?"* and *"Public vigilance alone can stem corruption"* and quiz competitions were organised.

Integrity pledge by the staff at HQs, Nagpur

Integrity pledge by the staff at RC, Bangalore

Integrity pledge by the staff at RC, Delhi

Integrity pledge by the staff at RC, Jorhat

Integrity pledge by the staff at RC, Kolkata

Integrity pledge by the staff at RC, Udaipur

Gram Sabhas Vigilance Awareness Programme (VAW)

Vigilance Awareness Gram Sabhas programme was conducted for the farmers of Garanda village, Parseoni Taluka of Nagpur District as part of VAW 2022 celebration. During the programme, various

शेतकऱ्यांनो नियोजनात्मक शेती करा

गरंडा येथे सतर्कता व जागरूकता कार्यक्रमात डॉ. रघुवंशी यांचे आवाहन

Awareness Gram Sabhas programme at Garanda village, Nagpur lectures on role and importance of the agricultural schemes, programmes for enhancing livelihoods, crop production, seed production, weed control, soil health cards and their role in agricultural produce and production was delivered by the scientists to the farmers of the area. More than 50 farmers participated in the programme.

World Soil Day

The ICAR-NBSS&LUP celebrated World Soil Day on 05 December, 2022 at the Headquarters and its Regional Centres (RCs). On this occasion, various programmes were organised. At the headquarters, Nagpur Dr. Tapas Bhattacharyya, Former Vice Chancellor, BSKKV, Dapoli and Ex. Head, Division of Soil Resource Studies NBSS&LUP delivered a lecture on "Soils: Where Food Begins" through hybrid mode. All the scientists of the Bureau attended this lecture.

- RC, Delhi celebrated World Soil Day at KVK Chholas, Gautambudhnagar, Noida. Dr. Jaya

N Surya, Pr. Sc. & Head, Dr. Ashok Kumar, Sr. Scientist, and Dr. Sunil Kumar, Scientist delivered lectures. On this occasion pamphlets were also distributed to the dignitaries and farmers.

- About 200 students and teaching staff of Central Academy Senior Secondary School and St.

World Soil Day, 2022 celebrated by ICAR-NBSS&LUP, Regional Centre, Delhi at KVK Chholas, Gautambudh Nagar, Noida

Teresa Senior Secondary School, Udaipur, participated in the programme of World Soil Day at RC, Udaipur, and Scientists of the centre acquainted them with the importance of soil and theme of the programme. At RC, Jorhat, lectures were delivered by the scientists on this occasion.

- ICAR-NBSS&LUP, Regional, Centre Kolkata organized World Soil Day, 2022. Scientists of the

Celebration of World Soil Day at RC, Udaipur

Celebration of World Soil Day at RC, Jorhat centre delivered lectures on various topics related to "Importance of soil as a critical component of the natural system and as a vital contributor to human wellbeing". On this occasion, in collaboration with Sasya Shyamala Krishi Vigyan Kendra, RKMVERI, RC Kolkata organised a programme for the farmers of Tihuria village, Sonarpur. Dr. T. Chattopadhyay and Dr. S. Bandyopadhyay, Sr. Scientists of RC Kolkata delivered lecture on the importance of soil in crop production and planning. total of 47. of farmers participated in the programme and 23. soil health cards were distributed.

- **Krishi/Kisan Mela, Kisan Goshthi**

Distribution of soil health cards to the farmers of Tihuria village, Sonarpur

Celebration of World Soil Day at RC, Kolkata

- Scientists and staff of the Regional Centre Delhi participated in the Pusa Krishi Vigyan Mela, organized by the ICAR-IARI, New Delhi during 9 -11 March, 2022.
- Organized programme for celebration of "Farmers Awareness Campaign on Efficient and Balanced use of Fertilizers (including Nano-Fertilizers)" at Khangoda (Sidipur), Gautam Buddha Nagar district, UP. On this occasion, Dr. Sunil Kumar, Scientist & other staff participated in the event

Hon'ble DDG (NRM) Dr. SK Chaudhari, visited stall of ICAR-NBSS&LUP (L), and farmers, students and scientists interacted (R) during Pusa Krishi Vigyan Mela, 2022

and delivered lectures regarding awareness on the topic.

- *"Kisan Bhagidari, Prathmikta Hamari"* programme organized by the state agricultural departmental officials of Haryana, and ICAR-NBSS&LUP, Regional Centre, Delhi at Mundaka village of Firozpur Jhirka, Mewat, Haryana on 28.04.2022. Dr. Ashok Kumar and Dr. Sunil Kumar, Scientists and Dr. D. K. Katiyar, CTO of the Regional Centre, Delhi participated in this programme.
- RC, Udaipur organised a Kishan Ghosthi on ***Kisan Bhagidari Prathmikta Hamari*** on 28.04.2022

Pamphlet released during Farmers Awareness Campaign at Khangoda (Sidipur), Gautam Buddha Nagar district

Farmers' participation during "Kisan Bhagidari, Prathmikta Hamari' programme

under *Azadi Ka Amrit Mahotsav* programme at Chihano Ka Guda village Tehsil Vallabhnagar, Udaipur. 50 farmers participated the programme and discussed their agriculture related issues.

- ICAR NBSS and LUP, Regional Centre, Kolkata celebrated ***Kisan Bhagidari Prathmikta Hamari***

Kishan Ghosthi on *Kisan Bhagidari Prathmikta Hamari* organised by RC, Udaipur

under Azadi ka Amrit Mahotsav in collaboration with Sasya Shyamala KVK & Directorate of Jute Development, Kolkata on 26 April, 2022. A total of 110 farmers participated in the programme in offline mode and 320 farmers participated in virtual mode. The KVK also organized a Kisan Fair. Dr. S. Bandyopadhyay, Sr. Scientist, delivered a lecture on Prakritik Kheti (Natural Farming) to the farmers.

- RC, Bangalore celebrated Azadi ka Amruit Mahostav in July 2022 by conducting lectures

on "Use of Modern technology in managing man and wild conflict by Kushal Konwar Sharma and "Krishi becoming Rishi" by Sri Kamalesh D Patel

- Scientists and staff of RC, Kolkata, participated in the exhibition of 26th Sundarban Kristi Mela O Loko Sanskriti Utsab from 20-29 December 2022 at Kultali, Basanti, South 24 Parganas.
- Two villages namely Andulgoria (300 SC farm families) & Seoraderia (80 SC farm families)

26th Sundarban Kristi Mela O Loko Sanskriti Utsab

Participation of farmers in *MERA GAON MERA GAURAV* programme were selected for MERA GAON MERA GAURAV programme under Bhangar 1 block of South 24 Parganas of WB on 09.06.2022. About 25 farmers participated in the programme.

- RC, Bangalore organised Kisan Diwas programme at Chikka Kurgodu village on 23.12.2022.
- Regional Centre, ICAR-NBSS&LUP, Jorhat participated in the exhibition in connection with Regional Agricultural fair organized by Assam Agricultural University during 12.03.2022 to 14.03.2022.
- Regional Centre, Jorhat participated in the Momentum North East-2022 organized in association with PHD Chamber of Commerce and Industry, New Delhi at North East Zone Cultural Centre, Shilpgram Punjabari, Guwahatii, Assam during 24-25 March 2022.
- Awareness program on balanced use of fertilizers for the benefit of farmers was organized at SCSP village Parcharhalli, Madderi Panchayath, Kolar district, Karnataka. About 125 farmers & farm women were participated

Swachhta Pakhwada

For creating awareness of cleanliness and to keep office and residential premises neat and clean, the headquarters and regional centres of ICAR-NBSS&LUP organized various programme for Swachhta Pakhwada (15-12-2022 to 31-12-2022).

- Regional Centre, Delhi observed Swachhta Pakhwada during the period 15-12-2022 to 31-12-2022. An awareness programme for school children was held in Sarvodaya Vidyalaya, IARI, PUSA, New Delhi by conducting quiz, essay competitions.
- RC, Bangalore organised Swatchtha Abhiyan programme on 22.12.2022 for school children at Vidhurahaswatha

Dr A. Velmurugan, ADG (S&W), ICAR-NRM Division, New Delhi distributed prizes and interacted with staff of RC Delhi on Swachhta Pakhwada

Dr A. Velmurugan, ADG (S&W), as Chairman of Swacchatta Abhiyan ceremony on 30-0-12-2022, distributed prizes to the winners of various competitions organized for school children

- ICAR-NBSS&LUP, Regional Centre, Udaipur observed "Swachhta Hi Sewa" from 02-31 October 2022.

