Annual Report 2012-2013

NBSS&LUP

National Bureau of Soil Survey and
Land Use Planning (I.C.A.R.)
Nagpur - 440033

Annual Report 2012-2013

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Preface

THE Bureau can look back with pride on what it has achieved in RD & T programmes undertaken during 2012-2013. Significant R&D achievements have been, among others, development of Decision Support Systems (DSS) for land use planning of districts of Nadia (West Bengal), Almora (Uttarakhand) and Bundi (Rajasthan), development of a Geoportal each of Indian Soil Information System and District Soil Information System for selected districts of the country, revision of agro-ecological subregion maps of the Indo-Gangetic Plain (IGP) and Black Soil Region(BSR) of the country, development of soil nutrient maps of the state of Assam, prediction of global warming effect on soil organic carbon status and assessment of effect of different nutrient management interventions on total organic carbon in the long-term fertilizer experiment (LTFE) site of Palampur, Himachal Pradesh. The Bureau continued to provide software solutions to a number of research activities, such as, soil correlation and land evaluation. The year has also been remarkable in that we reached out to more number of stakeholders in a more purposeful manner and involved them in planning as well as implementation of our programmes. The number of linkages with national and international organizations grew substantially. The Bureau continued to use new science and emerging technology namely, nano-technology in pedological studies, soft computing techniques in land evaluation and neural network based pedo-transfer functions in estimating hydrological properties of soils. It becomes important for me to mention that the focus in 2012-13 was largely on R&D activities in land use planning and varied aspects of land use planning were addressed at different levels.

Human resource development (capacity building) through education and training continued to be a major activity. The Bureau organized a number of training programmes for its stakeholders in its mandated areas of work. A number of staff underwent national trainings in varied fields. The Bureau brought out a total of 245 publications including 39 research papers in various national and international referred journals. Compared to last year, there has been a marginal increase in the number of research papers published in referred journals. I am confident, with the 2 NAIP projects (one under component-3 and the other under component-4) and 2 of the subprojects under the National Network Project on District Level Land Use Planning expected to be completed by March 2014, we shall see a promising increase in the total number of (quality) research publications in the coming year.

I am thankful to the Chairman and members of Research Advisory Committee (RAC), the Chairman and members of Institute Management Committee (IMC)) and the Member-Secretary of Institute Research Council (IRC) for the guidance and support provided in formulating and pursuing our RD&T programmes.

I am highly grateful to Dr. S. Ayyappan, Secretary, DARE and Director General, Dr. A.K. Singh, former Deputy Director General (NRM), Dr. A.K. Sikka, Deputy Director General (NRM) and Dr. P. Minhas, Assistant Director General (Soils), ICAR, New Delhi for their able guidance and continued support and also for encouraging new research initiatives.

I appreciate the sincere and dedicated efforts put in by the scientists in the huge task of compiling and editing the report. I am extremely pleased to place the Annual Report (2012-13) for public scrutiny. I welcome suggestions and feedback from the readers.

(**DIPAK SARKAR**)
DIRECTOR

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Executive Summary

THE National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) conducted research under five broad themes, viz. Inventorying Natural Resources, Remote Sensing, GIS and Cartography, Basic Pedological Research, Soil Survey Data Interpretations and Applications and Land Evaluation and Land Use Planning. Some of the significant research achievements have been development of Decision Support System (DSS) for land use planning for three districts, development of a Geoportal each of Indian Soil Information System and /District Soil Information System for selected districts of the country, revision of agro-ecological subregion maps of the Indo-Gangetic Plain (IGP) and Black Soil Region(BSR) of the country, preparation of soil nutrient maps of Assam, prediction of global warming effect on soil organic carbon status and assessing effect of different nutrient management interventions on total organic carbon in the long-term fertilizer experiment (LTFE) site in Palampur, Himachal Pradesh. The Bureau continued its endeavours to use new science and emerging technology namely, nanotechnology in pedological studies and soft computing techniques in land evaluation. Imparting education to PG students, organizing training for stakeholders and deputing its staff for various trainings (in India and abroad) formed the key components of capacity building activities. The Bureau not only maintained but also increased the linkages and collaborations with a number of national and international oganisations. A brief on research project-based achievements and other important non-project activities is given below.

Research Achievements

Inventorying Natural Resources

Soil and land resources inventory was undertaken at different levels namely, village block, panchayats and districts of different states for identifying soil potentials and constraints and assessing fertility status (in a few cases). Soil suitability evaluation was also undertaken for a number of crops in a good number of projects. Soil correlation activity was taken up in different states. 19 per cent of the area in Durgada Nagenhalli village in Tumkur district, Karnataka suffered from slight and severe erosion whereas 28 per cent area was moderately eroded. In Multala village of Anantpur district, Andhra Pradesh, nearly 52.1 per cent of the area was severely eroded. 47 per cent variations in apple

fruit yield in Shimla district of Himachal Pradesh were attributed to slope, organic carbon, available zinc, soil depth AWC and CEC. 52 per cent area in Sunderpur village, Lakhan Majra block, Rohtak district of Haryana was affected by sodicity and 25 per cent area in Guraohti village (of the same block) was salinity affected whereas 12 per cent of the area was poorly drained.

Nearly 56.6 per cent was moderately eroded and 27.8 per cent was severely eroded in Katonigaon panchayat of Jorhat district, Assam. Water harvesting is suggested to improve crop productivity. In East Lahing gram panchayat, Jorhat district, 34.8 per cent of the area was suitable for banana and potato, 29.1 per cent for tea and 25.1 per cent of the area was highly suitable for rice. Ten soil series were tentatively identified and mapped into 16 soil mapping units (as phases of soil series) in the gram panchayat. Physico-chemical characterization of soils of three NICRA villages representing different agro-ecological systems in northern states of India indicated that the soils of AER 15 in Uttar Pradesh were mildly to strongly alkaline, low in available N and P. Soils of AER 14 in Himachal Pradesh were rich in organic carbon, medium in N, high in P, K, S and micronutrients. The moisture status of soils of Sibsagar district in Assam was estimated during post kharif season to explore the possibility of growing a second crop. For growing a second crop in light textured soils, irrigation would be an essential requirement.

Physico-chemical characteristics of soils in Hasnabad and Namkhana blocks, 24 Parganas, West Bengal, identified soluble sodium and calcium as the dominant cations and chlorides and sulphates as the dominant anions in the former and sodium and magnesium were the dominant cations and chlorides and suphates were the dominant anions in the latter. In Rohtas district of Bihar, the soils in Inceptisol order occupied 54.8 per cent of the area followed by the soils in Alfisol order with 19.7 per cent area, 9.1 per cent area in soils under Entisol order and 6 per cent area in Vertisol order. 41.4 per cent soils are highly suitable for paddy whereas 20.1 per cent soils are moderately suitable. Land evaluation was undertaken in soils of Aurangabad district, Bihar for different crops in different physiographic units. In Patnagarh subdivision in Odisha, very deep soils covered 37.04 per cent of the area, moderately deep soils covered 33.1 per cent, shallow soils covered an area of 10.9 percent, deep soils covered 7.8 per cent and slightly deep soils covered 1.1 per cent area in the subdivision. Soils of the Bolangir sub-division of Odisha (AESR 12.1) were observed to have medium AWC and a LGP of 180-210 days. Thirty-two Benchmark soils of Odisha state were characterized and classified for agro-technology transfer. Twenty one soils belonged to high lands, 9 soils belonged to coastal plain and 2 soils belonged to Dandakarnya region. Soils of Mahanadi basin in Bolangir district, Odisha over pediment and upland were cropped for paddy, maize and cotton in summer and oilseeds and pulses in winter. Cropping intensity increased on undulating dissected plains and gently to very gently sloping riverine plain. 38 soil series in Chittorgarh district, Rajasthan have been mapped as 70 soil series associations. Two soil series were mapped in Jhalarapatan block of Jhalawar district, Rajasthan.

Information on soils, socio-economic interpretation and land use indices were integrated to develop a soil quality index in the ten villages of Bhadesar tehsil, Chittorgarh district, Rajasthan. Soils of Bhadesar and Gudha had the highest soil quality index due to gentle slopes, better soil depth and fine texture. 9 soil series have been finalized for inclusion in the National Register of soil series namely, 2 from West Bengal, 5 from Goa and 2 soil series from Rajasthan.

Remote Sensing, GIS and Cartography

Multi-criterion analysis was carried out in GIS using land use, erosion, land capability, Storie Index and Require productivity index based on ranking to

delineate priority areas to implement soil and water conservation measures in selected Blocks of Bankura, Puruliya and West Mednipur districts of West Bengal. Seven priority classes were delineated. Run-off estimation was done to prioritize area for soil conservation measures in Badajorenala micro-watershed of Utkal Plain of Odisha. Relatively higher run-off was estimated under Typic Haplustepts and Typic Haplustalfs cultivated to *kharif* paddy with clay loam to silty clay soil. Soil fertility parameters were predicted in soils of West Bengal using visible and near infrared (VNIR) soil reflectance measurements. Relatively good calibration models have been obtained for OC, available N, phosphorus (P_2O_5) and potassium (K_2O) with a coefficient of determination (r2) of more than 0.60 and RFD values greater than 1.70 indicating that these soil properties can reliably be predicted from soil reflectance data. Best spectral model was developed with an r2 value of 0.705, 0.816 and 0.611 for sand, silt and clay content, respectively in soils of the Indo-Gangetic Plain (IGP).

A comparative assessment was done of soil maps prepared using conventional and remote sensing approach in terms of map accuracy, cost and time saving in basaltic terrain of Nagpur district. The overall accuracy of soil map prepared by remote sensing approach had an accuracy of 59 to 73% at 90% probability whereas, the soil map prepared by conventional approach had an accuracy of 67 to 85% at 90% probability level. It was observed that there was about 23% saving in cost and 32% in time when remote sensing-based soil mapping is done.

A methodology for preparing detailed soil map depicting phases of soil series at cadastral-level in basaltic terrain has been described using high-resolution digital elevation model (DEM) generated from Cartosat-1 stereo pair and Cartosat-1 sharpened IRS-P6 LISS-IV data. Descriptive statistics of soil properties analyzed from limited data sets indicated spatial variability in soil pH (6.2 to 8.7), EC (0.06 to 0.62 dS m^{-1}), OC (0.18 to 1.17 per cent) and available K (123 to 762 kg ha^{-1}). A proto type Geoportal (standalone) for Indian Soil Information System with soil database on 1: 250000 scale was developed. A proto type Geoportal (standalone) for District Soil Information System with soil database on 1: 50000 scale was developed. Land productivity potential map for cotton in Wardha district of Maharashtra was generated. Spatio-temporal variability in area, production and productivity of rice was found to be significant in Haryana (4.2%, 6.3% and 2.0%) followed by Karnataka (1.1%, 2.7%, 1.6%). West Bengal has the highest area (56.30 lakh ha) followed by Uttar Pradesh (51.86 lakh ha). A document on "Data Content Standard-Soils" ver. 3.0 has been generated and released by NSDI which contains data specifications of soil resource database.

Pedo-ecological units were delineated by integrating terrain parameters, soil parameters, rainfall and cropping system to predict land productivity potential (LPP) for cotton crop in Wardha district of Maharashtra. Using the integrated information, land productivity potential map for cotton was generated. Spatio-temporal variability of major crops in different states of India for land use planning indicated that the growth in area, production and productivity of rice were found to be significant in Haryana (4.2%, 6.3% and 2.0%) followed by Karnataka (1.1%, 2.7%, 1.6%). West Bengal has the highest area (56.30 lakh ha) followed by Uttar Pradesh (51.86 lakh ha). Under soil resource database for National Spatial Data Infrastructure, a document on "Data Content Standard-Soils" ver. 3.0 has been generated and released by NSDI which contains data specifications of soil resource database.

Basic Pedological Research

Relationship of geomorphic processes has been established for major landforms of Karnataka which helps in establishing the aggredational / degradational nature of the terrain, nature of weathering and other superficial characteristics.

This knowledge is essential for understanding the spatial variability of soils.

Clay content, depth, bulk density and available water were the soil properties identified affecting land use and management in watershed of Chotanagpur plateau, West Bengal. Thus four functional units which are equivalent to soil map units were identified that do not differ significantly with respect to these soil properties. Attempts are being made to revise the methods of determination of available potassium (In NH_4OAC) in shrink-swell soils which are dominated by smectite minerals. Different extractants were tried to get relationship between the forms of K and crop response. Two new extractants were screened out for the determination of available K which showed promising results which gives optimum values within the range of standards used to indicate soil-test-crop response values. Mineralogical investigations of shrink-swell soils of central highlands (Malwa and Bundelkhand) hot subhumid dry eco-region indicate chlorized smectite as dominant mineral along with mica and kaolin. Sub microscopy studies of sand fraction indicate presence of zeolite and highly weathered feldspars. Multiple regression equation was developed and relationship between water retention characteristics and soil properties were established for dominant shrink-swell soils of Yavatmal district, Maharashtra. Geochemical analysis of shrink-swell soils of Yavatmal district shows a curvilinear relationship of fine clay with Al and Ca plus Mg as Mg and Al are structurally a part of smectite, normalizing the diluents effects of carbonate in these soils. Attempts are being made to separate nano clays from fine clays of shrink-swell soils from across different agro-ecological subregions of the country by sonification and centribugation.

Soil Survey Data Interpretations and Applications

Soil fertility assessment and soil health monitoring in traditional rubber growing areas of Kerala, Karnataka and Tamil Nadu were attempted. Soils were analysed to find deficiency of Mg^{++} and Ca^{++}. Research on microbial biomass carbon indicated its decrease with soil depth in forest, cultivated land and tea garden in north-eastern region. While interpreting soil nutrient database for site specific fertilizer recommendations, available P is reported higher in Darjiling, Dinajpur and Kochbihar in West Bengal. Similar exercise in selected districts of Jharkhand showed that acidity, low organic carbon and phosphorous are limiting in soils.

Simulation of Century and Roth C models indicated a good agreement between model and actual observations in field. The results of Roth C model showed that treating soils as different layers will predict actual effects of global warming in accelerating decomposition of soil carbon. To help the models using Roth C, Century and Info Crop, nearly 100 soil series were completed in an user-friendly manner. Georeferenced soil information system permitted identification of minimum datasets for monitoring soil quality and land evaluation in the IGP and BSR. These database also helped in revising the agro-ecological subregion boundaries to generate modified AESR maps of IGP and BSR.

Land Evaluation and Land Use Planning

Various research activities in land evaluation and land use planning included, among others, land use planning at district and watershed levels, working on soil suitability evaluation for crops, contingency planning, impact of different policies on land use and participatory methods of land use planning. National network project on land use planning was continued in different districts/ watersheds of the country and interventions to utilize available resources, for example, opening of hard crusts between surface soil and sub-soil at regular intervals, suggesting land use based on land resource inventory (horticulture, forage, forest etc.) were proposed. Existing land use options in representative areas

were evaluated and alternative options were suggested based on soil mapping units identified through survey and consultation with the farmers. Similarly, fertilizer management practices in combination with type of seed were evaluated in a representative village of Haryana. Based on the analysis, soil series(s) were identified for optimum crop production. As a part of inventorization using modern tools for integrated watershed development, IRS P6 LISS IV data were analysed in GIS environment and thematic soil maps were prepared.

A case study was conducted in National Capital Region (NCR), New Delhi to analyse the temporal changes and its impact. It was noted that net sown area in Haryana NCR is declining faster than that in the rest of the state. On the other hand, study on natural resources management issues indicated that despite availability of natural resources, poverty prevails in many parts of the country. However, there cannot be a generic approach/solution to mitigate poverty through utilization of natural resources. Declining per capita land availability is a major concern for the country. Analysis indicates that human population in Eastern plains of the country must be deployed in activities other than agriculture, primarily, because carrying capacity of available land has reached saturation level. Central part of the country faces a paradoxical situation where surface water, ground water goes unutilized despite relatively lower population and better per capita land availability.

Efforts to mitigate effects of climate change through resilient agriculture were continued through research on contingency crop planning. New challenges in land resource management were addressed through research on land evaluation for rainfed Bt cotton. The interface between soil-based technologies and on-field research was provided by two projects *viz*., Tribal Sub-Plan (TSP) and NAIP C-3. NAIP sub-project on livelihood security. Different modules of technologies implemented in the project villages were refined and the impact has been assessed. Implementation of interventions derived from optimal plan to utilize natural resources has demonstrated that livelihood security of agrarian population can be achieved.

Post Graduate Education

- Seven M.Sc. (LRM) and three Ph.D. (LRM) students submitted their thesis during the current academic session, in the Post-Graduate Education and Research programme undertaken at the Hqrs. with Dr. PDKV, Akola.

Training Organised

- Seven trainings were organized in the field of latest techniques of Remote Sensing, GIS, Carbon Modelling, Soil Survey and Mapping and Land Resource Management.

Training Received

- Three officials from the Bureau received training in various fields. Of these, one official received international training.

Ongoing and completed projects

- Ongoing Institutional projects : 62
- Ongoing Externally funded projects
  - DST sponsored : 03
  - NAIP projects : 03
    - * As consortium lead institute : 02
    - * As consortium partner : 01
  - State Govt. sponsored : 12
  - Total : 80
- Completed projects : 32
  - Institutional : 10
  - Externally funded : 22

Linkages

A number of new linkages were developed with various organizations in addition to the priorly existing ones.

Publications

- Research papers published : 39
- Reports/Bulletins : 41
- Books : 03
- Book chapters : 42
- Popular articles : 10
- Seminar/Symposia papers : 108
- Others : 02

Awards and Recognition

- This year has been a rewarding year for the Bureau as its scientists and staff were honoured with a number of awards and recognitions.

1 NBSS&LUP : A Profile

Genesis

Subsequent to 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 and address regional specific issues in the mandated areas of work. Besides, there are a number of units and sections, which provide scientific and technical support to the research divisions and regional centres in accomplishing varied tasks.

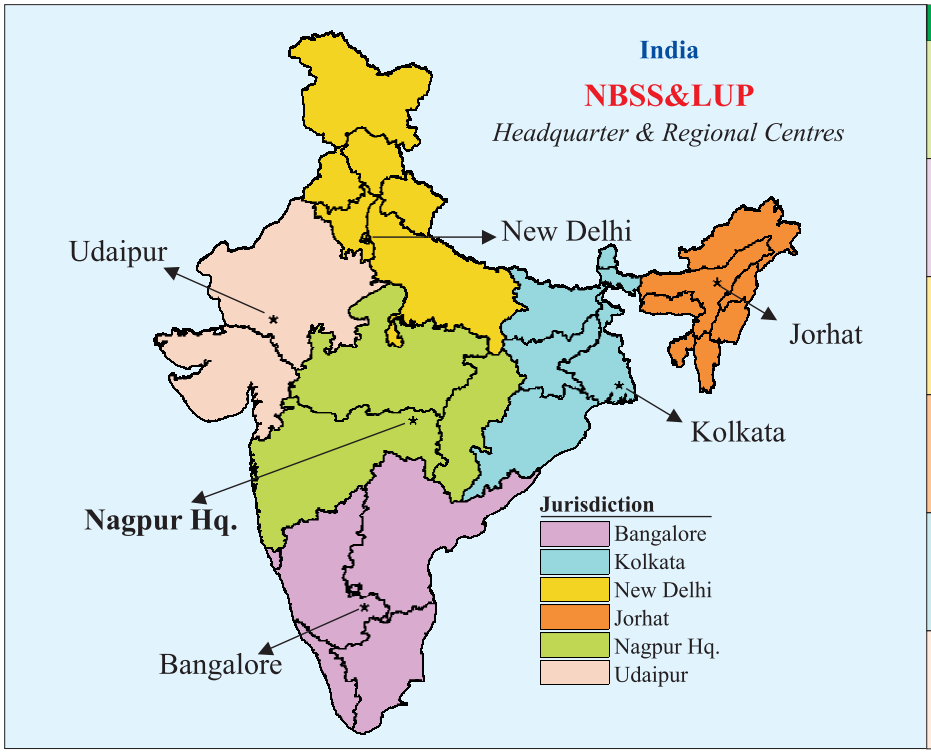
The Bureau is the country's only premier national institute mandated for research, development and training (RD&T) in the field of soil survey, land use planning and allied aspects. Over the years, the Bureau has excelled as a centre of RD&T in Soil Survey and Land Use Planning at national and international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

Location

The Hqrs. is located on Amravati Road (Kolkata-Mumbai National Highway 6). It has in its close vicinity the ICAR-affiliated National Research Centre for Citrus (NRCC), Ginning Training Centre (GTC) a regional centre of Central Institute for Research on Cotton Technology (CIRCOT), and Regional Remote Sensing Centre (RRSC) (ISRO). The campus of the Bureau is also quite close to Nagpur University. The Hqrs., therefore, has locational advantage which facilitates multi-disciplinary studies, inter-institutional interactions and research linkages, etc. A map showing location of the Hqrs and the five regional centres is shown below.

Mandate

- To conduct soil survey and mapping of the soils of the country to promote scientific and optimal land use programmes in collaboration with relevant institutions and agencies.



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- 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, in collaboration with other relevant agencies.
- To impart training and education to create awareness on soil and land resources and their state of health.

The role of the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) becomes all the more important in view of the serious challenges the country faces in terms of shrinking soil and land resource base, soil/land degradation, depleting nutrient stock, deterioration in soil/land quality, changing climate, land use conversion and non-judicious planning of land use.

Major Research Themes

- Inventorying Natural Resources
- Remote Sensing, GIS and Cartography
- Basic Pedological Research
- Soil Survey Data Interpretation and Applications
- Land Evaluation and Land Use Planning

Training Areas

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

Management

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

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

Infrastructural Facilities

- ***Laboratories***

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

- X-ray diffractogram
- Scanning Electron Microscope
- Inductively coupled Plasma Spectrometre
- Atomic Absorption Spectrophotometer
- Spectroradiometer
- Latest Remote Sensing and GIS softwares

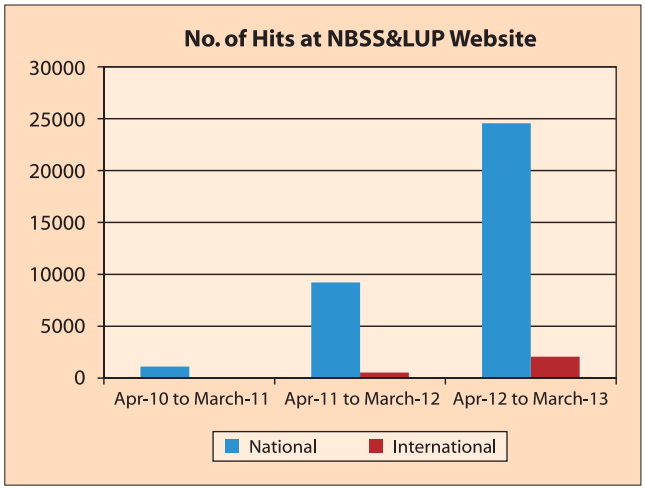
The facilities available in micromorphology and GIS laboratories are the best in the country that match international standards.

- ***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.

NBSS&LUP Website

The Bureau posts all important information about its activities, particularly about research projects, publications, linkages, educational trainings, staff and infrastructure on its Website (http://www.nbsslup.in). The year 2011-12 has been particularly a very momentous year for the Bureau as traffic to its website increased significantly.



Major Achievements

- ***1975-2010***

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

- An outstanding achievement has been in generating the Soil Resource Map of the Country on 1:1 million scale and its different states (on 1:500,000 scale).
- A 20-Unit Agro-ecological region and a 60-unit Agro-ecological sub-region map of the country were developed for regional planning.
- 273 soil series have been entered into the National Register*.
- A method has been developed for using remote sensing data, namely IRS-1C PAN merged data for large scale mapping of soils at village and watershed level.

(282 soil series have been entered into the National Register upto March 2013)*

- Soil reflectance properties have been successfully used as a potential tool to provide information on a wide range of soil properties.
- The Bureau has been an active partner in generating harmonized statistics of the degraded lands/wastelands according to which the country has about 121 m ha area under different forms.
- As per estimates made by the Bureau, the total carbon stocks in Indian soils at 150 cm depth is up to a 64 pentagrams (pg) (1 Pg = 10 to the power of 15 g) with considerable amount of inorganic form. This is the first ever estimate made on SOC stocks at national level.
- The Bureau developed land use options for 5 agro-ecosystems, namely, Rainfed, Irrigated, Arid, Hill and Mountain and Coastal.

➢ 2010-2012

Software Solutions

The Bureau has developed software solutions for soil correlation and land evaluation. The softwares have replaced age old, tedious and time-consuming manual methods of undertaking the aforesaid activities.

Development of Farmer's Advisory Services

A Farmer's advisory services has been developed to guide growers of vegetables, rice, fruits and pulses of West Bengal on the soil-fertility management, and has been hosted on www.wbagrisnet.gove.in of the NIC server, and is linked with the mobile cell-phone.

Soil Nutrient Maps

Soil (macro and micro) nutrient mapping has been undertaken by the respective Regional Centres of Kolkata and Jorhat at different levels of priority – districts, blocks, watersheds, villages and farms of the eastern and north-eastern states of the country. This activity has generated high utility soil-nutrient maps and revolutionized soil-fertility management in the states.

New Initiatives

- **Decision Support System (DSS) for Land Use Planning**

  A DSS each has been developed for land use planning for the districts of Mysore, Karnataka, Bundi, Rajasthan, Almora, Uttarkhand and Nadia, West Bengal.

- **Soil Resource Mapping for farm planning in India and development of national portal on soils**

  Lack of site specific data, particularly on soils and situation specific recommendations have been the major causes for the failure of most of the development schemes that operated in the past in our country. The project is planned to fill this vital gap by generating site-specific soil and other land resources data. The project will be executed by using modern techniques, tools and facilities in **a consortia mode** by involving State Departments of Agriculture, State Agricultural Universities, State Remote Sensing Applications/Service Centres, National Remote Sensing Centre, Soil and Land Use Survey of India and State Land Use Boards. The **National Bureau of Soil Survey and Land Use Planning (ICAR)** will act as a nodal agency by providing the required scientific/technical back up and **National Informatics Centre** will facilitate the establishment of National Portal of Soil and other land resources of the country for effective dissemination of the information.

- **Applications of Soft Computing Techniques in Land Evaluation**

  Land evaluation, the process of assessing land for defined uses, is an important prerequisite to undertaking land use planning. The Bureau,

in keeping with the latest developments in land evaluation, has initiated a research programme on applications of soft computing tools namely, fuzzy logic and artificial neutral networks in this field.

- **Nanotechnology Applications in Pedology**

  In keeping with the need of making concerted research efforts for development of technologies to sustain food security in the country, the Bureau has initiated a research programme on applications of nanotechnology in separating and characterizing soil nano particles (<100 nm) for studying soil formation and soil nutrient dynamics.

Linkages

The Bureau maintains close linkages with many national organizations like ICAR institutes, State Agricultural Universities and post-graduate teaching departments, and National Remote Sensing Centre (NRSC), Hyderabad for procurement of satellite data.

It maintains close linkages with international organizations like ICRISAT, Hyderabad, CYMMIT, New Delhi and ISRIC, ITC, The Netherlands .

Thrust Areas for XII Plan

- Development of land resource inventory for farm planning in India to provide site-specific database and recommendations.
- Development of demand driven soil resource inventory of disadvantaged districts, command areas, prioritized watersheds, villages and farming systems.
- Conducting basic and strategic research in pedology, remote sensing applications using GIS to soil resource mapping, land evaluation and land use planning using new science and emerging technologies.
- Assessment and monitoring of soil quality including soil carbon stock assessment.
- Assessment of degraded lands in the country at different levels for updating their status.
- Preparation of blue prints for efficient land use planning at different levels.
- Implementation of Tribal Sub Plan programme to provide soil based land use planning and to impart training in the selected tribal areas.

Flagship programmes

- Development of land quality indicators for sustainable land management in dominant land use systems of selected agro-eco sub-regions of India
- Development of Decision Support System (DSS) for land use planning at watershed level.

Platform programmes

- Conservation Agriculture
- Water Platform
- National Initiative on Climate Resilient Agriculture (NICRA)

Plan Budget (2012-13)

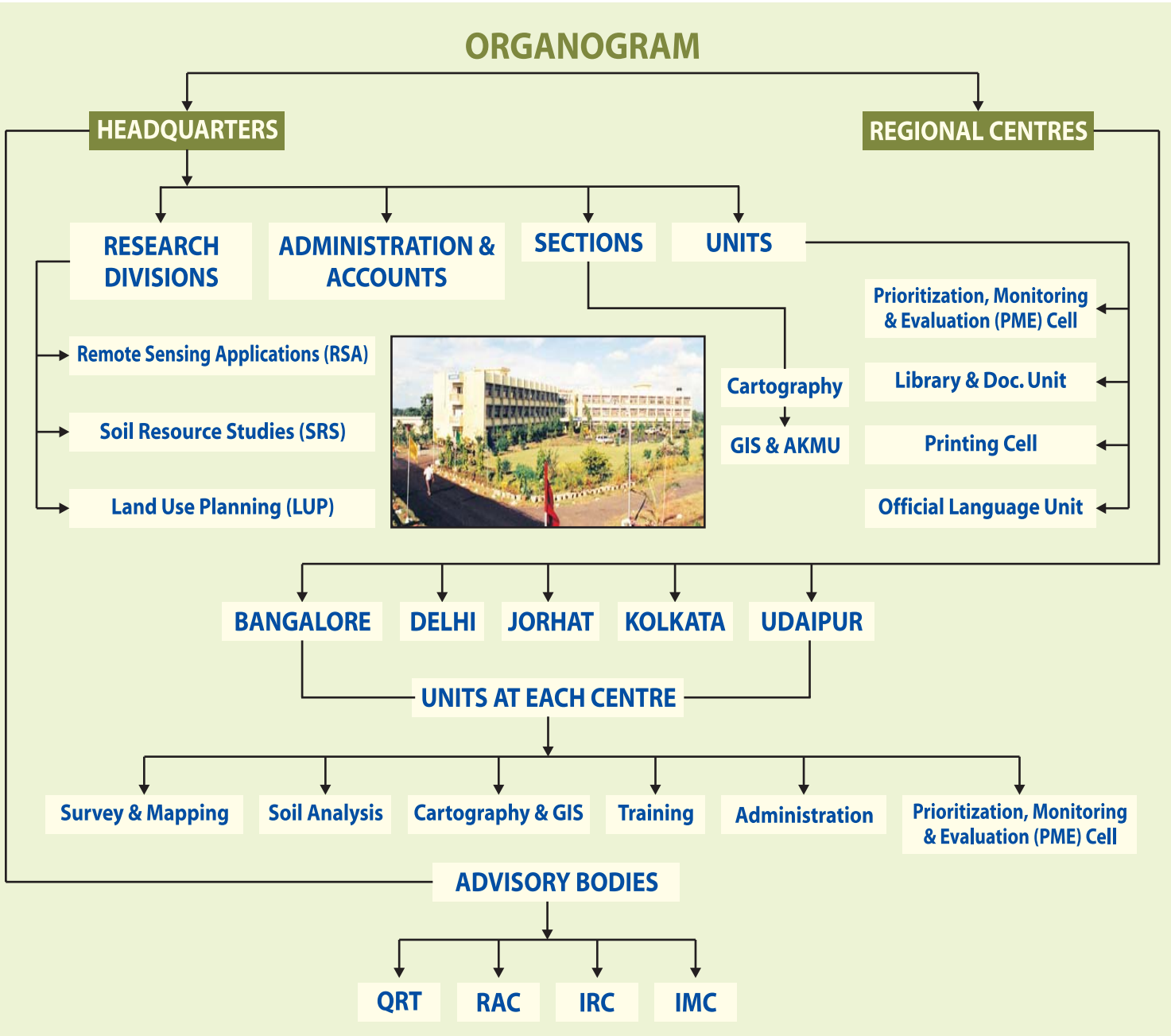
Funds Received : Rs. 375.00 lakhs
Funds Utilized : Rs. 374.98 lakhs

Staff Strength (as on 31.03.2013)

Sl. No.	Name of Post	Total		
		S	F	V
1.	RMP	01	01	00
2.	Scientific	99	75	24
3.	Technical	188	163	25
4.	Administrative	67	58	09
5.	Skilled Sup. Staff	76	71	05
	Grand Total	431	368	63

S: Sanctioned; F-Filled; V-Vacant

ORGANOGRAM


HEADQUARTERS
REGIONAL CENTRES
RESEARCH DIVISIONS
ADMINISTRATION & ACCOUNTS
SECTIONS
UNITS
Remote Sensing Applications (RSA)
Soil Resource Studies (SRS)
Land Use Planning (LUP)
Cartography
GIS & AKMU
Prioritization, Monitoring & Evaluation (PME) Cell
Library & Doc. Unit
Printing Cell
Official Language Unit
BANGALORE
DELHI
JORHAT
KOLKATA
UDAIPUR
UNITS AT EACH CENTRE
Survey & Mapping
Soil Analysis
Cartography & GIS
Training
Administration
Prioritization, Monitoring & Evaluation (PME) Cell
ADVISORY BODIES
QRT
RAC
IRC
IMC

RESEARCH ACHIEVEMENTS

2

2.1 Inventorying Natural Resources

- Soil and Land Resources Inventory
- Issue-based Survey: Soil Nutrients, Degradation and Desertification
- Soil Correlation and Classification

Land resource inventory of Durgada Nagenahalli village, Kortagere taluk, Tumkur district, Karnataka for integrated development

The project was carried out to provide the site-specific Land Resources Inventory (LRI) for planning and implementing various interventions under NICRA project implemented by Krishi Vigyan Kendra Hirehalli (IIHR), Bangalore. The moderate to steep slopes in the hills/rocky lands and gentle slopes in the uplands favour easy detachment and removal of soil particles from the surface. The

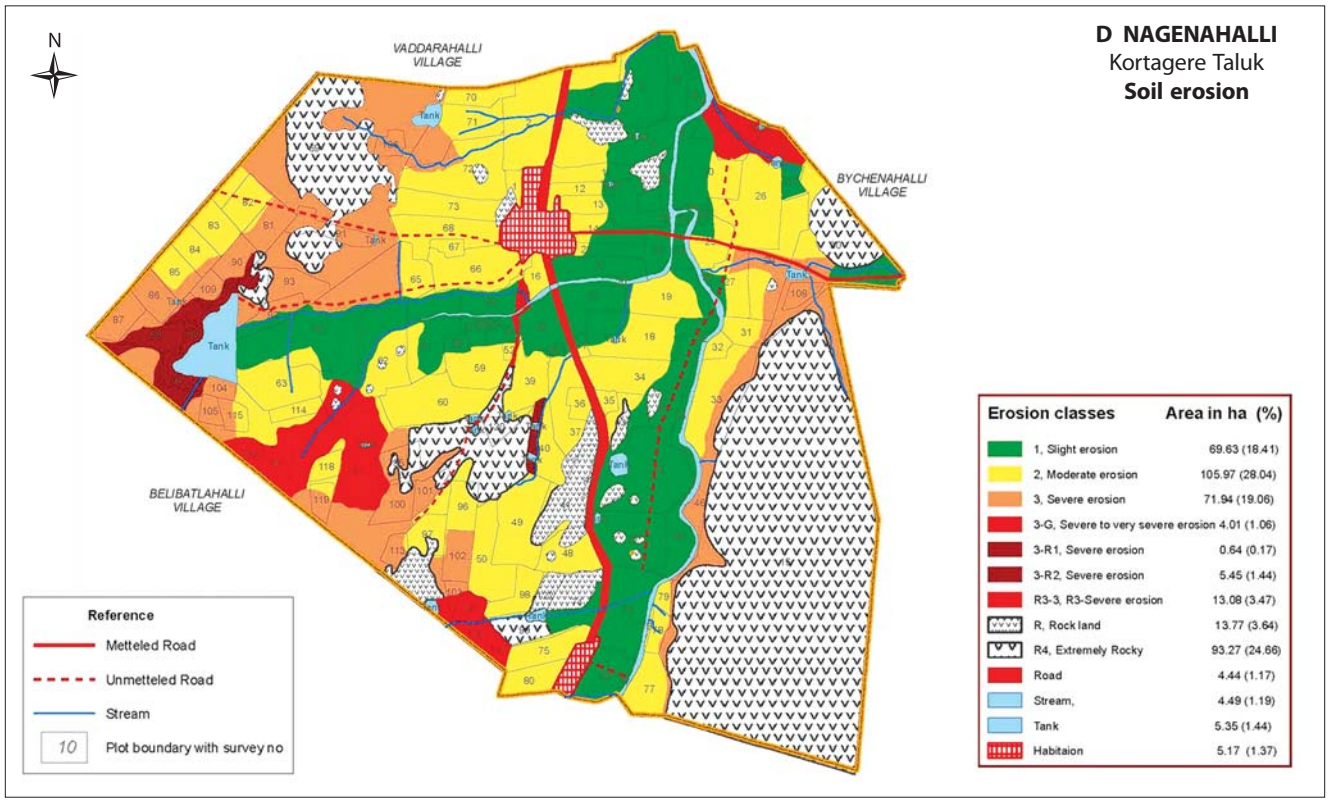


Fig. 1: Soil erosion map, D Nagenahalli, Kortagere Taluk

occurrence of sandy surface in upland soils associated with stones and gravel on the surface. Gully erosion is very common in the footslope areas. Soils that are slightly eroded cover an area of about 73 ha (19%), moderately eroded area covers about 106 ha (28%) and severely eroded area covers area 72 ha (19%) (Fig. 1).

Overgrazing by small ruminants in these areas is not allowing natural regeneration of vegetation and hence thus exposing the soils for degradation. *Pongamia spp*., *gooseberry*, *Azaridacta gravelia*, subabul, mulberry and caliandra need to be promoted in marginal lands. The area receives on average rainfall of about 800 mm. Large catchment for rainwater is available in the form of rock out crops and here all the rainfall is available for harvesting through farm ponds (7x7x3 m) to increase the cropping intensity.

The terraced cultivated fields having multiple/ complex slopes. Erosion problem continues in spite of terracing needs for create additional bunds to break the slope into homogenous units.

Land resource inventory for farm planning in Lakhan Majra block of tehsil and district Rohtak, Haryana (LRI-FP)

Detailed Soil Resource Inventory was carried out for seven villeges of Lakhan Majra block on scale 1:250,000 for farm level land use planning and identify the problem / potential areas. The village-wise land use statistics is presented in table 1.

Soil maps were prepared for all the villages. Soil map with suitability maps for major crops, fertility map and suggested land use maps for Tatauli village (model village) were generated (Fig. 2). The land resource information on present land use, soils,

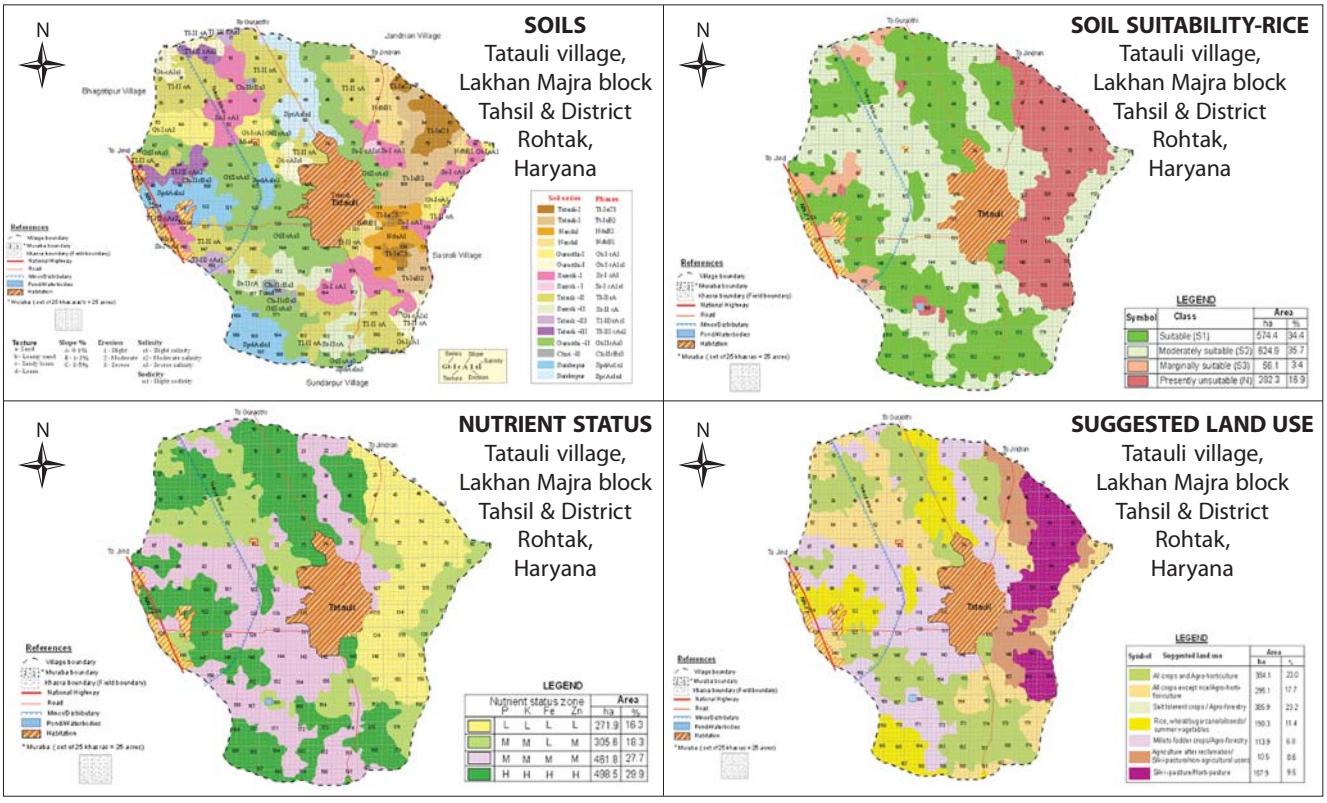


Fig. 2: Soil, nutrient status and suggested land use maps of Tatauli village, Lakhan Majra block for village level planning

suitability for dominant crops, problems/potentials, socio-economic constraints and management needs were integrated for different land use options.

Table 1: Village-wise land use statistics in Lakhan Majra block, Haryana

Village name	Strong to very strongly alkaline (%) of TGA	Salinity/ sodicity (%) of TGA	Poorly drained soils (%) of TGA
Sunderpur	52	13	-
Chiri	30	-	11
Tatuli	15	20	-
Guraothi	-	25	12

The information generated in the Lakhan Majra block can be a base line for development/planning of similar areas of the district and thus be helpful to the farmers, extension workers/officials and planners.

Land resource inventory of Katonigaon panchayat of Titabar block of Jorhat district of Assam (LRI-FP)

Detailed soil survey was carried out with the objectives (i) characterization and mapping of the existing land resources of Katonigaon Panchayat, (ii) identification of constraints in crop production and land utilization and (iii) land evaluation for identifying promising, viable and sustainable land uses. It is observed that Nagajanka 1, 3 and 4 soil series were suitable for tea plantation under good management practices while Nagajanka 2 and Bacha series may support short duration paddy and *rabi* vegetables with irrigation facilities.

Nearly 54.6% of area is moderately eroded and 27.8% is severely eroded. Loss of nutrients increase in fallow area, poor water management, and lack of irrigation facilities are the major constraints identified. To increase the productivity of the crops. Water harvesting technologies may be adopted on priority basis. The cultivation of vegetable in pady fallow of Bachabihari soil series may be encouraged.

Land resource inventory of East Lahing Gaon panchayat of east Jorhat development block, Jorhat district, Assam (LRI-FP)

Detailed soil survey of East Lahing Gaon Panchayat was carried out to identify the problems and potentials of mapping units for viable and sustainable land uses.

The land suitability assessment for crops indicated that 34.8% area was suitable for banana and potato, 14.8% for cabbage, respectively. Nearly 29.1% soils were highly suitable for tea and 25.1% for rice. Strong soil acidity and low cation exchange capacity are the major constraints towards crop production. Lack of irrigation facilities, poor farm management, scarcity of labours are the major problems of the area. Short term bund fishery in flood plains, installation of shallow tube well with pump sets for micro irrigation and construction of suitable rain water harvesting units, renovation of drainage streams, (Jagduarjan and Kaliapanijan) may facilitate the cultivation of *rabi* crops. In soils of Seojipam series, tea is the only potential crop, hence, tea plantation with homestead animal husbandry is proposed. In Changmai series, banana is recommended as homestead plantation with tea. In Janzi and Panitola series, cultivation of cabbage and potato is suggested in rice-fallow lands under shallow tube well micro-irrigation in raised bed furrow method. In Churamoni series, integrated paddy-cum-backyard poultry/ duckery is suggested and short term organized bund fishery is proposed during *kharif* season.

Land resource inventory for farm planning in different agro-ecological regions of India sub project: Bhadesar tehsil (cluster of 10 villages) in Chittaurgarh district (Rajasthan) (LRI-FP)

The detailed soil survey report of cluster of ten villages covering an area of 5163 ha of Bhadesar tehsil of Chittaurgarh district was prepared.

Besides, for integration of soil related information (slope, soil depth, particle size distribution and

surface texture), socio-economic information (literacy rate, workers, irrigability) and land use indices have been carried and described village-wise in all ten villages in Bhadesar tehsil. To see the relationship among these parameters simple correlations have been studied. The village-wise pattern of indices has been described. High soil quality index has found to be ranging between 3.7-4.2 may be due to lower slope gradient, fine surface texture and PSC and moderately deep to deep soil (Table 2). Highest literacy index encountered in Bhadsora (1.29) may be due to higher number of education facilities while in Daulatpura village the index was the lowest due to least number of education institutes. Higher agricultural labourers index ranges between 2.84-2.86 may be due to more number of people land less and poor education facilities in these villages which forces them to work as farm labourers (Table 3). The cultivator index was the highest (>1.2-1.4) in most of the villages but was the least (0.75) in Bhadsora village (Table 4). This may be due to less per capita agricultural land available, high literacy and also because of the location on main highways in Bhadsora village causing people to go outside to work in different places of country. The trend was reverse for non agricultural laborers index which was found highest in Bhadsora villages (1.78) and this may be due to high education and also low per capita agricultural land as people prefer to migrate to other place for jobs rather than to work as agricultural labour within the villages.

The higher net sown area index may be due to gentler slopes and deep fine textured soil. While unculturable waste land area index and culturable waste land index was found highest in most of the villages except Bhadsora and Gudha. High index of all villages except Bhadsora and Gudha soils may be due to slope gradient, shallow soils and comparatively loamy texture as compared to Bhadsora and Gudha villages.

Table 2: Soil quality index of cluster of ten villages

Villages	Slope index	Depth index	PSC index	texture index (Surface)	Compo-site soil Index
Bagund	2.87	2.38	2.81	3.74	2.95
Bhadsora	3.90	3.20	4.00	3.84	3.74
Daulatpura	3.36	2.97	3.66	3.95	3.49
Gudha	4.17	3.80	4.50	4.35	4.21
Madanpura	3.33	3.19	3.79	4.17	3.62
Narbadia	3.74	2.87	3.58	4.15	3.59
Nardhari	3.46	2.65	3.48	4.24	3.46
Parliyawas	3.17	2.83	3.07	4.14	3.30
Sohankhera	3.59	2.02	3.97	3.59	3.29
Surajpura	4.50	2.50	4.21	3.93	3.79

Table 3: Demographic index of cluster of ten villages

Villages	Literacy index	Total workers index	Agl. Labour index	Cultiva-tors index	Non-Agr. Workers index
Bagund	0.91	1.00	0.18	1.19	0.58
Bhadsora	1.29	0.91	0.93	0.75	1.78
Daulatpura	0.37	1.15	1.31	1.20	0.34
Gudha	0.82	0.84	1.94	1.23	0.13
Madanpura	0.55	1.13	2.84	1.17	0.13
Narbadia	0.69	1.14	0.38	1.12	0.75
Nardhari	0.86	0.69	4.05	0.94	0.57
Parliyawas	0.65	1.22	0.00	1.36	0.08
Sohankhera	0.71	1.23	2.86	1.18	0.09
Surajpura	0.74	1.11	0.00	1.36	0.10

Table 4: Land use index of cluster of ten villages

Villages	Irrigation index	Net sown index	Uncul. Waste land index	Cult. Waste land index
Bagund	0.74	0.80	1.30	1.21
Bhadsora	0.81	1.30	0.59	0.66
Daulatpura	0.89	0.87	1.53	0.94
Gudha	0.74	1.13	0.79	0.89
Madanpura	0.77	0.84	1.15	1.21
Narbadia	1.91	0.67	1.22	1.51
Nardhari	1.05	0.71	1.45	1.29
Parliyawas	1.39	1.09	1.12	0.76
Sohankhera	0.68	0.87	1.00	1.24
Surajpura	1.01	1.02	0.97	1.01

Land resource inventory and GIS database for farm planning in the coastal region of West Bengal

Soil resource survey was carried out in Hasnabad block, 24 Parganas (north) and Namkhana block, 24 Parganas (south) by integrating the IRS LISS IV P6 satellite data and cadastral map (base map) on 1:12,500 scales. After extensive field work and laboratory analysis, three soil series in Hasnabad and two soil series in Namkhana block were identified. These were mapped with three phases of salinity viz. slight, moderate and severe. The relevant soil properties of the identified series are shown in table 5.

Soil water extract (1:2) in Hasnabad block indicated that sodium and calcium ranged from 0 to 8.0 and 1.4 to 7.5 $meql^{-1}$ respectively. In 25 - 100 cm depth, the concentration of Ca and Mg ranged from 3 to 9.1 and 1.5 to 6.7 $meql^{-1}$. Chlorides and sulphates in 0-25 cm depth ranged from 0.5 to 38.0 and 0.1 to 5.5 $meql^{-1}$, whereas in 25- 100 cm depth it was 0.55 to 33.0 and 0.2 to 8.0 $meql^{-1}$.

The soil water extract (1:2) in Namkhana block indicated that in 0-25 cm depth, sodium and magnesium were the dominant cations, varying from 4.5 to 39.7 and 0.30 to 12.40 $meql^{-1}$ respectively. In 25-100 cm depth, the concentration of cations ranged from 4.4 to 55.2 and 0.20 to 13.2 $meql^{-1}$. Chlorides and sulphates in 0-25 cm depth ranged from 2.5 to 43 and 0.7 to 6.1 $meql^{-1}$, respectively, whereas their content in 25-100 cm depth varied from 2.5 to 56.0 and 0.9 to 6.5 $meql^{-1}$. Distribution of cation and anions in representative pedons of Hasnabad and Namkhana series is shown in table 6.

Table 5: Important morphological and physico-chemical properties of soil series identified in Hasnabad and Namkhana block

Horizons	Depth(cm)	Colour	pH (1:2)		EC(1:2)	OC	Sand	Silt	Clay
			H_2O	KCl	dSm^{-1}	(%)			
Hasnabad-silty clay loam(Coarse-silty Fluventic Haplustepts)									
Ap	0-14	DYB	7.1	6.6	1.79	1.03	2.1	64.0	33.9
Bw1	14-54	YB	8.1	7.2	0.65	0.12	1.1	85.0	13.9
Bw2	54-84	OB	8.1	7.4	0.59	0.16	0.1	79.6	20.3
2C1	84-120	OB	8.2	7.4	0.84	0.15	0.2	80.1	19.7
2C2	120-146	OB	7.8	6.9	0.89	0.19	2.4	61.4	36.2
Hasnabad-silty clay (Fine Aquic Haplustepts)									
Ap	0-16	VDGB	7.6	7.0	1.1	0.62	0.8	61.4	37.8
Bw1	16-43	DGB	7.7	6.8	0.87	0.36	0.8	55.3	43.9
Bw2	43-69	DB	7.7	6.8	0.89	0.24	0.9	54.7	44.4
Bw3	69-92	LOB	7.9	7.0	0.96	0.15	2.1	63.2	34.7
Bw4	92-120	LOB	7.9	6.7	0.92	0.24	2.5	59.7	47.8
Bw5	120-144	OB	7.8	6.7	0.81	0.15	4.0	39.6	56.4
Hasnabad-clay (Fine Aeric Endoaquepts)									
Ap	0-16	DB	4.7	4.2	2.33	1.2	1.2	29.3	69.5
Bw1	16-33	VDGB	7.0	6.2	2.06	0.88	0.9	27.3	71.8
Bw2	33-62	VDGB	4.8	4.3	3.82	1.45	1.9	32.4	65.7

cont...