Swachhta Hi Sewa observed at RC, Udaipur

World Pulses Day, 2022

World Pulses day was organized by ICAR-NBSS LUP, RC Kolkata in collaboration with Sasya Shyamala KVK at Sasya Shyamala KVK, Sonarpur on 10 February 2022. Dr. S K. Ray, Head of the Regional Centre Kolkata made his valuable introductory remarks on the importance of World Pulses Day followed by speech delivered by Dr. B.N. Ghosh. A training programme on

crop production & planning was organized for the 56 number of beneficiary SC farm families of Majherpara village of Canning 2 block to observe the World Pulses Day with the joint expertise from NBSS LUP & Sasya Shyamala KVK.

National Poultry Day, 2022

National Poultry Day was observed by ICAR-NBSS&LUP, Regional Centre, Kolkata in collaboration with Sasya Shyamala Krishi Vigyan Kendra on 19th March, 2022 at Sasya Shyamala Krishi Vigyan Kendra, Arapanch, South 24 Pgs., West Bengal. 60 numbers of farmers participated in the programme.

- RC, Jorhat organized World Environment Day programme on 04.06.2022. Dr. R.S. Meena, Senior Scientist, Regional Centre, Jorhat delivered

lecture on this day on the topic "Soil survey for land resource management".
- RC, Jorhat observed Cyber Jaagrookta Divas on 06.10.2022.
- The Bureau celebrated Anti-terrorism Day on 21.05.2022 and Anti-terrorism pledge was administered to all the staff members.

On World Environment Day, tree plantation by Dr. U.S. Saikia, Head (Acting)

Cyber Jaagrookta Divas

- The Bureau celebrated '**Rashtriya Ekta Diwas**' on 31.10.2022 with a pledge of national integrity.
- ***Kisan Diwas*** was organised on the birth centenary of Choudhary Charan Singh, former prime minister of India, on 23 December, 2022, at Jhadol village of Sarada Tehsil, Udaipur district.
- International Yoga day was observed on 21.06.2022.

RC, Udaipur celebrated ***'Rashtriya Ekta Diwas***

RC, Udaipur organised ***Kisan Diwas*** on the birth centenary of Choudhary Charan Singh

- RC, Bangalore, organised a lecture on "Quantitative Application of AEM for Regional Groundwater Productivity in Fractured Basement Rocks" by Dr. Subash Chandra on 06.07.2022.

7 MoUs, LINKAGES AND COLLABORATIONS

MoU signing

- A Memorandum of Understanding (MoU)has been executed between the Department of Geography, Jagannath Barooah College, Jorhat 785001, Assam and the ICAR-NBSS&LUP, Jorhat Regional Centre on 01-12-2022. This MoU is making provisions for imparting education/ research collaboration in different branches of natural resource management and geography.

MoU signing ceremony on 01.12.2022

- An MoU has been signed between Director, ICAR- NBSS&LUP and Directorate of Cinchona and Other Medicinal Plants, Govt. of West Bengal on 13.01.2022 at ICAR- NBSS&LUP, Regional Centre, Kolkata. Dr. S.K. Ray, Principal Scientist & Headfrom ICAR- NBSS&LUP, RC, Kolkata and Dr. Samuel Rai, Director, Directorate of Cinchona and Other Medicinal Plants, Govt. of West Bengal

MoU signing between ICAR_NBSS&LUP, Kolkata and Directorate of Cinchona and Other Medicinal Plants, Govt. of West Bengal

had signed the MoU. The total budget of the project was Rs. 8,00,000/- (Rupees Eight Lakhs Only). Dr. S.K. Reza has been selected as the P.I. of the project.

- On launching REWARD project for Odisha, an MoU has been signed between Dr. B.S. Dwivedi, Director, ICAR-NBSS&LUP and Sh. H.K. Panda, Director, DSC & WD, Govt. of Odisha in presence of Dr. S.K. Ray, Principal Scientist and Head, Dr. S. Bandyopadhyay, Project leader and Dr. N.G. Patil, Principal Scientist and Head, Division of Land Use Planning and Scientists of Regional Centre, Kolkata on March, 02nd, 2022. The project cost was about Rs. 4.8043 Crores. It covers about 1.25 lakh hectares area of Sambalpur and Koraput districts.

- A MoU has been signed on 16th February, 2023 between ICAR-NBSS&LUP and VNMKV, Parbhani for collaborative research related to the soils of Marathwada region to solve the basic issues and problems in Natural Resource Management and allied areas. The MoU has been signed Dr. Mishra, Honorable Vice Chancellor, Marathwada Agricultural University, Parbhani and Dr. BP Bhaskar, Director (Act.), ICAR-NBSS&LUP.

Linkages with foreign Country

Name of the Institute	Purpose
Institut National de la Recherche Agronomique(INRA), France	Accompanying the adaption of irrigated agriculture to change (ATCHA Project)

Linkages with State Government and other Institutes

Name of the Institute	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
Department of Agriculture & Farmers' Welfare, Govt. of Bihar	Collaboration in LRI of Bihar state
Department of Soil Conservation and watershed Development (DSC&WD), Govt. of Odisha	Collaboration in World Bank funded REWARD project for LRI work in Odisha
Department of Agriculture, Govt. of West Bengal	Collaboration in LRI at district & block level and Soil Correlation activities
Sasya Shyamala Krishi Vigyan Kendra under Rama Krishna Mission Vivekananda Educational and Research Institute, Arapanch, South 24 Pgs, West Bengal	Collaboration in SCSP Programme
West Bengal State Watershed Development Agency (WBSWDA)	Integrated Watershed Management Programme (IWMP) in West Bengal
Krishi Vigyan Kendra, North and Middle Andaman District (under ICAR- CIARI), Nimbudera, Middle Andaman, A&N Islands	Collaboration in LRI of North and Middle Andaman District
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.
Directorate of Cinchona and other Medicinal Plants, G.T.A., Govt. of West Bengal, Mungpoo, Darjeeling	Land resource inventory of Cinchona and other medicinal plants growing area of Darjeeling district in large scale using geo-spatial techniques
Land Resource Inventory for Climate-Resilient Agriculture in Selected Clusters (POCRA), Govt. of Maharashtra	To enhance agriculture productivity and climate resilience of farmers through the adoption of improved production technology, on-farm, and community-based water management, improved soil health and water use efficiency
Karnataka Watershed Development Department (KWDD), Bengaluru	LRI for watershed development to prevent drought (WDPD)
REWARD Project Watershed Development Department, WDD, Government of Karnataka	Guidance to be provided on all aspects related to Land Resources Inventory in 100 project taluks and in collaboration with SAU partners
REWARD ProjectDirectorate of Soil Conservation & Watershed Development, (DSC & WD), Govt. of Odisha,	LRI of selected clusters of micro watersheds of Koraput & Sambalpur districts of Odisha
Land resource inventory of Arunachal Pradesh in large scale for agricultural land use planning using geo-spatial techniques	LRI of 22 Districts of Arunachal predesh
MoU Signed with TNSLURB (Tamil Nadu)	An agreement for mapping of fallow lands in Tamil Nadu
Signed an agreement with Govt. of Karnataka in collaboration with GSI.	For preparation of district resource maps of Karnataka

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
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
ICAR- CIARI, Port Blair, A&N Islands	Collaboration in LRI of North and Middle Andaman District
ICAR- ATARI, Kolkata	Collaboration in Mera Gaon Mera Gaurav Programme in the state of West Bengal
Institute of Agricultural Sciences, University of Calcutta	Research & Teaching

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
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
Adani Transmission Ltd., Ahemedabad	Provide soil data for prospecting location for laying of transmission tower in India.
Neopark Technologies, Mumbai	Development of Hyper spectral model in Maharashtra

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.

8 TRAINING AND CAPACITY BUILDING

Trainings conducted

Date	Training details & venue
February, 7-11	Farmers' training programme under SCSP programme by ICAR-NBSS&LUP, Regional Centre, Jorhat on "Enhancement of agricultural production sustainability through improved Management of Field and Horticultural Crops, Soil Health, Plant Protection, Animal Husbandry and Fisheries for SC farmers"
February, 08 - 28	DST-NGP sponsored Winter School on 'Advance geospatial technologies for assessment and monitoring of land degradation in changing climate' at ICAR NBSS&LUP, Nagpur
March, 01 – April, 30	Techniques of Soil Survey and Laboratory Analysis for 20 soil survey officers and laboratory staff of Maharashtra Government. Sponsored by : Directorate of Irrigation Research & Development, Pune, Government of Maharashtra
March, 26	Training to 80 SC community beneficiaries on "Scientific crop cultivation" at Pinjauri village, Yamunanagar, Haryana
May, 26-28	Regional centre, Bangalore organized "REWARD trainers training program".
July, 19-20	LRI-pre-field and post field activities for 6 project staff members of UAHS, Shivamogga , Karnataka under WDPD project
July, 27-28	Training on Landform Delineation using Digital Interpretation Techniques using ArcGIS was organized by NBSS&LUP, Bangalore for UAS, Bangalore project staff of REWARD
September, 26-30	5 days of physical training on "Soil Monolith preparation" to Dept of soil sciences Staff's of Tamil Nadu Agricultural University, Main Campus, Coimbatore, Tamil Nadu.
October, 10-13	Training program was organised under REWARD on Image interpretation of images for SAU partners for UAS Raichur & UAS Bangalore
October, 18-20	LRI, field Survey training organized at Dharwad for 38 UAS-Dharwad Scientists and project staff of REWARD
November, 21-23	LRI Training program was organised under REWARD-Karnataka project for 35 UAS-Bangalore Scientists and project staff of REWARD
December, 20-21	Training on Landform Delineation using Digital Interpretation Techniques using ArcGIS was organized by NBSS&LUP, Bangalore for College of Horticulture, Bidar, UHS, Bagalkote and UAHS, Shivamogga

Classroom teaching and field training.