Bw3	62-89	VDG	4.3	3.5	3.06	0.58	5.1	17.5	77.4
Bw4	89-125	VDG	4.9	4.3	3.02	0.41	0.8	23.0	76.2
Namkhana-silty clay (Fine Aeric Endoaquepts)*									
Ap	0-14	DGB	6.2	4.3	0.45	0.69	0.3	46.6	53.1
Bw1	14-56	G	6.8	5.7	0.96	0.26	0.2	40.5	59.3
Bw2	56-81	G	6.5	5.6	2.57	0.25	1.4	47.0	51.6
Bw3	81-108	G	5.1	4.2	2.91	0.28	0.2	49.1	50.7
Bwg4	108-130	VDG	4.2	3.4	2.78	0.80	2.2	44.1	53.7
Namkhana-silty clay loam (Fine Aeric Endoaquepts)*									
Ap	0-19	DG	6.7	5.8	2.7	0.73	0.6	64.6	34.8
Bw1	19-58	DYB	7.8	6.9	3.16	0.29	0.8	51.0	48.2
Bw2	58-91	VDG	7.1	6.2	3.91	0.26	1.2	48.0	50.8
Bw3	91-124	B	5.6	4.4	5.93	0.43	0.4	50.3	49.3
Bw4	124-165	B	4.8	4.0	1.24	0.46	2.0	52.5	45.5

DYB- dark yellowish brown, YB- yellowish brown, OB- olive brown, VDGB-very dark greyish brown, DG-dark gray, B- brown, G-gray, VDG- very dark gray, LOB- light olive brown.

* yellow jarosite mottles (hue) have been found in Namkhana soils.

Table 6: Cation and anion composition of soil water extract in meq l^{-1} (soil 1:2;water 1:2)

Depth (cm)	Na^+	K^+	Ca^{+2}	Mg^{+2}	CO_3^-	HCO_3^-	Cl^-	SO_4^{-2}
Hasnabad-silty clay loam								
0-14	3.7	0.01	6.8	1.7	Tr	Tr	13.5	0.6
14-54	2.3	0.01	2.1	0.8	Tr	1.5	1.5	0.6
54-84	3.0	0.01	2.1	1.1	Tr	1	3.5	0.6
84-120	3.2	0.01	1.8	1.2	Tr	2	5.5	0.7
120-146	3.5	0.01	2.3	1.7	Tr	0.5	6.5	0.6
Namkhana silty clay								
0-14	3.8	0.22	0.5	0.9	Tr	0.5	3.2	1.8
14-56	9.6	0.38	0.8	1.6	Tr	0.5	7.8	2.9
56-81	19.2	1.09	3.6	1.6	Tr	0.5	17.6	5.8
81-108	23.8	1.41	3.5	1.6	Tr	1.0	19.6	5.6
108-130	21.9	1.54	3.3	1.8	Tr	Tr	9.6	5.8

Land resource inventory for farm planning in Jhalarapatan block of Jhalawar district of Rajasthan

The project aims to provide the site-specific database needed for farm planning in Jhalarapatan micro-watershed. The detailed database generated at micro level will form the basis for prioritizing, initiating and executing any land-based developmental programms.

Total area of Jhalarapatan micro-watershed is 1722 ha.

The detailed survey of soils and land resources was carried out and mapping of 6 villages (Neemoda, Khanpuriya, Salarya, Govardhan Niwas, Mundlya Kheri, Chandloi) is over. Overall 70 observations have been taken including augur, minipits and profiles. Tentatively two soil series have been identified (Table 7).

Neemoda Series (Nmd)

The Neemoda series is a member of fine, smectitic, hyperthermic Typic Haplusterts. The soils of Neemoda have very dark brown, moderately alkaline, silty clay loam surface horizon and dark greyish brown, strongly alkaline, clayey B horizon. They have developed from alluvium and occur on nearly level plain lands with 0 to 1 per cent slope. The physico-chemical properties of Neemoda soil series are presented in table 8.

Khanpuriya Series (Khp)

The Khanpuriya series is a member of the fine mixed, hyperthermic Typic Haplustepts. The soils of Khanpuriya series have very dark greyish brown, moderately alkaline, silty loam surface horizon, and dark greyish brown, strongly alkaline, silt loam B horizon. They have developed from alluvium and occur on nearly level plain lands with 0 to 1 per cent slope. The physico-chemical properties of Khanpuriya soil series are presented in table 9.

Table 7: Soil series identifying characteristics in Jhalarapatan micro-watershed

Soil series	Depth (cm)	Texture	Gravels (Vol %)	Horizon colours	Reaction with dil.HCl	Horizon Sequence
Neemoda	>150	sicl,c, sic,scl	15-20	10YR 2/2, 10YR 2/2, 10YR 2/2, 10YR 2/2, 10YR 4/2	e, es, ev	Ap-Bw-Bss-Ck
Khanpurya	25-50	sil,scl	-	10YR 3/2, 10YR 3/2, 10YR 3/2, 10YR 5/2	es, ev	Ap-Bw-Ck

Table 8: Physico-chemical properties of Neemoda Series

Depth	Horizon	Sand	Silt	Clay	Texture	pH (1:2.5)	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)
		----------%----------							
0-23	Ap	9.42	51.49	39.09	sicl	8.3	0.29	0.76	7.82
23-49	Bw	9.59	39.87	50.54	c	8.7	0.34	0.56	8.71
49-72	Bss1	8.59	41.72	49.69	sic	8.9	0.47	0.43	9.82
72-135	Bss2	8.90	41.68	49.42	sic	8.8	0.81	0.40	12.94
135-165	Ck	48.87	21.39	29.74	scl	8.9	0.57	0.24	23.06

Table 9: Physico-chemical properties Khanpuriya series

Depth	Horizon	Sand	Silt	Clay	Texture	pH (1:2.5)	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)
		----------%----------							
0-9	Ap	9.01	73.19	17.80	sil	8.3	0.38	0.42	4.35
9-26	Bw1	10.17	72.27	17.56	sil	8.4	0.30	0.39	4.61
26-36	Bw2	11.52	64.7	23.78	sil	8.5	0.34	0.40	9.61
36-50	Ck	49.27	22.05	28.68	scl	8.68	0.22	0.11	23.32

Land resources of Muttala village for integrated watershed development

This project was taken up to generate site-specific resource database of Muttala village (1,788 hectares) in Atmakur mandal of Anantapur district, Andhra Pradesh for integrated watershed development by using cadastral map of the village as a base along with high resolution satellite imagery (IRS LISS IV and Cartosat-1). The area is mainly drained by Pedda Vanka river. The major crops grown in the area are groundnut, pigeon pea, castor and horticultural crops (mango and citrus) in rainfed-uplands and vegetables (tomato, chillies and okra) in the irrigated lowlands. The Muttala village receives average rainfall of 575 mm and rainfall varied from 245 mm and 762 mm. Last 10 years climatic data shows that length of growing period is 11 weeks which starts from the last week of August and continues up to the end of October (Fig. 3).

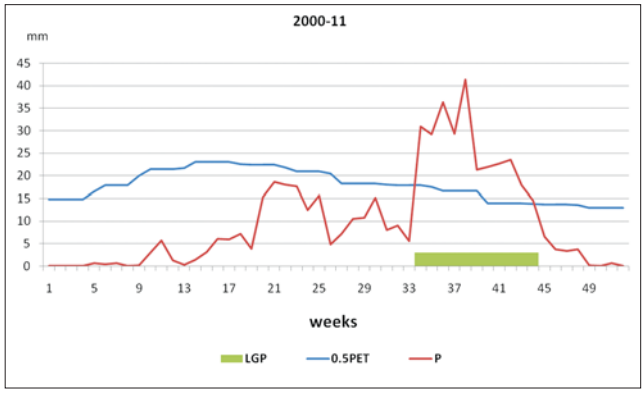


Fig. 3: Length of growing period of Atmakur mandal, Anantapur distirct

The detailed soil survey was carried out by using cadastral map (1: 10,000 scale) as a base in conjunction IRS LISS IV and Cartosat-1 were used to identify the landforms and other surface features. Based on visual interpretation of data, village was broadly divided into hills/ridges, summits, gently sloping uplands and lowland / valleys. Rocky hills and rock lands cover nearly 150 ha. Very gently to gently sloping lands cover nearly 71.4 per cent of the TGA. Lowland and valley cover nearly 11.3 per cent.

Seven soil series (41 phases) were tentatively identified and area was mapped into five soil series (32 phases) occur in the hills and upland areas and two soil series (5 phases) in the lowland area.

Nearly 69.4 per cent area is occupied by shallow (25-50 cm) and slightly deep (50-75 cm) soils and very shallow (10-25cm) soils occupies only 2%. The erosion assessment showed that 34.3 per cent of the area had soil loss more than 20 tones ha^{-1} $year^{-1}$. Severely eroded area covers an area of 931 ha (52.1%), moderately eroded 426 ha (23.9%) and slightly eroded about 185 ha (10.4%). Soils were grouped under 5 land capability classes (6 sub-classes). Nearly 185 ha (10.4%) area in the village had good cultivable lands (Class II) with moderate limitations of drainage. Soil suitability assessment indicated that groundnut, horse gram, sorghum, and pearlmillet are suggested uplands.

Fig. 4: Formation of initial gullies due to absence of conservation structures

The absence of conservation structure has reflect in the formation of gullies (Fig. 4). The measures like breaking slopes, contour farming, compartmental bunds, broad bed and furrows, conservation furrows, and mulching are to be taken up at the individual farmer's field. Inter-bund trenches have to be created for diverting rainwater into village tank. Continuous staggered contour trenches, gully plugging and agro-forestry, silvipasture, stone enclosures have been suggested for 64.08 ha of the

watershed where soils are gravelly loam and severely eroded with 3-5% slope.

Shallow rooted annual crops are suited for 71 per cent of uplands having shallow soils (<75 cm depth). Custard apple and jujube are recommended for shallow soils.

Soil Resource Mapping of Shimla District, Himachal Pradesh for horticulture plantation

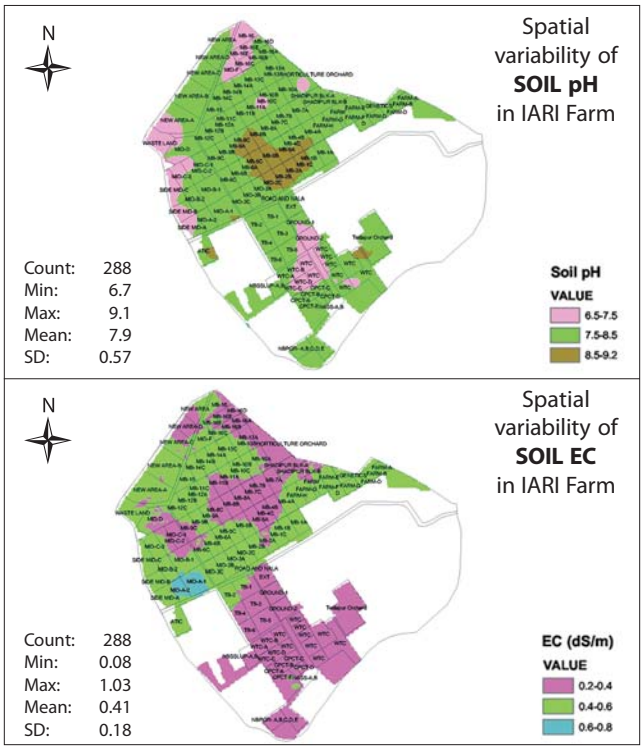
Part (70,000 ha) of Shimla district (H.P.) was selected for soil resource mapping (1:250,000 scale) to assess potentialities for horticulture. Visual interpretation of LISS IV data on 1:250,000 scale in combination with SOI Toposheets was done for physiography and land use. Physiographically, the area was delineated into summits/ridge tops, reposed hill slopes, piedmont and valley which were further sub-divided on the basis of land use and slope. Geologically, the area consists of quartzite, phyllites/quartzite and represents humid sub-temperate climate with MAT 15°C and MAR 900-1200 mm having LGP >300 days. The interpreted data and groundtruth indicated that area is dominantly under forest (53%) followed by cultivation (21%) under pasture and wastelands soil-physiography relationship was established. Twenty soil series were tentatively identified and mapped. Physiographically, 6 series fall occur on moderately sloping summits/ridge tops and 12 on steeply to very steeply sloping sides/ reposed slopes and 2 on moderately steeply sloping valley terraces.

A step-wise regression analysis was performed to determine dependence of apple fruit yield on different variables. The results revealed that

- 14% variation in yield were accounted by altitude alone. When it is combined with slope, organic carbon, available Zn, 40% variations could be explained. Inclusion of other parameters, such as, depth, AWC, CEC could account for 47% variations in yield.
- There are other environmental factors such as hill storms, spring frost, weather at the time of flowering and snowfall and site parameters such as aspect, drainage, erosion and physical condition of soil and timeliness of field operation, length on dry spells generally affect the yield.
- Elevation and slope are the two strong variables that had significant impact on yield.

Soil resource inventory of IARI Farm, New Delhi

Soil Resource Inventory of IARI farm was carried out on 1:4000 scale using grid observation. Ten soil series have been tentatively identified and mapped into 16 soil mapping units as phases of soil series. Thematic maps *viz* soil pH, EC, OC, available N, P, K and CEC of the soils, fertility maps have been generated and spatial variability has been studied (Fig. 5). The study reveals that pH of the soils varied from 6.7 to 9.1, EC from 0.08 to 1.03 dSm^{-1}, OC from 0.06 to 1.11%. Available N from 132 to 514 $kgha^{-1}$, available P from 3.1 to 254 $kgha^{-1}$ and available K from 98 to 1879 $kgha^{-1}$, respectively.



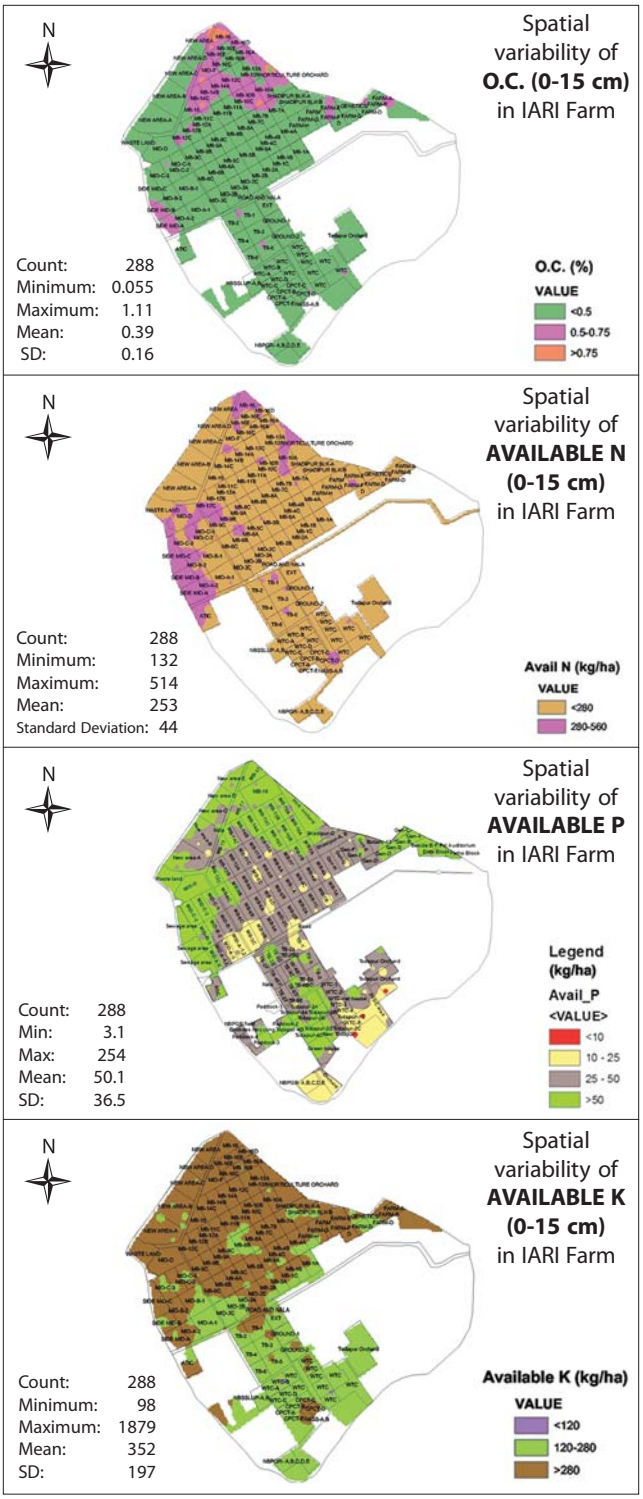


Fig. 5: Spatial variability of soil properties, IARI Farm, New Delhi

Study of crop moisture availability of soils during post – *kharif* period in Sibsagar district of Assam

The objectives of the project were (i) to quantify the moisture status of soils during post- *kharif* period, (ii) to explore the possibility of growing a 2nd crop (*rabi*) in the rice-fallows and (iii) to establish the relationship between various soil properties (organic carbon, particle-size, moisture at 33 and 1500 kPa.

In this study, soil samples were collected from 18 locations representing active flood plain, recent flood plain, lower flood plain and lowland of Sibsagar district of Assam. Soil moisture was estimated at different suctions *i.e.*, at 33, 100, 300, 500 and 1500 kPa. Correlation study shows that bulk density had a negative correlation with O.C (-0.277 at 5% level of significance). Soil moisture tension, both at 33 and 1500 kPa were negatively correlated with all the sand fractions and positively correlated with clay and O.C. About 75.6% variability in moisture content at 33 kPa and 70.9% at 1500 kPa with independent soil variables (B.D., O.C., sand, silt, clay and very fine sand) is explained by the regression model. At an average, soil moisture removal rate of 5mm day^{-1}. In winter, light soils could hold water for a period of 10 to 13 days, medium soils for 29 to 33 days and for heavy soils 28 to 37 days. It is estimated that the actual soil moisture supplying capacity of light textured varies from 46 mm to 62 mm, medium textured soils from142 to 166 mm and of fine textured from 139 to 183 mm. Irregation for *rabi* crops in light soils is must.

Soil resource inventory and land evaluation of Rohtas district, Bihar (1:50,000 scale) for land use planning

Soils resource inventory of Rohtas district, Bihar was carried out on 1:50,000 scale and soils were mapped into 32 soil mapping units as soil series associations of 25 soil series. Inceptisols cover (54.8%), Alfisols (19.7%), Entisols (9.1%), Vertisols

(6.0%), rock outcrops (4.5%) and miscellaneous area(5.9%) of total geographical area (TGA) of the district. Among Suborders, Ustepts cover (35.2%), Aquepts (19.6%), Ustalfs (10.9%), Aqualfs (8.8%), Orthents (7.7%), Usterts (6.0%) and Psamments (1.4%) of the TGA. Among great groups, Haplustepts (35.2%), Endoaquepts (19.6%), Haplustalfs (10.9%), Endoaqualfs (8.8%), Ustorthents (7.7%), Haplusterts (6.0%) and Ustipsamments (1.4%) of the TGA associated with 19 families.

The soils of the district were grouped into 4 land capability classes and nine 9 sub-classes. The major limiting factors were erosion, texture, gravelliness and shallow soil depth in Kaimur plateau; poor drainage and clayey texture in the alluvial plain. Nearly, 54.6% area of the district falls under land capability class (LCC-II) with the sub-classes of IIw (19.2%), IIe (28.7%) and IIs (6.7%). The area under LCC-III accounted for 16.7% of the district with the sub-classes of IIIw (5.9%) and IIIe (10.8%). The LCC-IV covers an area of 8.1% of the district under the sub-classes of IVes (6.7%) and IVsw (1.4%), respectively. The LCC VII was mostly mapped on residual hills and Kaimur plateau and accounted for 11.2% area of the district.

Suitability evaluation indicated that 41.4% and 20.1% area of the district were highly and moderately suitable for paddy cultivation respectively (Fig. 6), whereas 29.4% area of the district was highly suitable; 23% area moderately suitable; and 22.1% area marginally suitable.

Soil resource inventory and land evaluation of Aurangabad district, Bihar (1:50,000 scale) for land use planning

Figure 7 presents the soil map of Aurangabad district, Bihar. Soil suitability evaluation was

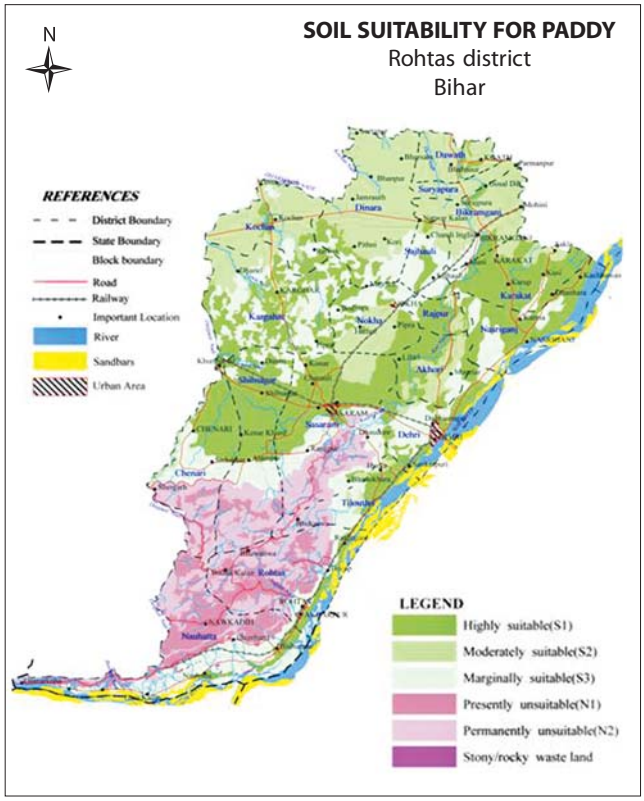


Fig. 6: Soil suitability map for paddy of Rohtas district

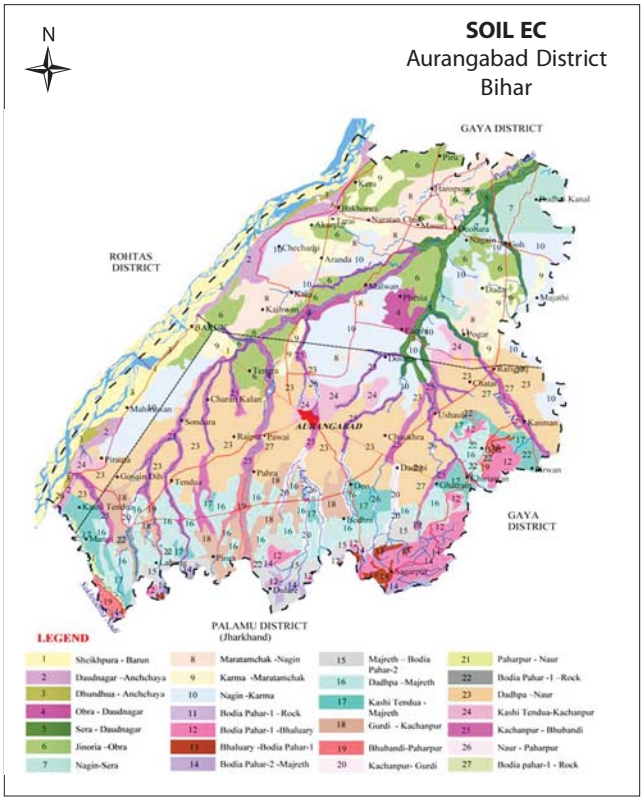


Fig. 7: Soil map of Aurangabad district, Bihar

undertaken in different soil mapping units of the district of Aurangabad for different crops. Soil map unit 2 (Table 10) occurring in flood plains were moderately suitable for wheat, maize, gram, lentil, pigeon pea, mustard, sesame groundnut and pea; marginally suitable for rainfed bunded rice and potato. Soil map unit 4, 5, 6, 7, 8, 9 in river valleys and old alluvial plains were moderately suitable for wheat and maize; marginally suitable for rainfed bunded rice, gram, lentil, pigeon pea, mustard, sesame groundnut and vegetables. Soil map unit 16, 17 and 18 covering undulating uplands were moderately suitable for wheat, maize, pigeon pea, mustard and sesame; marginally suitable for rainfed bunded rice, gram, lentil, groundnut and potato. Soil map units 19, 20, 23, 24, 25 of undulating plain were moderately suitable for wheat, maize, pigeon pea, gram, lentil and sesame; marginally suitable for rainfed bunded rice, mustard, groundnut and vegetables. River terrace associated with soil mapping unit 1 was moderately suitable for maize, lentil, and sesame; marginally suitable for rainfed bunded rice, wheat, gram, mustard and groundnut. Hills and hillocks with rock outcrops under mapping unit 11, 12, 13, 22, 27 were permanently unsuitable for agricultural crops and to be kept under agro-forestry and / or MPT of forest spp.

Table 10: Suggested crop and cropping sequences in different mapping units of Aurangabad district, Bihar

Soil map unit	Recommendation
1	*Kharif* - Rainfed bunded rice/ maize-gram/lentil *Rabi* - Wheat – mustard/ sesame-fallow
2	*Kharif* – Rainfed bunded rice/ maize-gram/lentil *Rabi* – Wheat – mustard/sesame-vegetables
4, 5, 6, 7, 8, 9	*Kharif* – rainfed bunded rice – vegetables *Rabi* – Wheat – potato/onion/tomato/ cabbage/cauliflower
16, 17, 18	*Kharif* – Rainfed bunded rice- gram *Rabi* – Wheat / mustard/ sesame – fallow
19, 20, 23, 24, 25	*Kharif* – Rainfed bunded rice- gram *Rabi* – Wheat / mustard/ sesame – fallow
11, 12, 13, 22, 27	Afforestation with quick growing forest species/Agro forestry

Soil resource inventory and geodatabase for developing land use planning in Patnagarh sub-division, Bolangir district, Odisha

Soil resource inventory was taken on 1:50000 scale for Patnagarh sub-division, the north western part of Bolangir District covering an area of 186596 hectare in Odisha. Four physiographic divisions viz. Hills, pediments, uplands and dissected plains were delineated on khondalite and granite-gneiss of Archaean formation.

Soil-Physiography relationship (Fig. 8) showed that the soil on the hill side slopes were moderately deep to deep, dark reddish brown to reddish brown, well drained, sandy clay loam on the surface and sandy clay to clay in the sub-soil. The soils on the pediments were slightly deep to moderately deep, dark brown to dark reddish brown, well drained, sandy loam soils on surface and gravelly sandy loam (gravel 60-70%) in the sub-soil. Moderately sloping uplands had deep, dark yellowish brown to dark brown, well drained, sandy clay loam on surface and sandy clay to gravelly sandy clay in the sub-soil. However, on the lower elevations, the soils were moderately deep, well drained, brown to dark reddish brown, sandy loam on the surface and gravelly sandy clay in sub-soil. Dissected plains were

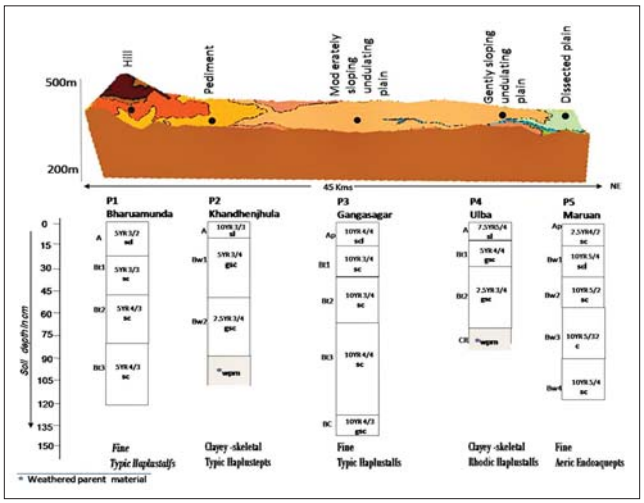


Fig. 8: Soil-physiographic relationship in Patnagarh sub-division of Odisha

associated with deep dark greyish brown to yellowish brown, moderately well to somewhat poorly drained, sandy clay (surface) and sandy clay to clay soils in the sub-soils.

During the survey, thirteen soil series were identified and soils were mapped in 12 soil series associations. Very deep soils covered 37.04%, moderately deep soils (33.1%), shallow soils (10.9%), deep soils (7.8%) and slightly deep soils (1.1%).

Soil resource inventory and geo-database for developing land use planning in Bolangir sub-division, Bolangir district, Odisha

The Bolangir sub-division of Bolangir district covers an area of 2002.78 km^2 and falls under AESR 12.1 *i.e.* hot moist sub-humid ESR with medium AWC and LGP of 180-210 days. During the year, soil-physiographic relationship was studied in 5 block of the subdivision (Fig. 9). It is observed that the soils on the elevated undulating upland were yellowish red, shallow to slightly deep, well drained, sandy clay loam on the surface and gravelly sandy clay in sub-soil. Other soils on dissected plains down the slope had dark reddish brown to dark yellowish brown, slightly deep to deep, well drained sandy loam to sandy clay loam on surface and clay/gravelly clay in the sub-soil. A lowest topographical position, the soils were very dark greyish brown/very dark grey to dark yellowish brown/dark brown, deep to very deep, moderately well to somewhat poorly drained, clay on the surface and clay to silty clay in the sub-soil.

Characterization and classification of benchmark soils of Odisha for agro-technology transfer

Benchmark soils represent single soils or suite of soils that have the large extent within one or more major physiographic regions; hold key position in the soil classification system; has special importance to one or more significant land uses, or has significant ecological importance. Such kind of thirty two soils have been identified in the state of Odisha. Physiographically, twenty one soils belonged to highlands, nine soils to coastal plain and two soils to Dandakarnya. Location of benchmark soils are shown in figure 10. Land uses and variations in morphological properties of benchmark soils of northern Eastern Ghats are shown in figure 10. Morphological and physico-chemical properties of seven benchmark soils belonging to seven sub-physiographic regions within three dominant physiographic regions are shown in table 11.

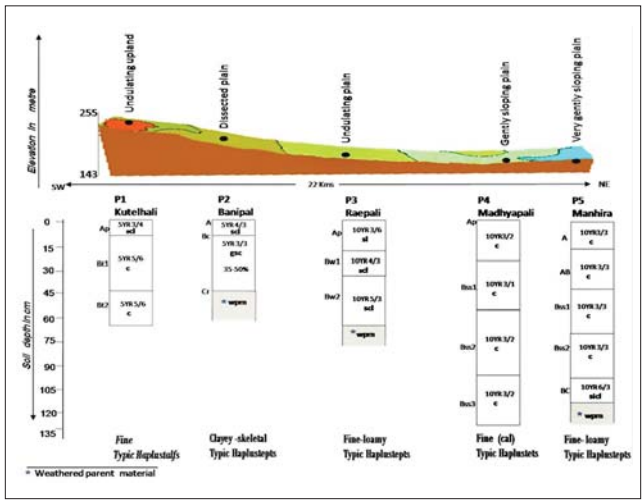


Fig. 9: Soil-Physiography relationship in Bolangir sub-division of Bolangir district, Odisha

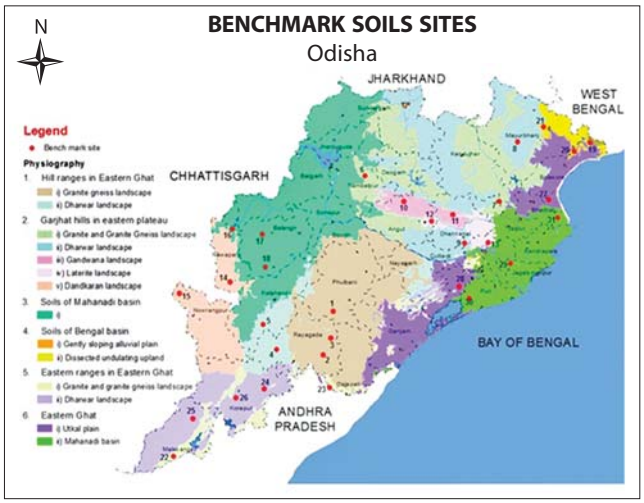


Fig. 10: Location of benchmark soils in Odisha

Table 11: Physical-chemical properties of some Benchmark soils of Odisha

Horizons	Depth (cm)	Colour	Structure	pHw 1:2.5	OC	Sand	Silt	Clay	AWC	CEC cmol(+) kg^{-1}	BS (%)
							(%)				
BM No.4 Eastern Ghat: village - Dongrepadar, Kalahandi (Fine-loamy, mixed hyperthermic Rhodic Paleustalfs)											
Ap	0-17	2.5YR 3/6	m 2 sbk	5.8	0.34	46.4	28.1	25.5	19.3	9.0	64
Bt1	17-48	2.5YR 3/6	m 3 sbk	6.0	0.27	40.2	31.7	28.1	21.7	9.8	69
Bt2	48-79	2.5YR 3/4	m 3 sbk	6.2	0.20	41.6	29.9	28.5	28.7	10.5	72
Bt3	79-110	2.5YR 3/4	m 3 sbk	6.3	0.21	37.6	33.3	29.1	24.9	11.4	74
Bt4	110-152	2.5YR 5/4	m 3 sbk	6.3	0.21	36.6	30.3	33.1	26.1	12.3	75
BM No.15 Dandakaranya: village - Daibota, Nawarangpur (Fine-loamy, mixed hyperthermic Typic Haplustalfs)											
Ap	0-14	7.5YR 4/6	m 2 sbk	5.8	1.04	41.8	33.0	25.2	16.7	15.3	63
Bw	14-38	5YR 4/4	m 2 sbk	5.9	0.59	41.6	32.3	26.1	18.4	15.2	66
Bt1	38-71	5YR 3/3	m 2 sbk	5.9	1.0	37.0	29.5	33.5	19.4	15.9	67
Bt2	71-108	5YR 3/4	m 3 sbk	5.8	0.67	35.3	30.6	34.1	13.4	14.9	64
Bt3	108-150+	5YR 3/4	m 3 sbk	6.0	0.46	34.3	31.0	34.7	12.9	15.3	69
BM No.17 Mahanadi basin: village - Sakoma, Bolangir (Fine, smectitic hyperthermic Typic Haplusterts)											
Ap	0-15	10YR 3/2	m 3 abk	7.5	0.62	17.7	43.5	38.8	10.3	19.0	76
Bw1	15-28	10YR 3/2	m 3 abk	7.8	0.35	16.2	40.2	43.6	10.2	20.1	78
Bw2	28-55	10YR 3/1	c 3 abk	7.9	0.27	13.4	46.9	39.7	8.3	19.6	80
Bss	55-98	10YR 3/1	c 3 abk	8.0	0.32	15.8	38.4	45.8	12.9	20.2	81
BC	98-127	10YR 3/1	c 3 abk	8.0	0.32	17.8	37.1	45.1	11.4	20.0	82
Cr	127-140					weathered granite-gneiss					
BM No.19 Bengal basin village - Saksai, Baleswar (Fine-loamy, mixed hyperthermic Typic Haplustepts)											
Ap	0-14	10YR 4/4	m 1 sbk	4.6	0.49	22.9	56.5	20.6	21.7	13.0	52
Bw1	14-40	10YR 3/6	m 1 sbk	5.4	0.23	20.4	60.8	18.8	22.7	12.8	57
Bw2	40-63	10YR 3/4	m 2 sbk	6.1	0.14	23.2	56	20.8	20	13.2	65
Bw3	63-88	10YR 3/4	m 2 sbk	6.1	0.14	20.3	60.8	18.9	19.9	13.4	67
Bw4	88-139	10YR 4/4	m 2 sbk	5.9	0.15	4.1	56.1	39.8	26.8	16.8	65
C	139+	7.5YR 4/3	massive								
BM No.24 Eastern Ghats: village - Sonabeda, Koraput (Fine-loamy, mixed hyperthermic Typic Rhodustalfs)											
Ap	0-15	2.5YR 4/6	m 2 sbk	5.3	0.70	43.5	20.2	36.3	9.7	6.0	65
A2	15-31	2.5Y 3/6	m 2 sbk	5.3	0.64	24.4	38.8	36.8	13.1	7.7	64
Bt1	31-51	2.5YR 3/6	m 2 sbk	5.2	0.55	60.2	11.5	28.3	12.5	7.6	63
2Bt1	51-93	2.5YR 3/4	massive	5.6	0.49	28.5	11.2	60.3	15.5	9.5	69
2Bt2	93-135	2.5YR 3/4	m 2 sbk	6.1	0.18	28.1	19.4	52.5	9.5	8.9	72
2Bt3	135-165	2.5YR 3/4	m 2 sbk	6.1	0.13	34.5	15.9	49.6	10.0	8.6	73

cont...

BM No.27 Utkal plain: village - Dolasahi, Bhadrak (Fine, mixed hyperthermic Typic Haplustepts)											
Ap	0-25	10YR 5/4	massive	4.3	0.77	14.4	55.2	30.4	14.1	15.5	50
Bw1	25-50	10YR 5/6	m 2 sbk	6.0	0.21	12.5	34.6	52.9	8.2	20.0	64
Bw2	50-79	10YR 5/6	m 2 sbk	6.0	0.15	17.0	42.5	40.5	11.6	19.0	65
Bw3	79-109	10YR 5/4	m 2 abk	5.9	0.15	26.0	30.6	43.4	13.2	19.2	71
Bw4	109-137	10YR 5/2	m 2 abk	5.9	0.13	45.1	22.4	32.5	10.2	18.2	72
Bw5	137-152+	2.5YR 5/2	m 2 sbk	5.9	0.12	17.1	52.5	30.4	12.4	19.0	72
BM No30 Mahanadi delta: village - Mangalpur, Puri (Fine-loamy, mixed hyperthermic Typic Haplustepts)											
Ap	0-12	10YR 6/6	m 1 sbk	5.7	0.38	26.9	53	20.1	15.7	7.5	61
Bw1	12-33	10YR 4/4	m 2 sbk	7.1	0.25	27.7	47.9	24.4	12.8	9.0	73
Bw2	33-62	10YR 3/4	m 2 sbk	7.1	0.24	10.7	54.9	34.4	11.6	14.1	72
Bw3	62-92	10YR 3/4	m 2 sbk	7.2	0.27	6.9	57.2	35.9	22.3	15.6	72
Bw4	92-119	10YR 3/3	m 1 sbk	7.6	0.13	43.6	38.5	17.9	15	8.5	78
	119-140+				Water saturated						

Influence of land use and management on soil properties in Mahanadi Basin of Bolangir district in Odisha

The project was conceived to understand the influence of land uses and management on soil properties in the state of Odisha (17°31' and 22°31' N; 81°31' and 87°3°' E) covering an area of 1,55,707 km^2 area, producing food and livelihood for about 36 million of people. The state receives 1300 to 1500 mm rainfall in three months. The state is divided into three physiographic regions viz. Highlands, Dandakarnya and 440 km long coastal region opening in Bay of Bengal. The state has variety of soils, varying from red laterites to grey brown and black soils, suffering from slight to severe erosion. The irrigation potentiality through major and minor projects is higher in the coastal areas and highlands than Dandakarnya region. However, the productivity of the cereals and the cash crops is in reliance with availability of moisture.

For assessing the impact of present land use and management on soil organic carbon and silt content, a sampling was done based on landforms-soils-land uses during the year and soil samples were collected from 0-25 cm depth in Mahanadi basin of Bolangir district (Table 12). The data on land use and management were collected by interacting with the farmers. Pediments and upland were cropped for paddy, maize or cotton in summer, oil seeds and pulses in winter at places, whereas cropping intensity increased on undulating dissected plains and gently to very gently sloping riverine plain where paddy-oilseeds/pulses are grown in sequence. The analysis of soil samples is in progress.

Soil resource inventory and land evaluation of Chittaurgarh district for land use planning

The project was undertaken to prepare soil resource inventory of Chittaurgarh district (10.86 lakh ha) for land use planning on 1: 50,000 scale using geo-coded merged data IRS 1D (PAN) and IRS P6 (LISS III). Total 38 soil series have been identified and mapped into 70 mapping units in the district.

Land capability and irrigability and the suitability of soils for various crops is shown in table 13.

Table 12: Samples sites from the different cropping systems in Bolangir district, Odisha

Landforms		Cropping system	Samples collected
Hills	Forest cover		4
Att land (Pediment and upland with erosional phase)	Mono cropping Mixed cropping/ Inter cropping	Paddy, Millet, Maize, Cotton Paddy + pulses, Cotton + pulses, Maize + pulses, Millet + pigeon pea	16 16
Mal land (Upland with depositional phase)	Mono cropping Cropping sequence	Paddy Paddy – gram, Paddy – mustard, Paddy – vegetable - Paddy	4 12
Berna land (Undulating and dissected plain)	Cropping sequence	Paddy – gram, Paddy – mustard, Paddy – sunflower, Paddy–wheat, Paddy–groundnut, Paddy–Vegetables	24
Bahal land (Gently to very gently sloping riverine plain)	Cropping sequence	Paddy – chilckling vetch (*Lathyrus sativus*), Paddy – field pea, Paddy – mung bean, Paddy – green gram, Paddy – vegetables	20

Table 13: Land Capability (LCC), Irrigability (LIC) and suitability of Soils for major crops of Chittaurgarh District, Rajasthan

S. No.	Soil series	LCC	LIC	Suitability Class						
				Maize	Wheat	Barley	Soybean	Mustard	Sorghum	Chickpea
				Aravali Landscape						
1	Umedpura	Vies	6st	N	N	N	N	N	N	N
2	Dhokpani	Ves	4st	N	N	N	N	N	N	N
3	Kakra	IVes	4st	S3	S3	S3	S3	S3	S3	S3
4	Mawai	IIIes	3st	S2	S3	S3	S3	S3	S3	S3
5	Aravela	IIes	2s	S1	S2	S2	S2	S2	S1	S2
6	Jolar	IIs	2s	S2	S2	S2	S1	S2	S1	S2
				Eastern Rajasthan upland						
7	Borda	VIes	6st	N	N	N	N	N	N	N
8	Madanpura	Ves	4st	N	N	N	N	N	N	N
9	Narsinghpur	Ves	4st	N	N	N	N	N	N	N
10	Bagund	IIIes	3st	S3	S3	S3	S3	S3	S3	S3
11	Bhadsora-b	IIIes	3st	S2	S2	S2	S2	S2	S2	S2
12	Nardhari-a	IIs	2s	S2	S2	S2	S2	S2	S2	S2
13	Daulatpura-c	IIs	2s	S1	S2	S1	S1	S1	S1	S2
14	Nardhari-b	IIs	2s	S2	S2	S2	S2	S2	S2	S2
15	Daulatpura-d	IIs	2s	S2	S2	S2	S1	S2	S1	S2
16	Sadri series	IIs	2s	S1	S2	S2	S1	S1	S1	S1
17	Kiratpura	IIs	2s	S1	S1	S1	S1	S1	S1	S1
18	Parliyawas	IIIs	3s	S3	S3	S3	S3	S2	S3	S3
19	Arthola	IVs	4sd	S3	S3	S3	N	S3	S3	N
20	Gumanpura	IIs	2s	S2	S2	S2	S2	S1	S1	S2

cont...

Pathar and Bundelkhand (Vindhyan landscape)										
21	Sajanpura	VIes	6st	N	N	N	N	N	N	N
22	Ranchhorpura	Ves	5st	N	N	N	N	N	N	N
23	Pratapura	IVes	4st	S3	S3	S3	S3	S3	S3	S3
24	Mainagar	IIIes	3st	S2	S2	S2	S2	S2	S2	S2
25	Chauhankhera	IVes	4st	S3	S3	S3	S3	S3	S3	S3
26	Arniajosh	IIIes	3st	S2	S2	S2	S2	S2	S2	S2
27	Besera	IIs	2s	S2	S1	S1	S1	S1	S1	S1
28	Harmitiya	IIs	2s	S1	S1	S1	S1	S1	S1	S1
29	Chaprol	IVs	4sd	S3	S3	S3	N	S3	S3	N
30	Bacheri	IIIs	3s	S3	S3	S3	S3	S3	S3	N
Malwa Plateau										
31	Chormagra	VIes	6st	N	N	N	N	N	N	N
32	Achalpur	Ves	5st	N	N	N	N	N	N	N
33	Dahvaliya	IIIes	3st	S3	S3	S2	S2	S2	N	S2
34	Unakhod	IVes	4st	S3	S3	S3	S3	S3	N	S3
35	Gopalpura	IIIes	3st	S2	S2	S2	S2	S2	S2	S2
36	Nayakhera	IIs	2s	S2	S1	S1	S1	S1	S3	S1
37	Gadela	IIs	2s	S2	S2	S1	S2	S1	S2	S2
38	Devgarh	IIIs	3s	S3	S2	S2	S3	S2	S2	S3

Where, S1 highly suitable, S2, moderately suitable, S3- Highly suitable, N- Unsuitable

Correlation of soil series of India (CSSIP)

The objective of the project is to establish new soil series in states and Union territories of the country after correlating the existing series and update the information at National level. A series of soil correlation meetings were held both at HQ's and regional centres' level to finalize the series. The field correlation trips were also organized at Karnataka and Goa states wherein personnel from line department participated.

During the year, nine soil series were finalized through field and laboratory correlation (Table 14) and these series were given the status of established soil series for their entry in the National register. These series includes 2 each from West Bengal and Rajasthan and 5 from the State of Goa. Thus the total number of soil series in the National Register is 282.

Correlation of soil series of the eastern region (West Bengal, Bihar, Jharkhand, Odisha, Sikkim and A&N Islands) (CSSIP)

Sixteen soil series were identified from soil resource mapping data of Birbhum district, West Bengal and were correlated for the finalization of soil series at the national level. Two soil series namely, Motimahal (Fine-loamy Ultic Haplustalfs) and Kharbona (Fine-loamy Aeric Endoaqualfs) occurring on gently sloping plateau and moderately sloping pediment respectively were finalized for entering them subsequently into the National Register.

Correlation of soil series of India and their placement in the National Register for the western region (Gujarat & Rajasthan) (CSSIP)

Five soil series *viz*. Ganglas, Dabla Chanda, Rajyas, Sanwata and Motipura were identified for

registration in National Soil Register of India. Out of five new soil series four belongs to Bhilwara and one belong to Chittorgarh district of Rajasthan. The soils series of Bhilwara were sandy loam in texture whereas soil series from Chittorgarh was clayey. Description of the soil series has been given in table 15.

Table 14: Soil series entered into the National register

S. No.	State	Series No.	Name of Series	Classification
1.	West Bengal	274	Kharbona	Aeric Endoaqualfs
2.	West Bengal	275	Motimahal	Ultic Haptustalfs
3.	Goa	276	Arukot	Typic Paleustalfs
4.	Goa	277	Bandoli	Kanhaplic Haplustults
5.	Goa	278	Gavane	Ultic Haplustalfs
6.	Goa	279	Madgaon	Kanhaplic Haplustulfs
7.	Goa	280	Zuvari	Typic Endoaquepts
8.	Rajasthan	281	Ganglas	Typic Haplustepts
9.	Rajasthan	282	Dabla Chanda	Typic Haplustepts

Table 15: Description of soil series under process of registration in National Register from western India

	Ganglas	Dabla Chanda	Rajyas	Sanawata	Motipura
Classification	*fine-loamy, mixed, hyperthermic family of Typic Haplustepts	fine loamy, mixed (calcareous), hyperthermic family of Typic Haplustepts	fine loamy, mixed, hyperthermic family of Typic Haplustepts	fine, smectitic, hyperthermic family of Typic Haplusterts	fine-loamy, mixed (calcareous), hyperthermic family of Typic Haplustepts
Location	25^{0}44'43" N and 75^{0}23'25" E	25^{0}39'55" N and 75^{0}01'55" E	25^{0}29'29" N and 74^{0}35'56" E	24^{0}53'N and 74^{0}31'E	25^{0}43'35" N and 75^{0}17'09" E
Site address	village Kuchalwara, tehsil Jahazpur, Bhilwara	village Dabla Chanda, tehsil Shahpura, Bhilwara	village Danta Nilab, tehsil Mandal, Bhilwara	Village Sanawata, tehsil Kapasan, Chittaurgarh	village Motipura, tehsil Jahazpur Bhilwara
Distribution and extent (ha)	304246	139993	33224	25892	108887
Land capability sub-class	IIIs	IIIs	IIs	IIs	IIIs
Productivity potential	Medium to high	Medium	Medium to high	Medium to high	Medium to high
Average solum depth (cm)	60.4	57.2	82.4	140	118
pH	7.4	9.0	7.8	7.8	8.5
Soil texture	sandy loam	sandy loam	sandy loam	clay	sandy loam

* The soil temperature regime is hyperthermic for all the soil series.

2.2 Remote Sensing, GIS and Cartography

- Remote Sensing and its Applications
- Digital Database and Thematic Mapping

Area prioritization for land use planning in some selected blocks of Bankura, Puruliya and West Medinipur districts - a remote sensing and GIS approach

Prioritization of area for implementing soil conservation measures using multi-criteria approach

Multi criterion analysis was used for prioritizing the land to implement soil and water conservation measures in part of Bankura, Puruliya and West Medinipur districts of West Bengal based on land use, erosion, land capability classification, Storie and Riquier productivity index model. Nine ranking classes were assigned in ascending order from 1 to 9 in order of maximum to minimum priority (Table 16). Through multi-criteria analysis in the GIS environment and merging of classes, seven priority classes were identified (Fig. 11, Table 17).

Moderately to severely eroded hills, crests and steep pediments mostly under sparse vegetation forest fringe areas, (11%) was classified under high priority class. Soils associated with these landforms were shallow to moderately deep, excessively drained to moderately well drained associated with sandy loam to sandy clay loam on the surface and gravelly sandy loam to sandy clay loam texture in the sub-surface and. Low priority areas (57%), belonged to the lower and upper alluvial plains associated with deep to very deep, moderately well to well drained soils with sandy clay loam to clay loam texture. The remaining area (32 %) falls under the category of medium priority that needs soil and water conservation measures.

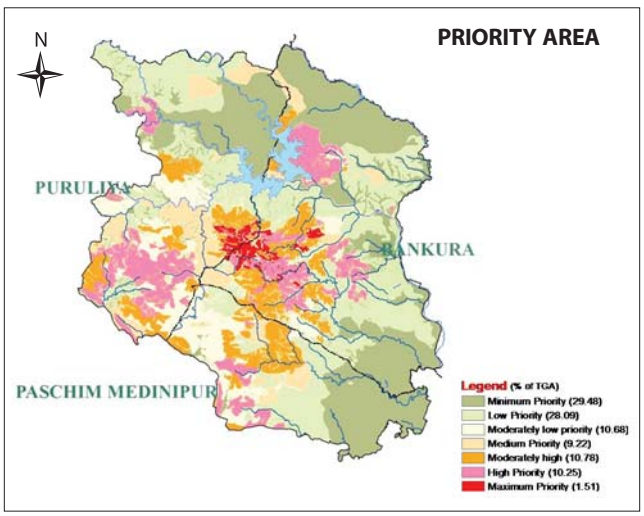


Fig. 11: Priority area of Bankura, Puruliya and West Medinipur districts

Table 16: Parameters for multi-criteria analysis, their influence and class ranks

Class [soil loss (t/ha/yr)]	% of TGA	Rank
Raster - Erosion, Influence – 40%		
< 5	11.05	9
5.1 - 10.0	46.16	8
10.1 - 15.0	9.16	6
15.1 - 20.0	12.25	4
20.1 - 30.0	21.39	2
Raster-Soil Productivity Index (Riquier Model), Influence-20%		
< 30	1.51	1
30.0 - 40.0	14.51	2
30.0 - 40.0	17.88	4
50.1 - 60.0	16.16	6
60.1 - 65.0	24.43	8
> 65	25.51	9
Raster - Soil Productivity Index (Storie model), Influence : 20%		
< 10	1.51	1
10.1 - 20.0	11.41	2
20.1 - 40.0	13.06	4
40.1 - 60.0	29.16	6
60.1 - 80.0	38.69	8
80.1 - 83.6	6.16	9
Raster - Land Capability Classes Influence – 10%		
Class I	18.37	9
Class II	33.27	7
Class III	19.33	6
Class IV	16.11	4
Class V	6.4	3
Class VI	6.51	2
Raster - Land Use Influence - 10%		
Kharif	46.90	2
Rabi	3.23	2
Settlement	3.36	3
Plantation	1.28	4
Forest	23.27	4
Forest Fringe	3.36	6
Fallow	17.57	7
Wasteland	0.57	8
Stony	0.46	9

Table 17: Priority classes and their distribution

Class	Area(km^2)	% TGA
Minimum Priority	839.43	29.48
Low Priority	799.72	28.09
Moderately low priority	304.13	10.68
Medium Priority	262.52	9.22
Moderately high priority	307.04	10.78
High Priority	291.72	10.25
Maximum priority	42.95	1.51

Natural resource assessment using Remote Sensing and GIS – A case study in Badajorenala Micro-watershed in Utkal Plain of Odisha

Run-off estimation was done to prioritize the area for soil conservation measures, following USDA modified Soil Conservation Service Curve Number (SCN-CN) method. The method provides an empirical rainfall-run-off relationship for run-off estimation as a function of soil type and land use. Prior to the estimation of run-off, hydrological grouping has been done for the watershed based on infiltration rate. Soil map units 1,2,7 and 8 (Table 18) were classified under Hydrological class C characterized by loam to clay loam texture, low infiltration rate and low rate of water transmission (0.05-0.15 inch hr^{-1}).The soil map units 5 and 6 were grouped under Hydrological class D which have high run-off potential and very low rate of water transmission (0-0.05 inch hr^{-1}). The map unit 3 grouped with Hydrological class B have moderate infiltration rate and moderate rate of water transmission (0.15-0.30 inch hr^{-1}). The highest run-off was estimated in the soil map units 4 and 5; the lowest run-off was calculated for soil map units 6 and 7. The run-off was estimated 510 to 528 thousand m^3 for soil map units 1, 2 and 3. Estimated runoff for unit 8 was 267.56 thousand m^3. The average annual run-off yield of the entire watershed during the period 2001 to 2009 was estimated to

Table 18: Soil hydrological groupings and land use in the watershed

Soil Map Unit	Soil Classification	Land use	AWC (mm-m)	Soil texture	Hydrological class	Estimated run-off (thousand m^3)
1	Loamy-skeletal Lithic Ustorthents	Thin forest-cashew plantation	53.0	Loam	C	528.27
2	Loamy-skeletal Typic Haplustepts	Cashew plantation-upland paddy	92.0	Clay loam	C	527.95
3	Loamy Lithic Haplustepts	Mixed forest-grazing	49.0	Loam	B	510.71
4	Fine loamy Typic Haplustepts	*Kharif* paddy	144.0	Clay loam	C	1284.97
5	Fine, Typic Haplustalfs	*Kharif* paddy	135.0	Silty clay	D	1022.80
6	Fine Typic Endoaqualfs	*Kharif* paddy	145.0	Silty clay	D	78.16
7	Loamy Lithic Ustorthents	*Kharif* paddy	42.0	Clay loam	C	20.34
8	Fine Loamy Typic Endoaquepts	*Kharif* paddy	152.0	loam	C	267.56

be 4208.21 thousand metre^3 with annual rainfall–runoff coefficient of 0.958. The information suggests that the micro watershed was highly prone to erosion. Therefore suitable soil and water conservation measures are to be taken on priority for protecting soil erosion in soil map units 4 and 5. The second priority is to be set for protecting soils of map units 8. The last priority is to be given for the area classified under map units 6 and 7.