Trainings attended

Date	Training Details & Venue	Participants
January, 19-28	10-days ICAR sponsored short course on “Bioprospecting Plant Microbiome : A Novelty to Plant Health Management in Organic Production System” organized by Department of Plant Pathology, Assam Agricultural University, Jorhat	Mr. D.K. Dutta Mrs. S. Chetia
Jan. 27 – Feb., 05	10 days training on Online ICAR Sponsored Short Course on *“Statistical Development for Data Analytics in Agricultural Experimentation*” organized by ICAR- IASRI-Pusa Campus, New Delhi.	Dr. Chandrakala, M. Dr. Amrita Daripa
February, 02-22	ICAR sponsored 21 days Winter School on “Application of Remote Sensing and GIS in Land Resource Management for Sustainable Agriculture” organized by ICAR-NBSS&LUP, Regional Centre, Kolkata	Dr. K.K. Mourya
February, 08 - 28	Attended DST-NGP sponsored Winter School on ‘Advance geospatial technologies for assessment and monitoring of land degradation in changing climate’ organized by ICAR NBSS&LUP, Nagpur; sponsored by DST	Dr. L.C. Malav Dr. Brijesh Yadav Dr. B. L. Tailor Dr. S. Chattaraj Dr. Amrita Daripa
April, 27-30	4 days training on LRI, Hydrology, DSS and DPR preparation under REWARD programme organized by Centre of Excellence on watershed management, UAS, Bengaluru; sponsored by REWARD, World Bank	Dr. S. Bandyopadhyay Dr. Amrita Daripa
May, 11-31	DST sponsored summer school on *“Applications of geospatial techniques in Agriculture”* organised in Tamil Nadu Agricultural University	Dr. Kalaiselvi. B.
June, 14-16	Three days on-line Hindi Workshop on “Experimental Designs and Analysis” (‘‘परीक्षणात्मक अभिकल्पनाएँ एवं विश्लेषण’’) organized by ICAR- Indian Agricultural Statistics Research Institute, New Delhi.	Mr. D.K. Dutta Mrs. S. Chetia Mr. Amitabh Baruah
June, 21-25	Online training programme on ‘Data Analysis Using “R” Software’ organised by Centre for e-Learning in collaboration with Dept. of Agricultural Statistics, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur	Dr. H. Biswas
July, 11-14	MANAGE sponsored online training programme on “Integrated Watershed Management for Strengthening PMKSY” organized by ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Udhagamandalam, Ooty and MANAGE, Hyderabad	Dr. U.S. Saikia Dr. R.S. Meena Dr. K.K. Mourya
August, 23-25	MANAGE- online Collaborative Training Program on “Strengthening of Rainfed Production System for Sustainable Agriculture”	Dr. R.S. Meena
September, 12-17	Six days Management Development Programme on *‘Developing Winning Research Proposals’* organised by ICAR-NAARM, Hyderabad	Dr. Chandrakala, M.
September, 14-16	MANAGE-NCNF-RRA NETWORK online Collaborative Training Program for Master Trainers on “Introduction to Natural Farming-Principles and Practices”	Dr. R.S. Meena
November, 01-21	NGP-DST Winter School in “Geospatial Science and Technology” (Level-1)’ at ICAR- Central Arid Zone Research Institute, Jodhpur and Supported by National Geospatial Program (NGP)- DST, Govt. of India, New Delhi.	Sh. Ajit Kumar
Nov., 14 - 25	12 days of Training on “Remote Sensing and GIS InPredictive Soil Mapping” conducted by Indian Institute of Remote Sensing (IIRS), ISRO, Dept. of Space, Govt. of India Dehradun – 248001, Uttarakhand, India	Dr. R. Srinivasan Dr. Mahaveer Nogiya Dr. L.C. Malav Dr. Brijesh Yadav Dr. Surabhi Hota
November, 14-25	Special course on “Remote Sensing and GIS in Predictive Soil Mapping” conducted by Indian Institute of Remote Sensing, Dehradun	Dr. H. Biswas
November, 03-23	21 days training program on ‘Geospatial Science and Technology (Level-1)’ to be held at ICAR-Indian Institute of Soil Science, Bhopal	Dr. Sunil, B.H.
December, 15-21	Training programme on “Computer Applications for Technical Personnel of ICAR” organized by ICAR-IASRI, New Delhi on virtual mode.	Mrs. S. Chetia
December, 26-29	4 days training on LRI, Hydrology, DSS and DPR preparation under REWARD programme organized by Centre of Excellence on watershed management, UAS, Bengaluru ;	Dr. S. Bandyopadhyay

9 WORKSHOPS/SEMINARS ORGANIZED

National Seminar organised by ISSLUP

A three-day National Seminar on "Managing Soils in a Changing Climate" was organised at ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur, during March 24-26, 2022, by the Indian Society of Soil Survey and Land Use Planning (ISSLUP) and co-sponsored by Indian Council of Agricultural Research (ICAR), ICAR-NBSS&LUP, NABARD, IFFCO, Mosaic, International Zinc Association and Pardeep Phosphate Limited. Dr J.C. Katyal, Former DDG (Edn) was the Chief Guest. About 180 delegates from different parts of the country participated and played a proactive and decisive role in Seminar deliberations. The presentations in the National Seminar included Memorial lectures (3), Invited lectures (30), Oral presentations, Poster presentations (104) and plenary session Chaired by Dr Ashok Dalwai, Chairman, National Rainfed Authority of India

Inauguration of National Seminar

Inauguration of National Seminar

Annual Convention organised by CMSI

The 24th Annual Convention and National Conference of the Clay Minerals Society of India was organized by ICAR- NBSS&LUP, Regional Centre Kolkata in collaboration with Anthropological Survey of India during 22-23 September, 2022. Dr. S. Bandyopadhyay, Sr. Scientist was the organizing secretary of this annual convention.

- One day seminar on Dynamics of soil health governance in collaboration with Fertilizer Association of India (Chennai) was organized. About 50 delegates participated in the event on 12.08.2022.
- Interaction meeting /workshop on Digital soil mapping organized with scientists from ISRIC, Wageningen, INRA France, CIMMYT centre, Bihar, IRRI, Philippines and ICAR-NBSS&LUP, Bangalore centre 8.12.2022
- ICAR-NBSS&LUP, Udaipur organized a Hindi Workshop on the topic "Rajbhasha Niti aur

Screenshot of the inaugural session of NGP-DST sponsored Winter School

Karyanvan". Smt. Seema Chopra, Director, Rajbhasha, ICAR, New Delhi, was the chief guest of workshop on September, 09, 2022.

- ICAR-NBSS&LUP, Udaipur organized a lecturer (online mode) on "Transparency in Public Procurement" by Sh. Jai Kaushik, Joint Director, Treasuries and Accounts Department, Jaipur, Rajasthan on November, 02, 2022.