Prediction of soil fertility parameters through Visible and Near Infrared (VNIR) soil reflectance data of West Bengal

The project was undertaken to investigate the relationship between various soil fertility parameters and soil spectral reflectance data (350 - 2500 nm) and to develop soil reflectance spectral model for prediction of soil fertility parameter. Total 2567 surface soil samples from Jalpaiguri and 24 Pargana districts of West Bengal were investigated to observe soil reflectance spectra using a FieldSpec Pro FR spectroradiometer (Analytical Spectral Devices Inc., Boulder, Colorado) at wavelengths from 350 to 2500 nm with a spectral sampling interval of 1 nm. Soil samples were analyzed at Regional Centre, Kolkata for pH, organic carbon, available N, P, K, S, Cu, Fe, Mn and Zn using standard methodology.

Soil reflectance spectra and its correlation with soil properties

Prior to statistical correlation, the raw spectral reflectance data were averaged at every tenth-nanometer wavelength interval from 360 to 2490 nm by integration technique to reduce the volume of data for analysis and to match it more closely to the spectral resolution of the instrument (3 to 10 nm). The reflectance values were then transformed with first derivative processing to minimize variation among samples caused in grinding and optical set-up. Figure 12 shows the correlation of different soil fertility related parameters with 1st derivative soil reflectance values.

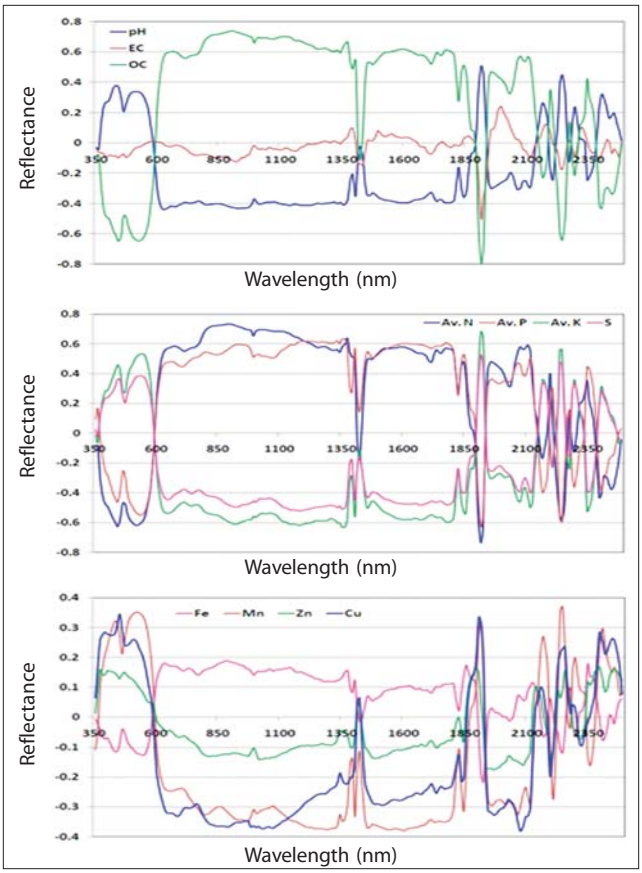


Fig. 12: Correlation of different soil fertility parameters with 1st derivative soil reflectance data

Development of soil spectral models

For developing spectral models to predict soil fertility parameters, the whole dataset was divided into two sets *viz.* calibration (50%) and validation (50%) sets. Calibration(s) between soil reflectance and soil parameters were performed using partial least square regression analysis. The best spectral model was chosen which resulted high coefficient of determination of validation (r^2), low root mean square error of prediction (RMSEP) and high RPD values.

The statistical parameters of the developed spectral models are summarized in table 19. Relatively good calibration models (Fig. 13) have been obtained for EC, OC, available nitrogen, phosphorus (P_2O_5) and potash (K_2O) which showed coefficient of determination (r^2) more than 0.60 and RPD values greater than 1.70 in independent validation datasets. This indicates that soil fertility variables *viz.* EC, OC and available nitrogen, phosphorous and potash can be reliably predicted from soil reflectance data. However, the spectral models for available sulphur and DTPA- extractable Zn, Cu, Fe and Mn lacked accuracy ($r^2 < 0.60$).

Table 19: Summary statistics for the spectral models developed by partial least-square (PLS) regression

S. No.	Soil fertility parameter	Calibration					Validation				
		N	No. of samples	Factors	r^2	RMSE	No. of samples	SD	r^2	RMSEP	RPD
1	pH	3378	1682	10	0.547	0.592	1696	0.88	0.521	0.592	1.49
2	EC (dS/m)	1087	546	7	0.723	0.194	541	0.37	0.668	0.115	3.19
3	OC (mg/kg)	3377	1697	5	0.649	12.97	1680	22.18	0.659	12.47	1.78
4	N (kg ha^{-1})	3254	1633	5	0.665	2.00	1621	3.44	0.675	1.86	1.85
5	P_2O_5 (kg ha^{-1})	2715	1363	4	0.831	1.32	1352	3.24	0.831	1.15	2.81
6	K_2O (kg ha^{-1})	3619	1810	10	0.669	4.37	1809	7.70	0.656	4.51	1.70
7	S (mg kg^{-1})	3301	1651	6	0.486	1.797	1650	2.49	0.475	1.721	1.44
8	Zn (ppb)	2816	1247	9	0.335	0.162	1569	5.61	0.138	0.229	1.15
9	Cu (ppb)	3392	1695	4	0.242	0.768	1697	10.55	0.233	0.781	1.15
10	Fe (ppb)	3392	1695	2	0.029	65.76	1697	66.93	0.004	66.77	1.00
11	Mn (ppb)	3392	1695	4	0.299	59.28	1697	72.40	0.321	59.61	1.21

Note: Square-root transformation were applied on all datasets before calibration except soil pH

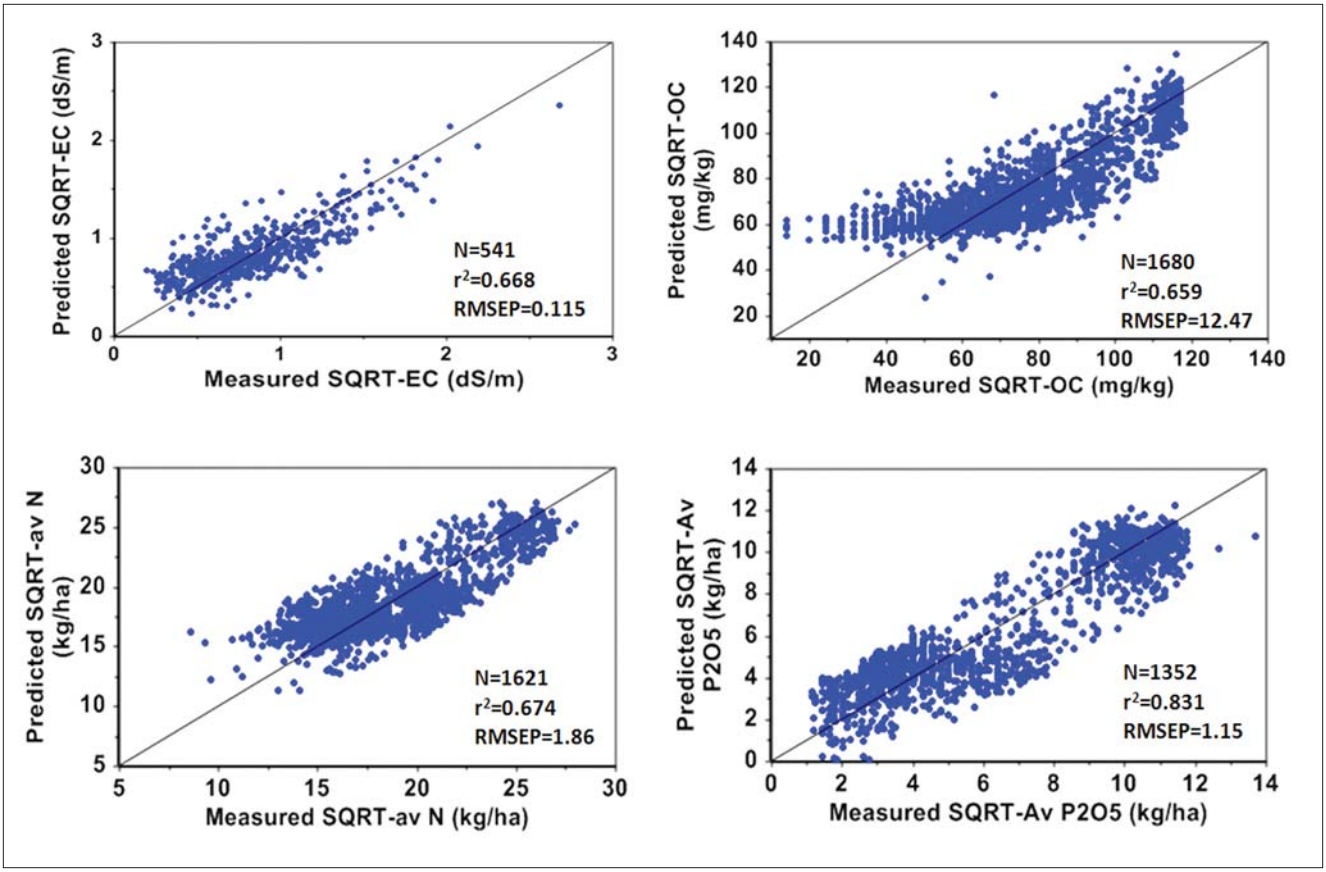


Fig. 13: Scatterplot of measured and predicted values of different soil fertility parameter in the validation datasets

Development of soil reflectance methods and low cost sensors for variable rate inputs in precision farming

Relationship between soil characteristics of the Indo-Gangetic Plains and laboratory measured soil reflectance data between 350- 2500 nm was investigated and to develop spectral models for prediction of soil properties from soil reflectance data were developed.

Soil textural properties

The soil samples from four clusters of villages located in the districts of Ludhiana, Bhatinda, Gurdaspur and Moga in Punjab state were analyzed for sand, silt and clay fractions using International Pipette method. The statistical parameters of soil textural properties are given in table 20.

Soil reflectance spectra and its correlation with soil properties

The statistical correlation of soil textural properties (sand, silt and clay) with first derivative soil reflectance data showed both positive and negative correlations at various wavelengths across the spectrum (Fig. 14). Sand showed negative correlation with 1st derivative soil reflectance between 350 to 800 nm and positive correlation between 1000 nm to 2200 nm. On the contrary silt and clay showed just the opposite trend as depicted by sand with soil reflectance.

Table 20: Descriptive statistical parameters of soil textural properties

Property	No. of samples	Mean	Min	Max	SD	Skewness	Kurtosis	Percentile		
								25th	50th	75th
Sand (%)	80	62.3	30.4	80.4	14.7	-0.64	-0.84	53.7	65.4	75.1
Silt (%)	80	21.7	4.7	53.0	12.5	0.87	-0.16	11.3	19.8	27.5
Clay (%)	80	16.0	2.6	25.2	4.8	-0.26	0.27	13.4	16.2	19.0

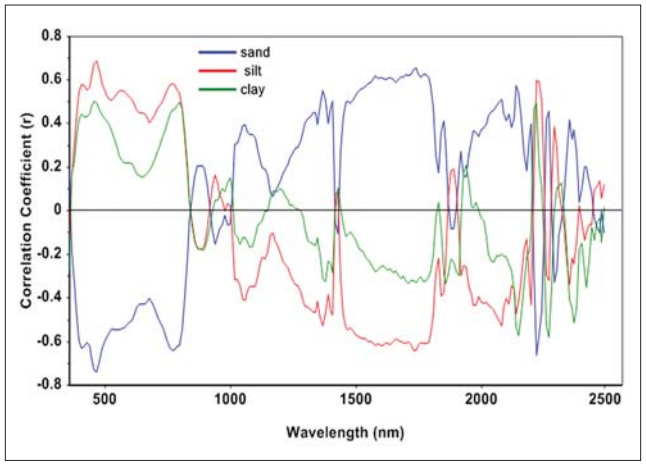


Fig. 14: Correlation of sand, silt and clay with 1st derivative soil reflectance data

Spectral data modelling

Partial least square (PLS) regression technique was used to develop spectral models for prediction of soil textural parameters. PLS regression decomposes both X and Y variables and finds new components, called latent variables, which are both orthogonal and weighted linear combinations of X variables. These new latent X variables are then used for prediction of Y variables. Unlike multiple linear regression, it can handle data with strong co-linearity in X variables. The best spectral model was chosen based on coefficient of determination in (r^2), root mean square error of prediction (RMSEP). The scatter plot of the measured and predicted values of the sand, silt and clay contents in cross-validation datasets are shown in figure 15.

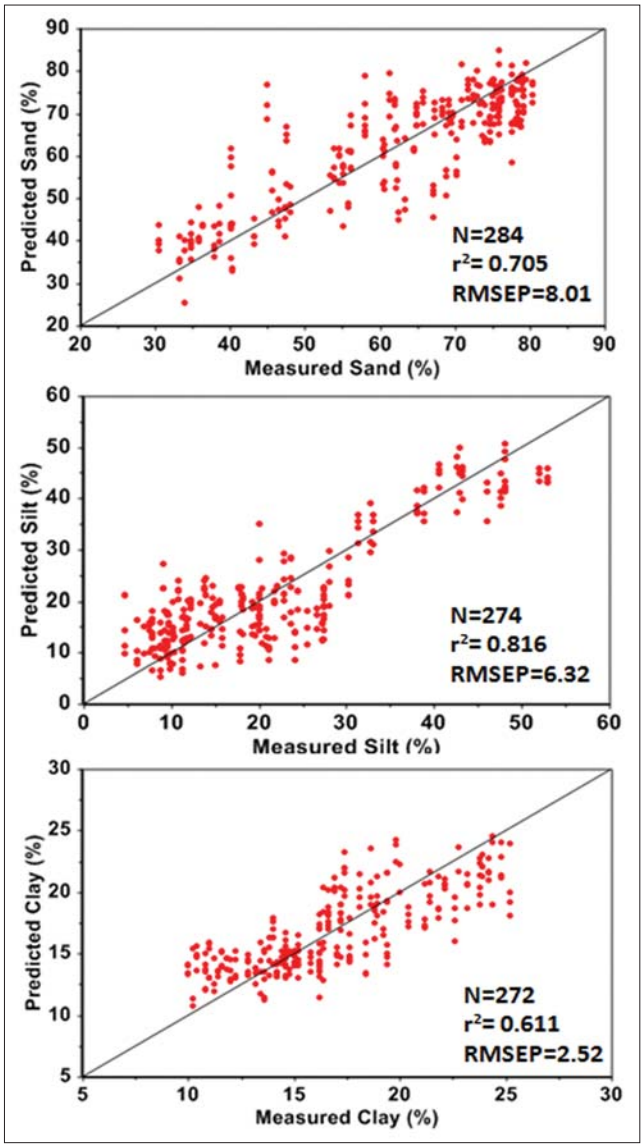


Fig. 15: Scatterplot of measure and predicted values of Sand, silt and clay contents in the cross-validation set

Comparative assessment of large scale mapping through conventional survey and remote sensing techniques- A case study in Parsori watershed, Katol tehsil, Nagpur district, Maharashtra state

The study was undertaken to compare the detailed soil maps prepared following conventional survey and using remote sensing techniques in terms of its accuracy and cost effectiveness.

Soil mapping

In conventional survey, soil map is prepared based on intensive field traversing and ground truth checking using cadastral map as base. Detailed soil map showing soil series and their phases have been prepared based on 136 observations spread uniformly in the watershed. A total of seven soil series were identified and mapped as phases of soil series into 26 mapping units (Fig. 16a). Surface characteristics *viz.* surface texture, slope, degree of erosion and stoniness have been used to delineate the phases of soil series.

In remote sensing approach, physiographic cum photomorphic units (comprising landform slope, land use and image characteristics) delineated based on visual interpretation of IRS-P6 LISS-IV PAN merged data (5.8m resolution) was used as base map for field work and developing landform-soil relationship for soil mapping. In all, 24 physiographic cum photomorphic units were delineated. A total of 75 pedons representing different physiographic cum photmorphic units were examined for establishing physiography–soil relationship. A total of 5 soil series were identified and mapped as phases of soil series into 12 soil mapping units (Fig. 16b). In the alluvial plain area,

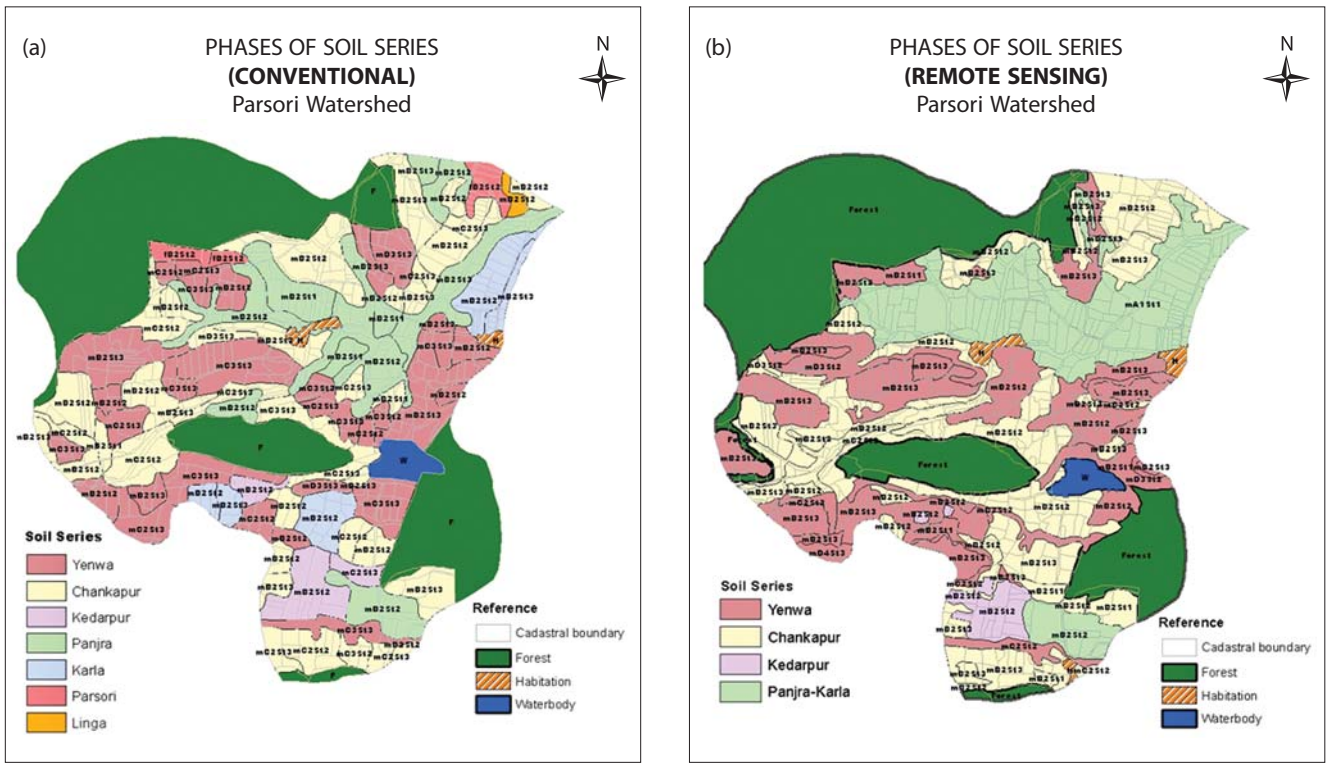


Fig. 16: Soil map of Parsori watershed prepared by conventional survey (a) and remote sensing (b)

the two soil series *viz.* Panjra and Karla could not be separated and hence mapped as Panja + Karla complex. Both Panjra and Karla soil series are deep to very deep, clayey, moderately well drained and mostly under double crop and hence, depicting similar image characteristics on the false colour composites.

Comparative assessment of soil map accuracy

For assessing the purity of map legend of soil map, methodology suggested by Forbes *et al.* (1987) was used. We used seven soil properties *viz.* soil depth, colour, texture, drainage, erosion, stoniness, and calcareousness for comparison. Each property was scored 1 to 4 depending on the increasing occurrence of a mismatch with the ground truth. Score 1 is given when all the observed characteristics of the ground truth matches with the reference (Soil map legend), Score 2 when some (i.e <20%) of the observed characteristics are in adjacent class, Score 3 when more than 20% are in adjacent class and one of them is in non-adjacent class and Score 4 is allotted when more than one of the observed characteristics is in non-adjacent class. The sum of observations falling in score 1 and 2 is referred to as "map purity" and those falling in score 4 are referred to as "strongly contrasting" soils. A map is rejected having unacceptable ground truth if either, (a) It is 90% certain that more than 15% of the map area has scored in score 4 with respect to reference, or (b) It is 90% certain that less than 50% of the map area has scored in Score 1 and 2 with respect to the reference. In absence of the above conditions the map is accepted.

We tested the acceptability and purity of soil map legend prepared using remote sensing techniques. One hundred thirty six (136) ground-truth observations taken during conventional survey were used. It has been observed that out of 136 observations, only one observation had a score of 4, so the map can be accepted. With respect to the criteria of purity, 90 observations (66%) had a combined score of 1 and 2; hence purity of the map prepared by remote sensing technique can be accepted.

Similarly, the soil map prepared by conventional technique was also tested for both the criteria using 75 observations taken during soil mapping using remote sensing techniques. Two contrasting pedons with a score of 4 were observed in conventional soil map which is less than 15 per cent, hence can be accepted. With respect to purity, the pedons having a combined score of 1 and 2 were 57 out of total 75 observations, hence purity of the conventional map can also be accepted.

The overall accuracy of soil map was determined using binomial test of accuracy (Rossitter, 2001). The results revealed that the map prepared by remote sensing technique had an accuracy of 59 to 73 per cent at 90% probability, whereas, the map prepared by conventional soil survey had an accuracy of 67 to 85% at 90% probability. So the maps prepared by both techniques can be considered to be reliable and acceptable.

Comparative assessment of cost and time saving

In the comparison of cost and time spent in soil mapping by both conventional and remote sensing technique, it was observed that there was about 23% saving in cost and 32% in time (no. of days) when RS based soil mapping was done.

Detailed soil mapping in basaltic terrain for land resources management using Cartosat-1 data

The project was undertaken to study the applicability of high resolution Cartosat-1 data

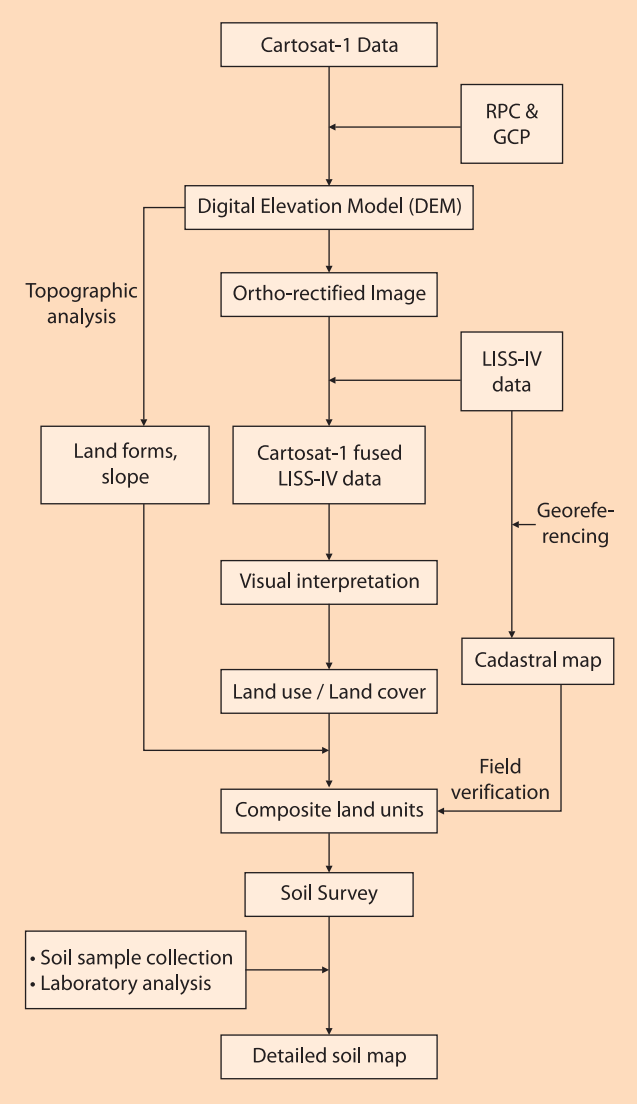


Fig. 17: Flow chart of the methodology

in detailed characterization of land resources and to develop the methodology for its application in detailed soil mapping.

Methodology for detailed soil mapping using Cartosat-1 data

Soils are normally mapped based on landform-soil relation. The accuracy of soil map largely depends on how precisely and accurately the landform units are delineated. A stereo pair of Cartosat-1 data provides the opportunity for precise and accurate delineation of landform units as it can be used to generate digital elevation model (DEM) for 3-D viewing of the area for delineation of landforms, generation of contours (10m) and deriving information on slope of land. The methodology for detailed soil mapping using Cartosat-1 data is presented in figure 17.

As a case study, Savli village of Wardha district was selected to test the methodology of detailed soil mapping using Cartosat-1 data. Ortho-rectification of Cartosat-1 was done. DEM was generated from Cartosat-1 stereo pair and contours at 10 m interval (Fig. 18a) and slope maps (Fig. 18b) were prepared. Using DEM and ortho-rectified Cartosat-1 data, anaglyph was generated for 3-D viewing and delineation of major landform units *viz.* plateau, escarpment, pediment, alluvial plain and narrow valley (Fig. 18c). The major landforms were further subdivided based on elevation. The pediments were subdivided in to upper and lower pediments and the alluvial plain was divided in to upper and lower alluvial plain. Land use/land cover map (Fig. 18d) of the area was prepared using Cartosat-1 sharpened IRS-P6 LISS-IV data (November, 2008; January 2010), Landform, slope and land use/land cover maps have been integrated and 48 PLU (physiography-land use) units were delineated (Fig. 18e). The representative sites on each physiography-land use unit were selected for detailed profile study. Fifty two profiles proportionate to area of each unit were studied and soils were grouped into 9 soil series (Fig. 18f) and mapped as phases of soil series.

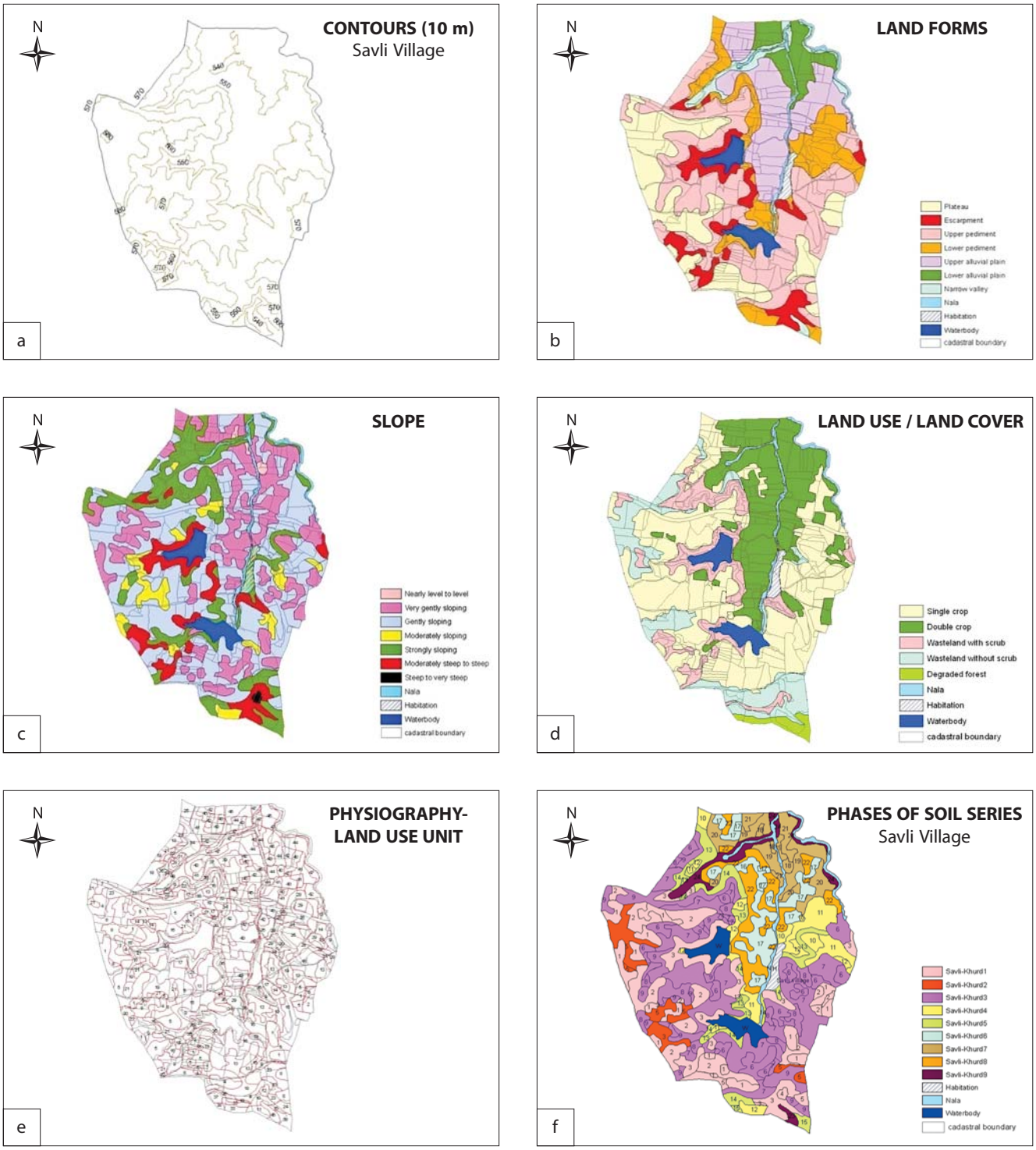


Fig. 18: Detailed soil mapping using Cartosat-1 data

Assessment and mapping of spatial variability of soil properties in basaltic terrain for precision agriculture using VNIR spectroscopy and geo-statistical techniques

The study was undertaken to quantify the spatial variation of soil properties in basaltic terrain using VNIR spectroscopy and geospatial techniques. Nagalvadi micro-watershed (area 460 ha) of Wardha district of Maharashtra located between 78°26' to 78°27'E longitudes and 21°8' to 21°10'N latitudes was selected for this study. The elevation ranges from 460 to 500 m above MSL. The climate is sub-tropical dry sub-humid with well expressed seasons.

Spatial variability of soil properties

Field work was carried to collect soil samples (0-20 cm depth) from 146 grid points at an interval of 200 m. Soil samples are being analyzed for pH, EC, organic carbon and available K. The analyses of 80 soil samples have been completed (Table 21).

Table 21: Descriptive statistics of soil properties

Property	No. of samples analyzed	Mean	Min.	Max.	SD
pH	80	7.6	6.2	8.7	0.72
EC (dS m^{-1})	80	21.7	0.06	0.62	0.10
OC (%)	80	0.55	0.18	1.17	0.18
Available K (kg ha^{-1})	80	276	123	762	138

Land use / land cover and physiography maps of the village have been prepared using Cartosat-1 sharpened IRS-P6 LISS-IV data (January 2008, November, 2008). The land use / land cover map (Fig. 19) indicates three classes *viz.* single crop, double crop and habitation. Physiographically, the area has been characterized into five physiographic sub-units (Fig. 20).

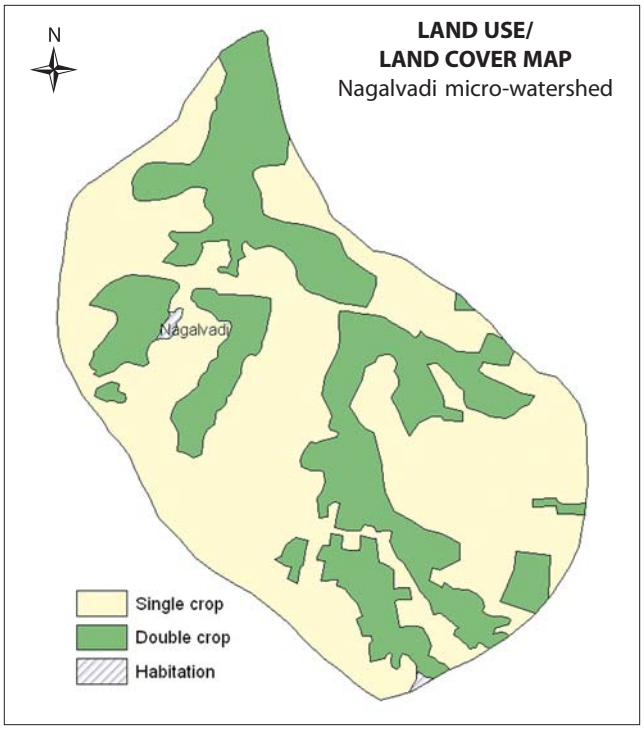


Fig.19. Land use/land cover map

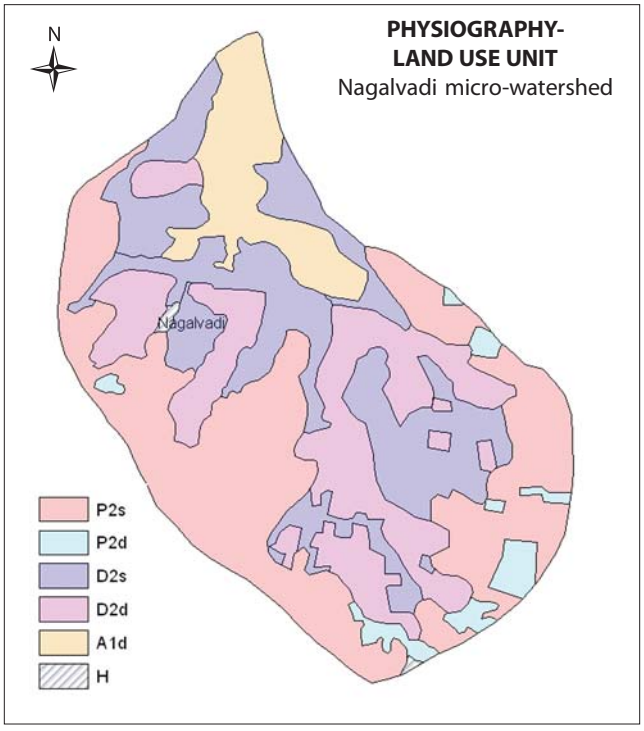


Fig. 20. Physiography map

Development of Indian soil information system (ISIS) - A GeoPortal

This project was aimed to design and develop standardized seamless Indian Soil Information System (ISIS) on the 1:250,000 scale in GIS using the available state wise SRM soil database with metadata to store, update, manage and query the geospatial soil database and to develop a GeoPortal (Standalone). During the reporting period, soil resource database at state level has been corrected for geometric errors and transformed to uniform projection system to make a seamless mosaic. The geometric errors have been corrected during the edge matching and uniform schema for the attributes has been standardized. The seamless mosaic of satellite database for India has been developed by using about 370 scenes of IRS-P6 LISS-III satellite data. To develop digital elevation models of India at 30 m, 375 scenes of Cartosat and 400 scenes of ASTER GDEM, were used. The climatic database for India has been generated using the available climatic data for 1600 stations. The 10 km grid point data of soil loss at state level for about 19,000 grid points has been compiled under ISIS. A proto-type Geoportal has been developed to assimilate, visualize and query the standardized soil resource and allied datasets of India (Fig. 21). The work on integration of soil information with soil loss, degraded/wastelands is in progress to enhance the utility of soil resource database.

Development of district soil information system (DSIS) on 1:50,000 Scale (50 Districts)

This project was aimed to design and develop District Soil Information System (DSIS) on 1:50,000 scale (50 districts) in GIS with uniform standards to store, process, manage the geospatial soil database at district level. During the period, the soil database of Jorhat, Morigaon, North Sikkim, South Sikkim, East Sikkim and West Sikkim (North-East region), Bastar, Wardha, Yavatmal, Raisen, Balaghat, and Ahmednagar (Central region), North Goa, South Goa, Chitradurga, Tumkur, Medak, Bellary (Southern region), Banswara, Bhilwara,

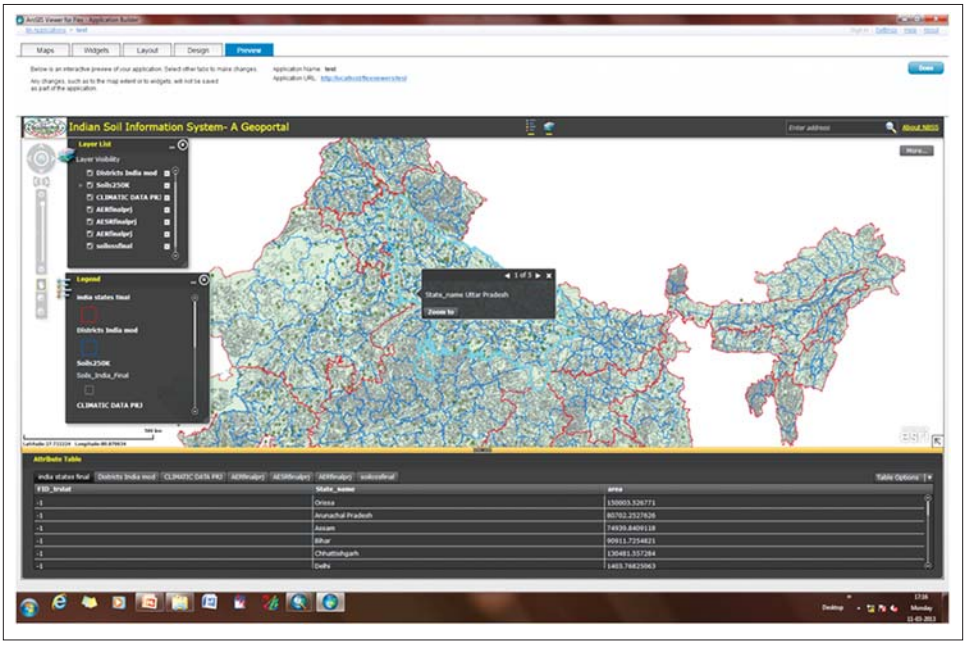


Fig. 21: Proto-type Indian Soil Information System (ISIS) - Geoportal

Bundi (Western region), Bardhaman and Madhubani (Eastern region), Nawashahar, Fatehgarhsahib, Delhi territory, Hoshiyarpur, Patiala (Northen region), districts have been digitized and converted into LCC projection system with datum WGS 84 to develop DSIS. About 30 terrain and soil based thematic database has been generated for each district. ASTER and Cartosat digital elevation data (30 m) and LISS III satellite data has been generated at district level. The input parameters were extracted from the reports and standardized with uniform data schema to generate the spatial and attribute database of each district. Soil resource information of 40 districts has been digitized, standardized and brought under DSIS (Fig. 22). Further, the developed district soil information systems has been brought under proto-type Geoportal of ISIS to visualize and query the standardized soil resource and allied datasets of the districts (Fig. 23). The work on further integration of District soil information system with soil loss, degraded/wastelands is in progress to enrich and enhance the utility of soil resource database.

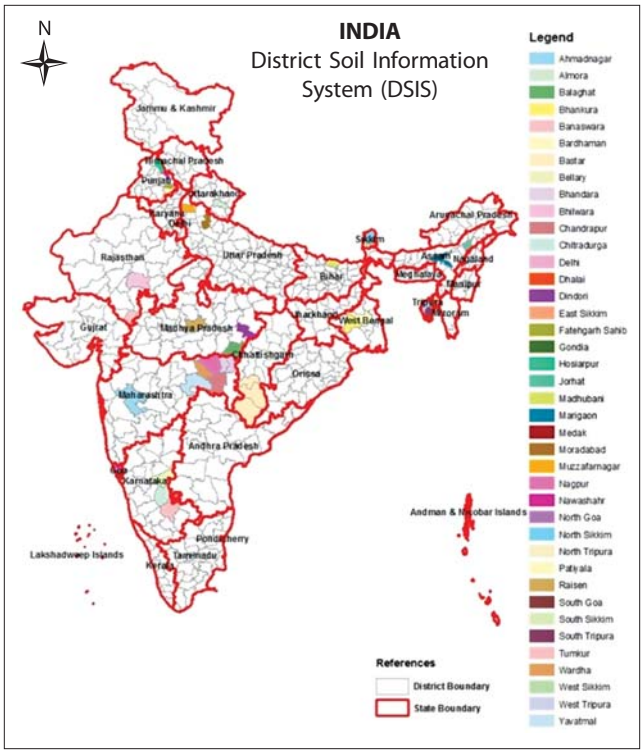


Fig. 22: District Soil Information System (DSIS) on 1:50,000 scale (40 districts)

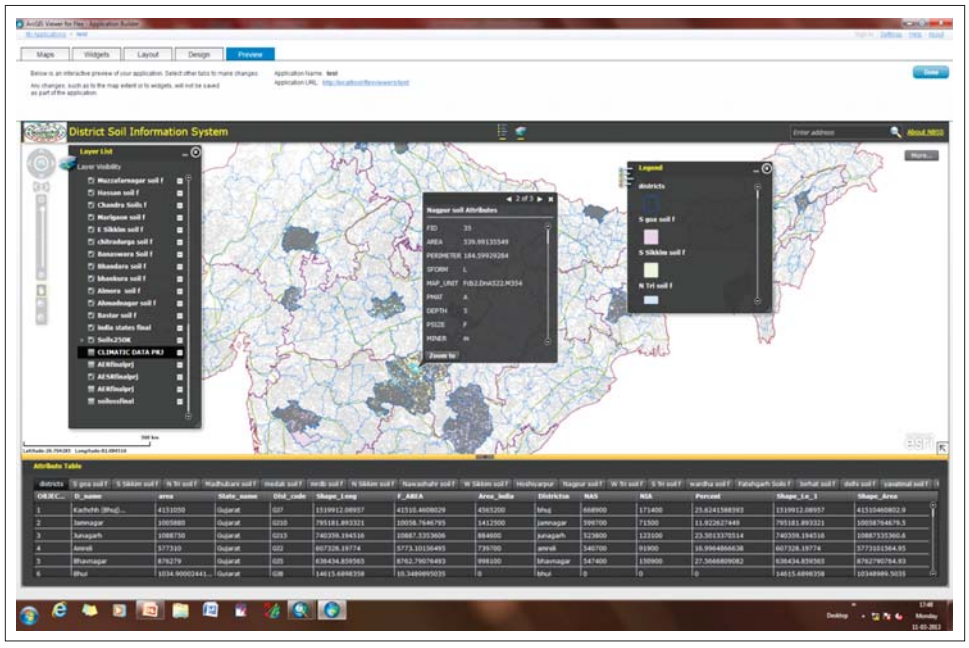


Fig. 23: District Soil Information System (DSIS) on 1:50,000 scale in ISIS Geoportal

GIS Modeling to Predict Land Productivity Potential (LPP) for Major Crops in Wardha District of Sub-Humid (Dry) Region, Eastern Maharashtra

The project was aimed to assess terrain, climate, and soil resource databases to delineate and characterize Pedo-Ecological Units (PEU) and to integrate the thematic parameters in mapping crop based Land Productivity Potential (LPP). During the reporting period, terrain information (elevation, slope and aspect) were incorporated to improve the accuracy of the land use land cover classification of IRS P-6 LISS III data for Wardha district. Major cropping systems of the district were derived using MODIS 16 days composite NDVI time series data for year 2010. Land capability classification of the district has been revised. Data mining algorithms were applied for machine learning of land capability classification through soil attributes. Pedo-ecological units (PEU) of the Wardha district were delineated by integrating terrain parameters (slope and topographic wetness index), rainfall data, cropping system and soil parameters (AWC, erosion, soil depth, permeability, texture, and drainage) on 1:50,000 scale. Six distinct pedo-ecological units were identified ranging from extremely poor to very good in crop production point of view (Fig. 24). The very poor and poor PEUs are associated with moderately steep to steep slopes, shallow soil depth, excessive drainage and coarse texture soils. The good and very good PEU's are associated with nearly level to level slopes, deep to very deep soils, well drained and clayey texture soils. Land productivity potential for soybean, cotton and wheat crops were generated based on integration of principle components of 4 years MODIS NDVI 16 days composites, Terrain parameters (slope, topographic wetness index), and soil attributes (soil depth, drainage, erosion, pH and texture) using weighted overlay analysis technique in GIS. Land productivity potentials of two crops, cotton and soybean were validated with the help of georeferenced field data on productivity (Fig. 25).

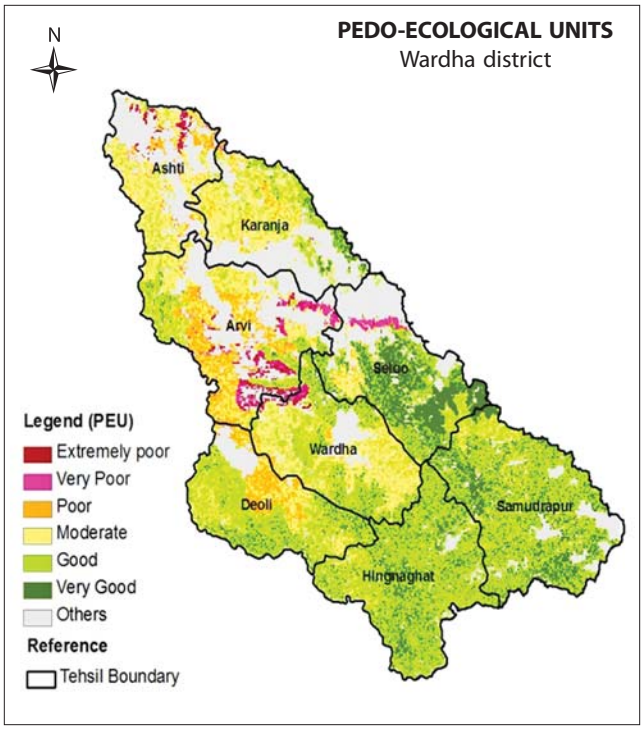


Fig 24: Pedo-ecological units of Wardha district

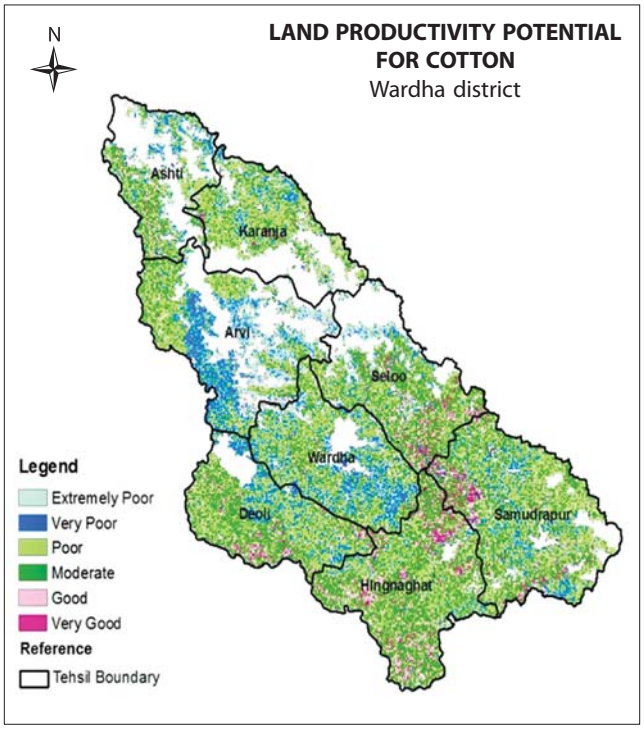


Fig. 25: Land productivity potential for Cotton

Assessment of spatio-temporal variability of major crops in different states of India for land use planning: A GIS based approach

The present study attempted to analyse the extent of change in area under major crops of India and to develop the spatial area database of major crops in GIS considering district as a unit. The compound growth rate (CGR) of area, production and yield of rice during the period from 1975-76 to 2009-10 shows an increasing trend in the states like Andhra Pradesh, Assam, Gujarat, Haryana, Karnataka, Maharashtra, Odisha, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal. Highest increase in area and production was observed in Punjab. The growth in area, production and yield under rice was found to be significant in Haryana (4.17%, 6.26% and 2%) and Karnataka (1.13%, 2.7% and 1.55%). West Bengal (5630.1 thousand ha) and Uttar Pradesh (5186 thousand ha) have highest area under rice according to 2009-10 statistics (Fig. 26). All the major producing states of wheat have shown an increase in area, production and yield of wheat from 1975-76 to 2009-10. Uttar Pradesh has highest acreage (9668 thousand ha) and production (27.5 m ton) of wheat and Punjab gives highest average yield of 4307 kg/ha in 2009-10. Area under wheat cultivation is highest in Uttar Pradesh (9.67 m ha) followed by Madhya Pradesh (4.28 m ha). Increase in area under wheat cultivation was found to be significant in Madhya Pradesh with a CGR of 1.2%.

National Spatial Data Infrastructure – Soil Resource Database

The objectives of NSDI are that the development of infrastructures for spatial information in the country to ensure proper spatial data storage made available and maintained at the most appropriate level. During the reporting period, as a NSDI Partner Institute, the nodal officer and Member Executive Council of NSDI from NBSS & LUP have

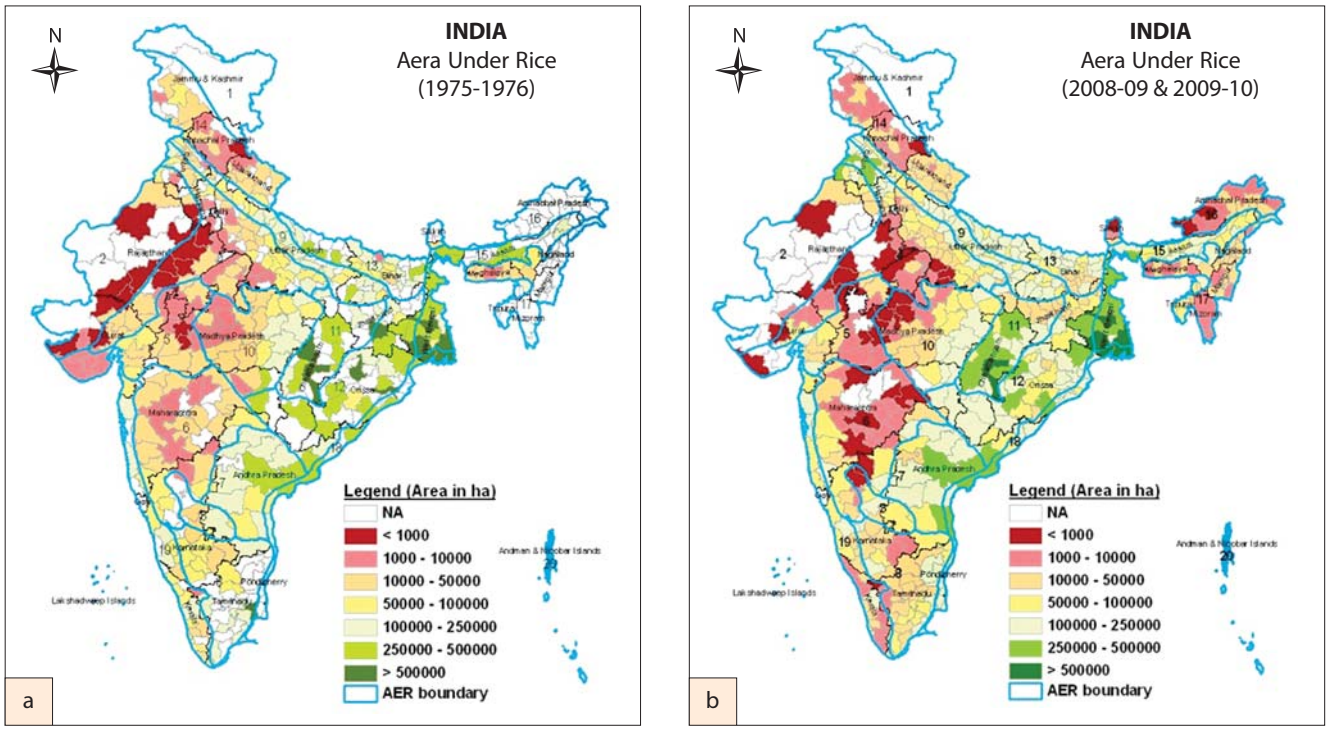
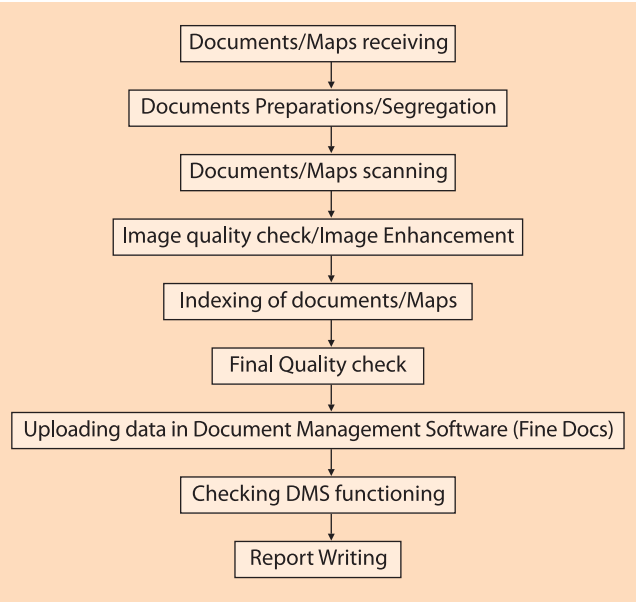


Fig. 26: Spatio temporal changes of rice cultivation in India in the year 1975-76 and 2009-2010

participated in Nodal Officers meetings of NSDI. NBSS&LUP as a Working Group Chairman in developing the document on "Data Content Standard - Soils" ver 2.0 has been revised and "Data Content Standard - Soils" ver 3.0 has been generated and the same has been released by NSDI in NSDI-12. This document represents a contribution to the Data Specification stage of the NSDI. It defines the scope of the spatial data themes and proposes specifications, which will provide a detailed definition of data content by means of application schema and feature catalogue.

Documentation and storing maps and photographs – a concept of Digital Map Library

The project was taken up in 2009 to collect and store soil maps, reports, photographs and other related images, which have been generated and accumulated since the inception of the Bureau in digital format to ensure their safety and easy retrieval through indexing. The steps involved in the development of digital Library, are as follows-



About 396 soil Survey reports 331 maps and diagrams prepared in digital mode and about 1405 photographs showing the soils landscape and landuse covering mainly western and southern states have been processed for documentation.

2.3 Basic Pedological Research

- Landform-soil Relationship
- Methods of Soil Analysis
- Soil Genesis and Mineral Transformation

Geomorphological analysis and study on landform-soils-land use relationships in Karnataka

On a broad level, 10 major landforms are demarcated by superimposing the geological information and climate. Using image interpretation of LISS – III images combined with the study of the crenulations of contour on different lithological settings, 47 landform sub units have been identified for the entire state. Window areas selected representing typifying landforms for detailed geomorphic analysis showed the variability clearly with reference to landforms and associated soils as well as the general land use/land cover patterns. For example, Afzalpur Township and environs represented the typical basalt terrain of northern Karnataka with plateau summits, side slopes including sharp and short escarpments and entrenched valley floors. Shallow to very deep, somewhat excessively to moderately well drained cracking clay black soils at various stages of development found to represent the various landform units. Basically jowar based land use pattern is observed dominantly with rainfed jowar, bajra and tur on plateau summits, followed by safflower, sunflower and chilies on the side slopes and under irrigated conditions on the valley floors sugarcane, paddy, sunflower, safflower and vegetables are grown.

In contrast, Someshwar area represents the three major landforms viz the transitional Malnad (Karnataka plateau), Western Ghat high hill ranges and the southern coastal plains (Fig. 27). Numerous residual hills, rolling to undulating valley-side slopes and narrow valley floors represent the Malnad plateau region. On the Malnad plateau, forests, pasturelands and rain fed paddy are associated with residual hills while eucalyptus and other plantations crops are grown on the side slopes. Paddy, *tur* and vegetables are common on the valley floors. However, on the Western Ghats structural high hill ranges, dense forest cover and pasture lands are observed. On the lower hills, wash slopes and intermontane valley floors coffee, paddy on bench terraces and cardamom are grown. For all the 47 landform units the variability of soils and its relationship has been established. The corresponding land use/land cover patterns are collected from the SRM data and from the study of other ongoing projects as well as from KSRSAC. For the sake of

Fig. 27: Basalt Mesa Complex, Garmpalli area, West of Chincholi, Gulbarga district

clarity, only a part of landform information is described (Table 22).

Geomorphic process relationships has been established for all the major landforms of Karnataka. This helps in establishing the aggradational/ degradational nature of the terrain, nature of weathering, regolith cover and other surficial characteristics present. Such knowledge is very much essential for understanding and studying the natural resources of an area, more so of the spatial variability of soils in particular. Such relationships available on the basalt terrain of northern part of Karnataka are schematically presented in figures 28 and 29.

Table 22: Landforms–soils–land use relationship in Karnataka granite/gneiss landforms

Landforms	Soils	Classification	Land Use/Land Cover	Area (%)
1. Hills and Ridges	Rock out crops associated with shallow, somewhat excessively drained, gravelly clay soils with very low AWC, moderately eroded.	Clayey-skeletal, mixed, Lithic Haplustepts Clayey-skeletal, mixed, Typic Haplustepts	Scrub Forest, Grassland	162609.4 ha (0.85%)
2. Tors, Domes and Inselbergs	Rock out crops	Rock land	Scrub forest, Ragi, Jowar, Groundnut	161341.2 ha (0.85%)
3. Rolling interfluves	Shallow to moderately deep, well drained, gravelly clay red soils with low AWC, strongly gravelly in the subsoil, with slight erosion, associated with deep, somewhat excessively drained, clayey red soils, severely eroded.	Clayey, mixed, Lithic Rhodustalfs Clayey-skeletal, mixed, Typic Rhoduslalfs. Fine, mixed, Typic Ustropepts Clayey-skeletal, mixed, Typic Haplustepts	Groundnut, Ragi, Jowar, Tur, Maize, Horsegram	363771.7 ha (1.91%)
4. Undulating Interfluves	Moderately deep to very deep, well drained, gravelly clay red soils with low AWC, strongly gravelly in the sub soil, with moderate erosion, associated with shallow, well drained, gravelly clay red soils with very low AWC, severely eroded.	Clayey-skeletal, mixed, Typic Rhodustalfs Clayey-skeletal, mixed, Typic Paleustalfs	Ragi, jowar, Groundnut, Mulberry, Sunflower, Red gram, Cotton, Horse gram, Tur, Bajra, Seasame	2946208 ha (15.47%)
5. Gently Sloping Interfluves	Deep, well drained, gravelly clay red soils, with slight erosion, associated with moderately shallow, well drained, gravelly red soils.Very deep, moderately well drained, calcareous, cracking clay black soils, with slight erosion, associated with deep, well drained, calcareous, clayey black soils.	Clayey-skeletal, mixed, Rhodic Paleustalfs Clayey-skeletal, mixed, Typic Rhodustalfs Very fine, mont., Typic Heplusterts Fine, mont., Vertic Haplustepts	Ragi, Jowar, Groundnut, Tur, Horse gram, Sugarcane, Bajra, Eucalyptus, Mulberry, Mango	2272614 ha (11.93%)
6. Nearly Level Interfluves	Deep, well drained, calcareous, cracking clay black soils, with moderate erosion, associated with moderately deep, well drained, calcareous, clayey black soils with slight salinity under irrigation.	Very-fine, mont., Typic Heplusterts Fine, mont., Vertic Haplustepts	Groundnut, Sunflower, Ragi, Cotton, Maize, Jowar, Horse gram, Eucalyptus	459390.2 ha (2.41%)
7. Narrow Valleys	Very deep, moderately well drained, cracking clay black soils, with moderate erosion, associated with moderately deep, well drained, clayey black soils.	Very-fine, mont., Typic Haplusterts Fine, mont., Vertic Haplustepts	Paddy, Jowar, Ragi, Groundnut, Mulberry, Tur, Maize	173351.4 ha (0.91%)
8. Broad valleys	Very deep, moderately well drained, clayey brown soils, with slight salinity in patches, associated with moderately deep, well drained, loamy black soils. Deep, moderately well drained, clayey alluvial soils, with problems of drainage and slight salinity in patches, associated with deep, imperfectly drained clayey over sandy alluvial soils.	Fine, mixed, Typic HaplusteptsClayey over loamy, mixed, Typic UstifluventsFine, mixed Typic HaplusteptsClayey over sandy, mixed, Vertic Haplustepts	Paddy, Sugarcane, Irrigated jowar, Cotton, Sunflower, Redgram, Green gram	1445896 ha (7.59%)

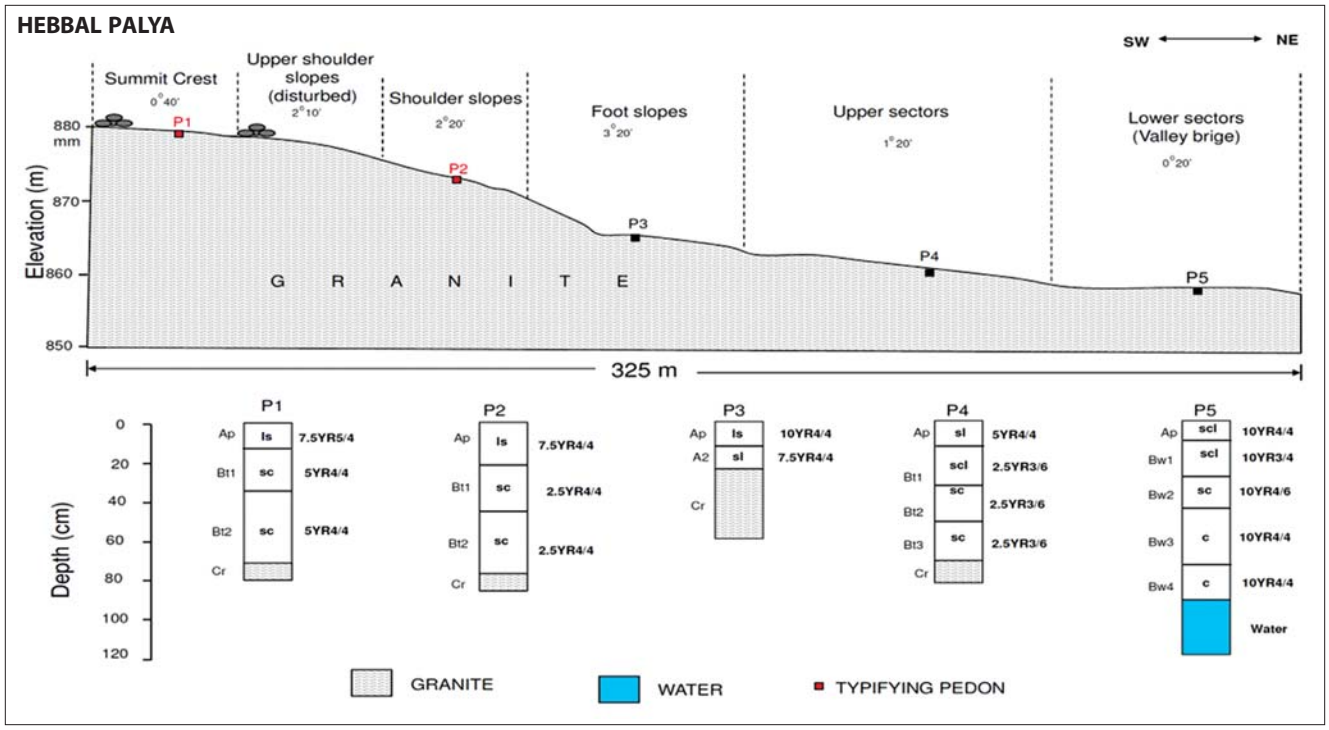


Fig. 28: Soil-physiography relationship at Hebbal Palya village

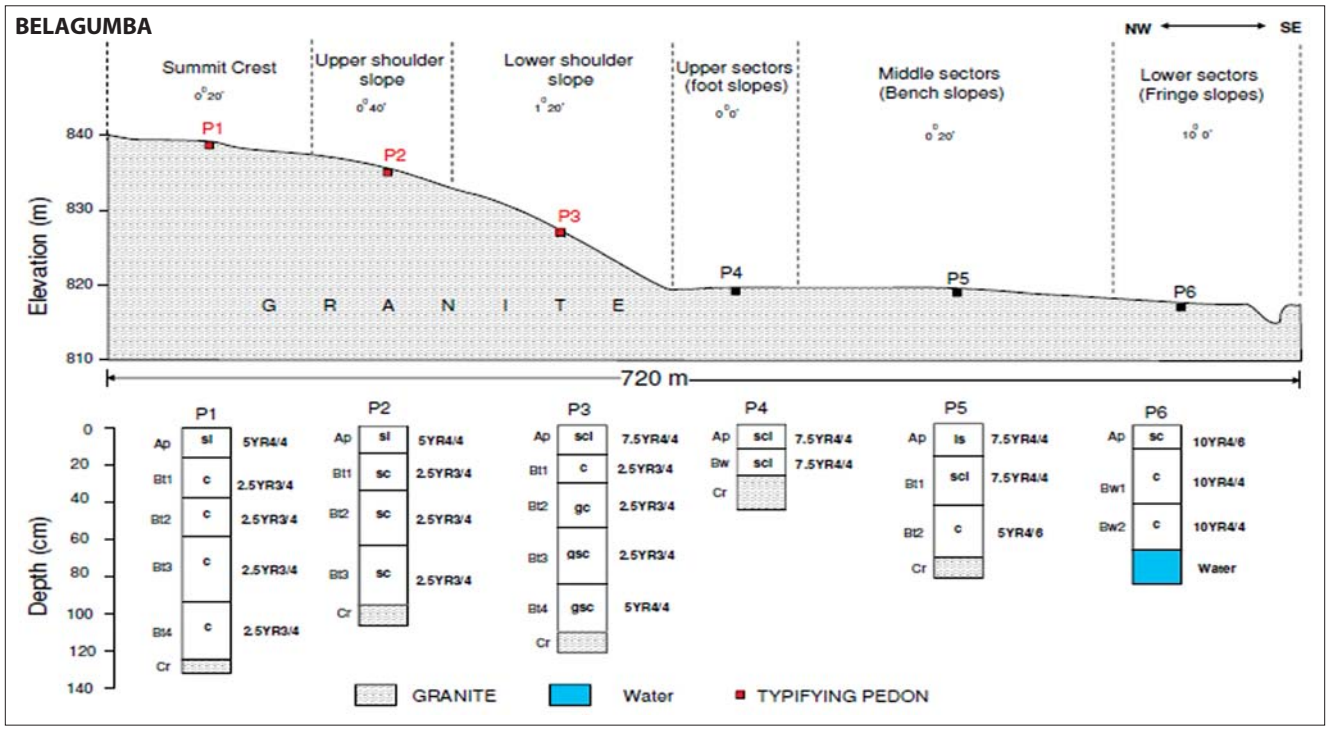


Fig. 29: Soil-physiography relationship at Belagumba village

Geomorphometric and hydrological evaluation of a micro-watershed in Chhotanagpur plateau, West Bengal for sustainable utilization of soil and water resources

The soil properties which affects land use and management have been identified. The clay content, depth, bulk density and available water content have been taken have been identified as soil properties greatly affecting the land use and management. The soil map units which do not differ significantly with respect to these soil properties have been classified under one functional unit. There were four functional units in the watershed as given in table 23 and Fig. 30.

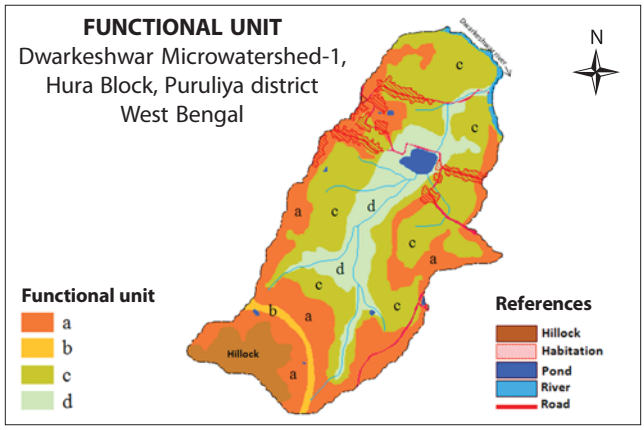


Fig. 30: Functional unit of Dwarkeshwar Microwatershed-1, Hura Block, Puruliya district

Table 23: Characteristics of mapping units of Dwarkeshwar micro-watershed

Functional Unit	Characteristics
a	Shallow to moderately deep soil (29-97cm) 12 to 15% clay content, bulk density 1.45-1.46g/cc, low AWC (<50mm/m).
b	Deep soil (100m), 13-16% clay content, bulk density 1.42 g/cc, moderate AWC (96mm/m).
c	Moderate deep soil (95-100cm), bulk density 1.34-1.48g/cc, medium AWC (98-122mm/m).
d	Moderately deep soil (98-100cm), 16-25% clay content, bulk density 1.37-1.50g/cc and medium AWC (97-118mm/m).

Revising methods for the determination of available potassium content in shrink-swell soils of India

Researchers in the recent past have broken the myth that except highly weathered ferruginous soils, soils of the Indo-Gangetic Plains (IGP) and the black shrink-swell soils are adequately supplied with available K. Experiences from long term fertilizer experiments under intensive cropping systems with high yielding crop varieties indicate that K from soils is getting depleted. This is evident from the crop response to addition of K in various soils of the country.

In many fora, slogans have been raised to revise fertilizer K recommendation for different crops based on neutral normal ammonium acetate (NH_4OAc) solution method for all soils in general and shrink-swell soils in particular. It is in this perspective that the present work has been taken for study.

K is generally adsorbed in small amounts by various soils. The exchangeable K values for majority of the IGP soils ranges from 3 to 8%, for shrink-swell soils it ranges from 1 to 2% and for ferruginous soils it ranges from 3 to 4%. It is quite often reported in the literature that micas, hydrous micas and vermiculites have high adsorption/fixation properties whereas smectites and kaolinites have low capacities. There are some reports that beidellite soil clays are great fixers for added K followed by vermiculite clays, and fixation is not appreciable in clays consisting of montmorillonite. Inspite of all these information, the K reserves of shrink-swell soils do not compensate for the higher amount of K release and adsorption (by 1N NH_4OAc) in these soils. Therefore, it is imperative to investigate whether the speciation of smectites would help to apportion the amount towards adsorption/desorption of K by 1N NH_4OAc in the shrink-swell soils.

Nine benchmark soil series *viz*. Panjri (Nagpur, Maharashtra), Nimone (Ahmadnagar, Maharashtra), Nabibagh (Bhopal, Madhya Pradesh), Sarol (Indore, Madhya Pradesh), Telgi (Bellary, Karnataka), Sokhda (Rajkot, Gujarat), Kasireddipalli (Medak, Andhra Pradesh), Kovilpatti (Tuticorin, Tamil Nadu) and Chunchura (Hooghly, West Bengal) from various parts of the country were chosen for the study.

X-ray diffractograms of fine clays of various soil series show the dominance of smectites with very small amounts of vermiculite. The smectites in most of the soil fine clays are partially hydroxyl-interlayered (Figs. 31 & 32). The semi-quantitative estimates of montmorillonite and beidellite/ nontronite show that (Table 24) the later (61-87%) dominated over montmorillonite (13-39%) not only in the Peninsular India, but also in the shrink-swell soils of the Indo-Gangetic Plains (IGP). Dominance of beidellite/ nontronite may have implications in K management of these soils.

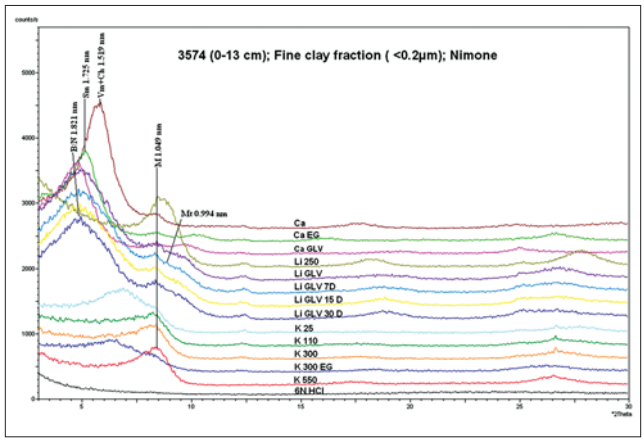


Fig. 31: XRD graphs of Nimone soil series

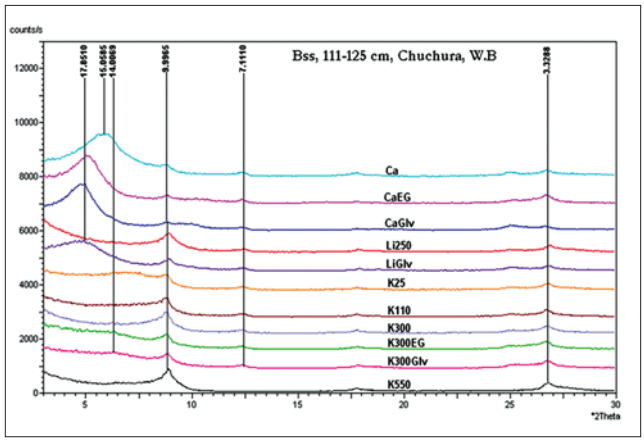


Fig. 32: XRD graphs of Chunchura soil series

Table 24: Montmorillonite and beidellite / nontronite ratio in selected soil series

Soil	Montmorillonite	Beidellite / Nontronite
Linga	39	61
Loni	19	81
Asra	13	87
Paral	23	77
Nimone	25	75
Chunchura	26	74

The $BaCl_2$ extractable K showed that constancy was attained after 30 extractions (Figs. 33 and 34). In Panjri soils the extracted K was slightly higher than Nabibagh and Sarol soils. The cumulative extraction of K by $BaCl_2$ varied from about 59-111 kg ha^{-1} in profile of Panjri soil series with highest value in the surface horizons. It is interesting that by $BaCl_2$ about 36 to 39% of K is extracted in the first three extractions. Extraction by some other reagents like 1(N) HNO_3 method (non-exchangeable) is much higher compared to 1(N) NH_4OAc method (exchangeable) within the soil profile of each series. The 1(N) HNO_3 method extracted about 3 to 9 times more K than 1(N) NH_4OAc method (Table 25). The non-exchangeable K for Chunchura soils is much higher compared to other soils of the Peninsular India due to the higher amount of mica in Chunchura soils (which is partly composed of Gangetic alluvium rich in mica) of the IGP as compared to the shrink-swell soils of the Peninsular region where mica is in traces.

Some other extractants for determination of available K gave interesting results. The 1(N) NH_4Cl method gave closer values, but slightly less than the

1(N) NH_4OAc method. The X_mY_n and the P_mQ_n extractants used for the determination of available K gave values in the medium to high range as per the recommendation of Muhr et al. (1965) (low - < 108 kg ha^{-1} K; medium – 108-280 kg ha^{-1} K, high - >280 kg ha^{-1} K) and other standards followed in India (low- < 125 kg ha^{-1} K; medium-125-250 kg ha^{-1} K; high- >250 kg ha^{-1} K). The X_mY_n reagent extracted 31-70% less K than the NH_4OAc reagent whereas the other reagent P_mQ_n extracted about 40-64% less K than the NH_4OAc extractant. The detailed dataset would be provided after further studies with large number of soil samples. These two extractants showed promising results and indicated optimum values within the range of Muhr et al. (1965) and other standards used to indicate soil test crop response values. However, the results are subject to vigorous tests with respect to large number of soil samples of shrink-swell type across various agro-ecological regions of India *vis-à-vis* plant response values.

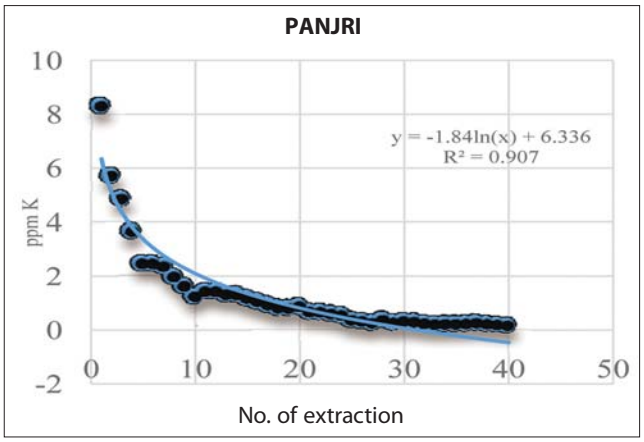


Fig. 33: Cumulative $BaCl_2$ extraction of K in Panjri series

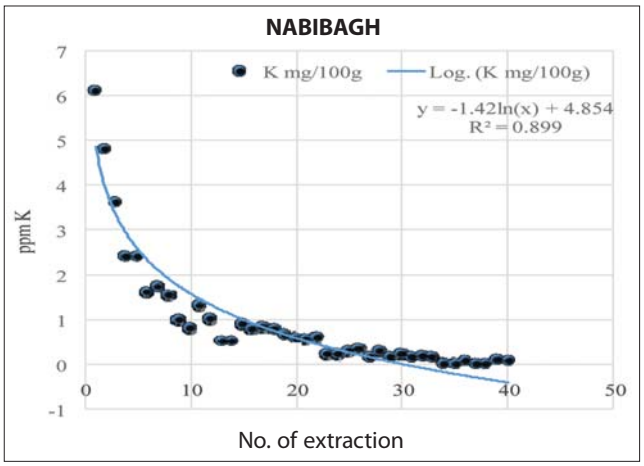


Fig. 34: Cumulative $BaCl_2$ extraction of K in Nabibagh series

Table 25: Comparative results of 1(N) HNO_3 and 1 (N) NH_4OAc methods of K extraction from some major shrink-swell soils in kg ha^{-1}

Sl. No.	Soil Series	1(N) NH_4OAc (pH 7.0) (Exchangeable)	1(N) HNO_3 (Non-Exchangeable)	NH_4OAc : HNO_3 ratio
1	Chunchura	426 - 507	3344 - 4752	1:9
2	Nabibagh	507 - 641	1738 - 2354	1:4
3	Panjri	620 - 798	1958 - 2288	1:3
4	Sarol	555 - 652	1738 -2420	1:3
5	Kovilpatti	313 - 647	616 - 1694	1:2
6	Kasireddipalli	345 - 517	1100 - 1738	1:3
7	Teligi	280 - 474	902 - 1408	1:3
8	Nimone	463 - 895	1496 - 2112	1:3
9	Sokhda	367 - 588	1078 - 1804	1:3

Studies on soil minerals and their genesis in selected Benchmark spots representing different agroeco-regions of India

The project is undertaken with the objective to collate available data and develop new datasets in appropriate format, identify and quantify the mineral assemblage in different fraction of soils, develop a protocol for quantifying biotitic mica in shrink-swell soils and their K- reserves in various size fraction and develop a comprehensive mineral atlas along with a detailed report of minerals in major soils of India.

Six soils from AER 10, were selected for detailed study of physical, chemical, mineralogical and microscopic analysis. The soils are formed from weathered basalt under subhumid (moist) climate with annual rainfall of >1000 mm. Majority of the soils are deep (except Boripani soils) moderately well drained and developed on gently to very gently

sloping lands of Deccan plateau and Satpura ranges in the state of Maharashtra and Madhya Pradesh. These are Vertisols with clay content varying from 45 to 75% of which more than 60% is fine clay. This is a common characteristic of the soils developed in this part of the country. Soils are neutral to moderately alkaline with pH ranging from 7.3 to 8.1 except the soils of Sakka where in pH is acidic. However pH of soils belonging to AER 10 is lower than AER 6 due to better average rainfall. But a slight increasing trend was noticed with depth in some pedons of AER 10.

$CaCO_3$ has an increasing trend with depth as also the clay carbonate. Bulk density of the soils vary from 1.4 to 1.8 Mg m^{-3}. CEC of the soils are high and base saturation is >80% in all the soils. $Ca^{+2}$is the dominant cation in the exchange complex followed by Mg^{+2} , K^{+} and Na^{+}. ESP of all the soils is low and has no detrimental effect on the soils and crops. EC of the saturation extract (ECe) is <1meq l^{-1} in all the soils and SAR is <5.

Mineralogy of some of the BM soils of AER 10 indicate that silt fraction of Linga soils had 1.4 nm peak which does not change its position on glycolation and persisted on K saturation and heating at 550˚C (Fig. 35a). This indicates that the smectite in this fraction is chloritized. Other minerals in this fraction include mica, kaolin, quartz and feldspars. The clay fraction of Linga soils are dominated by 1.4 nm minerals which on glycolation expands to 1.7 nm region indicating the presence of smectite (Fig. 35b). The 1.4 nm fraction on K saturation at ambient temperature gave a peak at 1.1-1.2 nm region which on further heating at 550^{0}C reinforces to 1.0 nm region indicating chloritization of the smectite interlayer. This is common in the shrink-swell soils developed from the Deccan basalt (Pal *et al.*, 2000, 2003). Here also diffraction pattern has peaks at 1.0 nm, 0.7 nm regions indicating the presence of mica and kaolin.

The XRD silt fraction of Boripani soils shows a peak at 1.2 nm region on Ca^{+2} saturation which on glycolation expands to 1.4 nm region indicating the presence of mixed layer mineral of mica and smectite. Here also the smectite is chloritized as observed from the behavior of the peak on K saturation and heating up to 550˚C. The total clay and fine clay fraction are dominated by smectite mineral with subdominant amount of mica and kaolin (Fig. 35c). The Kaolin in these fractions was confirmed by its characteristic peak at 0.7 nm region and its disappearance on K-saturation and heating at 550˚C.

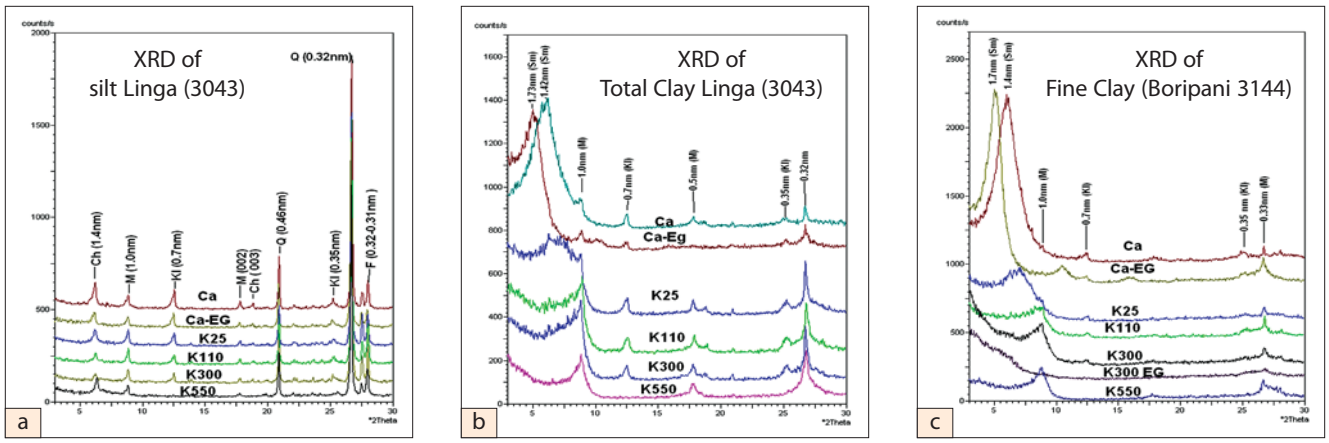


Fig. 35: Representative XRD patterns of the (a) silt, (b) total clay and (c) fine clay fractions of Linga soils and Boripani soils of sub humid moist climate, Ca = Ca-saturated, CaEG = Ca-saturated and ethylene glycol vapour treated, K25/110/300/300EG/550ºC = K – saturated and heated at 25º,110º,300º and 550ºC

Sm = smectite, Cl=chlorite, M = mica, Z = zeolite, Kl = kaolin, Q = quartz, F = feldspars.

In the soils of Nabibagh and Sakka, silt and clay fractions contain chloritized smectite along with mica and kaolin. Thus the mineralogy of silt fraction of the soils of the AER 10 are dominated by chloritized smectite along with mica and kaolin in subdominant amount. The clay fractions are dominated by smectites which are less chloritized than the silt fraction. The kaolin in the fine fraction indicates that they are formed in the humid climate of the past but their development in the present climate due to hydroxyl-interlayering of smectite and its transformation cannot be ruled out, particularly in soils where pH is acidic to slightly alkaline.

Scanning electron microscopy studies indicate the presence of muscovite mica, feldspars and well crystallized zeolites in the sand fraction of Nabibagh soils (Fig. 36). However the silt fraction does not give a characteristic XRD peak of zeolites. It indicates that zeolites are restricted to the coarser fraction of the soils. It has been reported that many Vertisols contains zeolites in their sand fraction and its presence as Ca-Zeolites is considered as a boon to replenish calcium in the exchange complex. Highly weathered feldspars and coarse feldspars grains with initiation of weathering were also observed in the sand fractions of Kheri soils (Fig. 37).

The sand and clay mineralogical characterization of soils and semi quantification of minerals from XRD is in progress.

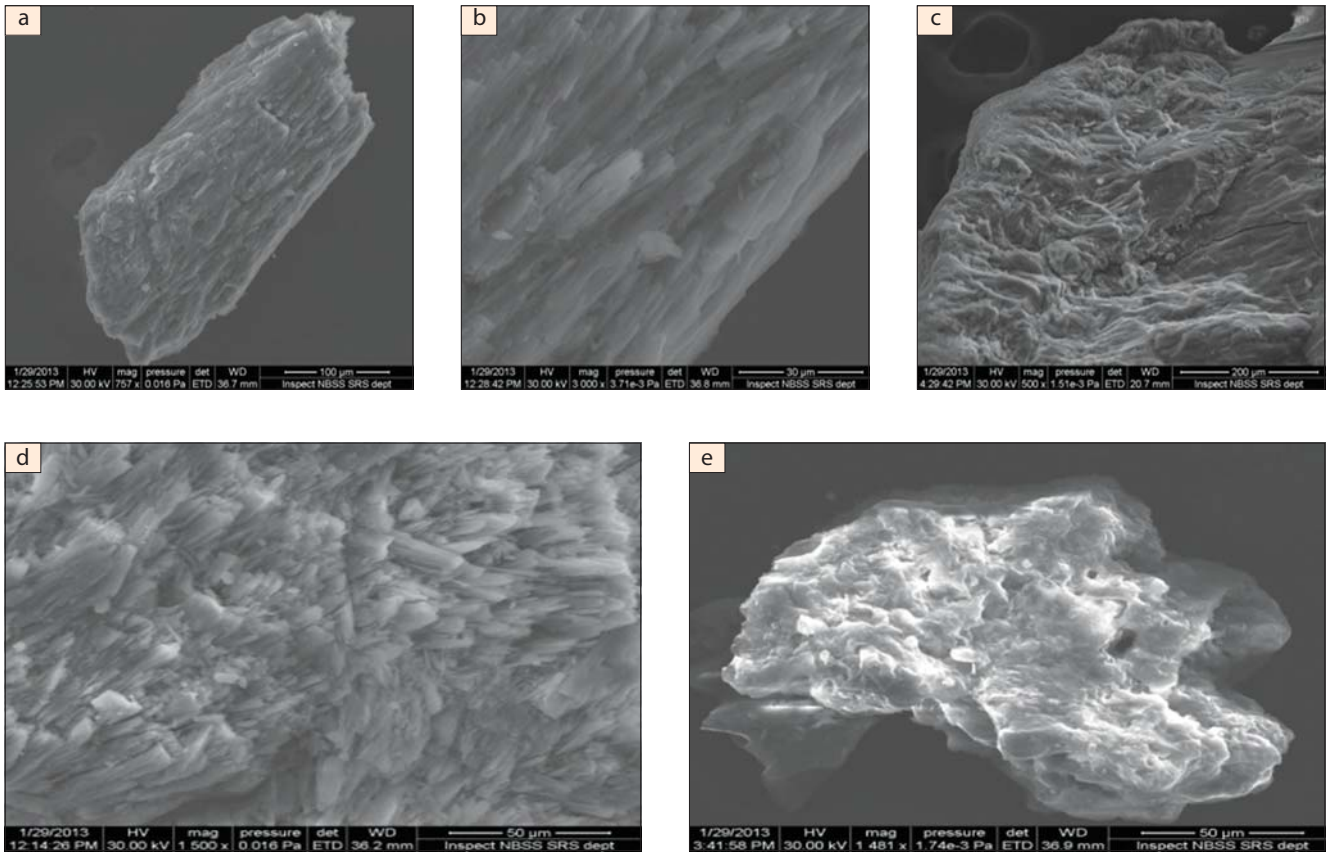


Fig. 36: Minerals in sand fraction of Nabibagh Soils, Madhya Pradesh (a) muscovite-mica, (b) mica flakes with opening of edges (c) biotite mica a precurser smectite, (d) elongated well developed zeolite, (e) highly weathered feldspar

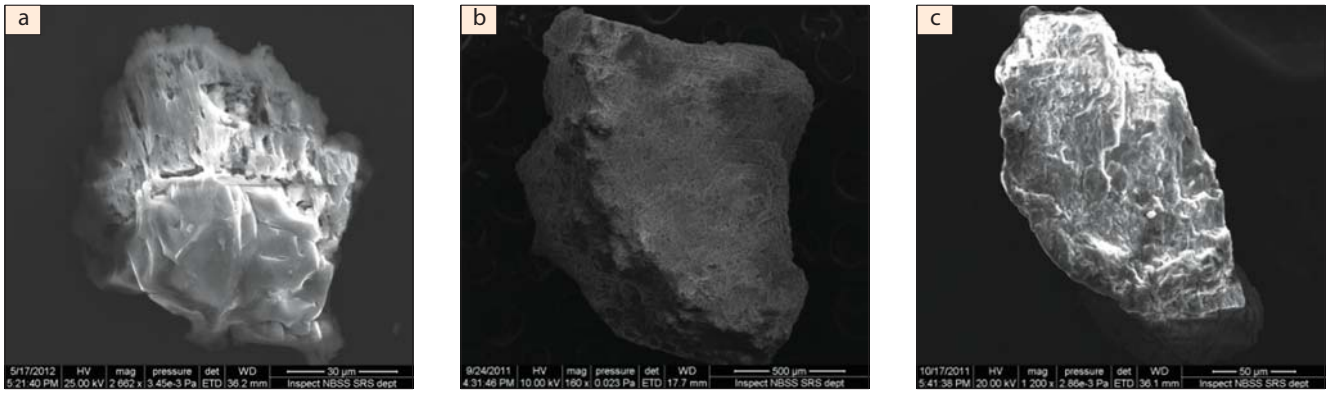


Fig. 37: Different types of feldspar (a) highly weathered (part) with edge pits, (b) relatively unweathered and (c) feldspars with strong weathering features under the subhumid climate

Water retention characteristics and saturated hydraulic conductivity of dominant soil series of Yavatmal district, Maharashtra

The profile distribution of sand (2 to 0.05 mm), silt (0.05 to 0.002 mm) and clay (less than 0.002 mm) in twenty three soil series of Yavatmal district shows more clay and silt than sand. The particle size at family level is very fine (clay >60%) for Wani, Pandhurna, Arunavati, Nagdhari, Kharbi, Arni, Dhanora and Dhanki series but fine (clay 35 to 60%) for Pandharkawada, Chanoda, Wanodi, Penganga, Kalamb, Selodi, Sindola, Jamwadi, Gahuli, Apti and Chikhalgaon series. The Loni, Lakhi, Met and Moho soils have fine-loamy with less than clay 35%. The fine clay is 50.34% in Bw1 horizon of Dhanki series, but decreased to 4.9% in Cr horizon of Selodi soil series.

The descriptive statistics of important soil parameters used in regression analysis is presented in table 26. The mean silt is 37.79% with coefficient of variation (CV) of 42.22 per cent whereas clay has mean of 46.69 per cent with moderate variability (CV) of 29.77%. These soils have shown high variability of organic carbon and calcium carbonate content with its mean of 0.5% ±0.31for organic carbon and 6.82%±7.10 for $CaCO_3$ content. The water retention of these soils showed moderate variability with it mean of 36.09% ± 8.43 for 33kPa, 22.42%±5.89 for 1500kPa and 13.62%±3.18 for plant available water.

Table 26: Descriptive statistics for soil parameters used in regression analysis

Statistics	Soil parameters						
	Silt	Clay	Organic carbon	$CaCO_3$	Soil water held (kPa)		PAWC
					33	1500	
	(%)						
Mean	37.79	46.69	0.50	6.82	36.09	22.42	13.62
SD(±)	15.74	13.88	0.31	7.1	8.43	5.89	3.18
CV(%)	42.22	29.73	62.2	104.2	23.36	26.25	23.37
Skewness	-0.43	-0.82	1.1	2.0	-1.11	-1.01	-0.51
Kurtosis	-0.64	0.82	3.59	4.74	2.01	0.83	2.25
Minimum	4.31	7.75	0.02	0.3	3.29	1.64	1.65
Maximum	62.16	68.79	2.03	36.58	56.22	32.33	23.89

The multiple regression equations were developed to show relation of field capacity (33 kPa) and permanent wilting point (1500 kPa) with particle size, organic carbon (OC) and $CaCO_3$ content as given below:

Retention of moisture at 33 kPa = 3.95 + 0.292 silt (%) + 0.41 clay (%);R^2 = 0.71**(n=75)

Retention of moisture at 33 kPa = 8.31 + 0.32 silt (%) + 0.38 clay (%) – 5.79 OC – 0.23 $CaCO_3$ (%);

R^2 = 0.70**(n=75)

Retention of moisture at 1500 kPa = 3.05 + 0.07 silt (%) + 0.15 clay (%); R^2 = 0.578**(n=75)

Retention of moisture at 1500 kPa = 5.422 + 0.093 silt (%) + 0.123 clay (%) – 3.293 OC – 0.085 $CaCO_3$

R^2 = 0.63**(n=75)

There is no change in R^2 with the inclusion of organic carbon and $CaCO_3$ in the regression equations to estimate retention of moisture at 33 kPa, but R^2 slightly increases in case of retention of moisture at 1500 kPa. The larger the R^2 value, the more important is the regression equation in characterizing the dependent variable

Geochemical characterization for reconstruction of physical and chemical properties of shrink-swell soils of Yavatmal district, Maharashtra

Six representative Vertisols in cotton growing Yavatmal district were selected for geochemical characterization in relation to parent material and for reconstruction of physical and chemical properties. The schematic geochemical patterns in these shrink-swell soils were interpreted and presented in Fig. 38. The strong positive relationship of total Al with clay is well expressed in 3rd order polynominal regression equation as clay(%) = 8E-05 (Al%)3-0.014 (Al%)2 +0.665 (Al%) with R2 value of 0.53** (Significant at 1% level). This relationship clearly shows that the high Al contents in clay soils is due to separation of fine grained clay minerals from quartz and feldspars during

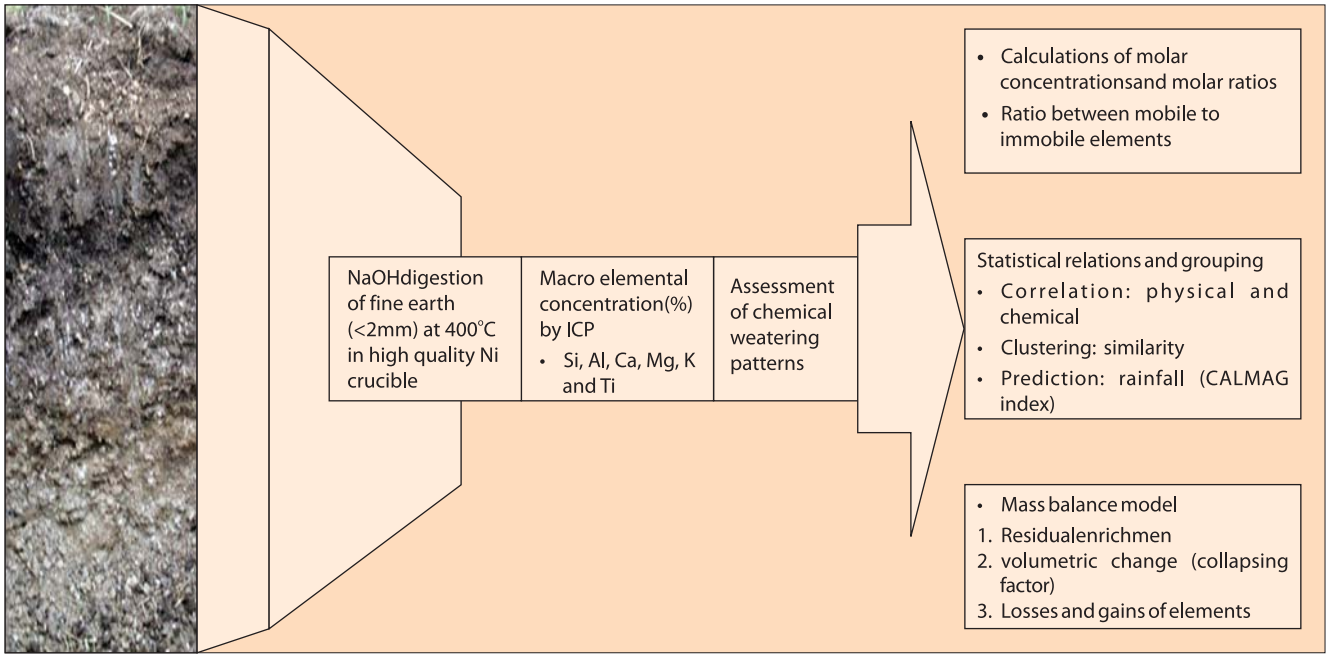


Fig. 38: Schematic flow chart of geochemical characterization of shrink-swell soils

transportation. Al is best predictor of total clay content because Al is concentrated in 2:1 phyllosilicate mineral structures.The relation is weakened because carbonate unpredictably dilutes Al in relation to clay. The fine clay is positively and strongly related with COLE(r=0.49**, significant at 1%Level) and organic carbon(r=0.65**) but negatively related with pH(r=-0.37*, significant at 5% level). The molar ratios of mK, mFe and mSi with mTi shows strongly negative and significant(1%level) relationship with COLE indicating higher values in soils have negative effect on shrink-swell potential of the soils. The Si may be related to COLE because Si contained in phyllosilicate mineral structure of 2:1. The $CaCO_3$ is positively and strongly related with molar ratios of mCa and mFe with mTi. This relationship is significant at 5% level. The Ca content in soils is a proxy for calcium carbonate content hence related strongly with Ca. The saturated hydraulic conductivity is negatively related with ratio of mCa and mMg with mTi. There is a strong positive relation between molar ratio's of K, Fe, Al and Si with Ti. Fine clay content correlates positively and curvilinear relationship with Al to Ca+Mg for all horizons. This relation is due to generation of exchangeable Ca and Mg from fine clay fraction and that of Mg is structurally a part of smectite concentrated in fine clay with Al stable constituent normalizing the diluents effects of carbonate. It appears that when fine clay is in lower amounts, carbonate tends to be in high amounts with weathering ratio increasing with decalcification.

Elemental composition

The elemental constituents that are relatively insoluble in well drained regolithweathering environments include Si, Al, Fe and Ti where as soluble constituents include Ca, Mg, K and Na. Among insoluble elements Si is dominant with mean of 23.9±3.5% with its minimum value of 13.09% in Bss3 horizons of Kharbhi soil (P7) and maximum of 36.01 % in Bss horizons of Dhanki series (P6) (Table 27). The Si distribution in the profiles shows an irregular trend in Chanoda (P1) and Wani soils (P2) with values varying from 16.63% (Bw, P2) to 26.52% in Bss horizons of Chanoda (P1), bimodal distribution in Nagadhari (P4 from 25.3 to 23.0 and then increase of 25.88%), gradational increasing trends Selodi (P3, 20.3 to 23.53%) and Dhanki (P6, 22.39 to 36.01%), gradational decreasing from 27.05 to 13.09% in Kharbhi soil (P7) and slight variations with depth in Loni soil (P5, 22 to 24%). These soils have mean of 8.82±1.18% Al, 6.2±1.74% Fe and 0.81±0.31% Ti concentrations with its maximum contents in slickenside zones. The total Al concentratins varied from 7.8 to 10.7% with slight variations with depth except in Chanoda series (P1) with 4.2% in Bss4 horizons (below 1.2 m). These soils showed distinct variations in Fe contents between the soils and also with in the profiles. The Fe content was less than 5% in Chanoda series (P1) and Wani series (P2) with depthwise increasing trends but slight decrease in lower layers of Wani soil (P2). The Fe content in Selodi (P3) and Kharbhi (P7) soils is 5 to 6% in control section but it is 7 to 10% in case of Nagdhari (P4), Loni (P5) and Dhanki (P6). In general, Ti content is less than 1 % except in Nagdhari (P4), Loni (P5), Dhanki (P6) and Kharbhi (P7) where Ti content in some horizons recorded more than 1%.