10 AWARDS, RECOGNITIONS AND FOREIGN VISITS

Awards

- Dr. Jaya N. Surya, Pr. Sci. & Head, ICAR-NBSS&LUP, RC Delhi received "Fellow Award of Society of Tropical Agriculture", New Delhi.
- Dr. R. Srinivasan, Senior scientist received the Outstanding Young Scientist award 2021-22 from Indian Society of Soil Survey and Land Use Planning, ICAR-NBSS&LUP, Nagpur.
- Dr. R. Srinivasan, Senior scientist received Outstanding Young Scientist award 2020-21 from The Society for Science of Climate Change and Sustainable Environment, New Delhi.
- Dr. V. Ramamurthy, Principal Scientist received Best poster award during Annual Convention of Indian Society of Soil Survey and Land Use Planning.
- Dr. S. Dharumarajan, Senior scientist received Best poster award in a Seminar on "Managing Soils in Changing Climate" during 24-26 March 2022, organized by the Indian Society of Soil Survey & Land Use Planning, Nagpur.
- Dr. Kalaiselvi, Scientist received Best poster award in a Seminar on "Managing Soils in Changing Climate" during 24-26 March, 2022, organized by the Indian Society of Soil Survey and Land Use Planning, Nagpur.
- Dr. M. Lalitha was awarded "First Place Winner" for Theme 2 at the Global Symposium on Soils for Nutrition – GSOIL4N's poster competition, held virtually on 26-29th July 2022 by the Food and Agriculture Organization of the United Nations.
- Dr. M. Lalitha was awarded the "Best Paper Award" by the Range Management Society of India in National Symposium on "Innovations in forage and livestock sector for enhancing entrepreneurship and farm productivity" on 1st November 2022 at ICAR-IGFRI, Jhansi
- Dr. K.K. Mourya was awarded with "Dr. S.P. Raychaudhuri Gold Medal Award" for the year 2021-22 by Delhi Chapter of ISSS, New Delhi.
- Dr. Lal Chand Malav received NESA Scientist of the Year Award 2022 by National Environmental Science Academy, New Delhi.
- Dr. R.P. Sharma received Award and Certificate of Best Oral Presentation in National Symposium on *Paradigm Shift in Cotton Cultivation* organized by the Cotton Research and Development Association, HAU, Hisar in collaboration with Maharana Partap University of Agriculture and Technology, Udaipur and ICAR, New Delhi during 08-10 August, 2022.
- Dr. Jayjayanti Mukhopadhyay, Asst. Chief Technical Officer and Smt. Aparna Das, P.A. received the Best Employee Awards 2022 on the occasion of the Foundation Day of the Institute.
- Smt. Soma Saha, Technical Officer received an award (including cash) on Kavya Abritti Pratiyogita organized by NARAKAS, Town Official Language Implementation Committee (Office-2), Kolkata, Ministry of Home Affairs, Dept. of Official Language, Govt. of India.
- Dr. Ranjan Paul received Budding Scientist Award 2022 of the Indian Association of Soil and Water Conservationists, ICAR-IISWC, Dehradun, India.
- Dr. Ranjan Paul received Early Career Clay Scientist Travel Grant for attending XVII-AIPEA International Clay Conference 2022 at Istanbul, Turkey from the International Association for the Study of Clays.
- Dr. Ranjan Paul received Best Poster presentation awardat the National Seminar on "Managing Soils in a Changing Climate" held at ICAR-NBSS & LUP, Nagpur, India during March 24-26, 2022 by the Indian Society of Soil Survey and Land Use Planning, ICAR-NBSS & LUP Campus, Nagpur.
- Dr. K. Karthikeyan was honoured with the "Soil Conservation Society of India – Special Research Award -2021" for his significant contribution in the field of soil survey/mapping, soil genesis, soil quality and development of soil water conservation plans.

Recognitions

- Dr Jaya N. Surya, Pr. Sci. & Head, ICAR-NBSS&LUP, RC Delhi nominated as Technical Expert for finalization of EOI cum TP related to survey and preparation of DPR for establishment of Chambal ravines farm of Morena, District Morena.
- Dr. R.P. Sharma, appointed as an expert (Agriculture section) in Rajasthan Public service Commission, Ajmer, Govt. of Rajasthan.
- Dr. G.P. Obi Reddy nominated by NSDI-DST as a chairman, NSDI-Executive Sub-Committee on implementation of “Interim Data Sharing Framework (IDSF), NSDI DST.

Foreign Visit

- Dr. S. Dharumarajan Visited James Hutton Institute, Aberdeen, UK to get advanced training in digital soil mapping and interaction with scientists of the Institute on possible future collaboration from 26.09.2022 to 30.09.2022.
- Dr. Ranjan Paul visited Istanbul, Turkey for attending the International Clay Conference held during 23-31 July, 2022. He also made oral presentation on “Amorphous clay minerals and soil acidity control organic carbon sequestration in humid tropical soils of India”.

Awards and honors (Committee members, etc)

- Dr. U.S. Saikia, nominated as a member of Task force agro-climatic zone of Eastern Himalayas to discuss the suitable strategies, research priorities, institutional linkage, extension and monitoring mechanism for the Eastern Himalayas zone. Prepared and submitted a Special report on ‘Effective and sustainable irrigation and drainage systems’for NE Indian states separately.

11 DISTINGUISHED VISITORS

Head Quarters, Nagpur

1. Dr. Ashok Dalwai, IAS, CEO, National Rainfed Area Authority, Ministry of Agriculture and Farmers Welfare, New Delhi on 25.03.2022
2. Dr. Himanshu Pathak, Secretary, DARE and Director General, ICAR on 27.08.2022
3. Dr. S.K. Chaudhari, Deputy Director General, NRM (ICAR) on 27.08.2022
4. Dr. C.D. Mayee, Former Chairman, ASRB on 27.08.2022
5. Dr. Tapas Bhattacharya, Ex. VC, BSKKV, Dapoli, Maharashtra on 05.12.2022
6. Sh. G.P. Sharma, Director (Finance), ICAR, New Delhi on 27.07.2022

Regional Centre, Bangalore

1. Dr. Chandrashekar Reddy, Dean, Tennesse University on 20.05.2022
2. DDG (NRM) Dr. S.K. Chaudhari visited the centre on 12.11.2022
3. Smt. Sudha IFS, Deputy Conservator of forests, Tamil Nadu State Planning Board, Chennai on 10.11.2022
4. Dr. David Rossetier, World soil information, Wageningen, Netherlands on 08.12.2022
5. Dr. Cecil Gomez, Scientist, INRA, France on 08.12.2022
6. Dr. Phillippe Legacherie , Scientist, INRA, France on 08.12.2022
7. Dr. S.P. Punia, Scientist, CIMMYT centre, Bihar on 08.12.2022
8. Dr. Harshit Ranjan, CIMMYT centre, Bihar on 08.12.2022
9. Dr. Bhavani, CIMMYT centre, Bihar on 08.12.2022

Regional Centre, Delhi

1. Sh. Kailash Choudhary, Hon'ble Minister of State for Agriculture & Farmers Welfare, Govt. of India
2. Dr. Trilochan Mohapatra, Secretary DARE & DG, ICAR, New Delhi
3. Dr. S. K. Chaudhari, DDG (NRM), ICAR, New Delhi
4. Dr A.K. Singh, DDG (Agricultural extension), ICAR, New Delhi
5. Dr. T.R. Sharma, DDG (Crop Science), ICAR, New Delhi
6. Dr. S.N. Jha, DDG (Agricultural Engineering), ICAR, New Delhi
7. Dr. A.K. Singh, Director, IARI, New Delhi
8. Dr. S.C. Dubey, ADG (Plant Protection), ICAR, New Delhi
9. Dr. D.K. Yadava, ADG (NASF), ICAR, New Delhi
10. Dr. Adlul Islam, ADG (Soil and Water Conservation), ICAR, New Delhi
11. Directors and Scientists of Delhi based ICAR Institutes, govt. officials, staff and retired heads of Regional Centre, Delhi.
12. Dr. A. Velumurgun, ADG (SWM), ICAR, New Delhi
13. Dr. Krishnandu Das, Ex-Pr. Sc., RC, Kolkata
14. Dr. A.L. Pharande, Dean, MPKV – Krishi University, Rahuri , Maharashtra
15. Dr. B.D. Bhakre, Associate Dean, MPKV – Krishi University , Rahuri , Maharashtra
16. Dr. Manju Nath, Scientist, CRIDA, Hyderabad

Regional Centre, Udaipur

1. Sh. Kailash Choudhary, Minister of State for Agriculture and Farmers Welfare, GoI, New Delhi on 19.05.2022
2. Dr. S.K. Chaudhari, DDG (NRM), ICAR-New Delhi, 11-12th August, 2022.
3. Dr. Seema Chopra, Director, Hindi Rajbhasha, ICAR-New Delhi,on 09.09.2022

Regional Centre, Kolkata

1. Dr. S.P. Ghosh, Former D.D.G., ICAR- NRM, ICAR, New Delhi
2. Dr. H.K. Panda, Former Director, DSC&WD, Govt. of Odisha.
3. Dr. Samuel Rai, Director, Directorate of Cinchona and other Medicinal Plants, Govt. of West Bengal.
4. Sh. Saradindu Das, Director of Agriculture, Govt. of Tripura
5. Dr. A. Bandyopadhyay, Former NAIP Nodal Officer
6. Dr. Gauranga Kar, Director, ICAR- CRIJAF
7. Dr. N.C. Sahu, Pr. Scientist & Head, SS KVK, RKMVERI, Sonarpur, South 24 Pgs.
8. Mrs. Shruti Mishra, Hindi Officer, Hindi Teaching Scheme, Central Hindi Training Institute, Kolkata