The soluble elements include Ca, Mg, K and Cu.These soils have mean (±SD) concentration of 7.55±7.39% of Ca, 2.25±1.51% of Mg, 1.94±0.4%K and 0.88±0.13% of Cu. The depth functions of Ca, Mg and K is irregular in all soils. The Ca in soils is varied from 2 to 37% with irregular trends in Chanda (P1, 2.49 to 3.87%) and Wani (P2, 2.85 to 5.73%). The Ca reaches maximum in Bss horizons of Selodi series (3.22 to 12%), Nagdhari series (P4, 7.85 to 35%), Loni series (P5, 2.95 to 10.3%), Dhanki series (P6, 3.63 to 9.66%) and Kharbi (P7, 7.55 to 36.6%). The high Ca contents are in agreement with the corresponding $CaCO_3$ contents measured in the soil profiles. Next to Ca, Mg is dominant with high

Table 27: Total elemental composition in soils

Soil series	Depth(cm)	Horizon	Total elemental composition(%)							
			Si	Al	Fe	Ti	Ca	Mg	K	Cu
Chanoda	0-18	Ap	23.6	8.27	3.24	0.04	3.87	1.67	2.05	0.91
limestone	18-35	Bw1	25.69	8.35	4.60	0.67	3.36	1.61	1.79	0.97
	35-61	Bss1	26.05	8.26	4.67	0.68	3.34	1.61	1.98	0.87
	61-97	Bss2	25.73	8.63	4.58	0.63	3.37	1.74	1.86	0.99
	97-128	Bss3	26.52	8.90	4.73	0.69	3.80	1.81	1.96	1.06
	128-150	Bss4	23.43	4.82	4.87	0.60	2.49	1.65	1.50	0.81
Wani/ sand stone	0-16	Ap	22.02	7.80	4.60	0.64	2.85	1.50	1.68	0.73
	16-37	Bw1	23.2	7.93	4.28	0.64	3.18	1.58	2.15	0.93
	37-70	Bw2	16.63	8.65	4.44	0.65	3.61	1.71	2.10	1.12
	70-100	Bss1	23.69	8.23	4.47	0.54	4.01	1.73	1.98	0.85
	100-130	Bss2	21.28	8.61	4.28	0.61	3.96	1.80	2.06	1.09
	130-150	Bss3	24.21	8.63	4.27	0.57	5.73	2.00	2.01	1.07
Selodi -Basalt	0-20	Ap	20.3	7.85	5.92	0.71	3.22	1.65	1.37	0.94
	20-50	Bw1	21.65	8.36	6.09	0.79	3.81	1.78	1.64	1.13
	50-80	Bss1	22.05	8.47	6.23	0.82	4.81	2.06	2.00	1.05
	80-110	Bss2	23.53	10.4	5.53	0.76	12.00	2.08	1.10	0.88
	110-150	Cr	22.5	7.84	5.48	0.37	3.21	1.20	1.77	0.69
Nagdhari-Basalt	0-12	Ap	25.3	9.46	7.76	0.74	7.85	2.54	1.98	0.69
	12-26	Bw1	26.03	10.20	7.45	1.38	4.07	1.33	2.54	0.94
	26-45	Bw2	26.69	10.70	7.57	1.17	4.58	1.59	2.60	0.96
	45-75	Bw3	23.65	9.88	7.30	0.80	14.1	2.52	2.29	0.75
	75-110	C1	24.93	9.73	6.57	1.04	35.00	6.78	2.56	0.97
	110-150	C2	25.88	9.06	5.46	0.71	7.60	2.39	2.42	0.72
Loni-Basalt	0-12	Ap	24.05	8.97	7.50	0.41	9.70	2.95	1.61	0.85
	12-28	Bw1	23.42	9.17	8.60	0.78	9.68	2.78	1.28	0.70
	28-52	Bw2	23.87	9.63	8.36	1.31	10.3	2.80	1.56	0.90
	52-84	Bss1	23.08	8.96	8.83	0.54	10.3	2.85	1.41	0.72
	84-120	Bss2	22.05	9.00	7.39	1.56	10.3	2.32	1.65	0.95
Dhanki-Basalt	0-20	Ap	22.39	9.01	6.62	0.84	3.63	1.31	1.9	0.80
	20-52	Bw1	25.14	10.20	7.98	1.17	9.66	2.65	1.97	0.82
	52-83	Bw2	28.53	10.10	10.2	1.24	5.36	1.25	1.97	0.84
	83-118	Bss1	36.01	9.66	8.9	1.01	6.06	1.61	2.15	0.89
	118-150	Cr	19.4	8.40	9.01	0.89	6.91	1.51	1.60	0.67
Kharbhi -Granite	0-14	Ap	27.05	10.10	5.96	1.35	7.55	2.61	3.00	0.91
	14-50	Bw	26.47	9.43	6.55	0.75	9.45	2.07	2.46	0.68
	50-78	Bss1	25.16	9.32	5.79	0.96	4.51	2.25	2.41	0.81
	78-111	Bss2	24.28	9.12	6.21	0.76	36.6	9.35	1.73	0.74
	111-150	Bss3	13.09	5.26	3.3	0.95	3.2	1.01	1.64	0.87

concentration in Bss horizons recording 9.35 % in Kharbhi (P7). The K distribution in soils is irregular with more than 2% in Nagdhari soil (P4). The Cu content is less than 1% but in some horizons of Chanoda (P1), Wani (P2) and Selodi (P3), its content is recorded more than 1% with irregular depth trends (Table 27). Based on coefficient of variation, the elements Si, Al and Cu are grouped as least variable (<15%), Fe and K as moderately variable (15-35%) and Ti, Ca and Mg as highly variable (>50%).

Transfer functions

The transfer functions between bulk oxides and physical and chemical properties is constructed as regression equations that offer explanations geochemical differences related local rainfall. Here the data sets of both surface and subsurface horizons were combined because vertisols are not textural profiles that experience minimal hydrolysis and have a physical and chemical framework governed by high smectite clay content regardless of horizon. The strong positive relationship of total Al with clay is well expressed in 3rd order polynominal regression equation as clay (%) = 8E-05(Al%)^3-0.014(Al%)^2 +0.665(Al%) with R^2 value of 0.53** (Significant at 1% level, Fig. 39). This relationship clearly shows that the high Al contents in clay soils is due to separation of fine grained clay minerals from quartz and feldspars during transportation. Al is best predictor of total clay content because Al is concentrated in 2:1 phyllosilicate mineral structures.The relation is weakened because carbonate unpredictably dilutes Al in relation to clay.

The fine clay is positively and strongly related with COLE (r=0.49**, significant at 1% Level) and organic carbon (r=0.65**) but negatively related with pH (r=-0.37*, significant at 5% level. The molar ratios of mK, mFe and mSi with mTi shows strongly negative and significant (1% level) relationship with COLE indicating higher values in soils have negative effect on shrink-swell potential of the soils. The Si may be related to COLE because Si contained in phyllosilicate mineral structure of 2:1. The $CaCO_3$ is positively and strongly related with molar ratios of mCa and mFe with mTi (Table 28). This relationship is significant at 5% level. The Ca content in soils is a proxy for calcium carbonate content hence related strongly with Ca. The saturated hydraulic conductivity is negatively related with ratio of mCa and mMg with mTi. There is a strong positive relation between molar ratio's of K, Fe, Al and Si with Ti. Fine clay content correlates positively and curvilinear relationship with Al to Ca+Mg for all horizons (Fig. 40). This relation is due to generation of

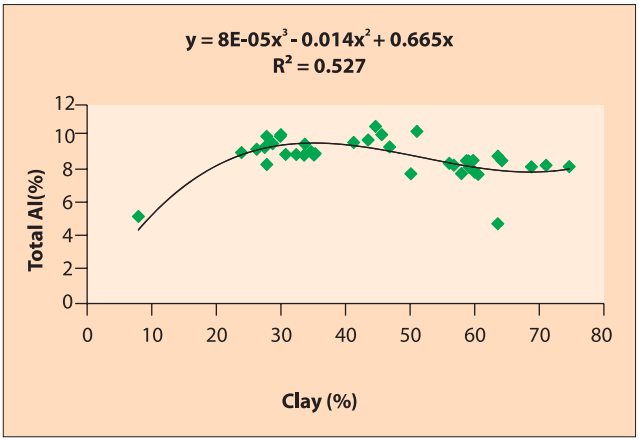


Fig. 39: 3rd order polynominal relation of total Al (%) with total clay

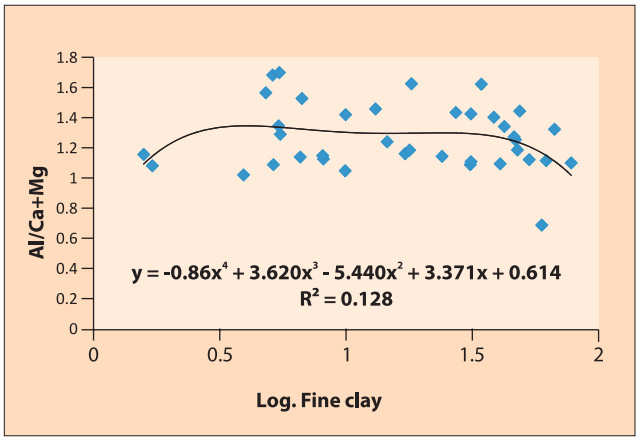


Fig. 40: Relation between Al/Ca+Mg to log Fine clay

Table 28: Correlation matrix for soil parameters

Soil variables	fine clay	bulk density	COLE	organic carbon	$CaCO_3$	Saturated hydraulic conduc-tivity (sHc)	pH	mCa/ mTi	mMg/ mTi	mK/ mTi	mFe/ mTi	mAl/ mTi	mSi/ mTi
fine clay	1												
bulk density		1											
COLE	.49**	.33*	1										
orgnic carbon	.65**		.44**	1									
CaCO3					1								
Saturated hydraulic conductivity(sHc)						1							
pH	-.37*		-.37*	-.53**			1						
mCa/mTi					.39*	-.41**		1					
mMg/mTi						-.38*			1				
mK/mTi			-.57**	-.47**						1			
mFe/mTi					.41*			.34*		.44**	1		
mAl/mTi			-.41**	-.40*						.84**	.71**	1®®	
mSi/mTi			-.44**	-.41*						.82**	.71**	.88**	1

**significant at 1%level
*significant at 5% level

exchangeable Ca and Mg from fine clay fraction and that of Mg is structurally a part of smectite concentrated in fine claywih Al stable constituent normalizing the diluents effects of carbonate. It appears that when fine clay is in lower amounts, carbonate tends to be in high amounts with weathering ratio increasing with decalcification.

These soils exhibit important physical and chemical differences reflecting environmental settings.These soils have high total clay and fine clay content with increasing depth trends indicating fine clay translocation(P1 and P2) with deceasing Ca/Mg ratio. The greatest abundance of fine clay with highest COLE value indicative of high shrink-swell potential.These soils have accumulation of total iron reflected in slickensides and reddish grey colours indicating rainfall is not sufficient enough to decalcify and intermediate intensities of pedoturbation have been more pronounced.

Nano-clay minerals of typical shrink swell soils: their separation and Characterization

Soils contain many kinds of naturally occurring inorganic particles having sizes from millimeter to nanoscale (<100 nm). These nano-size particles are highly reactive portion of clay fractions, which is more dynamic and can be modified for better agricultural growth and production. Standard protocol for separation of naturally occurring nano-particles are yet to be developed. In this process samples across the AESR of our country has been taken to have variability. The undisturbed horizon of the pedon has been selected to avoid the admixtures of soils. The protocol has been developed by taking 3 benchmark soils *viz.*, Kovilpatti, Linga, Sarol (because of its higher fine

clay percentage). To have the insight on purity of minerals at nanoscale the fine clay samples were subjected to X-ray diffraction with all possible treatments (Figs. 41, 42 and 43).

The nanoparticles were extracted from already separated fine clay (200nm) by sonication and centrifugation. During the process of separation, the finer sized particles got flocculated into larger-sized particles. This problem may be solved by altering the chemical environment of the colloid particles which would be reported in due course of time.

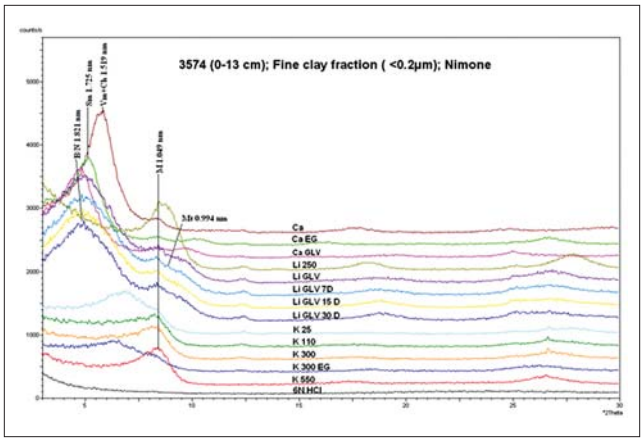


Fig. 41: XRD graphs of patterns of Kovilpatti soil series

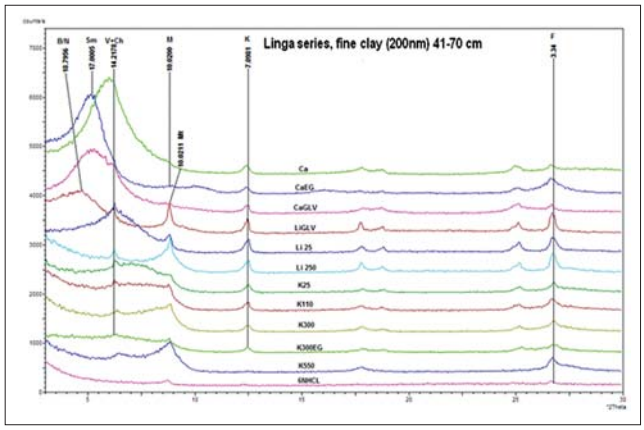


Fig. 42. XRD graphs of patterns of Linga soil series

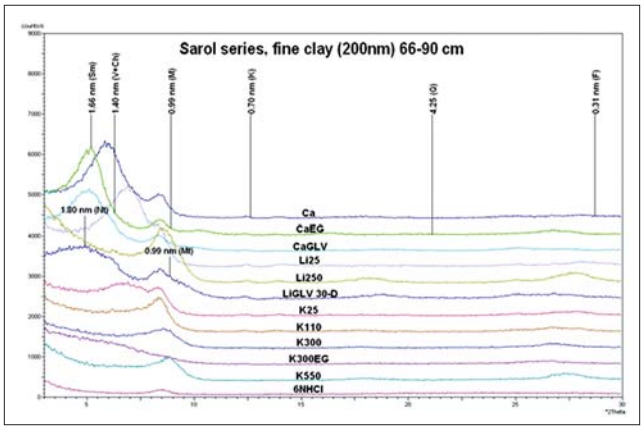


Fig. 43: XRD graphs of patterns of Sarol soil series

2.4 Soil Survey Data Interpretations and Applications

- Agro-Ecological Zoning
- Land Resource Management
- Soil Health/Quality and Monitoring
- Soil and Crop Modelling

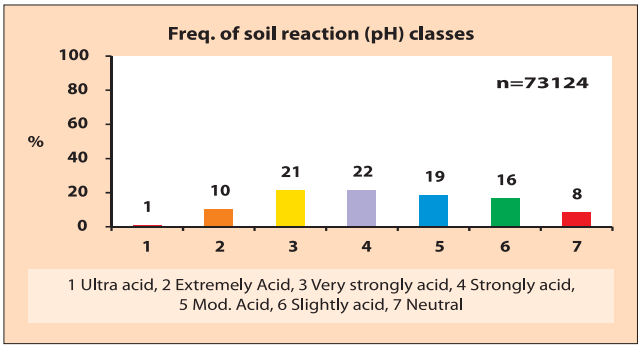
Soil fertility assessment and soil health monitoring in traditional rubber growing areas of Kerala, Tamil Nadu and Karnataka

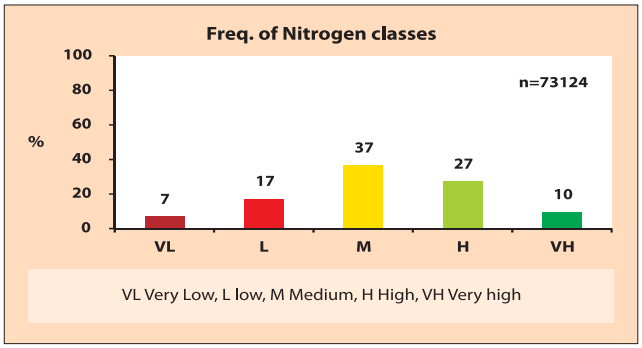
The objectives of the project are to document major, secondary and micronutrient status of rubber-growing areas of Kerala, Tamil Nadu and Karnataka through systematic soil sampling and analysis, to map soil fertility, to evolve site specific fertilizer recommendations and to establish and characterize soil health monitoring sites representative of the varied agro-climatic situations in the rubber-growing areas. Soil profile studies proforma has been refined and a separate proforma devised for gathering minimum dataset for each site. Completed soil morphological studies of Tamil Nadu and Karnataka states with 4 sites from Tamil Nadu, 11 soil health monitoring sites from Karnataka and finished 35 soil health monitoring sites in Kerala. Soil samples have been collected from the aforementioned sites for analysis them for different paremeters.

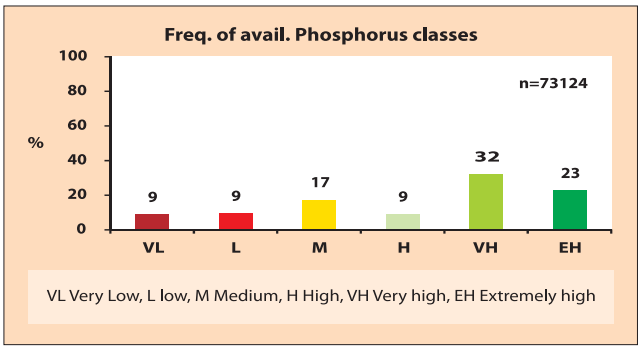
Soil based plant nutrient management plan for agro-ecosystems of Kerala

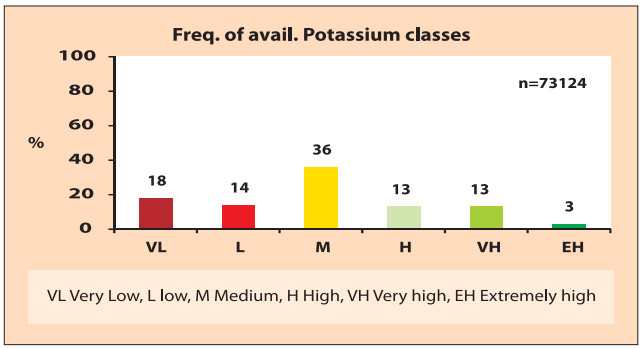
The overall objective of the project is assessment of the fertility of soils of Kerala in terms of its reaction and the content of plant available macro-, secondary and micro-nutrients. Frequency distribution of soil reaction and soil macro, secondary and micronutrients classes in different agro-ecosystems of Kerala is presented in Fig. 44. Ninety two per cent of the samples tested for acid reaction with fifty four per cent strongly to extremely acid (pH <5.5). Little or no attention paid to amelioration of soil acidity through regular application of liming materials is the prime reason for development of strong to extremely acid reaction in the soils. Nearly 25 per cent of the samples analysed were deficient in organic matter. Two third of the samples analysed showed higher levels of available phosphorus. About 30 per cent of the samples analysed were found deficient in potassium. Widespread deficiency of magnesium and calcium were noticed. The soils were adequately supplied with sulphur, iron, manganese, zinc and copper. Widespread deficiency of boron was recorded.

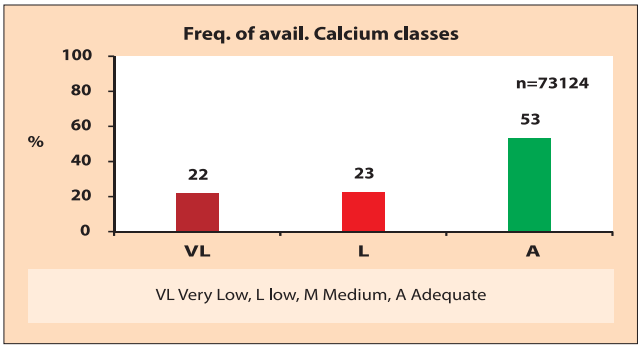
The adverse soil conditions like the unacceptable levels of soil acidification, high content of soluble phosphorus and deficiencies of calcium, magnesium and boron needs immediate amelioration to ensure satisfactory crop production from the highly weathered low activity clay soils of Kerala.

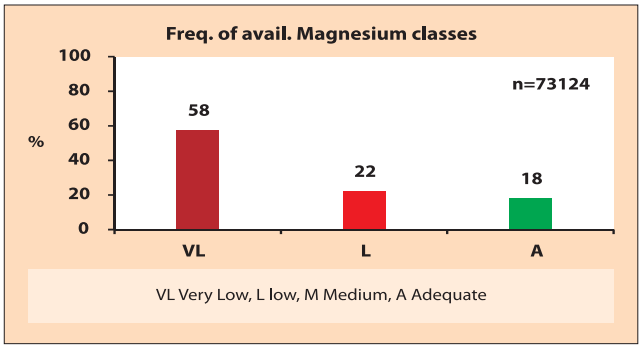


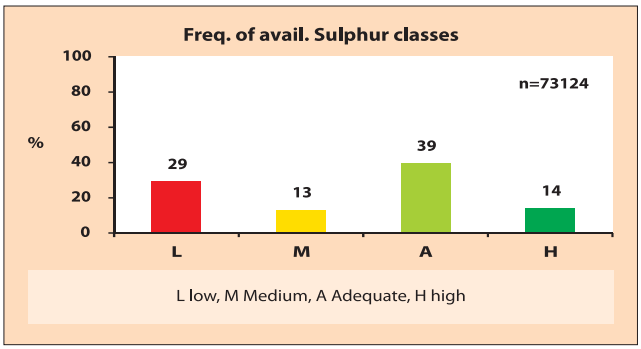












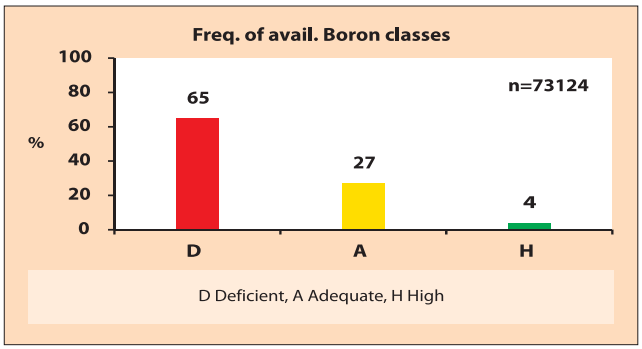


Fig. 44: Frequency distribution of classes of soil reaction, macro, secondary and micro-nutrients

Soil microbial biomass carbon and nitrogen in selected soil series of north-eastern region as affected by different land uses and varied agro-ecological conditions

The project work had following objectives (i) to determine microbial biomass carbon (MBC) and microbial biomass nitrogen (MBN) in selected soil series of NE region under different land uses systems and varied agro-climatic conditions and (ii) to establish relationship between MBC and MBN with different physico-chemical characteristics of the soils to use microbial biomass as a parameter for representing soil health.

A total of 90 soil samples were collected from 20 profiles located in four different states *viz.* Assam, Nagaland, Meghalaya and Arunachal Pradesh in three different land uses *viz.* forest, cultivated land and tea gardens covering four different agro-ecological sub regions of North Eastern Regions *viz.* 16.3; 15.4; 17.1 and 16.1 It was found that in Assam, microbial biomass carbon content ranged from 120.21 µg g^{-1} to 12.35 µg g^{-1}, 184.26 µg g^{-1} to 15.10 µg g^{-1} in tea garden and 248.16 to 17.10 µg g^{-1} of soils in cultivated land, tea garden and forest land respectively. Soil microbial biomass nitrogen content in the profiles of cultivated land ranged from 41.45 to 0.81 µg g^{-1} of soils and from 51.10 to 1.15 µg g^{-1} of soils in tea garden and 68.12 µg g^{-1} to 1.01 µg g^{-1} of soils in forest eco-system. From the study it was found that the microbial biomass carbon content was highest at the surface (0-20 cm) and decreased with soil depth in all the three land use systems.

Assessment of heavy metal pollution and its mapping in soils of contaminated areas of Morigoan, Dibrugarh and Tinsukia districts of Assam

The present study had following objectives (i) to identify the heavy metal contaminated areas and its spatial distribution and (ii) to assess risk of heavy metals contamination using geostatistical technique. Four contaminated areas from Jagiroad in Morigaon district, Ledo and Digboi in Tinsukia district and Namrup in Dibrugarh district of Assam were identified.

Source of heavy metal was obtained by three principal components (PC) by analysing the correlation matrix. The Bartlett sphericity test and the Kaiser–Mayer–Olkin test indicated that the normalized data were suitable for PCA. Varimax with Kaiser normalization rotation was applied to maximize the variances of the factor loadings across variances for each factor. The values of loadings as well as the cumulative percentage of variance (Table 29) showed that Cr, Pb and Ni are well represented by the first three PC, accounting for over 80% of the total variance for Cr and Pb. The Cr, Pb and Ni are highly loaded in PC1 which explains 38.88% of the total variance. There are significant correlations between their levels in the soils of the study area (Table 30), which imply that these three heavy metals in soils may have originated from a similar source, such as paper mill effluent because of the use of various cellulosic-based raw materials and chemicals used during the manufacturing process. But, in PC2, Cd showed a high value, distinguishing itself from other heavy metals. This may reflect different anthropogenic or geogenic sources and possible pathways of accumulation from other investigated heavy metals.

Table 29: Matrix of the three principal component (PC) accounting for most of the total variance

Heavy metals	PC1	PC2	PC3	Communities
Cr	0.82	0.07	-0.02	0.93
Cd	0.08	0.98	-0.02	0.97
Ni	0.70	0.53	-0.23	0.83
Pb	0.91	-0.10	0.20	0.89
Percentage of variance	38.88	30.51	21.15	
Cumulative percent	38.88	69.39	90.54	

Table 30: Pearson correlation coefficient of heavy metal contents

Heavy metals	Cr	Cd	Ni	Pb
Cr	1.00			
Cd	0.06	1.00		
Ni	0.40**	0.11	1.00	
Pb	0.22**	0.05	0.40**	1.00

** $p < 0.01$ level (2-tailed).

To study the heavy metal contents in paddy in Jagiroad paper mill eight sites (Jagibhakatgaon, Donga bill 1&2, Jan bill, Taranga bill 1&2, Bangalbari and Khar bill) were selected and fresh soil and paddy samples were collected and analyzed for heavy metals content. It showed that high Pb content in the soil will increase the plant Cd concentration, while high soil Cd will reduce the total Pb uptake by plant (Table 31). Pb incorporated into soils is nearly always tightly bound to organic or colloidal materials, or in a precipitated form; all of which serve to reduce the uptake of Pb into plant roots.

Table 31: Heavy metals (mg kg^{-1}) in soil and different parts of paddy from polluted areas (mean values of n=8)

Heavy metals	Pb	Ni	Cd	Cr
Soil	30.2	39.5	2.6	320.4
Root	13.1	21.2	1.3	48.6
Leaf	9.0	26..3	1.8	29.2
Seed	5.9	9.2	0.2	14.3

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning

The project was undertaken with the objectives of assessing nutrient status of soils of Assam on a spatial mode, creating a GIS-based data of soil parameters including macro and micronutrients and preparing district wise soil fertility map for 13 priority districts of Assam State on 1:50,000 scale. It was observed that extremely, very strongly and strongly acidic soils together covered 72.9% area of Tinsukia district, 82.4% of area of Karbi-Anglong district and 62.9% area of Bagsa district. It was observed that available phosphorus was low in 67.7% area of Karbi-Anglong district. It was also noticed that available Zn was deficient in 39.6% area of Tinsukia district and 38.2% area of Bagsa district. From the present study, it becomes evident that soil acidity together with the low to medium N & K status as well as deficient zones of zinc indicates in general the low fertility status of the districts and therefore requires attention regarding soil management practices for optimum agricultural production. Grid wise soil informations (pH, O.C., available N, P and K and available micronutrients including Fe, Mn, Zn and Cu) are linked with corresponding villages and Police Stations (Thana) for Sonitpur, Darrang, Nalbari, Bangaigaon, Lakhimpur and Dhemaji districts of Assam.

Assessment and mapping of some important soil parameters including macro and micronutrients for the state of Nagaland towards optimum utilization of land resources for integrated and sustainable development

The project had the following objectives assessing nutrient status of soils of Nagaland state on a spatial mode, creating a GIS-based data of soil parameters including macro and micronutrients and preparing district wise soil fertility map for 11 districts of Nagaland State on 1: 50,000 scale.

Base maps of Kohima, Dimapur, Peren, Mokokchung, Tuensang, Kiphire, Wokha, Zunheboto, Phek, Mon and Longleng districts of Nagaland state were prepared using Survey of India Toposheets at 1: 50,000 scale and grid points were demarcated at 1.0 m intervals. Grid wise soil samples have been collected from Kohima, Dimapur, Peren, Mokokchung, Tuensang, Kiphire, and Zunheboto districts.

Interpretation of soil nutrient database for site-specific fertilizer recommendation in different land use systems of West Bengal.

Soil pH and phosphorus relationship in the state of West Bengal

Mean available phosphorus was higher in Darjiling, Uttar and Dakshin Dinajpur and Koch Bihar than

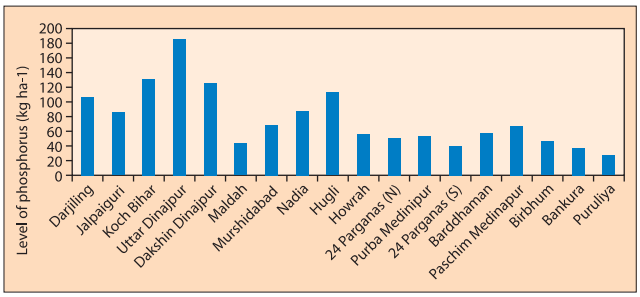


Fig. 45: Mean available phosphorus in different districts of West Bengal

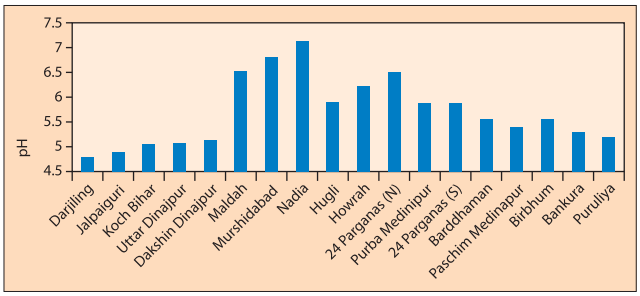


Fig. 46: Mean soil pH in different districts of West Bengal

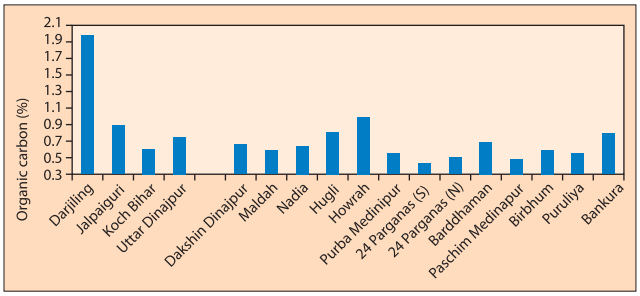


Fig. 47: Mean soil organic carbon in different districts of West Bengal

the other districts of West Bengal (Fig. 45). The mean content of available phosphorus in Hugli district was at par with that of Dakshin Dinajpur. Inspite of having low pH (Fig. 46) Darjiling, Jalpaiguri, Koch Bihar, Uttar and Dakshin Dinajpur districts had higher available phosphorus owing to higher organic carbon (Fig. 47) than Maldah, Murshidabad and Nadia districts.

Low content of nutrients in West Bengal

The low availability of phosphorus, potassium, boron and zinc have been found in the districts of Jalpaiguri (63.8%), Murshidabad (78%), Birbhum (90.2%), Bankura (86%), Nadia (94.6%) and Paschim Medinipur (69.9%) of TGA. Low contents of available phosphorus, potassium and zinc was found in the districts of Maldah (89.4%), and Haora (96.9%) of TGA. The low balance of potassium and boron was observed in the district of Dakshin Dinajpur (89.8%), whereas Koch Bihar district had inadequate level of potassium. The data indicated occurrence of low available phosphorus, potassium and boron in the districts of Hugli (92.6% TGA), Barddhaman (96.6% TGA) and Puruliya (73.1 % TGA). Low content of available phosphorus and zinc was observed in Purba Medinipur (83.5% TGA), North 24 Parganas (43.8% TGA) and South 24 Parganas (84.1% TGA). The low content of potassium and zinc in group was found in Uttar Dinajpur (92.9 % TGA) district whereas the soils of Darjiling are deficient in Boron in 61.3 percent (Table 32).

Table 32. Low balance of multiple nutrients in West Bengal

Districts	Particle size class	pH range	Phosphorus	Potassium	Zinc	Boron
Darjiling	Coarse-loamy	4.5-5.5	xx	xx	xx	*
	Fine-loamy	4.5-5.5	xx	xx	xx	*
	Fine	4.5-5.5	xx	xx	xx	*
Jalpaiguri	Coarse-loamy	4.5-5.5	**	**	xx	*
	Fine-loamy	4.5-5.5	**	*	**	*
	Fine	4.5-5.5	**	*	**	*
Koch Bihar	Coarse-loamy	4.5-5.5	xx	*	**	
	Fine-loamy	4.5-5.5	xx	*	**	

cont....

Uttar Dinajpur	Coarse-loamy	4.5-5.5	xx	*	**	
	Fine-loamy	4.5-5.5	xx	*	**	
	Fine	4.5-5.5	xx	*	**	
Dakshin Dinajpur	Coarse-loamy	4.5-5.5	xx	*	**	*
	Fine-loamy	4.5-5.5	xx	**	**	*
	Fine	4.5-5.5	xx	**	**	*
Maldah	Coarse-loamy	6.5-7.5	*	*	**	
	Fine-loamy	6.5-7.5	*	*	**	
	Fine	6.5-7.5	*	*	**	
Murshidabad	Coarse-loamy	6.5-7.5	**	*	**	*
	Fine-loamy	6.5-7.5	**	*	**	*
	Fine	6.5-7.5	**	*	**	*
Nadia	Coarse-loamy	6.5-7.5	xx	**	**	*
	Fine-loamy	6.5-7.5	**	**	**	*
	Fine	6.5-7.5	**	**	**	*
Barddhaman	Coarse-loamy	5.5-6.5	**	*	xx	*
	Fine-loamy	5.5-6.5	**	*	xx	*
	Fine	5.5-6.5	**	*	xx	*
Birbhum	Coarse-loamy	5.5-6.5	*	*	**	*
	Fine-loamy	5.5-6.5	*	**	**	*
	Fine	5.5-6.5	*	*	**	*
Puruliya	Coarse-loamy	4.5-5.5	*	*	xx	*
	Fine-loamy	4.5-5.5	*	*	xx	*
	Fine	4.5-5.5	*	*	xx	*
Bankura	Coarse-loamy	4.5-5.5	**	**	**	*
	Fine-loamy	4.5-5.5	**	**	**	*
	Fine	4.5-5.5	**	**	**	*
Paschim Medinapur	Coarse-loamy	4.5-5.5	**	**	**	*
	Fine loamy	4.5-5.5	**	**	**	*
	Fine	4.5-5.5	**	**	**	*
Hugli	Coarse-loamy	5.5-6.5	xx	**	xx	*
	Fine-loamy	5.5-6.5	xx	**	xx	*
	Fine	5.5-6.5	xx	**	**	*
Haora	Coarse-loamy	5.5-6.5	**	**	**	
	Fine-loamy	5.5-6.5	**	**	**	
	Fine	5.5-6.5	*	**	**	
Purba Medinipur	Coarse-loamy	5.5-6.5	**	xx	**	
	Fine-loamy	5.5-6.5	**	xx	**	
	Fine	5.5-6.5	**	xx	**	
North 24 Parganas	Coarse-loamy	5.5-6.5	**	xx	*	
	Fine-loamy	5.5-6.5	*	xx	*	
	Fine	5.5-6.5	*	xx	*	
South 24 Parganas	Coarse-loamy	5.5-6.5	*	xx	**	
	Fine-loamy	5.5-6.5	*	xx	**	
	Fine	5.5-6.5	*	xx	**	

xx- no problem;* severe problem ** moderate level

Assessment and mapping of some important soil parameters including macro & micro nutrients at block level for Dumka, Jamtara and Hazaribagh districts towards optimum land use plan

Soil pH, organic carbon, available phosphorus, potassium, sulphur, zinc, copper, iron, manganese and boron were analyzed for 14787 geo-referenced samples (0-20 cm) and block-wise nutrient maps were prepared in GIS environment for Dumka district. Data on soil pH, organic carbon and other nutrients status of Dumka, Masalia, Ramgarh, Gopikandar and Raneswar blocks are presented in table 33 and spatial distribution of pH, organic carbon, available boron and sulphur these blocks respectively is shown in figure 48. The data indicated that soil acidity (pH <5.5), low content (<0.5%) of organic carbon, available phosphorus (<10 kg ha^{-1}), available boron (< 0.5 mg kg^{-1}), sulphur (<10 mg kg^{-1}) and zinc (<0.5 mg kg^{-1}) were the major constraints in all the blocks of Dumka district. Low content (<108 kg ha^{-1}) of available potassium was also noticed in some blocks. As a whole 57.5, 63.3, 24.4 and 27.5% area of the Dumka district were affected with acidity low content of organic carbon, low available phosphorus, sulphur, boron and zinc were also observed in 38.1 and 21.6% area of the Dumka district respectively.

Table 33: Block-wise nutrient status of Dumka district

Attributes	Dumka	Masalia	Ramgarh	Gopikandar	Raneswar	Dumka district
	Area in sq. km. (%)					
pH(<5.5)	261.5 (68.9)*	318.0 (70.4)	231.0 (47.4)	77.1 (33.8)	279.8 (81.5)	2158.9 (57.5)
OC(<0.5%)	171.3 (45.1)	170.4 (37.7)	437.0 (89.6)	99.6 (43.7)	134.0 (39.0)	2379.3 (63.3)
Available P (<10 kg ha^{-1})	169.6 (44.7)	105.1 (23.8)	96.5 (19.8)	66.6 (29.3)	84.6 (24.6)	915.5 (24.4)
Available K (<108 kg ha^{-1})	27.1 (7.1)	101.3 (22.4)	27.7 (5.7)	37.6 (16.5)	56.7 (16.5)	410.7 (10.9)
Available S (<10 kg ha^{-1})	78.0 (20.5)	146.8 (32.5)	65.4 (13.4)	81.9 (35.9)	110.4 (32.1)	1034.4 (27.5)
Available Zn (<0.5 kg ha^{-1})	29.8 (7.9)	20.4 (4.5)	47.2 (9.7)	119.9 (52.6)	55.2 (16.0)	812.6 (21.6)
Available Cu (<0.2 kg ha^{-1})	21.9 (5.8)	16.9 (3.8)	19.0 (3.9)	32.3 (14.2)	3.0 (0.9)	234.7 (6.3)
Available Fe (<4.5 kg ha^{-1})	10.5 (2.8)	3.1 (0.7)	10.5 (2.1)	13.2 (5.8)	—	111.2 (2.9)
Available Mn (<2 kg ha^{-1})	—	—	—	5.1 (2.3)	—	61.7 (0.02)
Available B (<0.5 kg ha^{-1})	109.4 (28.8)	180.2 (39.9)	131.2 (26.9)	134.7 (59.1)	130.1 (37.9)	1430.3 (38.1)

( )* Percent area of the block in the parenthesis

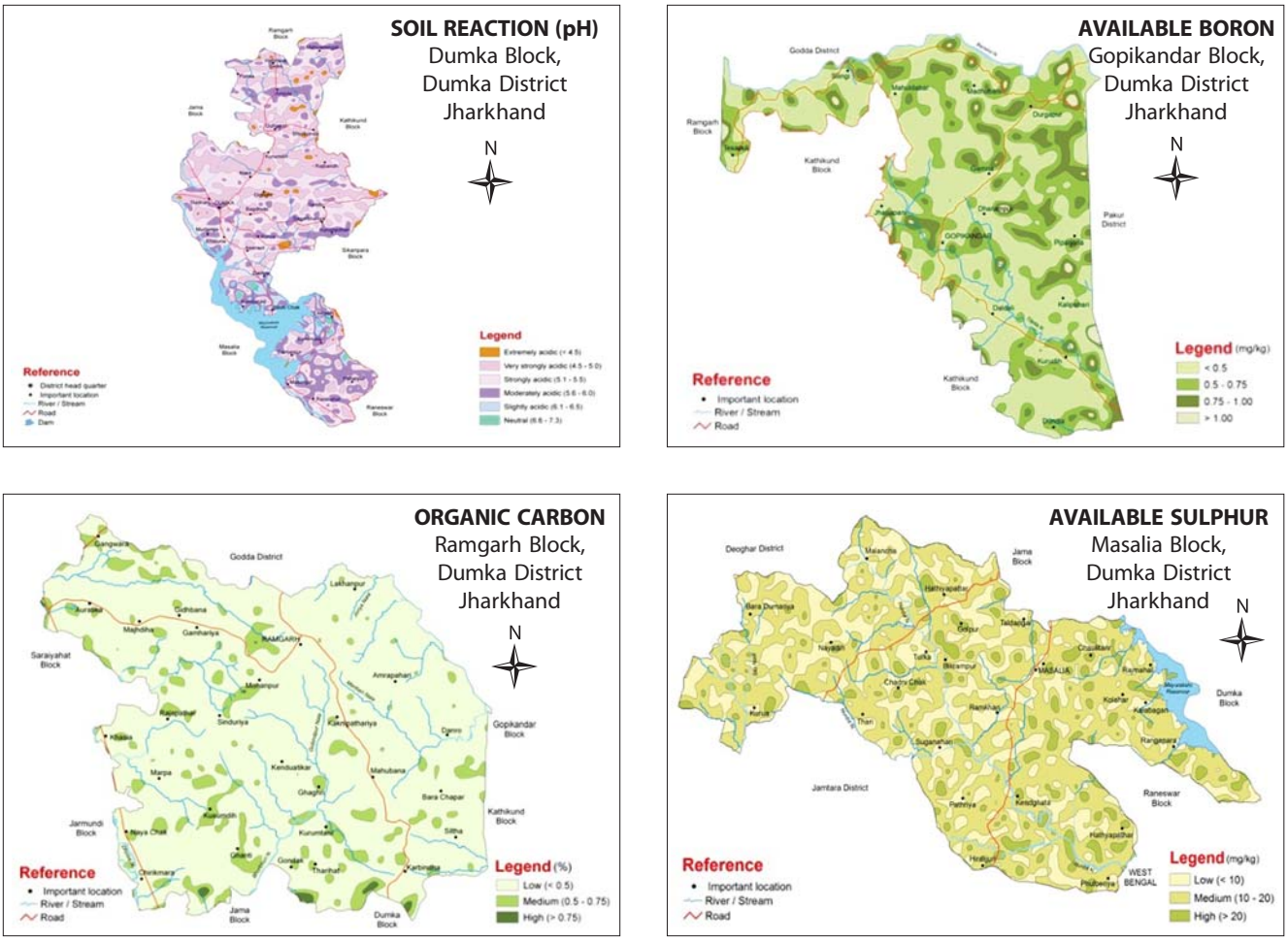


Fig. 48: Spatial distribution of pH, organic carbon, available boron and sulphur

Mapping of nutrient status in soils of Sikkim state towards land use planning

The project had the objectives assessing nutrient status of soils of Sikkim state on a spatial mode, creating a GIS based data of soil parameters including macro and micronutrients and preparing district wise soil fertility map for East, West, South and North districts of Sikkim State on 1:50,000 scale. Base maps of South, East, West and North districts of Sikkim were prepared and grid points were demarcated at 500 m intervals on cultivated area using Survey of India Toposheets at 1:50,000 scale. Grid wise soil samples have been collected from cultivated area of South and East districts of Sikkim. Using IRS Resourcesat–1 LISS III imagery of 18th October 2010 major landuse classes like forest, cultivable land, barren land, pasture land and snow covered area were delineated. Soil sampling (0-25 cm depth) was done based on grid observations at 500 m interval on the base map of 1:50,000 scale (Table 34).

Soil sampling of South District of Sikkim has been completed and soil analyses for few parameters were completed. Spatial distribution of soil pH classes of South Sikkim district have been given in Fig. 49.

Table 34: Number of grid observations collected from different districts of Sikkim

District	Area (km²)	Cultivated land (km²)	Area under land uses (km²)	No. of grids
West	1166	406.69	759.31	1638
South	750	430.16	319.84	1731
East	954	425.62	528.38	1703
North	4226	123.64	4102.36	488

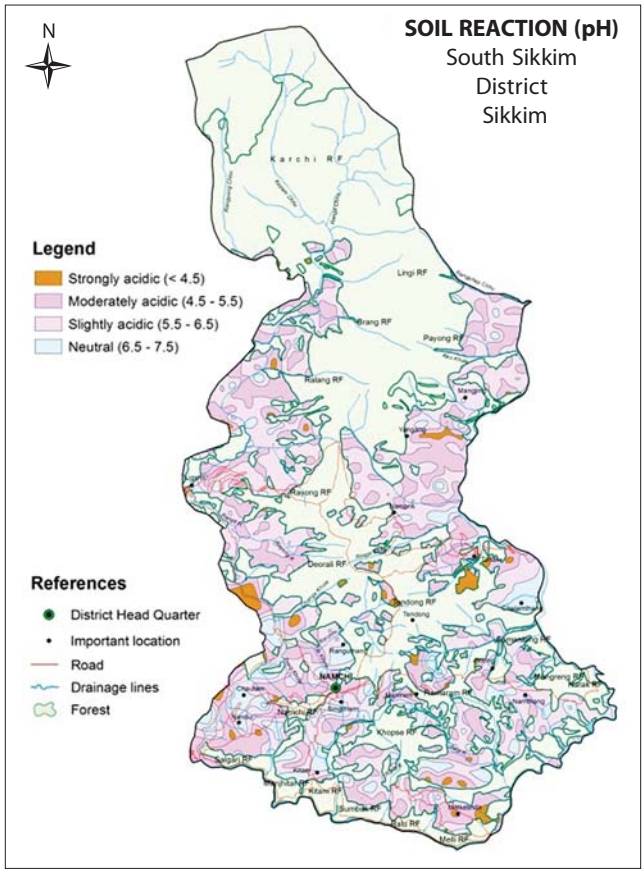


Fig. 49: Spatial distribution of soil pH classes of South district

Estimating available water content of soils of selected villages in Aurangabad, Dhule and Gondia districts of Maharashtra

Horizonwise soil samples were collected from 180 profiles located in different clusters of Aurangabad, Dhule and Gondia districts and analysed for different parameters. Textural classification indicated that 192 samples were 'clay' in texture. Clay loam and loam texture was observed in 62 and 27 samples respectively. Pedotransfer functions were developed to predict ASWC with varying degrees of accuracy indicated by root mean square error (RMSE) 0.018 to 0.096 m^3m^{-3} (Table 35). The errors were large in magnitude and hence PTFs for clay loam and loam texture were discarded. The hierarchical neural PTFs for predicting AWC were recommended for use.

Table 35: Accuracy of neural PTFs to predict AWC as indicated by RMSE

	PTF evaluation RMSE (m^3m^3)	Training	Testing
	Clay		
H1	Sand silt and clay content	0.0283	0.024
H2	H1 and OC	0.0263	0.0241
	Clay loam		
H1	Sand silt and clay content	0.0215	0.0332
H2	H1 and OC	0.0189	0.0311
	loam		
H1	Sand silt and clay content	0.051	0.0431
H2	H1 and OC	0.0967	0.0355

Changes in soil carbon reserve as influenced by different ecosystem and land use in India

Simulation of total organic carbon in the soils of Palampur

Two soil carbon models namely, Century and RothC were used to simulate the total organic carbon (TOC) in the soils of Palampur using the long term fertilizer experiment (LTFE) data. The simulation results of Century model showed that there was a significant increase in TOC when organic carbon was added through farm yard manure in combination with inorganic fertilizers (T5). A noticeable increase in TOC was also observed in a regular application of 100% NPK (T4), 100% NPK + Hand weeding (HW) (T7) and 150% NPK (T11)

within the experimental period (1972-2003) while a decreasing trend was observed in control treatment with no fertilizer and manure application (T 1). Moreover, the results of RothC indicated that there was rapid increase in TOC in treatment 5 with 100% NPK+FYM (T5) as compared to the control treatment (T 1: no inorganic and organic fertilizer application), treatment 4 (T4: 100% NPK), treatment 7 (T7: 100% NPK+HW) and treatment 11 (T11: 150% NPK).

Impact of nutrient management interventions on TOC turnover

RothC model was used to assess the long-term impact of nutrient management interventions on TOC turnover in the soils of Palampur LTFE site. The primary purpose of this exercise was to test the ability of a soil carbon model to simulate the long term dynamics of soil organic matter under various nutrient management interventions in different bio-climates with varying rainfall pattern. Thereafter, the tested model can be used for the future global change impact assessment in different environments. The RothC model was run from 1990 to 2050 with an interval of 20 years. The simulation results indicated that there was continuous decline in TOC in the control treatment (T1: no inorganic and organic fertilizer application) (Table 36).

However, there was significant increase in the TOC in the treatments 5 (100% NPK+FYM) and 7 (100% NPK+HW). It means over the years there would be total organic carbon built up under nutrient management interventions of 100% NPK+FYM and 100% NPK + HW.

Effect of global warming on modelled TOC stocks in soils of Palampur

RothC carbon model was used to find out the relationship between global warming and modelled TOC stocks. We presumed a subsequent increase in mean temperature of 0.25 ^{0}C per decade over 100 years (1990 to 2090) and ran RothC. In first case, we used eight layers of soil (0-12, 12-32, 32-53, 53-69, 69-87, 87-112, 112-135 and 135-162 cm) as separate entity and generated datasets for modelled TOC stock. In the second case, TOC stock was modelled considering entire soil depth of 162 cm as a single unit. The simulation results of both the cases were compared and illustrated in the Fig. 50. There was a marginal difference in the modelled TOC stocks in both the cases. TOC held within top 162 cm is found to be decreased by 10.86 per cent in single layer as compared to a fall of 10.06 per cent when the same soil was modelled dividing it into eight equal layers. The results show that treating soil as different layers will predict actual effects of global warming in accelerating

Table 36: TOC and its turnover in different treatments over years in Palampur LTFE site

(values in t ha^{-1})

Year / Treatments	1990	2010	2030	2050
		Palampur, Himachal Pradesh, India		
T1 (Control, No fertilizer and FYM)	19.08	19.07 (-0.04)	19.01 (-0.34)	18.99 (-0.47)
T4=100% NPK (recommended)	19.08	19.79 (4)	20.41 (7)	20.86 (9)
T5 = 100% NPK + FYM	25.89	31.39 (21)	35.88 (39)	39.14 (51)
T7 = 100% NPK + HW	19.08	20.55 (8)	21.88 (15)	22.82 (20)
T11 = 150% NPK	19.08	19.91 (1)	20.03 (2)	20.14 (2)

[a]Parentheses indicate percentage changes compared to 1990 for Palampur for 0-23cm soil depth.

decomposition of soil C and the resultant release of CO_2 from soil organic matter.

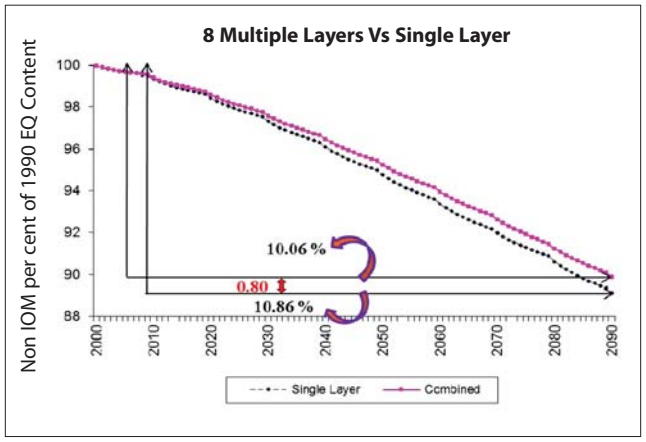


Fig. 50: Comparison of reduction in modelled carbon per cent in a 100 year span between single layer and combined 8 layers in Palampur soils due to the effect of global warming (rise in 2.5°C in a century as predicted by IPCC).

Soil series information for modeling

The physical and chemical data of 100 soil series were compiled from five zones of the country (20 soil series from each zone). The soil properties were arranged in the required formats specific to RothC, Century and InfoCrop models and will be used by the different partner institutes under NPCC and NICRA projects.

Georeferenced soil information system for land use planning and monitoring soil and land quality for agriculture

Generation of Soil and Terrain (SOTER) Database

Soil and Terrain (SOTER) datasets were finalized for 144 soil series in the IGP and 101 soil series in the BSR. The information on morphological, physical and chemical properties of the soils and climate and land use were created and linked in SOTER-GIS environment for monitoring soil and land quality.

Identification of minimum datasets for monitoring soil quality and land evaluation

Principal Component Analysis (PCA) technique was employed to identify the minimum soil parameters that can give interpretable information of soil quality and land evaluation. For the Indo-Gangetic Plains, datasets have been grouped into the Upper IGP covering Rajasthan, Punjab, Haryana, Uttar Pradesh, Delhi and Uttarakhand and Lower IGP consisting of Bihar and West Bengal. Six Principal Components (PCs) were obtained for the Upper IGP (Hot Spots) and lower IGP surface soils and the minimum datasets (MDS) obtained were – clay, saturated hydraulic conductivity, organic carbon, exchangeable sodium percentage, exchangeable magnesium percentage, soil solution K. The MDS for the BSR were saturated hydraulic conductivity, ESP, EMP, BD, OC, pH, WDC and silt. The relative soil quality index (RSQI) computed for surface (0-30 cm) and subsurface (30-100 cm) soils of the selected hotspots (BM Spots) are presented in boxes 1, 2 and 3. SQI maps were also developed for both the IGP and BSR.

Box 1. Soil data of Upper IGP (Hotspots)

Soil Series : (RSQI surface, RSQI subsurface)
Masitawali : (71.0, 62.5), Nihalkhera : (54.6, 10.3), Hirapur : (59.0, 53.9), Bhanra : (55.1, 100.0), Ghabdan : (75.5, 62.2), Phaguwala : (100.0, 48.1), Sakit : (59.4, 84.1), Zarifa-Viran : (52.6, 72.5), Dhadde : (66.2, 57.0), Fatehpur : (48.2, 69.9), Jagjitpur : (59.8, 67.0), Berpura : (70.3, 81.4), Simri : (43.0,78.0), Haldi : (56.3, 28.0), Jassi-Pauwali : (88.7, 57.7), Jodhpur-Ramana : (62.5, 83.2)

Box 2. Soil data of Lower IGP (Hotspots)

Soil Series : (RSQI surface, RSQI subsurface)
Sarthua : (100.0, 81.3), Belsar : (63.7, 77.1), Ekchari : (95.4, 95.0), Nanpur : (61.1, 78.5) Gaupur : (47.8, 78.1) Singhvita : (67.3, 100.0), Konarpara : (70.9, 82.3) Madhpur : (65.5, 93.9) Sasanga : (88.7, 89.4) Hanrgam : (79.8, 87.3), Seoraguri : (83.4, 84.3), Sagar : (97.2, 78.9), Chunchura : (96.4, 88.3), Mohanpur : (68.3, 93.0)

Box 3. Soil data of BSR (Hotspots)

Soil Series : (RSQI surface, RSQI subsurface)*
Kheri : (77.1, 86.6), Sakka : (69.9, 79.1), Nabibagh : (87.8, 100.0), Pahur : (81.4, 67.8), Loni : 90.1, 72.2), Panjri : (85.8, 95.6), Sarol : (100.0, 74.6), Nipani : (74.5, 52.4), Linga : (98.0, 93.1), Bhatumbari : (88.7, 66.7), Asra : (89.7, 66.4), Vasmat I: (71.0, 56.6), Vasmat II : (76.0, 70.0), Jhalipura : (63.0, 71.3), Paral : (71.1, 66.0), 95.0), Jajapur : (60.7, 37.9), Kasireddipalli : (77.9, 53.2), Konheri : (98.1, 91.2), Kalwan : (83.9, 53.4), Kovilpatt : (69.9, 79.1), Semla : (80.3, 64.7), Teligi : (93.2, 66.7), Sollarpuram : (69.7, 78.0), Sokhda : (54.8, 51.3), Nimone : (86.2, 69.0)

*RSQI was based on two MDS (PCA derived and selected based on experts' opinion). However, RSQI values from PCA derived MDS closely match with the values of experts' opinion.

Land Evaluation

Three quantitative land evaluation approaches *viz*., parametric, fuzzy modeling and soil property, crop response (SPCR) were used for evaluating the soils of selected benchmark spots of the IGP and the BSR.

Land Evaluation for Rice-Wheat Cropping System in the IGP

Eleven typical BM sites for rice and wheat belonged to land Class-I (Table 37) through modified Sys method. Interestingly, Fuzzy method could evaluate 7 and 2 spots as land class I for rice and wheat crops, respectively. The corresponding figures obtained as 3 and 7 for rice and wheat, respectively in SPCR method. In crop modelling approach 6 and 8 BM spots were evaluated as land class I for rice and wheat, respectively.

Land Evaluation for Cotton-based cropping system in BSR

Total seventeen benchmark spots were evaluated following three evaluation methods (with some exception in SPCR method). Total eight spots in the modified Sys, nine in fuzzy and three in SPCR methods were evaluated as land class I. Soybean crop were evaluated with two methods, where modified Sys method evaluated two BM spots and Fuzzy as five BM spots as land class I (Table 38). In the crop modelling approach Panjri site showed LC I (land suitability class I) for cotton and LC II for soybean. A closer look indicated that BM sites such as Bhola, Sarol, Sokhda, Achmatti, Kasireddipalli, Coimbatore and Panjri are rated as land class I by both modified Sys and fuzzy methods.

All the aforesaid methods could be used for LE for cotton and soybean in BSR notwithstanding their limitations. Barring the method using crop model, the other three methods could be used for LE for rice and wheat in the IGP. Fuzzy modeling-based method was, however, observed to be superior to the other methods both in land evaluation for the crops of interest in the BSR and IGP and developing threshold values of land quality parameters as it is intuitive, based on sound logic and robust in that it overcomes the limitations of the conventional methods namely dependence on yield and non assignment of weightages to the MDS parameters depending on their relative importance to the crop(s).

Table 37: Comparison of Land Evaluation methods adopted in rice-wheat system of the Indo-Gangetic Plains (IGP)

Sl. No.	AESR	Crop BM sites series	Soil Taxonomy	Modified Sys method				Fuzzy method				SPCP*			
				Rice		Wheat		Rice		Wheat		Rice		Wheat	
				LQI	LC	LQI	LC	LQI	LC	LQI	LC	LQI	LC	LQI	LC
Per humid (PH) bioclimatic system															
1.	15.3	Singbhita	Typic Dystrustepts	85	I	100	I	95	I	100	I	75	II	ND	ND
2.		Seoraguri	Typic Haplaquepts	85	I	100	I	ND	ND	100	I	76	II	ND	ND
3.		Nayanpur	Typic Endoaqualfs	95	I	90	I	ND	ND	72	II	74	II	ND	ND

cont....

Humid (H) bioclimatic systems															
4.	12.3	Gopalpur	Vertic Endoaqualfs	60	II	95	I	56	III	69	II	59	III	ND	ND**
5.	13.1	Ekchari	Vertic Endoaqualfs	85	I	90	I	59	III	55	III	67	II	97	I
6.	13.2	Haldi	Typic Hapludolls	95	I	95	I	95	I	72	II	86	I	ND	ND
7.	15.1	Madhpur	Typic Endoaqualfs	95	I	90	I	57	III	54	III	65	II	ND	ND
8.	18.5	Sagar	Typic Haplaquepts	60	II	37	II	ND	ND	57	III	63	II	ND	ND
Sub-humid Dry (SHd) bioclimatic systems															
9.	9.2	Itwa	Aeric Ochraqualfs	90	I	80	I	82	I	63	II	82	I	85	I
Semi-arid Dry (Sad) bioclimatic systems															
10.	4.1	Zarifa Viran	Typic Natrustalfs	81	I	81	I	91	I	52	III	100	I	90	I
11.	4.3	Sakit	Typic Natrustalfs	81	I	90	I	63	II	66	II	78	II	74	II
12.	4.4	Singhpura	Typic Haplusepts	81	I	60	II	69	II	61	II	ND	ND	97	I
13.	9.1	Fatehpur	Typic Haplusepts	81	I	85	I	93	I	66	II	ND	ND	100	I
Arid (A) bioclimatic systems															
14.	2.1	Shakhi	Typic Torrifluvents	34	IV	72	II	62	II	69	II	ND	ND	92	I
15.	2.3	Mashitawali	Typic Torrifluvents	38	IV	36	IV	61	II	61	II	ND	ND	86	I

*This method does not permit direct estimates of LQI and LC. We have improvised this method to assess LQIs and LCs on the basis of statistical parameter such as correlation coefficient (r) discussed earlier. For example, r of 0.86 is LQI of 86. For comparison, LC I corresponding to 80-100, LC II to 60-80, LC III to 40-60 and LC IV <40 have uniformly been applied for all the three methods.; **ND- Not done

Table 38: Comparison of Land Evaluation methods used in cotton-based cropping system in the Black Soil Region (BSR)

Sl. No.	AESR	Soils	Soil Taxonomy	Modified Sys' method				Fuzzy method				SPCP*		Crop modelling approach			
				Cotton		Soybean		Cotton		Soybean		Cotton		Cotton		Soybean	
				(LQI	LC	LQI	LC	LQI	LC	LQI	LC	LQI	LC	RYI	LC	RYI	LC
Sub-humid moist (SHm) bioclimatic systems																	
1.	7.3	Tenali	Halic Hapluserts	72	II	64	II	69	II	44	III	ND	ND	0.40	III	0.61	II
2.	10.1	Nabibagh	Typic Haplusterts	34	IV	62	III	69	II	64	II	87	I	0.46	III	0.89	I
Sub-humid dry (SHd) bioclimatic systems																	
3.	5.2	Sarol	Typic Haplusterts	85	I	36	IV	98	I	63	II	ND	ND	0.73	II	0.80	I
4.	10.2	Panjari	Typic Haplusterts	85	I	58	III	80	I	83	I	ND	ND	0.80	I	0.71	II
5.	10.3	Ghulghuli	Typic Haplusterts	85	I	60	III	76	II	77	II	ND	ND	0.65	II	0.79	II
Semi-arid dry (SAd) bioclimatic systems																	
6.	3.2	Teligi	Typic Hapluserts	51	III	60	II	57	III	51	III	ND	ND**	0.39	IV	0.76	II
7.	5.1	Bhola	Typic Hapluserts	90	I	38	IV	96	I	70	II	100	I	0.56	III	0.74	II
8.	5.3	Sokhda	Calcic Hapluserts	90	I	62	II	100	I	73	II	85	I	0.26	IV	0.52	III
9.	6.1	Nimone	Sodic Haplusterts	72	II	57	III	75	II	68	II	ND	ND	0.07	IV	0.18	IV

cont....

10.	6.2	Vasmat	Sodic Haplusterts	74	II	51	III	99	I	76	II	ND	ND	0.49	III	0.90	I
11.	6.3	Paral	Sodic Haplusterts	72	II	64	II	91	I	85	I	76	II	0.50	III	0.86	I
12.	6.4	Achmati	Sodic Hapluserts	81	I	60	II	82	I	72	II	ND	ND	0.63	II	0.77	II
13.	7.1	Nandyal	Chromic Haplusterts	51	III	62	II	59	III	61	II	60	II	0.75	II	0.85	I
14.	7.2	Kassired-dipalli	Sodic Hapluserts	85	I	60	II	93	I	86	I	ND	ND	0.73	II	0.78	II
15.	8.1	Coimbatore	Vertic Haplusepts	85	I	61	II	89	I	76	II	ND	ND	0.29	IV	0.30	IV
16.	8.2	Sidalghatta	Vertic Haplusepts	72	II	85	I	75	II	88	I	ND	ND	0.34	IV	0.56	III
17.	8.3	Kovilpatti	Gypsic Hapluserts	72	II	95	I	74	II	89	I	73	II	0.48	III	0.41	III

*This method does not permit direct estimates of LQI and LC. We have improvised this method to assess LQIs and LCs on the basis of statistical parameter such as correlation coefficient (r) discussed earlier. For example, r of 0.86 is LQI of 86. For comparison, LC I corresponding to 80-100, LC II to 60-80, LC III to 40-60 and LC IV <40 have uniformly been applied for all the three methods. **ND- Not done

Revision of Agro-ecological sub-region (AESR) boundaries

Based on additional set of data for length of growing periods (LGP), quantitative drainage map and additional soil data, the AESR boundaries have been revised for two important food production zones of India namely, the Indo-Gangetic plain (IGP) and the Black Soil Region (BSR). Initially, at the beginning of the project there were 53 AESRs (17 in IGP and 36 in BSR) in the study area, but after revision the number has been increased to 83 (29 in IGP and 54 in BSR, Fig. 51).

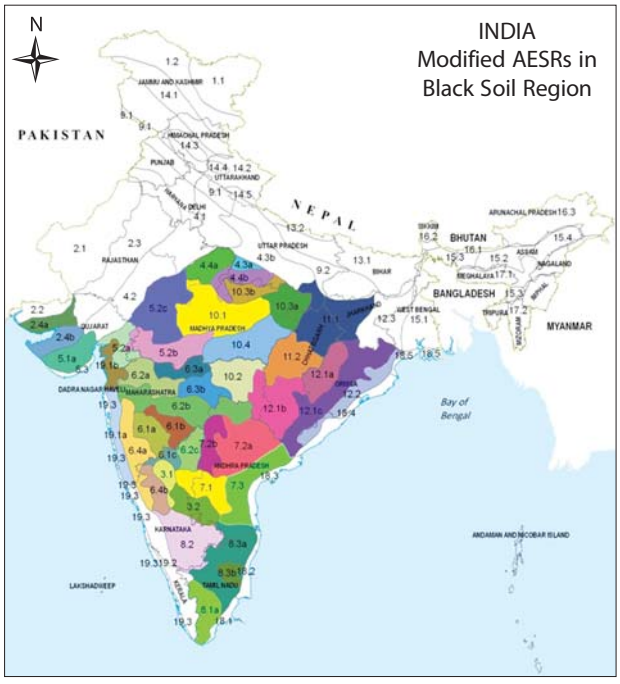


Fig. 51: Modified agro-ecological sub regions in Black Soil Region

2.5 Land Evaluation and Land Use Planning

- Farm/Watershed/District/Region/State/Country
- Soil and Land Use Model

Network project on "Land use planning of Tirumale sub-watershed in Magadi taluk, Ramanagara district, Karnataka for integrated development

The project was undertaken in collaboration with Karnataka State Watershed Development Department and aimed at providing the Detailed Land Resources Inventory (LRI) for net planning (the core activity of IWMP) and also to monitor, review and evaluate the Watershed development programmes. The average annual rainfall is 996 mm. Most of it is received between June and September from the southwest monsoon.

The class III lands occupy about 25 per cent of the area. Moderately sloping lands (5-10%) occupied the major parts of the watershed area (54%). Rock lands and denuded hills and hill slopes are the major land forms. Soils are deep (100-150 cm) (20 per cent area) and moderately deep (75-100 cm) (16 per cent area). Shallow and very shallow (10 per cent area). Loamy sand and sandy loams are the dominant surface soil textural groups found in the watershed. Sheet erosion is a serious problem in the very gently to gently sloping uplands. Only 3 per cent of the area showed low organic carbon content. Other areas had high organic matter content mainly due to the crop rotation followed in the region. Crop and soil suitability evaluation was carried out for all the major crops like finger millet, redgram, castor, arecanut, coconut, banana and mango. They are moderately to highly suitable. Fertility evaluation was carried out for major and micro nutrients. In the entire study area available nitrogen status is low. Available phosphorus content is high in 37 per cent area and in nearly 57 per cent area is medium. In 52 per cent of the area available potassium is low and in 41 per cent area it is medium. Available iron, manganese, copper and zinc are available in sufficient quantities except zinc, which is low in Hebbalapalya and Harthi villages. The available boron status low in the watershed area. Available sulphur was deficient in 38 per cent area and adequate 20 per cent of area. In 36 per cent area sulphur availability is optimum. Major constraints in the watershed include considerable is rock out crops and marginal lands, low ground water level and scarcity of labour.

Farmers identified water as the main limiting factor in achieving higher productivity/diversification of enterprises. Drilling of deep bore wells is very rampant and awareness in adoption of water

efficient irrigation technologies and tools like micro-irrigation are not at all adopted in the study area. Large number of bore wells have failed.

Potentials and opportunities observed in the area

The present rainfed cropping system consisting of finger millet, pigeon pea, castor, field bean is very ideal for maintaining soil health and utilizing soil resources from different depths of soil profile. In most areas top soil layer consists of lighter soil texture, which allows easy infiltration of water into the soil profile. The sub-surface layers are of heavy texture which store /hold good quantity of soil moisture thus allowing good performance of rainfed crops. Deep soils occur even below rocky surfaces in certain places allowing the good performance of tree crops like mango, jack fruits etc. Therefore, there is bright scope for tree crops. Nearness to Bangalore and suitable climate provides bright scope for the cultivation of high value fruit and vegetable crops. Protective cultivation is another good option to make best use of the resources and the market. Goat and sheep rearing is a most common enterprise and provides a good source of income.

The interventions suggested are effective use of LRI-Tirumale for Net Planning, opening of hard crust between surface soil and subsoil at regular intervals, monitoring silt, surface run-off, and organic carbon at bench mark sites, horticulture, forage & forestry in marginal lands (based on soil-site suitability) &fire protection and addressing nutritional deficiency of boron.

Land use planning of Buraka micro watershed in Mewat district of Haryana under irrigated ecosystem for integrated watershed development

The geo-coded IRS P6 LISS IV data on 1:12,500 scale was integrated to prepare the physiography map of the study area for detailed soil survey. On the basis of RS data and field observations seven physiographic units viz. hill tops, side slopes, inter hill basin, upper piedmont plain, middle piedmont plain, lower piedmont plain and stream terraces. Eleven soils have been identified and mapped into 22 soil mapping units. Soils of different mapping units have been described in Table 39. Major soils are Inceptisols followed by Entisols.

Table 39: Soils of Buraka watershed

Sr. No.	Mapping Unit	Description	Area (ha)	% of surveyed area
1.	**Buraka A Soils:** Very shallow, excessively drained, brown, gravelly sandy loam soils on slightly undulating hill tops (Loamy skeletal, Lithic Ustorthents)		39.9	7.36
1	AcC3$\overline{S}$R	Buraka A gravelly sandy loam, gently sloping, severe erosion with severely stony and moderately rocky.	21.2	3.91
2	AcC3$\overline{S}$R	Buraka A gravelly sandy loam, gently sloping, severe erosion with moderately stony and severely rocky.	18.7	3.45
2.	**Buraka B Soils:** Very shallow, excessively drained, brown to dark yellowish brown, gravelly sandy loam soils on moderately to strongly sloping hill side slopes (Loamy skeletal, Lithic Ustorthents)		76.6	14.12
3	BcD3$\overline{S}$R	Buraka B gravelly sandy loam, moderately sloping, severe erosion with moderately stony and rocky.	12.5	2.30
4	BcD3$\overline{S}$R	Buraka B gravelly sandy loam, moderately sloping, severe erosion with moderately stony and severely rocky.	19.9	3.67
5	BcE3$\overline{S}$R	Buraka B gravelly sandy loam, strongly sloping, severe erosion with moderately stony and severely rocky.	27.4	5.05

cont....

6	BcE3SR	Buraka B gravelly sandy loam, strongly sloping, severe erosion with severely stony and rocky.	16.8	3.10
3.	**Buraka C Soils:** Very deep, somewhat excessively drained, yellowish brown to dark yellowish brown, loamy sand soils on undulating inter-hill basin (Calcareous, Typic Ustipsamments)		16.8	3.10
7	CbC2	Buraka C loamy sand, gently sloping with moderate erosion.	16.8	3.10
4.	**Buraka D:** Very deep, somewhat excessively drained, brown to strong brown and dark yellowish brown, loamy sand to sandy loam soils on very gently to gently sloping upper piedmont plain (Typic Ustipsamments)		68.4	12.61
8	DbA1	Buraka D loamy sand, nearly level sloping with slight erosion.	23.0	4.24
9	DbB1	Buraka D loamy sand, very gently sloping with slight erosion.	39.8	7.34
10	DbC2	Buraka D loamy sand, gently sloping with moderate erosion.	5.6	1.03
5.	**Buraka E Soils:** Very deep, Well drained, brown to strong brown and dark yellowish brown, sandy loam soils on very gently to gently sloping upper piedmont plain (Coarse loamy, Typic Haplustepts)		19.3	3.56
11	EcB1	Buraka E sandy loam, very gently sloping with slight erosion.	19.3	3.56
6.	**Buraka F Soils:** Very deep, somewhat excessively drained, yellowish brown to dark yellowish brown, loamy sand to sandy loam soils on nearly level to very gently sloping middle piedmont plain (Calcareous, Typic Ustipsamments)		72.9	13.44
12	FbB_1	Buraka F loamy sand, very gently sloping with slight erosion.	54.8	10.10
13	FbC2	Buraka F loamy sand, gently sloping with moderate erosion.	18.1	3.34
7.	**Buraka G Soils:** Very deep, Well drained, dark yellowish brown, sandy loam soils on nearly level to very gently sloping middle piedmont plain Coarse loamy (Calc.), Typic Haplustepts]		54.8	10.10
14	GcA1	Buraka G sandy loam, nearly level sloping with slight erosion.	30.5	5.62
15	GcB1	Buraka G sandy loam, very gently sloping with slight erosion.	24.3	4.48
8.	**Buraka H Soils:** Very deep, Well drained, dark yellowish brown to strong brown, sandy loam soils on nearly level to very gently sloping middle piedmont plain (Coarse loamy, Typic Haplustepts)		37.4	6.89
16	HcA1	Buraka H sandy loam, nearly level sloping with slight erosion.	37.4	6.89
9.	**Buraka I Soils:** Very deep, somewhat excessively drained, yellowish brown to dark yellowish brown, loamy sand to sandy loam soils on very gently to gently sloping lower piedmont plain (Calcareous, Typic Ustipsamments)		61.0	11.25
17	IbB1	Buraka I loamy sand, very gently sloping with slight erosion.	29.3	5.40
18	IbC2	Buraka I loamy sand, gently sloping with moderate erosion.	31.7	5.85
10.	**Buraka J Soils:** Very deep, Well drained, brown to dark yellowish brown and strong brown, sandy loam soils on nearly level to very gently sloping lower piedmont plain [Coarse loamy (Calc.), Typic Haplustepts]		26.8	4.94
19	JcB1	Buraka J sandy loam, very gently sloping with slight erosion.	18.1	3.34
20	JcC2	Buraka J loamy sand, gently sloping with moderate erosion.	8.7	1.60
11.	**Buraka K Soils:** Very deep, somewhat excessively drained, brown to dark yellowish brown, loamy sand soils on gently to moderately sloping stream terraces (Calcareous, Typic Ustipsamments).		38.6	7.12
21	KbC2	Buraka K loamy sand, gently sloping with moderate erosion.	20.5	3.78
22	KbD3	Buraka K loamy sand, moderately sloping with severe erosion.	18.1	3.34
		Total	512.5	94.49
		Habitation	29.9	5.51
		GrandTotal	**542.4**	**100.00**

Some of the thematic maps developed are presented in Fig. 52.

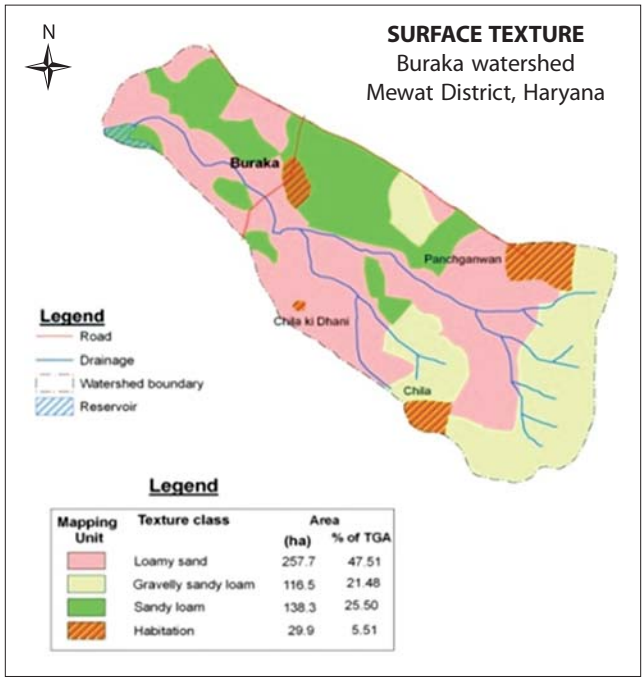


Fig. 52: Thematic maps of Buraka watershed, Haryana

Land Use Planning of Diring-Thanglong Micro-watershed of Karbi-Anglong and Golaghat Districts of Assam under Hill and Mountain Ecosystem for Integrated Development

The Project had the objectives of preparing the inventory of natural resources of the micro-watershed, identifying the potentials and constraints, evaluating land resources to suggest strategies for soil and water conservation measures and formulating alternate land use options for integrated development of the micro watershed.

The watershed occupies 2369.4 ha area from which the operational area for survey was 1088.2 ha. In the watershed, nine landform units were recognized *viz.*, steep hills covering 47.1%, isolated hillocks covering 0.7%, upper occupying 6.5%, lower piedmonts covering 11.9%, gently to very gently sloping uplands covering 8.9%, inter-hill valley occupying 5.9%, narrow valley covering 2.4%, foot hill plains occupying 4.1% and flood plains occupying 12.5% of area. 10 soil series were identified *viz.*, Diring-1, Diring-2, Diring-3, Diring-4, Diring-5, Thanglong-1, Thanglong-2, Thanglong-3, Bochagaon-1 and Bochagaon-2, respectively with 15 mapping units as phases of series. In the watershed, slope is categorized into four classes *viz.*, very gently sloping (1-3%) covering 27.9%, gently sloping (3-5%) covering 17.8%, moderately sloping (5-10%) covering 4.0% and moderately steeply sloping (10-15%) covering 3.2% of TGA. Four soil depth classes are recognized in the watershed *viz.*, moderately shallow soils covering 5.9%, moderately deep soils covering 3.2%, deep soils covering 18.3% and very deep soils covering 25.5% of TGA. Six surface texture classes were recognized in the watershed *viz.*, loam (4.8% of TGA), sandy loam (8.1% of TGA), silt-loam (11.8% of TGA), sandy clay loam (8.5% of TGA), silty clay loam (15.0% of TGA) and clay loam. Four soil reaction classes were assessed in the watershed *viz.*, very strongly acid (pH 4.5-5.0) covering 23.3%, strongly acid (pH 5.0-5.5) covering

7.1%, moderately acid (pH 5.5-6.0) covering 10.0% and weakly acid (pH 6.0-6.5) soils covering 12.5% of TGA. In the watershed, three productivity classes *viz.*, 'poor', 'average' and 'good' were recognized for field crops and three productivity classes *viz.*, 'extremely poor', 'average' and 'good' were recognized for plantation crops.

Land use planning of Khuskarni microwatershed, Birbhum, West Bengal for Integrated Development

Holistic land use plan (Fig. 53), consisting of agriculture, animal husbandry and fisheries has been developed in Khuskarni micro-watershed (1209 ha) of Birbhum district, West Bengal, representing hot sub-humid agro-ecological sub-region (AESR 12.3). Soil conservation measures such as construction of check dam (at <10% slope), percolation tank (at 0-3% slope) and renovation of farm ponds for increasing water productivity and restricting erosion has been the part of programme. Agro-forestry by combining oil seeds and pulse crops including mustard, ridge gourd and maize, with Bastard Teak, Palash along with lemon grass and medicinal plants in suitable combination is recommended on

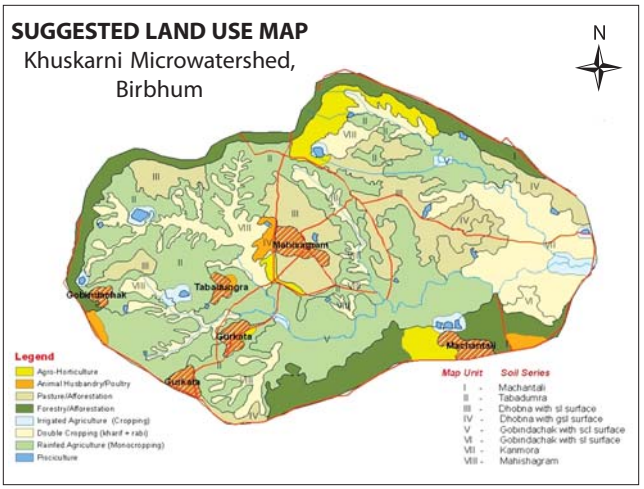


Fig. 53: Suggested land use map of Khuskarni Microwatershed, Birbhum

Machantoli soil series (slightly deep, fine-loamy Typic Haplustalfs) and on moderately deep, fine-loamy Haplustepts (Dhobna soil series). These soils occur on crest and undulating slope (37% TGA) and are prone to severe erosion. Agro-forestry helps in protecting the soils from erosion, but also provides safe pathways for run-off water to be collected in water harvesting ponds. Other deep, fine-loamy Typic Haplustepts (Tabadumra series) covering 19.01% area of the watershed is specifically identified for rainfed agriculture. Groundnut and black gram are the preferred crops. Legume-based cropping pattern would be better option from soil fertility and price front. For optimizing the productivity of the watershed, 32% area belonging to capability class VII and VIII needs to be allocated for animal grazing and agro-horticulture. Other two soil series characterized as deep, fine, Typic Haplustepts on depressed land (19.57% of TGA) is suggested exclusively for rice and pisciculture. It is expected that by implementing the suggested land use plan in Khuskarani watershed, additional 359.1 hectare area may be brought under double cropping and cropping intensity of the watershed may be increased from 110 to 145 per cent.

Land use planning of Chanavada watershed in Girwa tehsil, Udaipurdistrict, Rajasthan for Integrated Development

The Chanavada micro watershed is part of Jhakham, Gomti catchment covering an area of 1475 ha in Girwa block of Udaipur district in southern Rajasthan. Geologically the watershed is developed on argillaceous deposits composed of slates, phyllites and mica schist along with granites and quartzite. The climate of the watershed is tropical semi-arid characterized by hot summer and intense winter. The average rainfall is 650 mm. The mean summer and winter temperature were 35.7°C and 26.8°C, respectively. The soil temperature and

moisture regimes are 'Hyperthermic' and 'Ustic' respectively. Chanavada watershed is a part of Aravalli hills range hence the cultivation of crops is confined to stream and valley only.

The morphometric analysis of the watershed reveals that the watershed is 4th order, elongated in shape having mixed drainage pattern. The watershed comprised of two major landform *i.e.* hills and valleys. Based on the visual interpretation of satellite data, other collateral data and local micro features which were further subdivided into six landform units. These were (1) Steeply sloping hills (2) Moderately steeply sloping hills (3) Moderately sloping foot slope (4) Inter hill valley (5) Narrow valley and (6) Broad valley. Eight soil series were identified in the watershed and mapped in to 15 soil mapping units at the level of phases of soil series on 1: 4000 scales after establishing soil landform relationship. The study reveals that the soils of the steeply sloping hills were very shallow to shallow, dark brown to yellowish brown, gravelly sandy loam to clay loam. However, the soils of the moderately steeply sloping hills were shallow to moderately shallow, brown to dark yellowish brown, gravelly sandy loam to silt loam. On the other hand the soils of the moderately sloping foot slope were moderately deep to deep, dark brown to dark yellowish brown, sandy clay loam to loam texture. The soils of the Interhill valley were deep, well drained, dark brown to grayish brown, sandy loam to loam in the surface texture. The soils of the narrow valley are very deep, well drained, very dark grayish brown to brown, sandy clay loam to loam in the texture. The soils of the broad valley are deep to very deep, well drained, brown to dark brown, loam to silt loam with moderate permeability. The general slope of the unit ranges from 1-3%. These soils are cultivated for single crop of maize in *kharif* season, however in some patches, with irrigation facilities it is used for wheat cultivation in *rabi* season.

The soils of the hills are slightly acidic to neutral in reaction whereas the soils of the valley were neutral to moderately alkaline in reaction. All these soil are very high in organic carbon content on the contrary the content of available nitrogen is low. Most of the soils are medium to high in available phosphorous and available potassium whereas the content of available micronutrients was adequate to high. Taking in to account soil characteristics and land qualities, the soils were evaluated for Land Capability Classes, Land Irrigability Classes and suitability for various crops. The soils of the hills are not suitable for arable field crops and the soils of foot slope and narrow valley were marginal to moderately suitable for growing crops. The soils of the broad valley were the good cultivable lands with minor soil problem such as gentle slope, fairly satisfactory texture and slight stoniness. All climatically adapted crops can be grown under irrigation.

The major constraints for agricultural productivity in the watershed are steeply sloping land, severe erosion, shallow soil depth, strong stoniness and acute shortage of water for irrigation as well as drinking purpose. In addition to this lack of improved package of practices, improved varieties, irrigation facilities and migration of local people due to unemployment are some of the agronomic and socio-economic constraints in the area. To solve these problems there is a need for scientific approach with proper land use planning.

For the integrated development of the watershed, the existing land use may be modified for optimal utilization of natural resources to achieve higher productivity. Keeping this in view the suggested land use plan for the watershed was prepared (Table 40). This kind of land use options helps to establish new enterprises like dairy and animal husbandry and creates ways for self employment to the local people.

Table 40: Suggested land use plan for Chanavada watershed

Series	Landform	Slope (%)	Present land use	Constraints	Management need/ soil conservation measures	Suggested land use	Area (ha)
Chanavada–1	Steeply sloping hills	>30	Degraded lands / scrub land	Very shallow, strong stoniness, very severe erosion, steep slope excessively drained, rapid permeability and low in available water capacity.	Staggered trenching, gully controlled measures with LSCD, gully treatment	Afforestation	290.8
Chanavada–2	Moderately steeply sloping hills	15-30	Degraded lands/ scrub land	Moderately shallow, strong stoniness, very severe erosion, moderately steep slope, available water capacity, low in excessively drained and rapid permeability.	Trenching, Gully controlled measures with LSCD	Silvipasture	476.5
Chanavada–3	Moderately sloping foot slope	8-15	Cultivated (single crop)	Severe erosion, strong stoniness, moderate slope, moderate deep and rapid permeability.	V-ditches, contour vegetative bunds and contour vegetative hedges	Agro forestry	189.3
Chanavada – 4 & 5	Interhill valley/ Narrow valley	3-8	Cultivated (single crop)	Gentle slope, strong stoniness, severe erosion moderately rapid permeability and low in nutrient status.	Contour vegetative bunds, contour trenching and field bunding	Double cropping	279.5
Chanavada–6	Broad valley	3-8	Cultivated (single crop)	Strong stoniness, severe erosion, low nutrient status, gentle slope and rapid permeability.	Contour trenching, Nala bunds, contour vegetative bunds and field bunding	Double cropping	70.8
Chanavada– 7 & 8	Broad valley	1-3	Double crop	Moderately rapid permeability, moderate erosion	Deep ploughing in summer, crop rotation, mixed cropping, filed bunding and introduction of seasonal vegetable crops	Intensive cropping	166.1

Assessment of environmental and economic impact of the New Agricultural Policy of Karnataka on land use, land productivity and rural livelihood

All attempts were made to study the change in land use and impact of agricultural polices on land use/ land productivity and rural livelihood in Kuthanagere micro watershed located in Magadi taluk of Bangalore rural district for biophysical and socio-economic assessment by comparing baseline land use (1999) with current situation (2010). Review of literature on Karnataka agricultural policy and its impact on land use and rural livelihood indicates that the new economic policies have brought significant changes in rural Karnataka. The Karnataka Land Reforms Amendment Act

(1995) giving an extended definition to agriculture, enabled private acquisition of land for aquaculture and facilitated agro-based industries and housing societies to acquire agricultural land. In 1991 the average land holdings was 1.35 ha and 2.13 ha and it has decreased to 1.04 ha and 1.63 ha in 2006, respectively in Bangalore rural district and Karnataka state.

The total cropped area (top ten crops) was 249 thousand ha and it has decreased to 228 thousand ha in 2010 in Bangalore rural district. It is clear that land put to agriculture production is declining during this period. There is decline in area under food crops (finger millet, rice), oilseeds (ground nut) and pulses (tur) and on the other hand the area under commercial crops (mango, maize, coconut, areca nut) increased (Fig. 54).

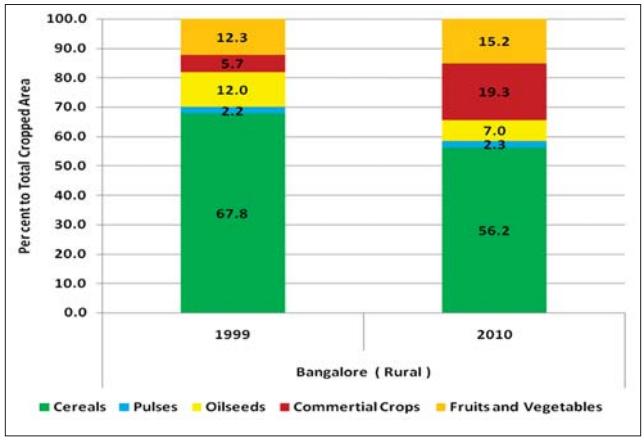


Fig. 54: Change in cropping pattern in Bangalore rural district

There is increase in the cost of human labour by 524 per cent in farming operations. The policy of decontrol of fertilizers and fuel oils has led to increase in the cost of hiring farm machinery by 71 per cent. The increase in cost of fertilizer varies with the soil nutrients. Maximum increase in price was found in Nitrogen (166%) followed by Phosphorus (64%) and Potassium (55%) (Table 41). Due to the change in economic policy, the increase cost of inputs is more than the increase in minimum support prices for finger millet cultivation.

Table 41: Change in cost of inputs and output price in Bangalore Rural District

Particulars	1999	2012	% Change	Type of Policy
Men Labour (md)	40.0	250.0	524.8	Rural employment
Women (wd)	25.0	150.0	499.9	Rural employment
Bullock labour (Bpd)	150.7	300.0	99.0	Rural employment
Tractor (hr)	350.0	600.0	71.4	Decontrol of Oil
Manure (q)	50.0	200.0	300.0	Decontrol of fertilisers
Nitrogen (kg)	8.7	23.2	166.6	Decontrol of fertilisers
Phosphorus (kg)	16.0	26.3	64.3	Decontrol of fertilisers
Potassium (kg)	15.8	24.5	55.3	Decontrol of fertilisers
Main Product price (Rs./q)	500.4	1200.0	139.8	Minimum support prices

Policy decontrolled fertilizer prices has resulted in higher cost of production more than the minimum support price leading to decline in profitability for finger millet. The per cent of labour in the total cost of cultivation increased from 41 to 51 per cent respectively from 1999 to 2012, which indicates decline in labor productivity in finger millet cultivation (Table 38). Post agricultural policy reforms, the increase in cost of production is more (250 %) compared to increase in minimum support prices (140 %) per quintal of finger millet, which led to decline in profitability in finger millet cultivation (Table 42).

Table 42: Change in profitability of finger millet cultivation in Kuthanagere micro watershed

Particulars	1999	2012	Change	% Change
Cost of Production (Rs/q)	399.6	1397.7	998.1	249.8
Minimum Support price (Rs/q)	500.4	1200.0	699.6	139.8
Net returns (Rs/ha)	5188.6	8278.7	3090.1	59.6
B:C Ratio	1.6	1.3	-0.3	-20.9

The detailed soil mapping information prepared by the NBSS&LUP during 1996 was used as baseline data for soil resources status. Field soil survey and socio-economic assessment was undertaken during months of May and June 2012 for documenting the changes in land use and soil variability. Compared to the baseline data (Fig. 55), about 84 per cent of farm households have changed the land use from annual crop finger millet to perennial mango plantation. Farmers are taking finger millet as inter crop up to 10 years of mango orchards. The Karnataka government is promoting land use change by crop diversification through implementation of watershed and horticultural development under National Horticultural Mission program (NHM). Farmers are utilizing the government development programs for land use change. The main reasons given for change of land use from annual finger millet to perennial mango plantation are, assured market, less fertilizer and labour requirement and erratic rainfall pattern.

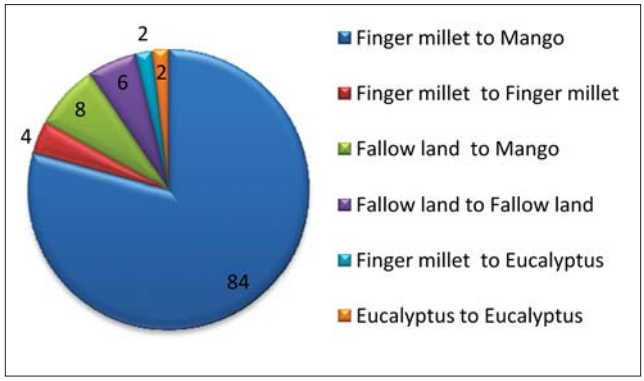


Fig. 55: Change in land use in Kuthanagere micro watershed

Delineation of potential areas for commercially important medicinal and aromatic plants in different agro-ecological zones of Karnataka using GIS tools

Ten medicinal and aromatic plants (MAP_S) selected for study namely; Amla (*Emblica officinalis),* Tulsi (*Ocimum sanctum)*, Sweet flag (*Baje*)- *acorus calamus,* sonamukhi- *Cassia angustifolia*, eucalyptus- *eucalyptus citriodora,* rosemary- *Rosmarinus officinalis,* and scented geranium- *Pelargonium graveolens* growing areas were characterized in 2011-12. This year, davana- *Artemisia pallens*, Vetiver- *Vetiveria zizanioides,* Ashvagandha- *Withania somanifera* and Eucalyptus- *Eucalyptus citriodora* growing areas were characterized. Out of 17 Agro-Ecological Zones (AEZ) of Karnataka, 8 AEZs have been inventorized during 2011-12 and 3 AEZs in 2012-13 covering 16 districts.

Soil samples collected were analysed using standard methods for pH, EC, Organic carbon, available N, P,K, Ca, Mg, S, Zn, Fe, B, Mn. Economic parts of MAPs collected were analysed for essential oil content and its composition. Yields of crops were correlated with rainfall, soil depth and chemical properties.

Eucalyptus citriodora is predominantly grown in Bangalore (AEZ- 7 and 8), Chikkaballapur and Kolar (AEZ-7) and Dharwad (AEZ-10). Highest oil content (3.2%) was recorded in AEZ-10 followed by AEZ-8 (2.86%). Leaf yield was significantly influenced by soil depth and rainfall. Tulsi is grown in Channapatna taluk of Ramanagaram district (AEZ-8), Bellary (AEZ-1) and Shimoga (AEZ-13). Highest leaf yield (87 t/ha) and oil content (0.7%) is recorded in deep sandy loam soils of Bellary. Tulsi leaf yield and oil content is significantly influenced by nitrogen, phosphorus and potash content of soil, rainfall and soil organic carbon. Davana is grown mainly Bangalore (AEZ- 7 and 8), Chikkaballapur and Kolar (AEZ-7) districts. Sandy loam soils recorded highest foliage yield (22.9t/ha) followed by clay loam (22t/ha), sandy clay (18t/ha) and sandy clay loam (17.8t/ha). Oil content was highest in sandy clay loam (1.02%) soils. Sandy loam soils recorded highest davanone content of oil as compared to sandy clay loam and sandy clay soils. Sandy clay loam and sandy clay soil recorded highest β davanone 2-ol content than sandy loam soils.

Ethayl Cinnamate content was not varied much between different soils (Fig. 56). Ashwagandha is predominantly grown in Gadag (AEZ-3) district. Root yield of ashwagandh varied from 6q/ha to 9q/ha. Medium deep sandy clay soils recorded highest root (9q/ha) and stem (10q/ha) as compared to deep sandy clay soils. Based on the relationship between soil parameters and rainfall of the site with productivity and oil/chemical composition of MAPs, soil site suitability criteria was refined for amla (Table 43) and davana (Table 44).

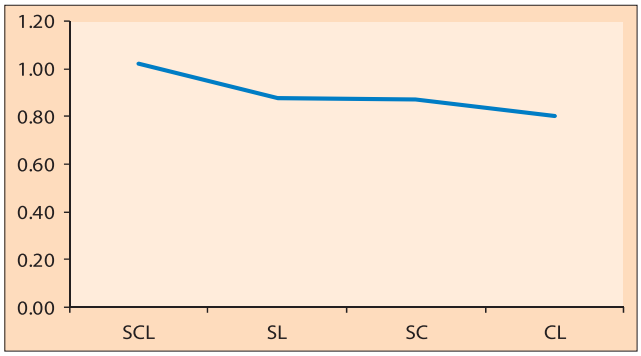


Fig. 56: Oil content of davana as influenced by soil texture

Table 43: Soil-site suitability criteria for Amla

Soil-site characteristics			Rating			
		Unit	Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Not suitable N
Climatic regime	Mean temperature in growing season	°C	30-34	35-38 25-29	39-40 15-24	
	Rainfall	*mm*	750-1000	100-1500 500-750	1500-2000 300-500	>2000 <300
Land quality						
Moisture availability	Length of growing period	*Days*	90-120	120-150	>150	<90
Oxygen availability to roots	Soil drainage	Class	Well drained	Mod.to imperfectly	Poorly drained Somewhat excessively drained	Very poorly drained Excessively drained
	Water logging in growing season	Days	<4	5-6	7-10	>10
Nutrient availability	Texture	Class	sl, scl, l, cl	sic, sicl, sc	cl, s, ls	c
	pH		5.5-7.5	7.6-8.5	8.6-9.0	
Rooting conditions	Effective soil depth	cm	>75	50-75	25-50	<25
	Stonnines	%	5-15	15-30	30-50	*>50*
	Coarse fragments	Vol %	Nil	15-35	>35	
Soil toxicity	Salinity (EC saturation extract)	dS/m	<1	1-9	>9	<50
	Sodicity (ESP)	%	Nil			
Erosion hazard	Slope	%	<3	3-5	5-10	

Table 44: Soil-site suitability criteria for Davana (irrigated)

Soil-site characteristics			Rating			
		Unit	Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Not suitable N
Climatic regime	Mean temperature in growing season	°C	24-28	29-32 20-23	15-19 33-36	<15 >36
Land quality						
Oxygen availability to roots	Soil drainage	Class	Well drained	Moderate	Imperfect	Poorly drained & Some what excessively drained
Nutrient availability	Texture	Class	sl, l, scl, cl, sil	sic, sc, sicl, c(m/k)	c(ss)	*ls, s*
	pH	1:2.5	6.5-7.5	6.0-6.5 7.5-8.5	<6; >8.5	
	CEC	C mol (P+)/kg	>15	10-15	<10	
	$CaCO_3$ in root zone	%	Non-calcareous	Slightly calcareous	Strong calcareous	
Rooting conditions	Effective soil depth	cm	>75	50-75	25-50	<25
	Coarse fragments	Vol %	<15	15-35	>35	
Soil toxicity	Salinity (EC saturation extract)	dS/m	Non-saline	1-2	2-3	
	Sodicity (ESP)	%	Non-sodic	10-15	>15	
Erosion hazard	Slope	%	1-3	3-5	5-10	>10

Efficient land use based integrated farming system for rural livelihood security in Aurangabad, Dhule and Gondia districts of Maharashtra

Interventions for livelihood improvement were implemented in participatory mode in Gondia district. Horizontal transfer of technology was emphasized during the period under report through dissemination in nearby villages . Site Specific interventions were implemented for Deori and Goregaon clusters. The major interventions implemented to improve the yield of paddy crop included - community nursery (well water management), site specific suitable variety, fertilizer doses and other agronomic practices. Residual soil moisture was utilized to grow *rabi* crops like linseed, lablab, lathyrus etc. Instead of pounding water, the farmers were advised to maintain less than 2.5 cm of ponded depth to maintain aeration. It was observed that the women from NAIP villages have turned ambassadors of Best Management Practices (BMP). They advised farmers in nearby villages to adopt line plantation with new spacing, seed rate and water management practices whenever called

upon as daily paid workers for transplanting. Thus the technology has created an impact and other farmers are also now willing to adopt the new practices.

Crop-based Interventions

kharif

The improved varieties of Paddy namely Khamang, HMT, Jaisriram and IR-64 were sown during the *kharif* season . The farmers were encouraged to adopt BMP (best management practices). The yield of paddy went up by 75 % on an average (Table 45) while the input cost was reduced. The farmers were convinced to use 5 kg/acre under improved method against the usual seed rate (30 kg/acre). Average additional yield of 1220 Kg per ha was earned additional income of Rs 14640 by farmers during (2012-13) *kharif* season.

Table 45: Yield of paddy by adopting improved method

Variety	Av. yield (t/ha)	Var.	No. of Benefi-ciaries	Area in ha	Av. yield t/ha
Local	1.62	Khamang	256	119.4	3.15
	(Last	HMT			2.82
	20 years)	Jaysriram			2.43
		IR 64*			2.99
Average					2.84

*Early Variety

Saving through community Nursery

Items	Traditional Method		Community Nursery	
	Requirement Kg/ha	Cost in Rs	Requirement Kg/ha	Cost in Rs
Seed	75*	1837	7.5	187.5
Labour	50**	3500	25	1750
Additional expenses for weeding				
Additional expenses on weeding	—	—	15	1050

*Seed cost **Labour man-days (female) rate

Rabi crops

Farmers were guided to grow different *rabi* crops like Lab-lab (*Dolichos lablab*), coriander (coriandrum sativum), lathayrus. During 2012-13, many farmers not only from opted villages but also from surrounding villages have accepted diversification and came forward to grow *rabi* crops and oilseed. Average additional yield of 0.370 t/ per ha accrued additional income of Rs 16650 to the farmers during (2011-12) *rabi* season.

Outcome

Cropping intensity increased by 30%. Income was raised by Rs. 6264/annum through gram and Rs. 16650 through Linseed/ha. The farmers were also willing to adopt community high pay off crops to fulfill their household needs and attachment towards SHG was strengthened.

High pay off intervention – garlic-community farming

The farmers were encouraged to grow the high pay off crop (Garlic) cultivated in small area with manual irrigation on co-operative basis as the soil preparation is difficult in paddy (Puddled + bunded) field. The group of 41 farmers participated to grow the garlic crop in one hectare area. Among them 11 farmers used drip irrigation. Average additional yield of 2444 Kg per ha was earned and additional saving of Rs 98000 occurred in the village through garlic crop during (2011-12) *rabi* season. Results are awaited for 2012-13.

Management of tank water and land resources

A group of 17 farmers was formed to grow watermelon (Var: Black sugar) in back water space (drying beds of surface water bodies). Few progressive farmers used gravity fed drip irrigation for watermelon in the tank bed. The crop condition

is good showing uniform stand. The yield data recorded for 2011-12 is as below.

Variety	:	Black Sugar
Group of farmers	:	17
Total yield in tones	:	38 kg/ha
Additional income	:	Rs. 1.53 lakhs

Livestock Interventions

Goat intervention

District Gondia is having abundance of natural resources which is suitable for goat rearing. The rural poor are engaged in goat rearing in this region as a source of income. Therefore along with poultry intervention a unit of 6 Osmanabadi goats (5 does +1 buck) was provided to 24 landless labourers and farmers. The number of animals has gone up by 171 during 2011-12 in addition to the animals provided. A total of 54 male and 28 female kids have been added in Goregaon cluster with additional income of Rs 83000/- and 48 male and 41 female kids have been added in Deori cluster with additional income of Rs 81800/- till March, 2013.Long term benefits are also achieved like upgradation of local goats and reduction in inbreeding depression.

Animal Health Check-up, deworming, vaccination and AI (Artificial Insemination) camps were organized in each village of both the clusters of Gondia district in synergy with officials from the State Animal Husbandry Department. In these camps near about 1676 number of animals were treated in project area. On an average Rs 600/- is saved by each livestock owner which were earlier spent towards treatment, vaccination etc. As a result of this activity there is reduction in incidence of foetal diseases like H.S. and B.Q. and reduction in economic and production losses due to disease like FMD. Reduction in losses due to parasites attack are also reported. Results of A.I. activities are also visible as birth of cross breed calves was also reported from project area.

Poultry intervention

In Gondia District majority of population are rearing local breeds of poultry .These breeds require on an average 4-5 months for achieving 1 kg weight. Laying capacity of these birds is very low.. Keeping these points in mind under backyard poultry intervention, selected 4 SHGs were provided with 350 number of one day old chicks of Giriraja,Vanraja and Swarnadhara breed in the Gonditimezari village of Goregaon cluster. The technical support in respect of management guidance and medication supplements was also provided. An income of Rs 88600/- was accrued through sale of meat. Birds aged 14-16th weeks were marketed after attaining weight above 1.5 kg. with FCR of 3.05-3.15.

Multiple Use of Water-Pisciculture

Deori cluster farmers (18 members SHG) harvested 795kg fish (till December, 2011) during 2011-12, from Jodabodi tank. An amount of 63600/- has been earned by SHG and more than 10 tonnes of (unharvested) fish remains in the tank.