Regional Centre, Jorhat

1. Mr. Abhijit Das, Zonal Manager, NE Region, UCO Bank, visited the Centre on 20.01.2022 regarding extension of benefits of Govt. Schemes to the farmers.
2. Dr. Mrityunjay Ghosh, Professor, Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, P.O. Krishi Viswavidyalaya, Dist. Nadia, West Bengal visited the Centre on 04.03.2021.
3. Sri Sanjay Gupta, Chief Engineer, CPWD, Guwahati visited the Centre on 23.06.2022.
4. Dr. Samuel, Deputy Director and Dr. Simon Rosangliana, Assistant Director (Agri), Department of Agriculture, Govt. of Mizoram visited the Centre on 05.07.2022.
5. Dr. K.K. Satapathy, Ex-Director, ICAR-NIRJFI, Kolkata visited the Centre on 06.07.2022.
6. Dr. (Mrs) Minakshi Phukan Hazarika, Head, Department of Geography, J.B. College, Jorhat visited the Centre on 28.10.2022.
7. Dr. Sanjiv Ranjan Bora, Head, Regional Agricultural Research Station, Assam Agricultural University, Jorhat visited the Centre on 30.10.2022.

12 PERSONNEL

SCIENTIFIC

Dr. B.S. Dwivedi, Director (w.e.f. 01.01.2022 to 07.09.2022)

Dr. B.P. Bhaskar, Director I/C (w.e.f. 08.09.2022)

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. Pramod Tiwary, Principal Scientist (SWCE) & Head (Actg.)
2. Dr. U.K. Maurya, Principal Scientist (Soil Science)
3. Dr. K. Karthikeyan, Senior Scientist (Soil Science)
4. Dr. Vasu, D., Scientist (Soil Science)
5. Sh. Gopal Tiwari, Scientist (Soil Science)
6. Dr. Ranjan Paul, Scientist (Soil Science)

DIVISION OF REMOTE SENSING APPLICATIONS

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

DIVISION OF LAND USE PLANNING

1. Dr. N.G. Patil, Principal Scientist (SWCE) & Head (Actg.)
2. Dr. M.S. Raghuvanshi, Principal Scientist (Agronomy)
3. Dr. Ravindra Naitam, Scientist (Soil Science)
4. Ms. Radhika C., Scientist (Agril. Economics)
5. Dr. P.C. Moharana, Scientist (Soil Science)
6. Sh. H.L. Kharbikar, Scientist (Agril. Economics)
7. Dr. A.O. Shirale, Scientist (Soil Science)

REGIONAL CENTRE, BANGALORE

1. Dr. Rajendra Hegde, Principal Scientist (Agronomy) & Head (Actg.)
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. Dr. (Ms) Vasundhara R., Senior Scientist (Soil Science)
11. Dr.(Ms) M. Lalitha, Scientist (Soil Science)
12. Dr.(Ms) M. Chandrakala, Scientist (Soil Science)
13. Dr.(Ms) B. Kalaiselvi, Scientist (Soil Science)
14. Dr.(Ms) Karthika, Scientist (Soil Science)

REGIONAL CENTRE, DELHI

1. Dr. (Mrs.) Jaya N. Surya, Principal Scientist (Soil Science) & Head (Actg.)
2. Dr. Ashok Kumar, Senior Scientist (Agronomy)
3. Dr. Rajesh Kumar Meena, Scientist (Soil Science)
4. Sh. Vikas, Scientist (Agricultural Statistics)
5. Ms. Ritu Nagdev, Scientist (Environmental Science)
6. Sh. Sunil Kumar, Scientist (Soil Science)
7. Ms Shilpi Verma, Scientist (Soil Science)

REGIONAL CENTRE, JORHAT

1. Dr. U.S. Saikia, Principal Scientist & Head (Actg.)
2. Dr. R.S. Meena, Senior Scientist (Soil Science)
3. Dr. K.K. Mourya, Scientist (Soil Science)
4. Dr. Surbhi Hota, Scientist (Soil Science)
5. Sh. Arijit Burman, Scientist (Soil Science)

REGIONAL CENTRE, KOLKATA

1. Dr. S.K. Ray, Principal Scientist & Head (Actg.)
2. Dr. B.N. Ghosh, Principal Scientist (Soil Science)
3. Dr. S. Mukhopadhyay, Principal Scientist (Soil Science)
4. Dr. Tapati Banerjee, Principal. Scientist (Geography)
5. Dr. T. Chatopadhyay, Senior Scientist (Soil Science)
6. Dr. SahKausar Reza, Senior Scientist (Soil Science)
7. Dr. S. Bandyopadhyay, Senior Scientist (Soil Science)
8. Dr. (Ms) S. Gupta Chaudhary, Scientist (Soil Science)
9. Dr. (Mrs.) Amrita Daripa, Scientist (Environmental Sci.)
10. Dr. SudiptaChattaraj, Scientist (Soil Physics)
11. Dr. Smt. Ruma Das, Scientist (Soil Science)

REGIONAL CENTRE, UDAIPUR

1. Dr. Banshi Lal Mina, Principal Scientist & Head (Actg.)
2. Dr. R.P. Sharma,Senior Scientist (Soil Science)
3. Dr. Roshan Lal Meena, Scientist (Agronomy)
4. Dr. Mahaveer Nogiya, Scientist (Soil Science)
5. Dr. Lal Chand Malav, Scientist (Env. Science)
6. Sh. Abhishek Jangir, Scientist (Soil Science)
7. Dr. Brijesh Yadav, Scientist (Soil Science)

TECHNICAL

HEADQUARTERS, NAGPUR

1. Sh. S.V. Bobade, Chief Technical Officer (FFT)
2. Dr. S.S. Nimkhedkar, Chief Technical Officer (FFT)
3. Sh. V.P. Patil, Chief Technical Officer (FFT)
4. Dr. A.P. Nagar, Chief Technical Officer (FFT)
5. Mrs.Smita Patil, Chief Technical Officer (FFT)
6. Dr. A.M. Nimkar, Chief Technical Officer (FFT)
7. Sh. V.N. Parhad, Chief Technical Officer (FFT)
8. Sh. P.V. Ambekar, Chief Technical Officer (Photo.)
9. Dr. (Mrs.) Ratna P. Roy, Asstt. Chief Technical Officer (FFT)
10. Dr. (Mrs.) Jiji Cyriac, Asstt. Chief Technical Officer (LID)
11. Sh. S.S. Gaikawad, Asstt. Chief Technical Officer (FFT)
12. Dr. M.T. Sahu, Asstt. Chief Technical Officer (P&E)
13. Sh. D.S. Mohekar, Asstt. Chief Technical Officer (FFT)
14. Sh. P.S. Butte, Asstt. Chief Technical Officer (FFT)
15. Sh. S.D. Meshram, Asstt. Chief Technical Officer (FFT)
16. Sh. Ajit Kumar Meena, Senior Technical Officer (FFT)
17. Sh. Laxminarayana M., Senior Technical Officer (FFT)
18. Ms. Moumita Ash, Senior Technical Officer
19. Sh. Amit Kumar Dash,Senior Technical Officer
20. Sh. H.J. Bhondwe, Technical Officer (FFT)
21. Sh. R.K. Bhalsagar, Technical Officer (FFT)
22. Mrs.UjwalaTijare, 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, Technical Officer (FFT)
28. Sh. Rupesh Kumar Amarghade, Technical Officer(WS)
29. Sh. V.T. Sahu, Technical Officer (FFT)
30. Sh. S.K. Mendhekar, Technical Assistant (FFT)
31 Sh. J.B. Padole, Technical Assistant (FFT)
32. Sh. P.N. Jadhav, Senior Technician (FFT)
33. Sh. S.R. Singade, Senior Technician (FFT)
34. Sh. A.M.G. Sheikh, Senior Technician (FFT)
35. Smt. Nisha A. Lade, Senior Technician (FFT)
36. Sh. Atul Dankhade, Senior Technician (WS)
37. Sh. L.G. Sontakke, Senior Technician (WS)
38. Sh. S.A. Bhoyar, Senior Technician (FFT)
39. Mrs. K.B.J. Prasanna Rani, Technician (LT)
40. Sh. Deepak Ganvir, Technician (WS)
41. Smt. S.N. Gajbhiye, Technician (FFT)