Modeling impact of climate change on soil quality and land use in arid, semi-arid and sub-humid regions of Karnataka for agricultural sustainability

In semi-arid region, Yellampalli, Harpanahalli and Anekalu soils were characterized for rainfall and land use data from 1969 to 2011. Soils of Yellampalli (AESR-3, AEZ-7; rainfall 686 mm/year) are deep, red gravelly clay. Record of soil studies carried out in 1971 and 1986 were compiled and new samples were collected for 2012. Analysis of annual rainfall and soil erosion and extreme rainfall events (>100 mm/week) from 1969 to 2011 indicated that years of below normal rainfall are more in the first decade of 21st century and extreme rainfall events increased from 1986 onwards

(Fig. 57). The direct impact of rainfall and extreme events increase on soil erosion caused aggregate-destruction added to that rapid surface runoff, which decreased infiltration capacity of soil (Table 46).

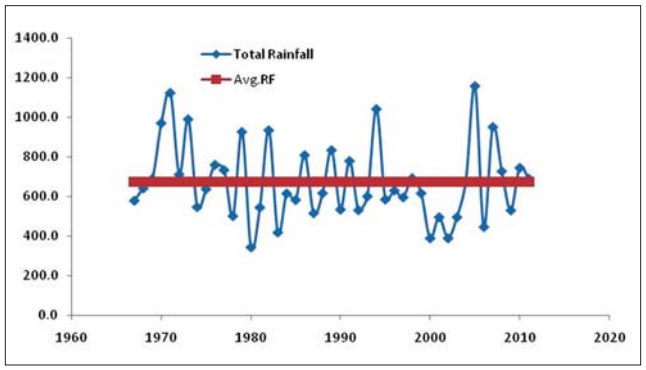


Fig. 57: Total and average rainfall distribution at Bagepalli

Soils of Harpanahalli and Anekallu (AESR-3, AEZ-4; rainfall is 733 mm/year) are medium deep and deep red soils respectively. Soil data pertaining to 1969 and 2005 were available for these sites. New samplings were made at the same site in 2012. Soil pH and organic carbon content significantly decreased over the time in Harpanhalli soils.

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

To know the needs of the tribal people, a participatory diagnosis exercise was carried out in the hamlet. In most of the hamlet, maximum participation was of women and very few men participated in Participatory Rural Appraisal (PRA) exercise to identify the problems and prioritize them. The community needs identified are listed as follows:

- Drinking water is the most important problem
- Protecting crops from elephants
- Lack of irrigation facilities
- Lack of bullocks or tractor for ploughing the land.
- Timely non availability of agricultural inputs like seeds, fertilizers & technical knowhow
- They have showed keen interest in short term benefit activities
- Women folks are interested in animal husbandry activities like Dairying, Goat/sheep rearing and Backyard poultry and Value addition of finger millet and home based activities.

Interventions implemented include

(i) *Community drinking water supply:* Based on the suggestions mutually agreed upon by all the stakeholders, mini water supply programme was implemented in Channagudi, Arlahalli, Devanadi and Kere hadi hamlets. This programme helped to provide continuous and good quality drinking water to 170 families.

Table 46. Changes in Chemical properties of Yellampalli soils over a period of 4 decades

Horizon	Depth (cm)			pH (water)			OC (%)		
	1971	*1986*	*2012*	*1971*	*1986*	*2012*	*1971*	*1986*	*2012*
Ap	0-18	0-15	0-13	6.0	7.4	8.1	0.84	0.45	0.10
Bt1	18-47	15-42	13-43	6.4	6.9	7.6	0.31	0.25	0.55
Bt2	47-69	42-70	43-69	7.0	7.4	7.1	0.18	0.17	0.40
Bt3	69-89	70-90	69-105	7.0	8.3	7.0	0.15	0.07	0.37

(ii) *Distributed high range torches:* To scare away the elephants, high range torches were provided to cultivators whose fields are in fringes of forest. There was no elephant menace during *kharif* 2012 and farmers could take good crops.

(iii) *Seed production of horse gram and cowpea* : High yielding varieties of horse gram (PHG-9) and cowpea (PKB-6, PKB-6 and AV-5) seeds were given to innovative tribal farmers for seed production with buy back facilities.

(iv) *Skill development* : Tribal farm women were trained for value addition of finger millet and small scale bakery at Bangalore. Ragi malt and other value added products being prepared by the tribal women have been supplied to Swami Vivekananda Youth Movement Hospital and Tribal student hostel.

Dynamics of Land Use and its Impact on Soil properties in Jalandhar District of Punjab

The suitability of major crops of Jalandhar district has been evaluated on the basis of soil-site characteristics and the suitability criteria for the crops grown in the district which includes rice, wheat, maize and chick pea (Fig. 58 and Table 47).

Table 47: Area under different crops (%)

Crop	Suitable	Mod. Suitable	Marginally Suitable	Unsuitable
Wheat	60	26	6	5
Rice	40	51	7	-
Maize	29	56	7	-
Chickpea	29	57	6	5

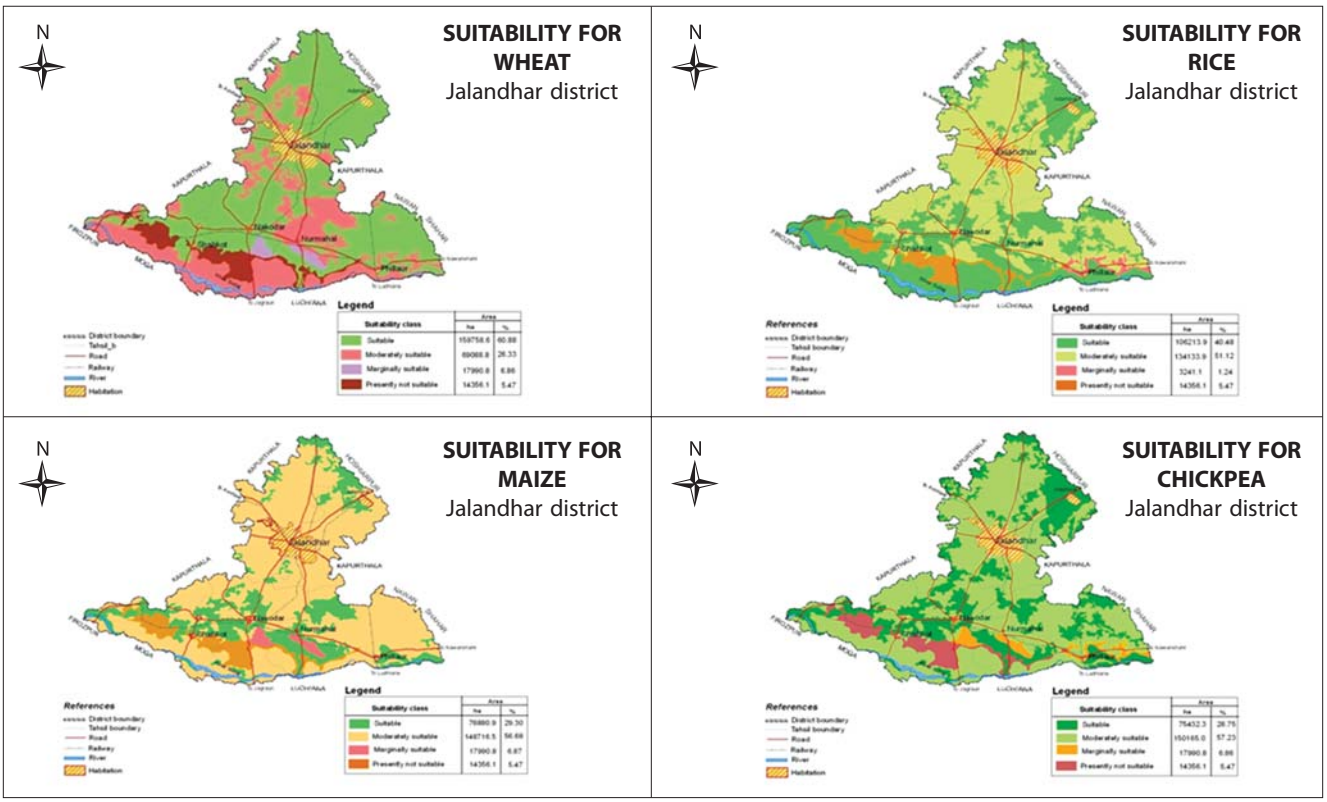


Fig. 58: Suitability maps for dominant crops, Jalandhar district

Alternate Land Use options for Chhata tehsil of Mathura district towards sustainable crop production and livelihood security.

Socio-economic data of farming households of Chhata tehsils were collected from 14 villages in different soil mapping units covering 8 soil series. In total, 140 farmers were interviewed as per the stratified sampling technique. Randomly 14 landless labourers were also interviewed to know their livelihood in the rural occupational structure/set up. About 80 per cent of the population is engaged in agriculture and allied activities. Secondary occupational activities in the area are livestock and daily wage labourer. Farming (exclusive) is the major occupation for males (68.2 per cent) followed by both farming and agricultural labourer activities (13.3 per cent). Majority of the females (68.9 per cent) are housewives and only 22.1 per cent females perform both farming and household activities.

Amongst cropping pattern, rice and wheat are the dominant crops in irrigated areas while mustard, sorghum, pearl millet and cluster beans are the main rainfed crops. Other important crops grown in the region are sugarcane, cotton and pigeon pea. Cropping pattern of tehsil shows highest area is under wheat (52.3 per cent) followed by rice (24.8 per cent) mustard (8.2 per cent) and fodder crops (7.7 per cent). Small percentage of area is under pearl millet (4.3 per cent) and sugarcane (0.1 per cent) (Fig. 59). At some places vegetables are also cultivated but on very small area suggesting that the chances of crop diversification are very well in the region. Water table in the Chhata area ranges from as high as 1 to 1.2 m to as low as 18-21 m. Source of irrigation are canal and tube-wells. 17.8 per cent of the irrigated area is irrigated by canals, 38.3 per cent by tube-wells and 43.8 per cent both by canals and tube-wells. Crop yield is low in waterlogged and saline soils and ground water quality is poor in large area.

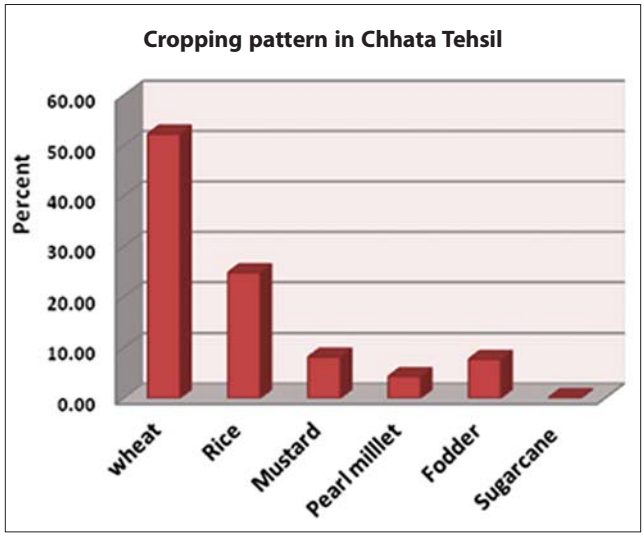


Fig. 59: Cropping pattern in Chhata Tehsil

Rank wise constraints for agricultural production are non-availability of water (58.9 per cent), low prices of produce (12.3 per cent), high cost of inputs (10.9 per cent), insufficient availability of electricity (6.8 per cent), non-availability of seeds (5.4 per cent) and fertilizers(5.4 per cent) in time respectively.

Farmers of the area expressed that crop yield can be improved by addressing their local problems viz., non-availability of water, water logging, soil salinity and alkalinity (Table 48).

Table 48: Farmers response to suggestions for improving crop yield

Suggestion to improve crop yield	Farmers response (Per cent)
Timely water availability for irrigation	50.00
Reclamation of salt affected soils	17.54
Proper Drainage	32.46

Evaluation of management practices for different sustainable cropping systems in major soil series of Shikohpur village in Haryana

Six soil series have been identified of which four soil series namely, series A, B, C and D of Shikohpur village were selected to find the soil based management practices for sustainable cropping systems in the area. The soils are mostly very deep,

excessively to well drained with pH 8.2-8.7 and coarse loamy to loamy sand in texture. The soils are classified as Inceptisols with area 62.5 per cent and Entisols 17.9 per cent. Total forty eight farmers, twelve from each soil series were selected for collection of data on socio-economic, crops grown, their *Kharif* season yield and management practices. On the basis of analyzed data four type of management practices (MP) were observed under pearl millet-wheat cropping system *viz.*

I) Inorganic fertilizers NPK @ 70:30:0 kg ha^{-1} with own seed;

II) NPK @ 100 :40: 00 Kg + 5 t FYM ha^{-1} with hybrid seed;

III) NPK @ 140:70:00 Kg + 10 t FYM ha^{-1} with hybrid seed and

IV) NPK @ 140: 70: 00 Kg + 15 t FYM ha^{-1} with hybrid seed during *Rabi* season.

Management practice I for wheat are:

I) NP K @ 60:40: 30 Kg ha^{-1} with own seed;

II) NP K @ 100:40: 30 Kg ha^{-1} with pioneer seed;

III) NP K @ 120: 60:30 Kg ha^{-1} with pioneer seed

IV) NP K @ 140:70:30 Kg ha^{-1} with pioneer seed.

The major constraints for crop production in the village as reported by the farmers are termites, cow dung beetle and blue bulls (100 per cent), electricity (96.3 per cent), low economic return (95 per cent), Non availability of quality fertilizers (94 per cent), seed (89 per cent) and pesticides (86 per cent) in time. Other components are low price of produce and high cost of inputs, non availability of market information, labour at the time of sowing and harvesting, credit and storage facilities and low rainfall.

Highest wheat equivalent yield (WEY) 60.0 q ha^{-1} (Table 49) was reported in management practice IV in soil series A followed by soil series B and C. Almost similar trend was observed in other management practices. The lowest yield was recorded in management practice I under soil series D. Whereas highest nutrient use efficiency was observed in management practice I with Soil series A, B, C and D followed by management practices II, III and IV. The increase in nutrient unit reduction in efficiency of production system from 18.39 in soil series A with MP I to 10.02 in soil series D with MP IV.

Table 49: Wheat equivalent yield (q ha^{-1}) and nutrient use efficiency (%) in pearl millet-wheat cropping system

Particulars	Management practice I	Management practice II	Management practice III	Management practice IV	Mean
Soil series A	38.63	50.74	56.68	60.00	51.51
Soil series B	36.86	48.39	53.82	55.58	48.66
Soil series C	35.1	43.63	48.15	52.78	44.92
Soil series D	34.34	40.86	45.39	48.39	42.25
Mean	36.23	45.91	51.01	54.19	46.83
Nutrient use efficiency (%)					
Soil series A	18.39	15.47	13.63	12.42	
Soil series B	17.55	14.75	12.94	11.51	
Soil series C	16.71	13.00	11.58	10.93	
Soil series D	16.35	12.46	10.91	10.02	

Productivity of soil series A was higher wheat equivalent yield (WEY) in all management practices followed by soil series B, C, and D. Management practice IV higher results productivity than that of MP III, II and MP.

Development of district level land use plan for Almora district, Uttarakhand under Hill and Mountain ecosystem (NePDiLUP)

Ten production systems have been identified in the district. Wheat-Mustard/Mandua are the major cropping production system in hill terraces. While rice-wheat-potato cropping system in the broad valleys. On the basis of generalized soil map, agro-ecological units, land use/land cover and production

systems, land management units (LMU) have been determined (Table 50). It contains 10 units. The farm household data was collected by interaction with farmers of various land holding categories and other stake holders covering major soil units and production systems in the district. Majority of the farmers are under marginal to small land holding categories (75 per cent). Agricultural practice is mainly confined to terraced side slopes and valleys, major constraints are adverse climate, limited cultivated land; limited choice of crops, non-availability of quality seeds, fertilizers/chemicals and lack of infrastructure and marketing facilities.

Table 50: Salient Characteristics of Land Management Units, Almora District

LMU	Soil	Major Production System
1	Excessively drained, gravelly loam soil on steeply sloping summits/ Ridge tops	Mandua-Horti-Reetha plantations + Livestock
2	Excessively drained, gravelly sandy loam to gravelly loam soils on mod. steeply sloping summits/side slopes	Wheat-Mandua and Vegetables + Livestock
3	Excessively drained, gravelly sandy loam to loam soils on mod. sloping summits/side slopes	Wheat-Mandua-Mustard-Potato+ Livestock
4	Excessively drained, gravelly sandy loam soils on steeply sloping ridge tops/side slopes	Wheat-Mustard, Jhungra and Pulses+ Livestock
5	Some what excessively to exce. drained, gravelly sandy loam soils on steeply sloping side slopes	Wheat-Mustard – Horti - spices (Tej Patta) + Livestock
6	Excessively drained, gravelly sandy loam soils on steeply sloping side slopes	Wheat-Mustard+ Livestock
7	Some what excessively drained, sandy loam soils on mod. steeply sloping valley terraces	Wheat-Mandua+ Livestock
8	Some what excessively drained, loamy sand to sandy loam soils on mod. sloping valley terraces	Wheat-Mandua-/ rice- Lentils/ vegetables+Livestock
9	Well drained, loam to clay loam soils on gently sloping valley terraces	Rice-Wheat-Potato
10	Excessively drained, gravelly sandy loam soil on steeply sloping escarpments/summits/ridge tops	Fodder crops/ social forestry-pastures+Livestock

* Forest is in inclusion

Development of District Level Land Use Planning for Jorhat District, Assam under Rainfed Eco-system (NePDiLUP)

The project was undertaken with the following objectives: (i) to evaluate land resources and socio-economic conditions in relation to land use, (ii) to examine the performance of current and future land utilization types and analyze alternate land use options, (iii) to develop methodologies for multiple decision-making criteria for evaluating the possible tradeoffs after the suggested land use options are adopted and (iv) to prepare interactive decision support system to assist land managers at district level for land allocation.

Multiple Goal Linear Programming was used to get maximum net returns and as well as sectoral allocation of lands for various crops. It has been noticed that cultivation of rabi-vegetables, potato and mustard in rice-fallows appear to be highly promising in LMU-1 and 2, whereas, plantation of citrus and tea are highly promising in LMU-5, 6 and 8. In LMU-3, mustard and potato are viable crops provided with adequate supply of all agricultural inputs. In LMU-4 and 8, *rabi*-vegetables can be grown in raised bedded furrows using shallow tube well with pump sets as micro irrigation. A Decision Support System (DSS) of the district has been prepared through building query forms using MS Access software, where the land management unit has been recognized as primary key which has been linked with sub divisions, blocks and village level informations of the district in a relational data base matrix. The suggested alternative land use options for LMU-1 is described in Table 51. The strategic measures to be taken in LMU-1 may be depicted as follows:

- Use of flood resistance paddy varieties *viz.*, *Plaban, Jalashri* & *Jal Kuwari* in flood prone zones.
- Use of HYV of Paddy *viz.*, *Ranjit, Swarnamasuri, Bahadur, etc.* with recommended dosages of fertilizers.

Table 51: Suggested land use options for LMU-1

Suggested Options	Livestock and fishery components (in land holdings)			
	Landless	Marginal	Small	Medium & large
Integrated Paddy -Livestock-Fishery Paddy (Sali)-*Rabi*-vegetables Paddy (Sali)-Potato Paddy (Ahu)-Paddy (Sali)-Paddy (Boro) Paddy (Sali)-Black gram-Mustard Paddy (Sali)-Black gram-Paddy (Boro)	Small & Backyard Poultry/ Duckery + Goatery	Backyard Poultry/ Duckery + Goatery + Cow	Backyard Poultry/ Duckery + Goatery + Cow + Bullock + Homestead/ Backyard Pond Fishery	Backyard Poultry/ Duckery + Goatery + Cow + Bullock + Piggery +Organized Bunded Fisher

- Construction of suitable rain water harvesting structures for irrigation of early *Ahu* , *Boro* paddy and *Rabi* crops.
- Cultivation of Potato and other *rabi* vegetables in broad bedded furrows.
- Cultivation of Rapeseed & Mustard (M-27, TS-36, TM-4) and Black gram (T-9, PU-31) after rice with recommended fertilizer dosages.

Development of district level land use plan for Nadia district in West Bengal under irrigated ecosystem (NePDiLUP)

Nadia district in West Bengal under irrigated agro-eco-system has been selected for the development of perspective land use planning. Nine Land Management Units (LMUs) were identified by the spatial integration of land units, present land use and farming/production systems. Each land management unit was evaluated for their potential and limitations based on the inherent soil characteristic, benefit-cost ratio and net return. The farm household data collected from all the land management units have been analyzed for identifying economically viable and biophysically suitable crops and cropping systems and also for identifying different constraints in each LMU and suggestions to improve productivity. Poor quality seeds, high cost of labour and electricity and erratic rainfall are the major farming constraints identified in the district (Table 52). Heavy texture with impeded drainage, moderate flood hazard resulting in loss of fertile surface soils, high cost of agricultural inputs, low prices of product and non-availability of labour were also the other identified constraints. Arsenic contamination in ground water and soil is also reported.

Multiple Goal Liner Programme (MGLP) was used under a set of given constraints for agricultural development in the district to evolve land use options. The following were the goals set for area allocation to different components of agriculture in the district.

1. Maximum net returns without any constraints
2. Maximum net returns with minimum area under cereals
3. Maximum net returns with minimum area under cereals and pulses
4. Maximum net returns with minimum area under cereals, pulses and oilseeds.

The model has allocated area for different crops in various seasons with respect to each goal. Expected net returns for the district varied from Rs. 24,578 to Rs. 29,053 ha^{-1} under different goals. For obtaining such returns the different combination of crops for different LMUs has been suggested (Table 53). Goal 1 is achievable in the district, if 33.1, 28.1, 19.4 and 17.0% of the gross cropped area is allocated for jute, rice, mustard and vegetables respectively, whereas Goal 2 could be

Table 52: Farming constraints affecting the crop yield in Nadia district, West Bengal

LMU (No. of Farm families)	Per cent of farmers (Ranking of problem)							
	Soil	Rainfall	Seeds	Fertilizer	Labour	Electricity	Cost of inputs	Prices of product
LMU 1 (20)	60 (8)	80 (4)	100 (3)	70 (7)	100 (1)	100 (2)	70 (6)	80 (5)
LMU 2 (42)	88 (7)	100 (4)	100 (3)	82 (8)	100 (2)	100 (1)	90 (5)	88 (6)
LMU 3 (25)	76 (7)	100 (2)	92 (4)	76 (8)	88 (5)	100 (1)	100 (3)	80 (6)
LMU 4 (47)	77 (5)	100 (2)	100 (1)	74 (6)	91 (4)	93 (3)	72 (7)	67 (8)
LMU 5 (34)	33 (8)	100 (4)	100 (3)	59 (7)	100 (1)	100 (2)	94 (6)	100 (5)
LMU 6 (29)	72 (8)	93 (4)	100 (1)	72 (7)	96 (2)	93 (3)	76 (6)	86 (5)
LMU 7 (18)	67 (8)	100 (4)	100 (3)	78 (7)	100 (1)	100 (2)	100 (5)	88 (6)
LMU 8 (30)	80 (8)	90 (4)	100 (2)	80 (7)	100 (1)	90 (3)	87 (5)	80 (6)
LMU 9 (22)	45 (8)	95 (4)	95 (5)	73 (7)	100 (2)	100 (1)	100 (3)	82 (6)

Table 53: Goal *vs* crops and area (ha) allocation of Nadia district

LMU	Season	Crops	Goal 1	Goal 2	Goal 3	Goal 4
1	*Kharif*	Rice	8823	8823	8823	8823
	Pre *kharif*	Jute	6016	6016	6016	6016
	Rabi	lentil	-	-	6962	6962
	Rabi	Potato	9274	9274	2312	2312
2	*Kharif*	Rice	31910	31910	31910	31910
	Rabi	Boro	-	16605	-	19031
	Pre *kharif*	Jute	52463	35858	52463	33432
	Rabi	Lentil	-	-	37080	37080
	Rabi	Potato	37080	37080	-	-
3	*Kharif*	Rice	8521	8521	8521	8521
	Rabi	Mustard	6627	6627	6627	6627
	Annual	Banana	15467	15467	15467	15467
4	*Kharif*	Rice	87554	87554	87554	87554
	Rabi	Boro	-	113478	113478	113478
	Pre *kharif*	Jute	113478	-	-	-
	Rabi	Mustard	78111	78111	78111	78111
5	*Kharif*	Rice	10188	10188	10188	10188
	Rabi	Mustard	4065	4065	4065	
	Any season	Vegetables	31723	31723	31723	31723
	Rabi	Wheat	-	-	-	4065

cont...

6	*Kharif*	Rice	31252	31252	31252	10888
	Pre *kharif*	Jute	20364	20364	20364	20364
	Rabi	Mustard	33644	33644	33644	11301
	Annual	Sugarcane	-	-	-	2064
7	*Kharif*	Rice	1346	1346	1364	1364
	Rabi	Mustard	961	961	961	961
	Any season	Vegetables	3123	3123	3123	3123
8	Pre *kharif*	Jute	22756	22756	22756	22756
	Rabi	Brinjal	20179	20179	20179	20179
9	*Kharif*	Rice	2323	4323	11292	11292
	Rabi	Boro	-	-	7636	8969
	Pre *kharif*	Jute	-	-	1333	-
	Rabi	Mustard	2989	2989	-	-
	Rabi	Lentil	-	-	11958	11958
	Any season	Vegetables	8969	8969	-	-
Net Profit/ha (Rs.)	-	-	29,053/-	26,745/-	24,578/-	24,780/-

achieved if 48.1% of the gross cropped area is put up under *kharif* paddy followed by mustard (19.4%), vegetables (17.0%) and jute (13.1%). However, attaining goal 3 could be possible if 46.7, 18.5 and 15.4% of the gross cropped area is used for rice, mustard and jute respectively. The other objective could be ascertained if 51.5% of the gross cropped area could be utilized for rice, 16.1% for mustard, 13.7% for jute, 9.1% for vegetables and 8.1% for lentil.

Considering biophysical, socio-economic and MGLP output, an integrated land use plan for each LMU is suggested. A Decision Support System (DSS) was developed in MS- ACCESS for suggesting village wise recommendation of crops, fertilizers, suitable livestock and fishery with contingency measures. DSS also suggests contingency land use planning under the situation of delay or early monsoon withdrawal.

Development of district level land use plan for Bundi district (Rajasthan) under arid and semi arid ecosystem (NePDiLUP)

Land management units (LMU) have been generated by the spatial integration of land units, present land use, agro-ecology and farming/production system indentified from the farm household data. Each land management unit was evaluated for its potentials and limitations based on the inherent soil characteristics, benefit cost ratio and net return. Information generated has been analyzed through multiple goal linear program (MGLP), development of perspective land use plans and Decision Support System (DSS).

Land use option analysis through multiple goal linear program (MGLP)

The goals set for area allocation to different components of agriculture in Bundi district are as follows.

1. Maximum net returns (no constraints on minimum area crop allocation).
2. Maximum net returns with minimum area under cereals.
3. Maximum net returns with minimum area under cereals + pulses.
4. Maximum net returns with minimum area under cereals + pulses + oilseeds.
5. Maximum net returns with minimum area under cereals + pulses + oilseeds + commercial crops.

The MGLP projected the expected net returns under different objectives from Rs. 73614 to 34546 which is 6 to 12 times higher than the current average net return Rs. 6284 of the district (Table 54).

Land use option and Decision Support System

The suggested land use options have been finalized for the district by integrating MGLP, existing production system, bio-physical suitability of LMU, socio economic condition (livestock) and farmers expectation recorded during the house hold survey of the district. The suggested land use options are presented in Table 55.

Based on the information generated, collected & compiled from the secondary sources, a Decision Support System (DSS) was developed in MS-ACCESS for the district.

Table 54: Area allocation for different crops in each LMU as per goals for the district Bundi

Goals	Model-I	Model-II	Model-III	Model-IV	Model-V
Net returns (Rs/ha)	73614	66166	61229	58060	34546
LMU1	Black gram (100) Barley (100)	Black gram (100) Barley (100)	Black gram (28.8) Sesame (71.2) Barley (100)	Black gram (28.8) Barley (100)	Black gram (28.8)
LMU2	Sesame (100) Wheat (100)	Sesame (100) Wheat (100)	Sesame (100) Wheat (100)	Mustard (100)	
LMU3	Sesame (100) Mustard (100)	Sesame (100) Wheat (100)	Sesame (100) Wheat (100)	Mustard (100)	Mustard (100)
LMU4	Sesame (100) Gram (100)	Sesame (100) Wheat (100)	Sesame (100) Gram (35.64) Wheat (64.36)	Sesame (100) Gram (35.64) Mustard (64.36)	Sesame (100) Gram (35.64)
LMU5	Soybean (100) Wheat (100)	Soybean (100) Wheat (100)	Soybean (100) Wheat (100)	Soybean (100) Wheat (100)	Soybean (100) Wheat (100)
LMU6	Soybean (100) Wheat (100)	Paddy (96.30) Soybean (3.70) Wheat (100)	Paddy (96.30) Soybean (3.70) Wheat (100)	Paddy (96.30) Wheat (100)	Paddy (96.30) Wheat (58.33)
LMU7	Sorghum (100) Lentil (100)	Sorghum (100) Wheat (82.58)	Sorghum (100) Lentil (100)	Sorghum (100) Lentil (100)	Sorghum (100) Lentil (100)
LMU 8	Soybean (100) Garlic (100)	Soybean (100) Garlic (44.91) Wheat (52.62)	Soybean (100) Garlic (5.03) Wheat (94.97)	Mustard (8.83) Wheat (91.17)	Mustard (61.88) Wheat (38.12)
LMU9	Sesame (100) Coriander (100)	Sesame (100) Wheat (100)	Sesame (100) Wheat (100)	Mustard (100)	
LMU 10	Sesame (100) Fenugreek (100)	Sesame (100) Wheat (100)	Sesame (100) Wheat (100)	Wheat (100)	Wheat (100)
LMU 11	Soybean (100) Garlic (100)	Soybean (100) Garlic (100)	Soybean (100) Garlic (100)	Soybean (41.66) Garlic (63.23) Wheat (36.77)	Soybean (41.66) Garlic (3.95) Wheat (9.6)

Table 55: Suggested Land Use Plan for the District Bundi

LMU	Net Return (Rs/ha)	Existing Production System Crops/Cropping System	Suggested Land Use Plan			
			Crops/cropping systems	Livestock components		
				Small farmer	Medium farmer	Large farmer
1	12577	Maize/blackgram/sesame-wheat/mustard/lentil/gram	Black gram/sesame-Barley	C/B/+G+BP	C/B/+G+BP	Dairy+ poultry farm
2	11164	Sesame/sorghum-wheat/ papaya/other veg.	Sesame- wheat/mustard	C/B/+G	C/B/+G	Dairy
3	12209	Maize/sorghum/sesame-wheat/lentil/mustard	Sesame- wheat/mustard	C/B/+G+BP	C/B/+G+BP	Dairy+ poultry farm
4	14936	Maize/blackgram/sorghum-wheat/lentil/mustard	Maize/Sesame-wheat/ mustard/gram	C/B/+G+BP	C/B/+G+BP	Dairy
5	16149	Maize/soybean/sesame/ groundnut-wheat/gram/ mustard/taramira/potato/garlic	Soybean/sorghum/maize/ sesame- wheat/barley/ mustard/gram	C/B/+G+BP	C/B/+G+BP	Dairy
6	17562	Paddy/soybean-wheat Maize-Wheat/mustard/lentil	Maize/Sesame/sorghum/ paddy/cotton/soybean-wheat/barley/mustard/gram	C/B/+G+BP	C/B/+G+BP	Dairy
7	19026	Soybean-wheat/mustard Sesame/sorghum-wheat/gram/ fenugreek/coriandar	Sorghum/maize/soybean/ paddy-wheat/lentil/barley	C/B/+G+BP	C/B/+G+BP	Dairy
8	36983	Soybean/sesame-wheat/ corriandar/fenugreek/gram	Soybean/garlic-wheat/ mustard	C/B/+G+BP	C/B/+G+BP	Dairy+ poultry farm
9	14378	Soybean-wheat/garlic	Sesame/coriander-wheat/ mustard	C/B/+G+BP	C/B/+G+BP	Dairy+ poultry farm
10	21277	Paddy/soybean-wheat Maize-Wheat/mustard/lentil	Soybean/Sesame/wheat/ coriander/fenugreek-wheat/ mustard	C/B/+G+BP	C/B/+G+BP	Dairy
11	94744	Soybean-wheat/mustard Sesame/sorghum-wheat/gram/ fenugreek/coriandar	Soybean/Sesame/wheat/ coriander/fenugreek-wheat/ mustard	C/B/+G+BP	C/B/+G+BP	Dairy

Development of district level Land Use Plan for Gondia district, Maharashtra (NePDiLUP)

Tehsil wise distribution of land in all the 8 tehsils (Amgaon, Arjuni Moregaon, Deori, Gondia, Goregaon, Sadak, Salekasa and Tirora) of Gondia district was assessed. Land management units (LMUs) wise soil and various socio-economic parameters were tabulated for multi linear goal programming (MGLP) and DSS. It was observed that of the six LMUs identified, LMU-6 comprises the highest number of villages (235), followed by LMU-5, (Numbers of villages: 201), LMU-4(Numbers of villages: 174), LMU-1(Numbers of villages: 103), LMU-2(Numbers of villages: 73) and LMA-3(Numbers of villages: 19). The interventions identified for LMU-1 and LMU-2 are discussed below.

LMU1: Adoption of improved technologies with better varieties of paddy for increasing productivity, To intensify vegetable production during *rabi*

season, To encourage production of pulse, and feed and fodder for animal in *rabi* season, To encourage fish production by leasing of ponds to fishermen for a minimum period of five years with financial assistance for improvement of ponds with high yielding variety of fingerlings to enhance fish productivity.

LMU2: Adoption of best management practices for paddy, genetic upgradation of livestock for enhancement of alternative source of income. To build water harvesting structures. To develop mechanization for small holdings. Considering forest based socio-economic activities and community forest rights (CFRs) prevailing in parts of the district, it may be required to review and revise the land management units already identified earlier.

Land use dynamics in rural urban interface of NCR for regional planning – a case study of NCT-Delhi and Haryana sub-regions

National Capital Region (NCR) is one of the largest regions of the world and constitutes about 1 per cent area of the country. Haryana NCR sub-region is part of NCR, developed to accommodate the increasing population in Delhi agglomeration. In the last two decades it has experienced dramatic land use changes with the increasing population. It covers 30.4 per cent area of the state while its population is 43.54 per cent. The land use changes (Fig. 60)

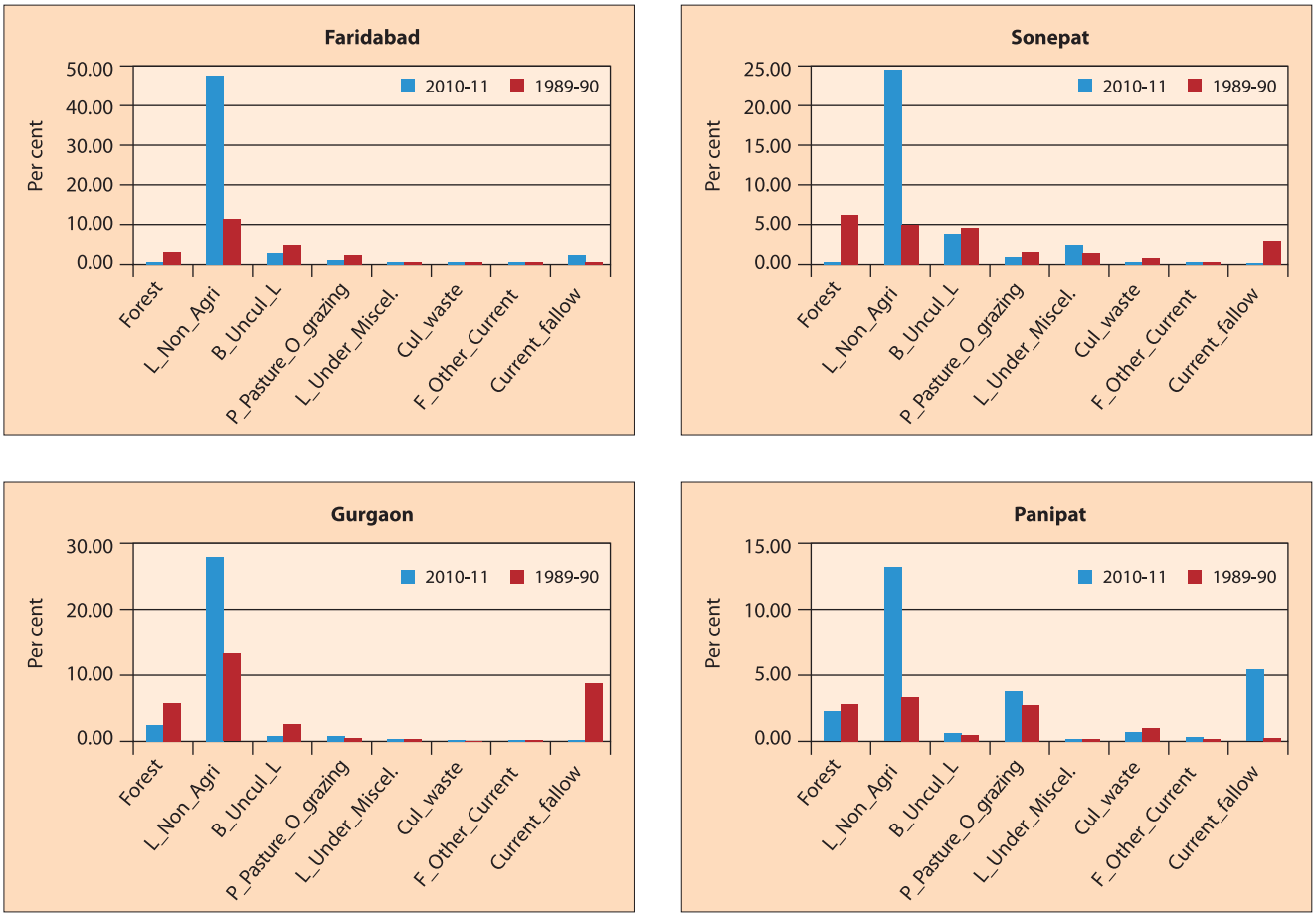


Fig. 60: Temporal Change in land Use other than Agriculture

reveal that the area under non agricultural uses is increasing at the higher rate in Haryana NCR sub-region than that of the state as a whole. The highest increase in area under non-agricultural activities during 1989-90 and 2010-11 is found in Faridabad followed by Gurgaon, Sonepat and Panipat.

Net sown area in the Haryana NCR sub-region has shown decline at the higher rate than the state average (Fig. 61). The highest decline in the net sown area is observed in Faridabad followed by Panipat, Sonepat and Gurgaon during 1989-90 to 2010-11. Reduction of net sown area at a significant rate is on account of growing population, industrial and commercial activities.

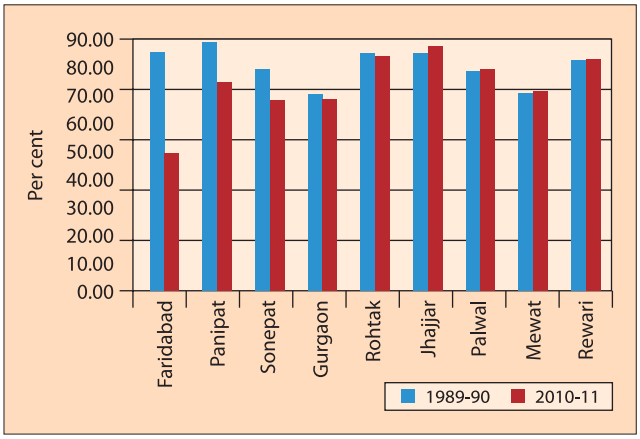


Fig. 61: Temporal change in net sown area in Haryana NCR sub-region

Primary data collected from 10 sample villages of Haryana NCR sub-region selecting 90 farmers around Sonepat, Gurgaon, Faridabad and Bahadurgarh reveal that land prices have increased manifold in the last decade in the NCR which has resulted sale of land at rapid rate.

Large chunk of land purchased during this period have remained out of agriculture for the average period of 5-10 years before it was put to non – agricultural uses. 20 Per cent of the large farmers and 5 per cent of the medium and small farmers who have sold land either to the Govt. agency or to the private Land players have purchased agricultural land within the distance of 40 Kms from their native place. About 90 per cent of the farmers who have purchased land outside their village have leased out their land for agriculture. Live stock population has drastically reduced in the sampled villages which is due to scarcity of fodder with reduction of agricultural Land. After the sale of land, agricultural economic activity has been reduced. The farmers in the high age group have gone unemployed as they do not want to venture into any other activity than agriculture. On the other hand younger generation engaged earlier as cultivators have engaged themselves in the property dealing business as a subsidiary economic activity. Only 10% have the regular economic activity as transporters/builders and about 10% of the work force is engaged in the service. The agricultural labourers have shifted to the nearby as factory workers and on daily paid employment. The major source of regular income to the city adjoining villages is through house rent.

Soil and land capability map for land use planning of Dzongu farm, North Sikkim district, Sikkim

Detailed soil survey of Dzongu farm, North Sikkim district, Sikkim was carried out with the objectives (i) to characterize, classify the soils and delineate their extent and distribution and (ii) to prepare the land capability maps and also evaluate soil- site suitability for different vegetables grown in the farm. Soil survey has been carried out using the available base map (1:12,500 scale).

An in-depth study of soils of the farm indicates that soil characteristics are more or less suitable for the production of a large number of crops. Most of the soils in the farm are excessively drained due to topographical condition and have very low moisture holding capacity. Severe to moderate soil erosion is the most serious problems of the farm due to which both soil and nutrient loss problems are prevalent. Therefore, artificial barrier is necessary to arrest soil as well as nutrient loss. Soils under all soil

mapping units of the farm are having coarse textured soils which limit the water holding capacity with poor storage of plant nutrients.

From this study the following recommendations were made:

a. The organic matter content of these soils medium to high (0.58 to 2.44%). However periodic monitoring is necessary.

b. It is observed that the surface soils of the farm showed acidic reaction (pH 4.5 to 5.0). It is recommended that some ameliorative measure are necessary in the farm to maintain the pH of the surface soils in near neutral range which will help to increase the efficiency of phosphatic fertilizers.

c. The soils of the farm do not show any deficiency of micronutrients viz. Cu, Fe and Mn, except Zn. However, periodical monitoring of micronutrient status of soils is recommended.

d. The soils may be put under cultivation of different crops according to the suitability rating.

Natural resources and land use issues in backward districts of India

An inventory of natural resources especially land, water, forest, ground water development, population and cultivated area was prepared and processed earlier (activity reported in AR 11-12). The Natural resources index map (Fig. 62) below shows that most of the districts are well endowed. Thus it is the efficient utilization of natural resources that appears to be a major concern for investigations. Characterisation and analysis of various data generated following information.

- Lack of rainwater management is a major issue in disadvantaged districts. Only nine districts receive less than 750 mm rainfall, whereas 17 districts have an annual average below 1000 mm. The spatial distribution

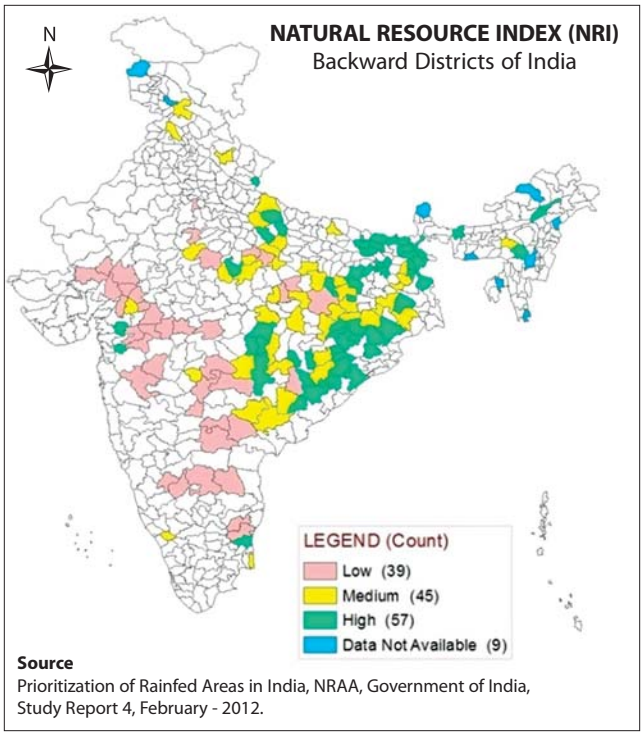


Fig. 62: Natural resource index map of backward districts of India

indicates that all districts with < 1000 mm rainfall are located in West, South and Central parts of India. Interestingly, the groundwater utilization in districts with more than 1000 mm rainfall is 36% as against 66% in relatively low rainfall districts. Based on the analysis, NRM strategies suggested to counter rainwater variability are listed in Table 56.

- Only nine of these 150 districts receive less than 750 mm rainfall, whereas 17 districts have an annual average below 1000 mm. The spatial distribution indicates that all districts with <1000 mm rainfall are located in West, South and Central parts of India. Interestingly, the groundwater utilization in districts with more than 1000 mm rainfall is 36% as against 66% in relatively low rainfall districts. Thus groundwater development could be an effective measure to overcome drought in these districts. Though there is no compelling

Table 56: Suggested NRM strategies

Rainfall variability	Implications	NRM strategies
Delayed onset of monsoon	Delayed sowing/nursery preparation, shorter crop season	Groundwater usage, Short duration crop/varieties, Use of Phosphorous fertilizer can be used at the time of planting, Intercropping
Early season dry spell	Poor crop stand, resowing may be required	Rainwater harvesting, groundwater usage, Phosphorous fertilizer can be used at the time of planting
Mid-season dry spell	Poor crop development, less number of panicles, less grains per panicles	Rainwater harvesting, choosing high tillering variety, groundwater usage
Late season dry spell	Poor grain development, less number of productive tillers	Rainwater harvesting, groundwater usage, short duration variety.
Prolonged wet spell	Incidence of pests and diseases	Integrated pest management, resistant varieties

evidence, it is fairly understood that management of water in small watersheds is an alternative or complementary option to an investment in building reservoirs, irrigation projects, lift irrigation *etc*.

- Of the 150 poor districts, 54 districts have < 40% area under cultivation. The mean forest area (45 %) in these districts is well above national average (23%) or average forest area (26%) in disadvantaged districts. The non timber forest produce (NTFP) can be a major source of income in these 54 districts.
- 47 districts have more than 60% area under cultivation and thus there is hardly any scope for increasing area under agriculture in these districts. These districts are home to 120.1 million population.
- Some of the districts like Satymev Puram and Bidar are completely devoid of forest with <1% TGA under forest. As many as 23 districts have less than 5% area under forest. There are no other natural resources that could contribute to economy/livelihood. It is apparent that natural resources related to agriculture in these districts in terms of utilization have almost reached the peak. It will be a great challenge to sustain livelihood in these districts as compared to rest of the disadvantaged districts.

Per capita cultivated land availability

- Currently (2011), it is 0.26 ha per person. In disadvantaged d7istricts, it ranges from 0.02 to 0.55 ha /person.
- The average availability (0.16 ha/person) is well below national average.
- all districts with low land availability are located in Eastern part of the country. It is in fact a cluster of districts cutting across states of U.P., Bihar, and West Bengal.
- Almost all the 39 districts with poorest of per capita cultivated land availability located in Eastern part throw up a complex situation wherein most productive soils, ample irrigation water availability, no competition for land uses (from sectors such as industry, forest *etc*.), waterlogging, natural disasters like floods and high population co-exist. Another 49 districts have relatively high average per capita cultivated land, although were less than national average. Thus total 88 districts are characterized by a *poor man to cultivated land ratio* signifying need to divert human population to other vocations.
- Districts like Murshidabad in West Bengal have shown very high agricultural productivity. Though, many districts have not

yet realized the potential productivity despite better conditions for agriculture, it is evident that increasing population is a bigger drag than other constraints. Fragmented land holdings are further divided with growth of family size. Thus 88 districts with more than 18 million population (66% of total disadvantaged districts population). Thus two third of the poor in India have to derive livelihood from a very small piece of land without any opportunities such as income through NTFP or crafts using locally available resources.

- In irrigation development, 48 of the 150 districts surpass the national average. Despite good irrigation development, the population residing in these 48 districts ($1.28X10^8$) is almost 45% of the total population ($2.8X10^8$) living in disadvantaged districts (Fig. 63). Thus the impact of water resources development has been diluted to the extent that these districts continue to reel under poverty. Almost 30% of the districts (42) have poorly developed irrigation resources. The groundwater development in these 42 districts is just 27%. Incidentally all these districts on an average receive 1487 mm rainfall. Thus substantial potential remains untapped.

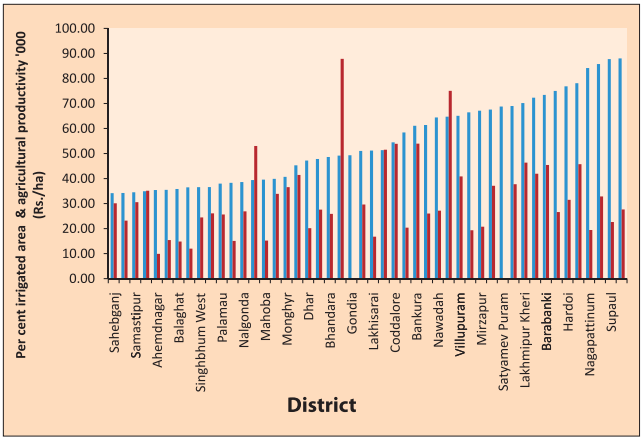


Fig. 63: Net Irrigated Area and Agricultural productivity in Irrigated districts

Land evaluation for rainfed Bt cotton in soils of Nagpur district, Maharashtra using soft computing techniques

The project was undertaken with the objectives of i) developing land evaluation criteria for rainfed Bt cotton, ii) applying two soft computing techniques namely, Fuzzy logic and Artificial Neural Networks to evaluate suitability of soils of Nagpur district, Maharashtra and iii) comparing the performance of the aforesaid techniques in suitability evaluation for the said land utilization type (LUT) i.e. rainfed Bt cotton.

Land evaluation criteria were developed for rainfed Bt cotton through identification of Minimum Dataset (MDS) and ranking of its constituting parameters as per expert knowledge and available literature (Kadu *et al.*, 2003, Pakhan *et al.*, 2010). Depth of soil, growing period rainfall, saturated hydraulic conductivity (sHC) and exchangeable sodium percentage (ESP) were the identified land quality parameters of the MDS and were assigned weightages on the basis of their relative importance to the LUT.

Salient findings

i) Land evaluation using Fuzzy Modelling-based method

Correlation of composite land indices with the LUT yield gave significant (at $\rho = 0.05$) positive value ($r = 0.72$), indicating that fuzzy modelling works well as a soft computing technique for land evaluation.

ii) Land Evaluation using Artificial Neural Networks

The algorithm developed for land evaluation understood the relationship between yield and MDS constituents in that the fitting accuracy was 0.63 and the error in yield prediction was 1.91 q/ha (through use of higher number of data-16 for validation, as against 6 used earlier), reduced from 2.5 q/ha obtained in the previous year.

In conclusion, the fuzzy and ANNs could be used for land evaluation for the LUT, the former through development of membership functions, overcoming the demerit of arbitrary cut off boundary that one comes across in conventional land evaluation method and assignment of weightages to each land quality parameters and the latter through establishment of the technique as a reliable yield prediction technique.

District level contingency crop plan for Maharashtra and Madhya Pradesh

The objectives of the project are documentation of district level natural resource inventory, and preparation of contingent crop plan (CCP) on different farming systems based mainly on soil depth and textural information. The NBSS&LUP was entrusted with the job of completion of CCP of 34 districts of Maharashtra and 50 districts of Madhya Pradesh in collaboration with agricultural universities of Maharashtra, M.P and CRIDA (ICAR). Contingent crop plan of districts of Maharashtra published earlier has been refined and published. The project exercise identified that the resilient soil area of Maharashtra is 8.4 million ha which constitutes 28% TGA of Maharashtra (Table 57). In the advent of climatic change and rainfall aberration, these resilient soils should be protected for sustainable crop production. The precise mapping of the soil area is urgently needed.