REGIONAL CENTRE, BANGALORE

1. Mrs. Arti Koyal, Chief Technical Officer (FFT)
2. Sh. K.V. Niranjane, Chief Technical Officer (FFT)
3. Dr. M. Ramesh, Chief Technical Officer (LT)
4. Sh. D.H. Venkatesh, Asstt. Chief Technical Officer (LT)
5. Mrs. K. Sujatha, Senior Technical Officer (WS)
6. Sh. Ranbir Chakraborty, Sr. Tech. Officer (FFT)
7. Sh. Jairamaiah, Technical Officer (FFT)
8. Mrs. K.V. Archana, Technical Officer (FFT)
9. Sh. N. Maddileti, Technical Assistant (FFT)

10. Ms. S. Parvathy, Technical Assistant (LT)
11. Sh. M.T.N. Murthy, Technician
12. Sh. N. Sampangi, Technician
13. Sh. C. Nagraj, Technician

REGIONAL CENTRE, KOLKATA

1. Dr. (Mrs.) J. J. Mukhopadhyay, Asstt. Chief Technical Officer (FFT)
2. Dr. Abhijit Haldar, Asstt. Chief Technical Officer (FFT)
3. Sh. V. Mohan, Asstt. Chief Technical Officer (LT)
4. Sh. A.K. Maitra, Senior Technical Officer (FFT)
5. Mrs. R. Basu, Technical Officer(LT)
6. Mrs. S. Saha, Technical Officer(WS)
7. Sh. P. Mondal, Technical Officer(WS)
8. Sh. S. Sarkar, Technical Assistant (FFT)
9. Sh. Sukonto Pal, Technical Assistant(FFT)
10. Sh. Siddharth Karmakar, Technical Assistant(LT)
11. Smt. Kalpana Biswas, Senior Technician (LT)
12. Sh. Mahesh Roy, Senior Technician (FFT)
13. Sh. Abhijit SampatMeshram, Technician (FFT)

REGIONAL CENTRE, NEW DELHI

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

REGIONAL CENTRE, JORHAT

1. Sh. Durnan Gogai, Technical Officer (WS)
2. Mrs. Shamoli Chetia, Technical Officer (WS)
3. Sh. Gopi Saikia, Technical Officer (WS)
4. Sh. Dilip K. Dutta, Senior Technical Assistant (WS)
5. Sh. N. Saikia, Technical Assistant (FFT)
6. Sh. Pradip Kotoky, Technical Assistant (FFT)
7. Sh. Chandeshwar Das, Technical Assistant (FFT)
8. Sh. Amitabh Baruah, Senior 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. Bansi Lal Jat, Technical Officer (FFT)
5. Sh. Nola Ram Ola, Senior Technical Assistant (FFT)
6. Sh. B.S. Kumawat, Technical Officer (FFT)
7. Sh. B.R. Meena, Senior Technical Assistant (WS)
8. Sh. Ambalal Bhoi, Senior Technical Assistant (WS)
9. Sh. C.K. Kumawat, Technical Assistant (FFT)
10. Sh. Sohan Lal Sharma, Senior Technician (FFT)
11. Sh. J.S. Rao, Senior Technician (FFT)
12. Sh. Shiv Pal Singh, Senior Technician (FFT)
13. Sh. Manish Choudhary, Senior Technician (WS)
14. Smt. Vandana Patil, SeniorTechnician (FFT)
15. Sh. Devilal Prajapat, Technician (FFT)
16. Sh. Shambhu Lal Meena, Technician (FFT)

ADMINISTRATIVE

HEADQUARTERS, NAGPUR

1. Shri Sanjay Bokolia, Chief Administrative Officer (Sr. Grade) (upto 02.08.2022)
2. Sh. Ashwani Garg, Chief. Finance & Accounts Officer
3. Sh. Devendra Kumar Dharam, Dy. Director (OL)
4. Sh. Toran Prasad, Assistant Administrative Officer
5. Sh. Kamlesh Sharma, Assistant Administrative Officer
6. Sh. Ajay Meshram, Assistant Administrative Officer
7. Sh. Nitin Mohurle, Assistant
8. Sh. U.S. Kapse, Assistant
9. Mrs.ShaluNandanwar, Assistant
10. Sh. S.M. Pathak, Private Secretary
11. Mrs. Rohini Watekar, Private Secretary
12. Mrs.Wasudha D. Khandwe, Private Secretary
13. Sh. N.B. Mankar, Assistant
14. Sh. S.S. Kamble, Upper Division Clerk
15. Sh. S.J. Patil, Upper Division Clerk
16. Sh. Swapnil B. Suryawanshi, Lower Division Clerk
17. Ms. Sonal M. Rekhate, Lower Division Clerk
18. Ms. Priya N. Kodape, Lower Division Clerk
19. Sh. Pradeep Kumar, Lower Division Clerk

REGIONAL CENTRE, BANGALORE

1. Ms. P. Chandrakala, Assistant
2. Sh. Pankaj Gopal Wani, Lower Division Clerk

REGIONAL CENTRE, KOLKATA

1. Ms. Bedantika Dutta, Assistant Administrative Officer
2. Mrs. Aparna Das, Personal Assistant

REGIONAL CENTRE, NEW DELHI

1. Mrs. Sunita Mittal, Assistant
2. Sh. Rahul Yadav, Junior Stenography

REGIONAL CENTRE, JORHAT

1. Sh. P.K. Das, Assistant Administrative Officer
2. Sh. Madan Das, Private Secretary
3. Sh. N.C. Baruah, Personal Assistant

REGIONAL CENTRE, UDAIPUR

1. Sh. Sumit Sindhu, Assistant Administrative Officer
2. Sh. Harish Rajput, Personal Assistant
3. Sh. Unnikrishnan Nair, K.K., Assistant
4. Sh. V.S. Sankhla, Assistant
5. Sh. Bhanwar Singh Devra, Lower Division Clerk

SKILLED SUPPORTING STAFF

HEADQUARTERS, NAGPUR

1. Sh. G.B. Topre
2. Sh. N.T. Thawkar
3. Sh. Ramesh Khawle
4. Ms. Merlin Anthony
5. Sh. Aniket Gedam
6. Mrs. Rina Yadav
7. Mrs. Gayatri Chighore
8. Sh. Rahul Taksande

REGIONAL CENTRE, BANGALORE

1. Sh. R. Balakrishna

REGIONAL CENTRE, KOLKATA

1. Sh. V.N. Mishra
2. Mrs. Radha Turi
1. Mrs. Alpana Roy
2. Sh. Krishna Guchait

REGIONAL CENTRE, NEW DELHI

1. Sh. Rakesh Kumar

REGIONAL CENTRE, JORHAT

1. Sh. Dilip Borah
2. Sh. R.C. Rajak
3. Sh. Raju Balmiki
4. Sh. J.C. Baruah
5. Sh. J.P. Gogai
6. Sh. PabitraGogai

REGIONAL CENTRE, UDAIPUR

- Sh. Mohanlal Meghwal

NEW ENTRANTS

1. Dr. Smt. Ruma Das, Scientist joined on 02.05.2022 (F/N) at ICAR-NBSS&LUP, Regional Centre, Kolkata after relieving from ICAR-IARI, New Delhi.
2. Shri Ajit Kumar Meena joined to the post of Sr. Technical Officer (T-6) (Soil Science) under Functional Group Field/Farm Technician w.e.f. 25.06.2022 at Division of RSA, Nagpur.
3. Shri Manish Olaniya joined to the post of Sr. Technical Officer (T-6) (Soil Science) under Functional Group Field/Farm Technician w.e.f. 25.06.2022 at Regional Centre, NBSS&LUP, New Delhi.
4. Shri Laxmanarayanan M. joined to the post of Sr. Technical Officer (T-6) (Soil Science) under Functional Group Field/Farm Technician w.e.f. 15.07.2022 at Division of SRS, NBSS&LUP, Nagpur.
5. Shri Ranabir Chakraborty joined to the post of Sr. Technical Officer (T-6) (Soil Science) under Functional Group Field/Farm Technician w.e.f. 25.08.2022 at Regional Centre, NBSS&LUP, Bangalore.
6. Dr. A.O. Shirale, Scientist joined on 30.08.2022 at NBSS&LUP, Division of LUP, Nagpur after reliving from ICAR-IISS, Bhopal.
7. Shri Devendra Kumar Dharam joined on 07.09.2022(A/N) on promotion at NBSS&LUP, Nagpur as Deputy Director (OL).
8. Dr. Arijit Barman, Scientist joined on 19.09.2022 at NBSS&LUP, Regional Centre, Jorhat after relieving from CSSRI, Karnal.
9. Shri Rakesh Kumar Jatav, Administrative Officer joined on 07.11.2022 at NBSS&LUP, Nagpur.
10. Shri Amit Kumar Dash joined to the post of Sr. Technical Officer (T-6) (Soil Science) under Functional Group Field/Farm Technician w.e.f. 19.12.2022 at NBSS&LUP, Nagpur.
11. Ms Moumita Ash joined to the post of Sr. Technical Officer (T-6) (Soil Science) under Functional Group Field/Farm Technician w.e.f. 19.12.2022 at NBSS&LUP, Nagpur.

RETIREMENTS

- Dr. P. Chandran, Principal Scientist and I/c, Head, Division of SRS, Nagpur 30.04.2022
- Dr. B.A. Dhanorkar, CTO, Regional Centre, Bangalore 30.06.2022
- Shri M.M. Bhagat, Technical Assistant, Nagpur

30.06.2022

- Shri R.A. Nasre, CTO, Nagpur 30.06.2022
- Dr. N.C. Khandare, CTO, Nagpur 31.07.2022
- Shri Devilal Oad, Technical officer, Regional Centre, Udaipur 31.07.2022
- Shri K. Paramesha, Technical Officer, Regional Centre, Bangalore 31.07.2022
- Dr. B.S. Dwivedi, Director, Nagpur 28.08.2022
- Shri Nirmal Saikia, SSS, Regional Centre, Jorhat 31.08.2022
- Dr. Dipak Dutta, Principal Scientist, Regional Centre, Kolkata 31.10.2022
- Shri S.C. Kolhe, Asstt. Administrative Officer Nagpur 31.10.2022
- Shri R.B. Mehto SSS, Regional Centre, New Delhi 31.12.2022
- Shri Bhoora Prasad, Asstt. Chief Tech. Officer, Regional Centre, Bangalore 31.12.2022
- Shri D.R. Borkar, Technical Assistant, Nagpur 31.01.2023

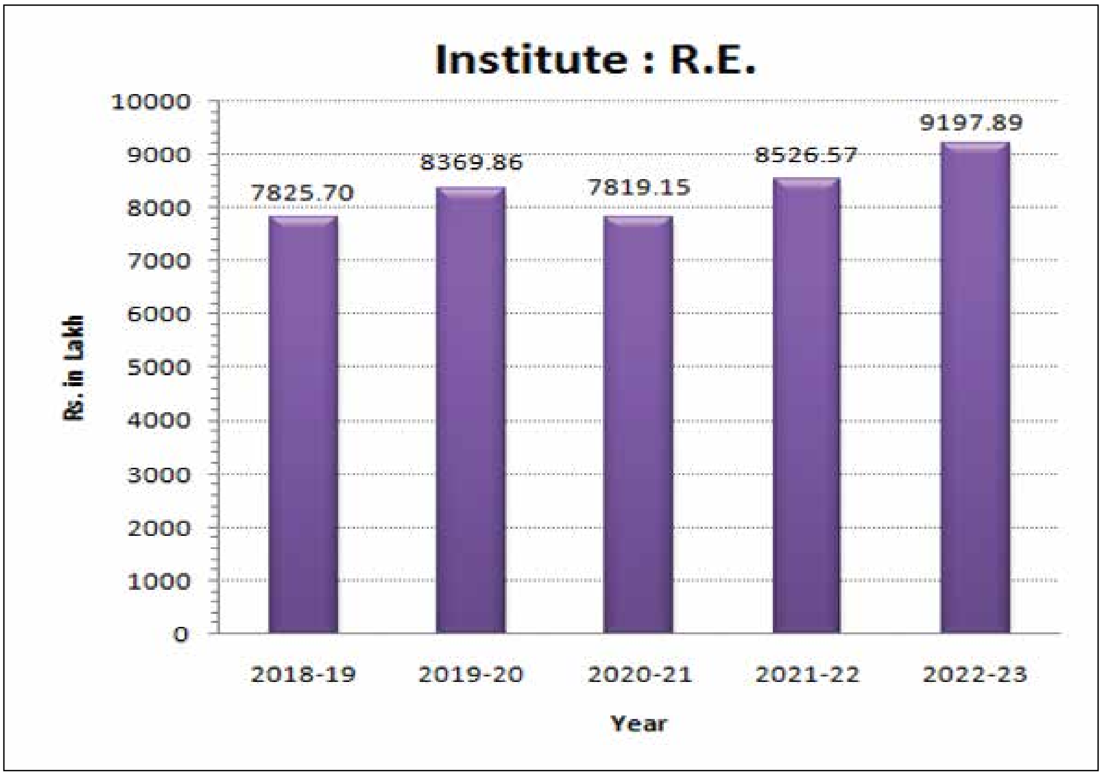
STAFF MOVEMENT

- Dr. R.S. Meena, Sr. Scientist transferred from Regional Centre, Udaipur to RegionalCentre, Jorhat.
- Dr. R.P. Sharma, Sr. Scientist transferred from NBSS&LUP, Division of SRS, Nagpur to Regional Centre, NBSS&LUP, Udaipur.
- Dr. S. Chattaraj, Sr. Scientist transferred from NBSS&LUP, Division of RSA, Nagpur to Regional Centre, NBSS&LUP, Kolkata.
- Shri Sanjay Bokolia, Chief Administrative Officer (Sr. Grade) transferred from NBSS&LUP, HQrs., Nagpur to ICAR, HQrs., New Delhi.
- Shri Kamlesh Sharma, Asstt. Administrative Officer transferred from Regional Centre, Udaipur to NBSS&LUP, HQrs., Nagpur.
- Shri Sumit Sindhu, Asstt. Administrative Officer transferred from Regional Centre, New Delhi to Regional Centre, Udaipur.
- Ms. Subhashree Satapathy, LDC transferred from NBSS&LUP, HQrs., Nagpur to IIWM, Bhubaneshwar.
- Ms. Shilpi Verma, Scientist transferred from Regional Centre, New Delhi to IARI, New Delhi

PROMOTIONS

- Dr. Ashok Kumar, Scientist promoted to the next higher grade Rs.8000/- (Level-12) as Sr. Scientist w.e.f. 03.06.2021.
- Dr. Mrs. R. Vasundhara, Scientist promoted to the next higher grade Rs.8000/- (Level-12) as Sr. Scientist w.e.f. 15.12.2021.
- Dr. Ravindra K. Naitam, Scientist promoted to the next higher grade Rs.8000/- (Level-12) as Sr. Scientist w.e.f. 15.12.2021
- Mrs. C. Radhika, Scientist promoted to the next higher grade Rs.8000/- (Level-12)23.06.2019.
- Shri V.N. Parhad, Asstt. Chief Technical Officer promoted to the post of Chief Technical Officer w.e.f. 12.05.2021.
- Shri V. Mohan, Asstt. Chief Technical Officer promoted to the post of Chief Technical Officer w.e.f. 19.11.2018.
- Shri S.C. Gharami, Ex. Sr. Technical Officer promoted to the post of Asstt. Chief Technical Officer w.e.f. 17.02.2019.
- Shri P.V. Ambekar, Asstt. Chief Technical Officer promoted to the post of Chief Technical Officer w.e.f. 17.04.2022.
- Shri Sunil Meshram, Sr. Technical Officer promoted to the post of Asstt. Chief Technical Officer w.e.f. 16.07.2021.
- Dr. Deepak Mohekar, Sr. Technical Officer promoted to the post of Asstt. Chief Technical Officer w.e.f. 17.11.2018.
- Shri B.S. Kumawat, Senior Tech. Assistant promoted to the post of Technical Officer w.e.f. 29.06.2021.
- Shri Kuldeep Singh, Senior Tech. Assistant promoted to the post of Technical Officer w.e.f. 04.11.2021
- Shri Amitabh Baruah, Tech. Assistant promoted to the post of Sr. Technical Assistant w.e.f. 24.11.2021.
- Shri C.K. Kumawat, Senior Technician promoted to the post of Technical Assistant w.e.f. 26.02.2019.
- Smt. Vandana Patil, Technician promoted to the post of Senior Technician w.e.f. 15.07.2021.
- Shri Mahesh Roy, Technician promoted to the post of Senior Technician w.e.f. 25.08.2021.
- Shri S.A. Bhoyar, Technician promoted to the post of Senior Technician w.e.f.15.09.2021.
- Smt. Kalpana Biswas, Technician promoted to the post of Senior Technician w.e.f. 18.07.2021.
- Shri Unnikrishnan Nair, Assistant granted MACP w.e.f.19.06.2021.
- Smt. P. Chandrakala, Assistant granted MACP w.e.f.12.12.2021.

13 BUDGET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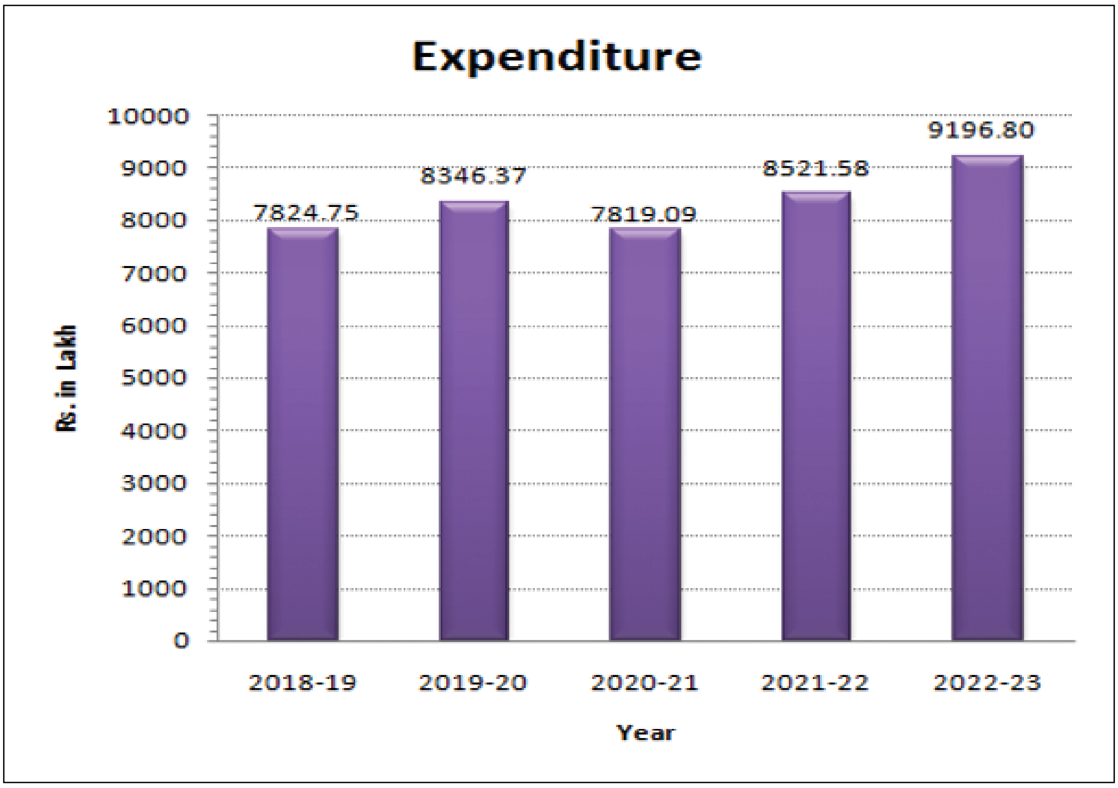
2019-20
2020-21
2021-22
2022-23
Year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8521.58
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2018-19
2019-20
2020-21
2021-22
2022-23
Year

ICAR-NBSS&LUP IN MEDIA

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Geospatial technologies have immense potential in inventory, mapping: Dr Dwiwedi

- NBSS&LUP and DST hold national-level Winter School on Advance Geospatial Technologies

Staff Reporter

ICAR-National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Nagpur inaugurated Department of Sci- Technolo-

tions, overall quality of life, human livelihoods and food security. He informed that geospatial technologies have immense potential in inventory, mapping and enable us to generate precise geospatial databases on a regular basis for better mapping and monitoring and management of lands at

that recent satellite data have immense potential in mapping and monitoring of degraded lands in the country.

Dr G P Obi Reddy, Principal Scientist and Course Director, Division of Remo- Applica-

नागपुर भास्कर

21 दिवसीय प्रशिक्षण कार्यक्रम का शुभारंभ

अधिकारी सीखेंगे मृदा सर्वेक्षण और प्रयोगशाला विश्लेषण की नई तकनीक

भास्कर संवाददाता | नागपुर

मृदा संसाधन अध्ययन विभाग, राष्ट्रीय मृदा सर्वेक्षण एवं भूमि उपयोग नियोजन ब्यूरो में मंगलवार को 21 दिवसीय प्रशिक्षण कार्यक्रम 'मृदा

से लगातार अनुसंधान कर रहा है, जिसका लाभ प्रशिक्षार्थियों को मिलेगा। महाराष्ट्र में चल रही भूमि सुधार परियोजनाओं में सहयोग प्राप्त होगा। कार्यक्रम की अध्यक्षता करते हुए ब्यूरो के निदेशक डॉ. बी. एस. द्विवेदी

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46th Foundation Day of ICAR-NBSS&LUP on 27th

Dr B S Dwivedi, Director, ICAR-NBSS&LUP addressing a press conference, on Thursday.

Staff Reporter

ICAR-National Bureau of Soil Survey and Land Use Planning

tion respectively. Dr CD Mayee, Former Chairman, Agricultural Scientist Recruitment Board (ASRB) will grace as the special invitee. Dr Dwivedi further elaborated, natural resources like soil, are facing

he said. The Bureau is collecti documenting the informa land resources of India fo 45 years for the benef developmental agencie departments, farmers user agencies, he add

NBSS&LUP, RC, Udaipur in News

किसान गोष्ठी का आयोजन

उदयपुर (वि)। आजादी का अमृत महोत्सव कार्यक्रम की श्रृंखला में भारतीय कृषि अनुसंधान परिषद के निर्देशानुसार भा.कृ. अनु.प. राष्ट्रीय मृदा सर्वेक्षण एवं भूमि उपयोग नियोजन ब्यूरो, क्षेत्रीय केन्द्र उदयपुर के

वाटरशेड विकास योजना को विश्व बैंक ने भी अपनाया : डॉ. द्विवेदी

- भाकृअनुप-एनबीएसएस और एलयूपी का स्थापना दिवस समारोह कल

भास्कर संवाददाता | नागपुर

भाकृअनुप-राष्ट्रीय मृदा सर्वेक्षण एवं भूमि उपयोग योजना ब्यूरो, नागपुर की वाटरशेड विकास योजना पर कर्नाटक सरकार ने अमल किया। वाटरशेड विकास योजना में तकनीकी सहायता से लाखों किसानों को मिट्टी और जल संसाधनों के स्थायी प्रबंधन के साथ कृषि उत्पादकता बढ़ाने में लाभ हुआ है। विश्व बैंक ने इस विकास मॉडल को अपनाया है और अन्य विकासशील देशों में एलआरआई की वकालत की है। यह बात ब्यूरो के निदेशक डॉ बी एस द्विवेदी ने कही। उन्होंने बताया कि 27 अगस्त को ब्यूरो 46वां स्थापना दिवस मनाएगा। ब्यूरो के निदेशक डॉ बी एस द्विवेदी ने बताया कि समारोह के मुख्य अतिथि केंद्रीय सड़क परिवहन मंत्री नितीन गडकरी होंगे। महानिदेशक और सचिव डेयर, डॉ हिमांशु पाठक, डॉ एसके चौधरी, उप महानिदेशक (एनआरएम) आईसीएआर नई दिल्ली क्रमशः समारोह के अध्यक्ष और विशेष अतिथि होंगे। डॉ सीडी माई, पूर्व अध्यक्ष कृषि वैज्ञानिक भर्ती बोर्ड (एएसआरबी) विशेष आमंत्रित के रूप में समारोह में शामिल होंगे।

ब्यूरो के निदेशक डॉ द्विवेदी ने बताया कि राष्ट्रीय मृदा सर्वेक्षण और भूमि उपयोग योजना ब्यूरो (आईसीएआर-एनबीएसएस और एलयूपी), नागपुर की स्थापना 1976 में तत्कालीन अखिल भारतीय मृदा और भूमि उपयोग सर्वेक्षण संगठन (एआईएस और एलयूएस) से कृषि और किसान मंत्रालय के डेयर / आईसीएआर के तहत की गई थी कल्याण। ब्यूरो का प्राथमिक उद्देश्य संबंधित संस्थान और सहयोग से भूमि उपयो के लिए देश मानचित्रण व के पांच क्षेत्रों जोरहाट, कोल स्थित पांच क्षेत्र

प्रेस कॉन्फ्रें एनजी पाटील, ड डॉ प्रमोद तिवारी, ओबी रेड्डी, डॉ कार रघुवंशी, डॉ निर्मल नीमखेड़कर, प्रकाश आनंद नागर प्रमुखता

Fri, 26 August 2022

शेतकरी मित्रांनी घाबरू नका
नियोजनात्मक शेती करा - डॉ रघुवंशी

- गरंडा येथे शेतकऱ्यांसाठी मोफत सतर्कता व जागरूकता सप्ताह कार्यक्रम
- अनेक शेतकऱ्यांनी घेतला लाभ

शेतकऱ्यांनो नियोजनात्मक शेती करा

गरंडा येथे सतर्कता व जागरूकता कार्यक्रमात डॉ. रघुवंशी यांचे आवाहन

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