Table 57: District-wise resilient soil of Maharashtra

District	Area ('000 ha)	(%) of Total	District	Area ('000 ha)	(%) of Total
Thane	2.87	0.39	Hingoli	175.22	36.34
Raigarh	0.00	0.03	Nanded	387.43	36.81
Ratnagiri	64.02	7.88	Osmanabad	174.84	23.14
Sindhudurg	58.84	11.34	Latur	254.79	35.70
Nashik	195.68	12.60	Buldhana	341.03	35.37
Dhule	79.86	11.15	Akola & Washim	492.62	46.54
Nandurbar	0.60	0.10	Amrawati	682.54	55.97
Jalgaon	294.13	25.05	Yeotmal	471.30	34.72
Ahmednagar	492.69	28.96	Wardha	245.42	38.97
Pune	206.49	13.22	Nagpur	428.32	43.40
Solapur	271.09	18.25	Bhandara	734.49	78.83
Satara	209.60	20.01	Chandrapur	731.21	63.97
Sangli	204.87	23.96	Bid	315.44	29.53
Kolhapur	272.05	35.49	Parbhani	333.69	53.79
Aurangabad	201.13	19.91	Gondia	734.49	78.83
Jalna	102.65	13.37			

3 Education and Training

Post Graduate Education in Land Resource Management (LRM)

A post graduate teaching and research programme is being conducted by the National Bureau of Soil Survey and Land Use Planning Nagpur in collaboration with Dr. Panjabrao Deshmukh Krishi Vidyapeeth (Dr. PDKV), Akola since 1987. This programme is coordinated by the Division of Land Use Planning. The Regional Centre, Kolkata has been conducting a similar programme in collaboration with Bidhan Chandra Krishi Vidyalaya (BCKV), Mohanpur since 1999.

3.1a. HQrs. Nagpur

3.1a (i) Post Graduate Teaching

Course No.	Title	Credit	Course Leader & Associates
	Courses offered for M.Sc. programme		
Soils-516	Introduction to Land Resource Management	(1+1)	**Course Leader : Dr. T.K. Sen** Associates : Dr. Rajiv Srivastava Dr. S. Chatterji Dr. P. Chandran Dr. J.D. Giri Dr. M.S.S. Nagaraju Dr. O.B. Reddy Dr. P. Tiwary
Soils-517	Land Evaluation	(2+1)	**Course Leader : Dr. D.K. Mandal** Associates : Dr. T.K. Sen Dr. J. Prasad Dr. S. Chatterji Dr. J.D. Giri Dr. K. Kartikeyan

Soils-518	Land resource constraints and their management	(1+1)	**Course Leader : Dr. Jagdish Prasad** Associates : Dr. Rajiv Srivastava Dr. D.K. Mandal Dr. S.K. Ray Dr. B.P. Bhaskar Dr. T.N. Hajare Dr. N.G. Patil
Soils-591	Seminar	(0+1)	**Course Leader : Dr. M.S.S. Nagaraju** Associates : Dr. S. K. Ray Dr. K. Kartikeyan
	Courses offered for Ph.D.		
Soils-608	Advanced Soil Genesis	(2+0)	**Course Leader : Dr. S.K. Ray** Associates : Dr. Jagdish Prasad Dr. P. Chandran Dr. B.P. Bhaskar Dr. T. Bhattacharyya
Soils-609	Advance Soil Mineralogy	(2+1)	**Course Leader : Dr. S.K. Ray** Associates : Dr. P. Chandran Dr. Jagdish Prasad
Soils-610	Land Evaluation for Land Use Planning	(2+1)	**Course Leader : Dr. S. Chatterji** Associates : Dr. T.K. Sen Dr. J. Prasad Dr. T. Bhattacharyya
Soils-611	Remote Sensing and Geographical Information System for Land Resource Management	(2+1)	**Course Leader : Dr. Rajiv Srivastava** Associates : Dr. J.D. Giri Dr. M.S.S. Nagaraju
Soils-612	Visual and digital interpretation techniques in soil mapping	(2+1)	**Course Leader : Dr. Rajiv Srivastava** Associates : Dr. J.D. Giri Dr. M.S.S. Nagaraju
Soils-691	Seminar	(0+1)	**Course Leader : Dr. M.S.S. Nagaraju** Associates : Dr. S.K. Ray Dr. K. Kartikeyan

3.1a (ii) Research

M.Sc. Programme

7 students were admitted into M.Sc. (LRM) programme in 2009 at Dr. PDKV, Akola and later joined NBSS&LUP in September, 2011 for their specialized course in LRM and have completed their courses and have submitted their theses. The titles of the theses are mentioned below.

- Developing a model of understanding for soil quality parameters in representative black soil regions of Maharashtra.
- Composition of interlayer material of soil clay smectites.
- Assessment of sewage irrigated land use system in Nagpur, Maharashtra.
- Appraisal of land resources of Tandulwani watershed in Nagpur district, Maharashtra using Remote Sensing and GIS techniques.
- Spatial variability of soil properties in Savli village of Wardha district of Maharashtra.
- Red and Black Soil association in Chandrapur district of Maharashtra.

- Studies on Soils of Soybean based cropping system in Risod tahsil of Washim district.

6 students were admitted into M.Sc. (LRM) programme in 2011 at Dr. PDKV, Akola who later joined NBSS&LUP in September, 2012 for their specialized courses in LRM. They have completed their course work and are at present engaged in research work for their theses. The titles of the theses are mentioned below.

- Influence of Micro-Topographyon Vertisols in Vani Valley, Yavatmal district, Maharashtra.
- Potassium availability for some common crops in shrink-swell soils : Evaluation of existing methods.
- Diffuse reflectance characteristics of soils of Parsori watershed of Nagpur district, Maharashtra.
- Impact of Industrialization on agricultural land use in Tirora tahsil, district Gondia, Maharashtra.
- Soil properties influencing rice production in soils developed on granite-schist catena of Chandrapur district, Maharashtra.
- Characterization and mapping of spatial variability in soil properties of orange growing soils: A case study near Katol of Nagpur district.

3 students were admitted into Ph.D. (LRM) programme in 2011 at Dr. PDKV, Akola, who later joined NBSS in September, 2012 for their specialized courses in LRM. They are undergoing the course work and are also engaged in research work. The titles of the theses are mentioned below.

- Genesis and quality of black and associated red soils under Teak and Sandle wood in Sioni district of Madhya Pradesh.
- Evaluation of methods of available Potassium in Vetisols in relation to their mineralogty.
- Spatial variability of soil properties in Nagalwadi micro-watershed for land resources in Wardha district of Maharashtra using Geospatial technique.

RESEARCH HIGHLIGHTS

The salient findings of the research work carried out by the M.Sc. (LRM) students of 2010 batch are given below.

❑ Studies on soils of soybean-based cropping system in Risod tahsil of Washim district

Salient findings

Low yield of soybean-based cropping system of Risod tahsil has been investigated through characterization of soils, agro-climate, yield correlation with soil properties and yield economics. Cropping system profitability economics were analysed. It has been found that soybean (sole) crop, soybean + pigeon pea (inter crop), soybean-wheat (sequence crop), soybean-chickpea (sequence crop) shows B:C ratio of 2.35, 3.29, 2.57, 2.82, respectively for Vertic Haplustept. Te highest monetary net returns of Rs. 28130per hactare was obtained from soybean + pigeon pea intercropping system with highest B :C ratio of 3.29.

The soybean equivalent yield was correlated with soil properties. The strong correlation coefficient obtained with water retention at 33 kPa (0.91), rainfall (0.90), clay (0.87), sand (0.86), silt (-0.90), water retention at 1500 kPa (0.72), exchangeable K (-0.74), base saturation (-0.84), and Zn (0.0.52), indicating yield influencing factors of soybean-based cropping system in the Risod tahsil of Washim district.

❑ *Assessment of sewage irrigated land use systems in Nagpur, Maharashtra*

Salient findings

The soils under sewage irrigation were moderately alkaline with surface pH ranging from 8.3 to 8.9 and in the control it was 7.9. The organic carbon content of sewage irrigated surface soils ranged from 0.65 to 1.52 per cent whereas that of control was 0.61 per cent. The micronutrients namely Fe, Cu, Zn and Mn were found to be more in sewage irrigated soils than that of control.

The trend of heavy metal concentration in the sewage irrigated soils was Pb > Ni > Co > Cr > Cd. Non-sewage irrigated soils contained considerably less amount of heavy metals.

Both sewage and well water were found to contain considerable amount of total dissolved salt (675 mg/kg). The Nitrate-Nitrogen content of the sewage water was 5.0 mg/L.

The study revealed that the concentration of heavy metals in the sewage irrigated soils were within the safe limit but the pH, Na^+ and Ec values of the sewage water tend towards moderate restriction for irrigation. Despite low content of heavy metals in sewage water, the soils irrigated with sewage water received considerable amount of metallic cations over time as compared to non sewage irrigated soils. It is, therefore, necessary to monitor sewage irrigated land use system periodically for ensuring the sustainability of waste water reuse in agriculture.

❑ Spatial variability of soil properties in Savli village of Wardha district of Maharashtra

Salient findings

Spatial variability of soil physical, hydraulic, chemical properties and soil fertility was quantified through semivariogram analysis and interpolated through ordinary kriging. Spherical model was found to be the most suitable to describe spatial variability of all soil properties except for clay, bulk density and available Cu, silt, bulk density, organic carbon and available Zn showed less spatial dependence in relation to range and nugget variance compared to other soil properties. Kriged soil maps depicted variability and the spatial distribution of respective soil properties and soil fertility. The soil maps prepared in site-specific decisions in variable rate fertilizer application and water management for increasing the farm productivity.

❑ Developing a model of understanding for soil quality parameters in representative black soil regions of Maharashtra

Salient findings

- Available literature and expert opinion helped to arrival minimum dataset for soil quality parameters for Vidarbha region. These are bulk density and saturated hydraulic conductivity (physical parameter) and pH, organic carbon, calcium carbonate (chemical parameter).
- Threshold limits of these soil quality parameters can be fixed on the basis of soil properties vis-à-vis crop performance.
- Soil quality can be assessed through a simple model developed in Visual Fox Pro (9.0) using the minimum soil quality parameters for shrink-swell soils of Vidarbha region.

❑ Appraisal of land resources of Tandulwani watershed in Nagpur district, Maharashtra using remote sensing and GIS techniques

Salient findings

- Visual interpretation of IRS-P6LISS-IV satellite data (1:80,000 scale), supported by ground truth, revealed that there are five major land use/land cover classes, viz. single crop, double crop, notified forest, wasteland and habitation in the watershed.

- Based on field study physiography-soil relationship was established and seven soil series (Tandulwani-1 to 7) were tentatively identified in different physiographic units.
- The pH value of the surface soils vary from 6.4 to8.4.
- The soils have low organic content and it ranges from 0.16to1.19 per cent in different horizons and is decreases with depth.
- Calcium is the dominant cation on exchange complex followed by magnesium, potassium and sodium.
- CEC of soils ranges from 20.9 to 75.3 cmol(p^+)kg^{-1}.
- Base saturation of soils ranges from 72.1 to 120.7 per cent.
- The soils, in general, have low available nitrogen and phosphorus but medium to high available potassium.
- According to land capability classification, the soils were grouped into land capability sub-classes as IIe, Ives and VIes.
- Appraisal of land resources viz. land use/ landcover, physiography, soils, can be characterized quickly and precisely at watershed land using IRS-P6LISS IV data for management and agricultural planning.

❑ Characterization of red and black soil association in Chandrapur district of Maharashtra

Salient findings

- The morphological, physical, chemical and mineralogical properties of the soils developed in at a catenary sequence of Chandrapur district indicate that the red soils are developed at the higher topographic position and the associated black soils are formed in the valleys at lower elevation.
- Smectite is formed from basalt and can transform to smectite-kaolinite interstratified mineral during the weathering of the tropical climate. The smectite is retained in the lower topographic position and valleys due to non-leaching environment and retention of bases.
- The smectite is formed from mica which under topical conditions transformed to smectite and then smectite-kaolin interstratified mineral due to its instability under humid and base poor condition, which is observed in all the 3 pedons.

❑ Composition of interlayer materials of soil clay smectites

Salient findings

- Fine clays of Nimone and Asra series are dominantly composed of smectite followed by vermiculites and small amount of chlorites.
- Removal of hydrox-interlayering from smectite interlayers by various extracting solutions have been very effective for the fine clays of Asra and Nimone soils.
- Ammonium oxalate and HCl gave very high concentration of elements extracted (Fe, Al, Mg, Ca and Mn) but in the process these extractants dissoluted the basic structural framework of minerals (smectites) as observed by semi-quantitative analysis.
- EDTA and sodium citrate, EDTA appears to be a better extractant due to superior chemistry of EDTA chelated compounds.
- EDTA and sodium citrate are found as better extractants than sodium tantarate, sodium acetate and sodium oxalate.

- To arrive at this conclusion the following points were considered.

  a) The range and various grades of hydrloxy-interlayered smectite,

  b) The stability and suitability of hydroxy-interlayered materials,

  c) Reaction conditions, and

  d) Nature of various extracting solutions.

Based on the above, factors, the 0.25 N EDTA (pH 7.0) is a better option (i) to remove hydrox-interlayering from smectites of peninsular India and (ii) to ascertain its composition.

Achievements and current strength of students

Degree awarded : 116 M.Sc. and 15 Ph.D. (upto 2011-12)

Students on roll : 6 M.Sc. and 9 Ph.D.

TRAININGS IMPARTED

Capacity building in the area of Remote Sensing and GIS applications in natural resource management through trainings is an important programme undertaken on a collaborative mode between NBSS&LUP and ISRO. The various trainings organized under this programme are discussed below.

The Division of Remote Sensing Applications (RSA) organized National Natural Resource Management System (NNRMS), ISRO-sponsored National level 21 day training programme on "Remote Sensing and GIS Applications in Natural Resource Management" from February 12 to March 4, 2013. Nineteen trainee officers in the field of agriculture, environment, geology, fisheries and animal sciences representing Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Gujarat and Jammu & Kashmir participated in the programme. During the training programme, the participants were exposed to various remote sensing techniques, spatial and attribute data generation in GIS and the utility of GPS in collecting the ground truth in the field of natural resources. The participants were also given the hands-on modules on various remote sensing and GIS data handling softwares. A project work was undertaken in Khutamba watershed to characterize, classify and map the physiography, land use/land cover, slope and soils using Cartosat-1 DEM and Cartosat-1 sharpened IRS-P6 LISS-IV data.

Dr. D.K. Das, Chief Guest(centre) and Dr. S.N. Das, Guest of Honour(2nd from left) at the inaugural function of ISRO-sponsored training programme seen with Dr. Dipak Sarkar, Director, NBSS & LUP, Nagpur.

- A 21 days Training Programme on "Application of Remote Sensing and GIS in Natural Resource Management" sponsored by NNRMS (ISRO) Bangalore was organized during 21st November to 11th December 2012 at Regional Centre, Kolkata. The training module was programmed with 37 theories, 18 practical classes and a capsule of fieldwork of four days. The training programme covered the various aspects of Remote Sensing and GIS applications in natural resource management. 25 officers participated in the training programme of which seven belonged to West Bengal, four from Odisha, one from Jharkhand, two each from Madhya Pradesh

and Karnataka and one each from Arunachal Pradesh, Meghalaya, Jammu and Kashmir, Maharashtra, Gujarat and Tamil Nadu. Dr. J. Krishnamurthy, Member Secretary, NNRMS SC-T, Deputy Director (US&U), EOS, ISRO, GOI inaugurated the training programme and Dr. V.C. Jha, Director, NATMO was the chief guest in the valedictory programme. Dr. Dipak Sarkar, Director, NBSS&LUP, Nagpur presided over the inaugural programme.

From the left: Dr. A.K. Sahoo, Principal Scientist, Prof. S.K. Sanyal, Chairman, QRT, NBSS & LUP (ICAR), Dr. J. Krishnamurthy, Member Secretary, NNRMS SC-T, Dy. Director (US & U), EOS, Indian Space Research Organisation, Department of Space, Government of India, Bangalore, Dr. Dipak Sarkar, Director, NBSS&LUP, Nagpur and Dr. S.K. Singh, Head, NBSS & LUP,RC Kolkata during inaugural programme of NNRMS-ISRO sponsored programme

- A 21 days Training Programme on "Application of Remote Sensing and GIS in Natural Resource Management" sponsored by NNRMS (ISRO) was organized during 16th January to 5th February, 2013 at Regional Centre, Delhi. 19 officers participated in the training programme.

TRAINING IMPARTED UNDER TRIBAL SUB PLAN (TSP) SCHEME

Regional Centre, Jorhat

- Regional Centre, Jorhat imparted15 days TSP sponsored training programme on "Geo-referenced Soil Resource Inventory and Mapping" at IETC, Medziphema, Nagaland, was imparted to the officials from different state departments of Nagaland from 20th March-3rd April, 2012 at Regional Centre, Jorhat.
- Regional Centre, Jorhat imparted 15 days TSP sponsored "Training Programme on Application of Remote Sensing and Geographical Information System for Soil Resource Inventory towards Land Use Planning" to the officials from different state departments of Mizoram held at Aizawl, Mizoram from 12-25th February, 2013.
- Regional Centre, Jorhat imparted Training to the farmers of Bhomoraguri Missing village of Pub Teok Circle, Jorhat district, Assam on improved cultivation practices of *Rabi* crops with efficient use of irrigation water, fertilizers, manures and pesticides, pig rearing and vermi-composting under Tribal Sub Plan (TSP) programme.

Regional Centre, Kolkata

A TSP sponsored Training Programme on "Application of remote sensing and GIS for watershed characterization and resource planning"

Shri R. S. Gopalan , Director, Agriculture Govt. of Odisha addressing the trainee officers at Bhubaneswar during the inauguration of TSP sponsored training programme

was organized by Regional Centre, Kolkata during the period from 25th July to 8th August, 2012 at Bhubaneshwar for the officers working in the tribal area of Odisha. 15 Officers from different districts of Odisha participated in the training programme. The programme was organized in collaboration Directorate of Watershed Mission Bhubaneswar, Odisha. Sixteen officers from the different parts of the state have participated. The training module was programmed with 23 theory and 31 practical classes with a capsule of fieldwork of 3 days. Apart from in house faculty, experts from State and Central Govt. organizations addressed the trainees to cover various aspects of remote sensing and GIS applications in watershed management.

OTHER TRAINING PROGRAMMES

- A training program on 'Advanced Animal husbandry' was conducted in Charbhata of Deorin cluster in synergy mode with MAFSU (December 4-8 2012). A total of 90 beneficiaries participated in the training program.
- A training programme was conducted for the SHG and farmers of Deori and Goregaon clusters on February 26, 2013 at Gondtimezari, Gondia district BY SGGVSS (NGOs). NABARD OFFICIALS were present to impart the training. A total of 200 beneficiaries participated in the training program.
- A 2 months training was organized during September-November 2012 for the 6 newly recruited scientists of NBSS&LUP at the Regional Centre, Bangalore.
- A 21 days training program on "Soil survey and land use plan for the state soil survey and soil conservation dept officials Govt. of Kerala was inaugurated on 26th March 2013. All the scientists and staff of the Regional Centre, Bangalore attended the function held at Regional Centre, Bangalore. Chief guest Dr Ramakrishna Parama, Head and Professor, Soil science, UAS, Bangalore gave a lecture on "Indian Farming Scenario".
- A five days training programme from 24-28th Sept 2012 was organized by Regional Centre, Bangalore to women Self Help Group members of H.D.Kote on "Value addition and small scale Bakery".
- Dr. S.K. Singh, Principal Scientist & Head, Dr. T. H. Das, Dr. A.K. Sahoo, Dr. S.K. Gangopadhyay, Dr. K. Das, Principal Scientists, Dr. S. Mukhopadhyay, Dr. (Mrs.) T. Banerjee, Sr. Scientist as Resource Persons, imparted training to the officers of Govt. of Odisha under the TSP Sponsored training programme on "Application of Remote Sensing and GIS for Watershed Management" during 25th July to 8th August, 2012 at Odisha, Bhubaneswar. 15 Officers from different districts of Odisha participated in the training programme.

TRAINING RECEIVED

- Dr. S. Srinivasan, Scientist, NBSS & LUP, Regional Centre, Kolkata, Dr. Shelton Padua Scientist of Jorhat Centre and Dr. Nisha Sahu Scientist GIS Section, Nagpur underwent two months training programme on "Soil Survey and Mapping" at NBSS & LUP (ICAR), Regional Centre, Bangalore from 10th September, 2012 to 9th November, 2012
- Dr. V. Ramamurthy attended one day training programme on "Research methodology and biostatistics" at PD_ADMS, Bangalore on 28-07-12.
- Dr. V. Ramamurthy attended DST sponsored Management Development Programme on "Decision support Systems and Technologies"

from 25th Feb to 1st March at Indian Institute for Foreign Trade (IIFT), New Delhi.

- Dr. R.S. Meena, Scientist underwent 2weeks training on "Soil Survey and Mapping" at NBSS&LUP, Regional Centre, Bangalore during 24.10.12 to 11.11.12
- Dr. R.P. Sharma, Scientist underwent 2 Months "Soil Survey and Mapping" at NBSS&LUP, Regional Centre, Bangalore during 10.09.12 to 10.11.12
- Dr. K. Karthikeyan attended an ICAR sponsored short course on "Application of nanotechnology in Soil Science and Plant Nutrition Research" 18-27 Sept., 2012 at Indian Institute of Soil Science, Bhopal, Madhya Pradesh.

4 Technology Assessed and Transferred

- The database developed from the soil nutrient mapping project of West Bengal utilised earlier for developing an user interface in form of an Advisory for the farmers of West Bengal was widely used by the farmers to take decision on management practices.
- A Decision Support System has been developed for Land Use Planning of Nadia district, West Bengal, Jorhat district, Assam and Bundi district, Rajasthan are being finalized that would help the district authorities and other stakeholders, including very much the farmers, in planning sustainable use of the land resources.
- Evaluation of soil-site suitability for specific crops is guiding the farmers in selecting suitable crops at the levels of watershed, block and districts in different agro-ecological subregions of the country.

5 Sections / Units / Cell

5.1 Prioritization, Monitoring and Evaluation (PME) Cell

The following jobs were undertaken and accomplished during the period

- Monitoring day-to-day Technical/Scientific work and achievements of the Bureau.
- Collection, storing and dissemination of scientific and technical information on soils to the various institutes as per demand.
- Maintenance of scientific/technical files, consultancy projects and QRT and RAC files and RPFs
- Necessary action on various technical papers/ letters.
- Preparation of Bureau's reports for DARE, ICAR Annual Report, monthly, quarterly target and progress report.
- Monitoring of progress of research projects.
- Compilation of six monthly targets and research progress of scientist and timely submission to ICAR.
- Organization of IRC, Heads of Regional Centres / Division meetings, project review meetings and development of proceedings.
- Development of background information for QRT, IMC, IRC and EFC.
- Preparation of scientific papers and slides for presentation by the Director at National/ International seminars and workshops organized by the different Scientific Societies/ Institutions.
- Preparation of material for Directors' Conference, Regional Committee meetings and other meetings.
- Providing audio visual support during seminars/workshops.
- Preparation of tables, charts and other display materials on the activities of the Institute.
- Preparation of ATR on decisions taken during different meetings and proceedings of such eetings.

- Finalization of Annual Report and background information of Annual Plan of the Institute.
- Technical inputs for finalization of publications of the research bulletins, technical reports.
- Undertaking RFD related activities.
- Preparation of newsletters (half yearly) of the Institute.
- Preparation of material for ICAR News and Reporter.
- Organization of research review and other meetings at Institute level.
- The targets and the achievements for the scientists were timely uploaded in the Half Yearly Progress Monitoring System for the Scientist (HYPM) for the period April – September, 2012 and October, 2012 to March, 2013. Summarized institute general information was also uploaded in the format.
- Two newsletters of the institute were published during the year 2012-13 for the period January-June, 2012 and July-December, 2012. Compilation of material, compilation, editing and finalization was done through the PME cell.
- The Quinqunial Review Team for the period 2007 to 2012 submitted its report to the ICAR. PME Cell has arranged the review meetings at the Head Quarter as well as at the Regional Centres. The Cell has provided all the support to the team mainly in finalization of the report.
- PME Cell collected, compiled and edited the material for NBSS Profile published in the ICAR News.
- Prepared the material for the Vision 2050 document.
- PME cell answered the questions asked under Right to Information Act, 2005 mainly the technical part.
- Compiled and prepared Annual Plan for the year 2013-14.
- Compiled and edited the material for finalization of the Annual report for the year 2011-12.
- Finalization of Technical bulletins and reports.
- The Cell processed the research papers for various journals and Seminar /Symposia.
- Reply to the technical letters addressed to the Director by different organizations. Individuals.
- Finalization of the programme of various trainings organized e.g. NNRMS, ISRO Sponsored, TSP Sponsored and other.

5.2 Library & Documentation Unit

Library Resources Development

The library procured 144 documents including 82 books and 62 annual reports. The total collection of the library was 15929 including bound journals. The library subscribed to 15 foreign and 25 Indian journals for Hqrs., besides 16 journals for Regional Centre libraries. Collection of bound journals was 3241. Total 886 readers visited the library. Total of 3649 documents were issued, 3818 documents were returned and 5771 documents were consulted.

Information Resources Development

The library envisions availability of latest information for its users and building a collection of latest resources is a continuous activity. For active participation of users in collection development, book exhibitions are arranged and selection of best, latest and useful books are made.

Documentation Services

Current information is disseminated to the scientists through inhouse services.

Current Titles Alert (CTA)

It is a monthly inhouse publication based on receipt of current journals in the library. The scanned copies of the content pages of journal issues are taken and distributed to all Centres/Divisions/ Sections of the Bureau which keeps scientific and technical staff abreast of latest information received in the library.

Library Automation Software

Library Automation Software SOUL (Software for University Libraries) developed by INFLIBNET, Ahmedabad is being used for library automation work. Data input of each book in the software is completed. Generation of Barcode labels for each book is also completed. Computerised issue – return service is in operation. It is a continuous process. Two user terminals installed in the library have facilitated the library user to access the databases and OPAC.

CD-ROM Service

International bibliographic database viz. CABI, AGRIS, and AGRICOLA in CD-ROM are available in the library. Tulsient CD Mirror Server has been installed and under LAN, the CD-ROM databases are accessed by 10 nodes spread over in two buildings of the Bureau.

- CABI Database (1972 to present) — CABI, U.K.
- AGRIS Database (1975 to present) — FAO, Rome
- AGRICOLA Database (1970 to present) — USDA, USA
- SOIL CD(1973 to present) — CABI, U.K.

These databases have been extensively used by research staff, M.Sc., Ph.D. students and others from Nagpur City. The user agencies in the country make use of these databases. CD ROM- based search and retrieval services have been provided with nominal charges; in print form or through CDs / Pen drives.

ISBN to NBSSLUP Publications

NBSSLUP publishes wide variety of publications in the form of annual report; research/technical bulletins, various scale maps of India and different States.

The ISBN/ISSN numbers are allocated to 154 NBSS publications till this period and copies of each publication are sent to concerned agencies for inclusion in their database. The publications are sent to prominent journals, abstracting/indexing services for review purpose in order to achieve wider information dissemination.

News Paper Clipping Service

The library is receiving 7 newspapers and two periodicals. The relevant cuttings pertaining to topical interest are brought to the notice of staff of the Bureau by displaying on library notice board.

Centralised Services

The Unit provides centralised services like photocopying comb/thermal binding and lamination of documents/maps sheets, etc.

Photocopying Services were extended to library visitors and cost of charges received was Rs. 1610.00.

Library Services through LAN

Local Area Network (LAN) has been established in the Bureau. Five Computer nodes have been provided for access to library information system from where bibliographic searching with various query modes is available. E-Mail and Internet facility has also been provided to two computers. Browsing of international libraries through Internet is in full operation. Subscribed online electronic journals and down loading was done using Internet facility. It is planned to go for subscription of more number of electronic journals in the coming years.

CD-ROM reading/writing facility has been installed in the library for downloading electronic journals, articles and access to publisher's catalogues. Online agricultural statistics database "Indiastat.com" was subscribed during the period. The readers have made extensive use of this database.

On-line Portals/ Journals through CeRA (NAIP)

CeRA (Consortium of e-Resources in Agriculture) is Consortium of e-journals (full text), a project under NAIP, ICAR and provided access to 123 libraries of National Agriculture Research System (NARS). The library is actively participating in the consortium by responding regularly through e-mails. We are getting access of more than 2000 online journals on agriculture. On-line full text journals of the following publishers are available on CeRA

i. Springer link
ii. Elsevier
iii. Taylor & Frances
iv. Annual Reviews
v. CSIRO
vi. Indian Journals.com
vii. American Society of Agronomy (ASA)
viii. Oxford University Press

Document Delivery System under CeRA

As per guidelines of CeRA, photocopy of the article requested by the participating institutes is being provided to the libraries / members. It is a continuous process. This facility is also extended to our five Regional Centers. The above e-resources can be accessed by visiting URL: http://www.cera.jccc.in through NBSS&LUP LAN.

5.3 Printing Section

A. Technical Bulletin

1. Assessment of Soil Loss for prioritization of sub-watershed – A remote sensing & GIS approach
   - Print Order – 200 copies
   - Pub. No. 137
   - Volume of work – XVI + 56 pages all in 4 colours

2. Acid Soils of India- Their Extent and Spatial Variability
   - Print Order – 250 copies
   - Pub. No. 145
   - Volume of work – XIV + 138 pages all in 4 colours

3. Compendium on Human Resource Development in Remote Sensing and GIS in Natural Resource Management
   - Print Order – 200 copies
   - Pub. No. 150
   - Volume of work – XII + 88 pages all in 4 colours
4. Remote Sensing and GIS in Digital Terrain Analysis and Soil-Landscape Modelling
   - Print Order – 250 copies
   - Pub. No. 152
   - Volume of work – VIII + 300 Demy Quarto
   - 17 forms in 4 colour and 60 form in B/W
5. Training Manual on GIS and Digital Image Processing
   - Print Order – 300 copies
   - Pub. No. 153
   - Volume of work – VI + 166 Demy Quarto
   - In 4 colours

B. Annual Report

1. NBSS & LUP Annual Report (2011-2012) (English)
   - Print Order – 500 copies
   - Volume of work XII + 172 pages in 4 colour
2. NBSS & LUP Annual Report (2011-2012) (Hindi)
   - Print Order – 200 copies
   - Volume of work XVI + 160 pages in 4 colour

C. Newsletter

1. NBSS&LUP Newsletter (Jan-June 2012)
   - Print Order – 500 copies
2. NBSS&LUP Newsletter (July-Dec. 2012)
   - Print Order – 500 copies

D. Map

1. Soil Loss Map of Nagaland – 200 copies
2. Soil Loss Map of Meghalaya – 200 copies
3. Soil Loss Map of Uttar Pradesh – 200 copies

E. Stationery items

1. Profile Sheet – 200 copies
2. Log book of Vehicle – 6

5.4 Sale of NBSS Publications from 1.4.2011 to 31.3.2012

Month	SRM Maps & Bulletin	Research, Tech.Bulletins & District Atlases	Total Amount Rs.
April- 2011	Rs. 1,5000/-	Rs. 1,900/-	Rs. 16,900/-
May- 2011	Rs. 2,500/-	Rs. 150/-	Rs. 2,650/-
June- 2011	Rs. 6,600/-	Rs. 1,425/-	Rs. 8,025/-
July- 2011	Rs. 11,500/-	Rs. 175/-	Rs. 11,675/-
Aug-2011	Rs. 3000/-	Rs. 5,000/-	Rs. 8,000/-
Sep- 2011	Rs. 5000/-	Rs. 1,900/-	Rs. 6,900/-

Oct- 2011	Rs. 71,100/-	Rs. 8,080/-	Rs. 79,180/-
Nov-2011	Rs. 2,700/-	Rs. 31,785/-	Rs. 34,485/-
Dec-2011	Rs. 26,000/-	Nil	Rs. 26,000/-
Jan-2012	Rs. 11,600/-	Rs. 1,725/-	Rs. 13,325/-
Feb-2012	Rs. 19,800/-	Rs. 7,200/-	Rs. 27,000/-
Mar-2012	Rs. 70,600/-	Rs. 6,325/-	Rs. 76,925/-
Total	Rs. 2,45,400/-	Rs. 65,665/-	Rs. 3,11,065/-
Payment recd by R/C	-	-	Rs. 1,14,595/-
Gross Total	-	-	Rs. 4,25,660/-

(Rupees Four lakh Twenty Five Thousand Six Hundred Sixty only)

List of New Publication received during the year 2011-12

Sr. No	Name of the publication	Publ. No.	Printed copies
1.	Planning and Management of Land Resources	-	298
2.	Soil Erosion of Himachal Pardesh maps		300 maps
3.	Agro-Ecological Region of Uttar Pradesh + map	148	300/300
4	Land Resource Atlas Vidarbha Region Maharashtra	147	180
5	Soil Erosion of Haryana publ.no.149	149	200/200
6	Soil Erosion Manipur maps	-	200maps
7	Soil Loss of Arunachal Pradesh	-	200 maps
9	Soil Loss of Sikkim	-	200 maps

During the period, 01.04.2011 to 31.03.2012, two Sales and Publications Committee meetings were organized and the prices of New Publication were fixed and the cost of old publications was also reviewed.

5.5 Agricultural Knowledge Management Unit (AKMU)

1. Maintenance of LAN Network

Maintenance of LAN Networking includes replacement of Internet switches of server room and old building i.e. Server Room CISCO Gigabit SX-LC mini-GBIC with SC-LC fiber patch cord and HP ProCurve-1700-24 port Gigabit Switches–3 no. and installation of one Hp ProCurve-1700 switch in RSA division. Laying of UTP Cat-6 cable 305 mtrs, Fixing of communication 6U Rack, Laying of 100 mtrs. Casing & PVC pipe, network project (communication rack), Cable Identification/Proper SMB, Fixing cable labeling at the front SMB & Jack Panel/Cable dressing.

2. New Connection of Internet

Four new internet connections have been provided to the new users during the reporting period.

3. Corporate Client System

Cyberoam [Unified Threat Management] and Symantec-11.0 MR5 antivirus for the server and

50 users. Cyberoam provided support for three aspect i.e. Antivirus &Antispam, Web & Application filter and Intrusion detection & Prevention (IDP). Symantec-11.0 antivirus for the server and 50 users to support the virus protection for the server as well as end users. Configuration of Server and 50 users in the Cyberoam. Cyberoam support for the access of internet through the Cyberoam. Create users of Cyberoam in the server for accessing the internet services, creating user accounts, modification of users account in the server, creating the internet access policies in the server. Monitoring the server and users day to day.

4. Management of Institute website

Staff of GIS Section was involved in work of designing and updating of the institute website, as required. Staff also involved in collection and compilation of web site material from the different Divisions, Sections and Regional Centers.

5. Maintenance of Video conferencing system

Staff GIS Section involved in maintenance of the Video Conference Unit with frequent checks on the incoming/outgoing link. Connect Video Conference Unit to the network for online communication. The IP based video conferencing system was installed in the institute. Under the system signal receiver at ARIS cell, Video codec and plasma panel were installed in the committee room. Under this system two locations can be connected to see and hear the other end of the communication site. This installed systems help in end-to-end interaction during the important meetings/conferences. Use 128kbps x 4 total 512kbps lease line.

5.6 Cartography Unit

In addition to being engaged in research work (project achievement reported under research theme), the unit provided support services for the following activities:

- Land Recourse Atlas of Vidarbha Region.
- Agro-ecological region of Uttar Pradesh.
- District contingent plan.

As a centralized services centre, the following work has been undertaken:

Final art work / cover page design of following documents-

- Perspective plan 2030
- NBSS and LUP publication – catalogue 2011
- Acid soils of India
- Soil loss of Haryana
- Soil of Hayatnagar
- Dharti 2010
- Annual Report 2010-11

Maps redesigned for offset printing (CMYK)

- Soil loss map of Sikkim, Manipur, Meghalaya, Nagaland and Arunachal Pradesh of north eastern states, were completed.
- Soil loss map of Haryana. Punjab and Himachal Pradesh.

Maps Published

- Soil loss map of Himachal Pradesh, Haryana, Manipur, Arunachal Pradesh and Sikkim.
- Agro-Ecological Region map of Uttar Pradesh.

Atlas Published

- Land Resource Atlas of Vidarbha Region.

Bulletin Published

- Agro-ecological Regions of Uttar Pradesh.

Digitization Work

- Base map of India showing district boundaries on 1:4 m scale
- Diagrams of soil scape showing soil-physiographic relationship of Bengal basin, North-eastern Region, Malwa plateau, Vindhyan landscape, Narmada valley.
- Soil depth map at district level of different divisions of Madhya Pradesh

Plotting, scanning and other printing jobs undertaken during the reported period includes-

- Total 53395 colour/monocolour prints (A3 and A4 size) were brought out of different project documents, Annual report, Technical report, ppts, maps and diagrams, media coverage and research papers.

Document Reproduction

- About 220928 copies were reproduced.

Other Activities

- Maintenance of classified documents and sending their annual safe custody.
- Correspondence with Survey of India and Ministry of Defence regarding security clearance of published maps.

5.7 हिन्दी अनुभाग

राजभाषा अधिनियम, 1963 और उसके अंतर्गत बने राजभाषा नियम, 1976 के अनुपालन एवं राजभाषा विभाग (भारत सरकार)/भारतीय कृषि अनुसंधान परिषद्, नई दिल्ली द्वारा समय-समय पर जारी किए जाने वाले '**वार्षिक कार्यक्रम**' में निर्धारित लक्ष्यों को पूर्ण करने के उद्देश्य से ब्यूरो (मुख्यालय), नागपुर में '**हिन्दी अनुभाग**' कार्यरत है।

हिन्दी प्रकाशन: वार्षिक हिन्दी कृषि पत्रिका '**मृदा दर्पण**' एवं वार्षिक हिन्दी पत्रिका '**धरती**' का प्रकाशन।

हिन्दी सप्ताह का आयोजन: ब्यूरो (मुख्यालय), नागपुर तथा उसके 5 क्षेत्रीय केन्द्रों (नई दिल्ली/उदयपुर/बैंगलूरू/कोलकाता एवं जोरहाट) में '**हिन्दी सप्ताह समारोह**' (दिनांक: 14-20 सितम्बर, 2012) का आयोजन किया गया और राजभाषा (हिन्दी) से संबंधित विभिन्न प्रतियोगिताओं का भी आयोजन बड़े उत्साहपूर्ण वातावरण में किया गया, जिसमें संस्थान के अधिकांश अधिकारियों/कर्मचारियों ने सक्रिय रूप से भाग लिया।

संयुक्त राजभाषा कार्यान्वयन समिति की बैठकें: संस्थान में राजभाषा (हिन्दी) की प्रगति एवं त्रैमासिक रिपोर्ट की समीक्षा करने हेतु तथा राजभाषा विभाग (भारत सरकार)/भारतीय कृषि अनुसंधान परिषद्, नई दिल्ली द्वारा जारी '**वार्षिक कार्यक्रम**' में 'क', 'ख' एवं 'ग' क्षेत्रों हेतु निर्धारित लक्ष्यों को पूर्ण करने के उद्देश्य से समय-समय पर उक्त समिति की बैठकों का आयोजन।

हिन्दी कार्यशालाएं: संस्थान में राजभाषा (हिन्दी) के प्रयोग को बढ़ावा देने के उद्देश्य से वर्ष 2012 में कुल तीन हिन्दी कार्यशालाओं का अयोजन किया गया जिसका विवरण निम्नानुसार हैं।

1. क्षेत्रीय केन्द्र, बैंगलुरू – दिनांक: 29 जून, 2012
2. क्षेत्रीय केन्द्र, नई दिल्ली – दिनांक: 29 अगस्त, 2012
3. क्षेत्रीय केन्द्र, नई दिल्ली – दिनांक: 11 दिसम्बर, 2012

हिन्दी कार्य निरीक्षण/मार्गदर्शन: राजभाषा (हिन्दी) कार्य निरीक्षण/मार्गदर्शन समिति द्वारा क्षेत्रीय केन्द्र, बैंगलुरू का दिनांक: 29 जून, 2012 को हिन्दी कार्य निरीक्षण/मार्गदर्शन हेतु दौरा किया गया।

प्रोत्साहन योजना: वर्ष 2011 में अपना सरकारी काम-काज मूल रूप से हिन्दी में कर रहे अधिकारियों/कर्मचारियों को '**प्रोत्साहन योजना**' के अंतर्गत निम्नानुसार नकद पुरस्कार वितरित किये गए।

1.	श्रीमती विमल खराबे, उच्च श्रेणी लिपिक	प्रथम-1	₹ 800/-
2.	श्री एम.एम. खान, पी.ए.	प्रथम-2	₹ 800/-
3.	श्री एम.एम. भगत, क्षेत्रीय सहायक (टी-2)	द्वितीय-1	₹ 400/-
4.	श्री अम्बालाल भोई, वाहन चालक (टी-2)	द्वितीय-2	₹ 400/-
5.	श्री आर.एम. तोहगाँवकर, वाहन चालक (टी-5)	द्वितीय-3	₹ 400/-
6.	श्री एम.डी. कड़व, वाहन चालक (टी-3)	तृतीय-1	₹ 300/-
7.	श्री आर.एन. झांबरे, वाहन चालक (टी-3)	तृतीय-2	₹ 300/-
8.	श्री ए.एन. पवार, वाहन चालक (टी-5)	तृतीय-4	₹ 300/-

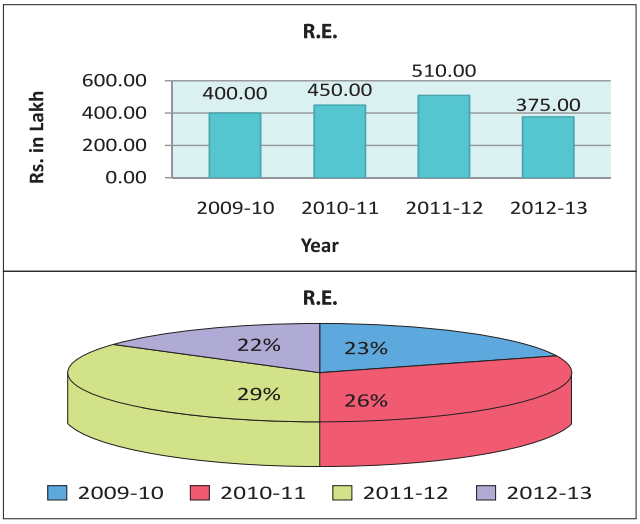
6 Linkages

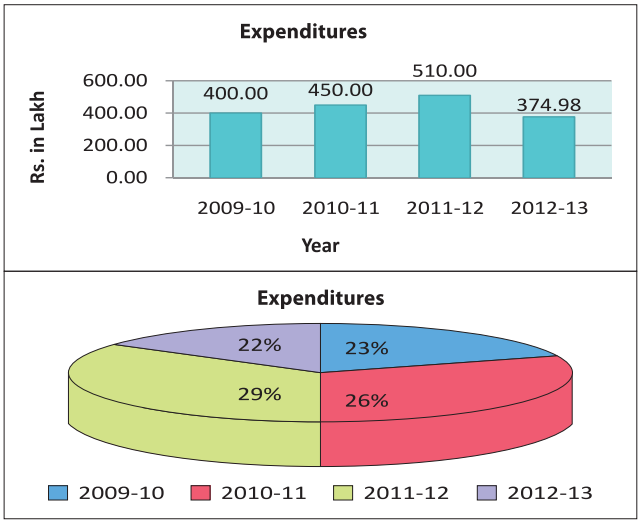
Name of the Institution	Area of research
National	
• SAUs (MPKV, Rahuri, MAU, Parbhani, Dr. PDKVV Akola, MAFSU, Nagpur, Maharashtra, BCKV, Mohanpur, Nadia, West Bengal)	Collaboration in implementation of research, teaching and training programme
• NRSC, Hyderabad/ RRSSC, Nagpur /Department of Space, ISRO/SAC, Ahemadabad	Collaboration in implementation of research projects and for procuring satellite data
• CMMACS, CSIR	Collaboration in research project on Suitability of Evaluation of Aromatic and Medicinal plants
• Indian Institute of Technology (IIT), Kanpur	Collaboration in NAIP research project
• IISS, Bhopal, CICR, Nagpur, NRCC, Nagpur and other ICAR crop Institutes	Collaboration in implementation of research programmes on assessment/land reconcilement of degradation (database of) and crop suitability evaluation
• Odisha Watershed Development Mission (OWDM), Bhubaneswar	Collaboration for developing linkage in Watershed Management in Odisha State
• Department of Agriculture, Govt. of West Bengal	Collaboration in Soil Survey, Fertility Mapping and Soil Correlation activities.
• National Informatics Centre (NIC), Govt. of India	Collaboration in development of Web based farmers advisory
• State Agricultural Departments	Collaboration in Soil Survey and Correlation activities and land use plan development and implementation of research programmes

• Department of Agriculture and Cane Development, Govt. of Jharkhand	Collaboration in block level fertility mapping in Jharkhand
• NGO [Bhartiya Agro Industries Foundation (BAIF), SGGVS, Gondia, Yojak, Nandurbar]	Collaboration in NAIP
• DST, New Delhi	Financial assistance for research projects
International	
• CIMMYT India, New Delhi	Developing soil resource inventory and demonstration for Borlaugh Institute of South Asia (BISA) at farms in Samastipur, Bihar and Jabalpur, Madhya Pradesh for Borloug Institute for South Asia (BISA).
• International Plant Nutrition Institute (IPNI), Asia & Africa programme, Gurgaon, Haryana	Collaboration in exchange ideas for Integrated Nutrient Management Programme in Eastern Region of India.
• ISRIC, ITC, The Netherlands	Developing geo-referenced Indian Soil Resource Information System
• ICRISAT, Patancheru, Andhra Pradesh	Collaboration in soil reflectance studies

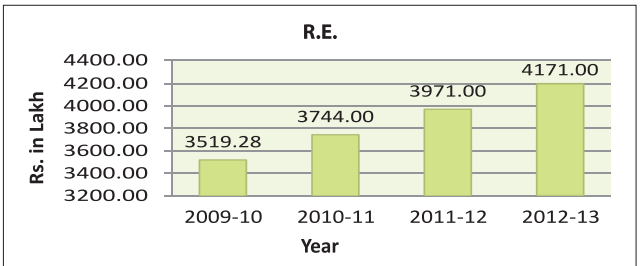
7 Budget : A Comparative Analysis

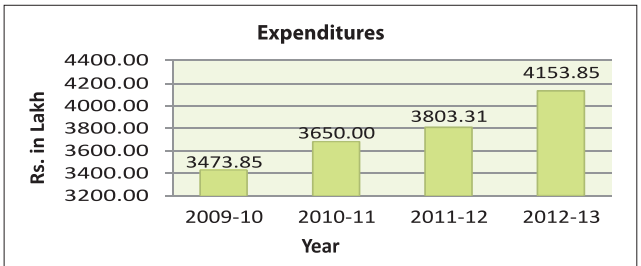
Plan

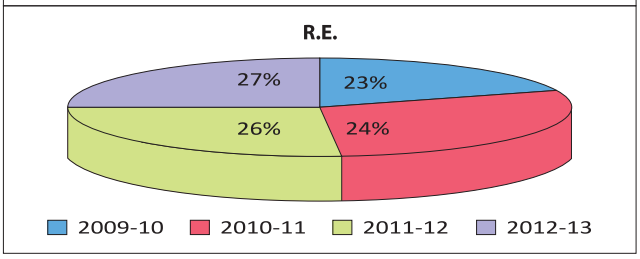


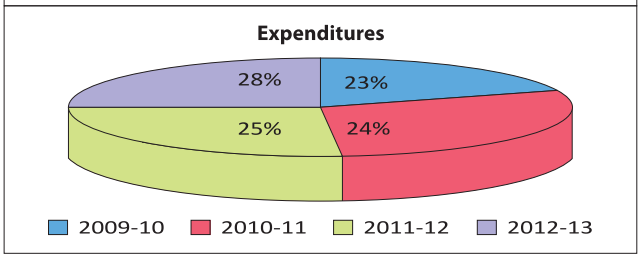


Non-Plan









8 Awards and Recognition

- Dr. Dipak Sarkar, Director and Dr. S.K. Singh, Principal Scientist and Head were awarded **"Shriram Fertilizer Award 2012"** by FAI, New Delhi for the outstanding work for Web and Mobile based Farmer's Advisory for the State of West Bengal.
- Dr. Jagdish Prasad has been awarded **"Special Research Award, 2012"** in recognition of his outstanding contribution in the field of soil and water conservation for the benefit of agriculture in the country by *Soil Conservation Society of India, New Delhi.*
- The poster paper presented on "Effect of Climate Change on Carbon Reserves in Soils of Palampur, Himachal Pradesh, India" at the National Seminar on "*Managing Land Resource for Sustainable Agriculture"*, Indian Society of Soil Survey and Land Use Planning, October, 12-13, 2012 Nagpur, by Dr. (s) S. K. Ray, P. Tiwary, A. M. Nimje, P. Chandran, K. Karthikeyen, T. Bhattacharyya, Dipak Sarkar, Jagdish, Prasad, B.P. Bhaskar, S. M. Sheikh and D.V. Balbuddhe was awarded the best poster.
- The paper presented on "Microbial Diversity Indices of Agro-ecological Subregions of Black Soil Region of India" by Dr. (s) K. Velmourougane, M.V. Venugopalan, A. Sahu, T. Bhattacharyya and Dipak Sarkar in National Seminar on "*Managing Land Resource for Sustainable Agriculture*", October 12-13, 2012, Indian Society of Soil Survey and Land Use Planning, Nagpur was awarded best poster.
- The paper presented on "Generation of farm specific land resources database for effective implementation of watershed development programs- a case study of Magadi model watershed in Karnataka" by Dr. K.V. Niranjane in National Seminar on Farmers' First held at Bangalore organized by CSWRTI, Dehradun during 14 -16 March 2013 was awarded the second best poster presentation.
- Mr. Roshan R. Wakode, a Ph.D. (LRM) student working under the guidance of Dr. Jagdish Prasad has been awarded Jawaharlal Nehru Scholarship for Doctoral Studies (Jawaharlal Nehru Memorial Fund).

9 List of Publications

Research Papers

Bante, Rashmi R., Srivastava, Rajeev, Nagaraju, M.S.S. and Jagdish Prasad (2012). Characterization and evaluation of land resources for watershed management in Vidarbha region of Maharashtra using RS and GIS. *Journal of the Indian Society of Soil Science* **60** : 261-268.

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Chaturvedi Arun, Patil, N. G. and Hajare, T. N. (2012) Land and livelihood issues in different stages of tribal resettlement. *Indian Forester,* **138** : 584-588

Chaturvedi, Arun, Obi. Reddy, G.P., Srivastava, Rajeev and Maji, A.K. (2012). Remote sensing and GIS applications in rainfed agriculture management. *J. Soil and water conservation*, 11 :174-180.

Dadhich R. K., Sharma, R. P., Kumawat, S. M., Singh, G. and Sahu, M. P. (2013). Use of ^{59}Fe Isotope in iron chlorosis for fodder sorghum bicolor. *Noto-are Agriculture*, ISSN 1941-2681. http://www.notoare.com/18973108.

Gangopadhyay, S.K., Baruah U. and Sarkar, Dipak (2012). Forest soils of Upper Brahmaputra valley of Assam – their characteristics and classification. *Agropedology*, **21** :1-9.

Gangopadhyay, S.K., Sarkar Dipak, Sahoo, A. K. and Singh. S.K. (2012). Soils of rainfed region of West Bengal and their productivity potential appraisal. *Journal of the Indian Society of Soils Science* **60** : 83-91.

Goswami S.N., Chaturvedi, A. and Gawande, R.S. (2012). Economics and resource use efficiency of rice farming in Gondia district of Maharashtra. *Agriculture Situation in India*, **68** :521-528.

Jatav, M. K., Manoj Kumar, Trehan, S. P., Dua, V. K., Lal, S. S. and Sharma, R. P. (2012) Influence of microorganisms inoculation on nutrient economy in Potato-radish crop sequence in North Western Himalayas. *Vegetable Science* **39** : 21-25.

Kolhe, A.H., Chandran, P., Ray, S.K., Bhattacharyya, T., Pal, D.K. and Sarkar, Dipak (2011). Genesis of associated red and black shrink-swell soils of Maharashtra. *Clay Research* **30** :1-11.

Mahesh Kumar, Singh, S.K., Raina, P. and Sharma, B. K. (2011). Status of available major and micronutrients in arid soils of Churu district of Western Rajasthan. *Journal of the Indian Society of Soil Science* **59**: 188-192.

Mandal D.K., Goswami S. N., Mandal, C., and Sarkar Dipak and Jagdish Prasad (2012). Sustainable use of shallow soils in the context of global climate change, *Indian Journal of Fertilizers* **8** : 32-44.

Mandal, D.K, Goswami, S. N., Mandal,.C., Prasad Jagdish and Sarkar Dipak (2012). Assessment of deep soils of India and their utilisation for food security in the context of climate change, *Indian Journal of Fertilizers* **8** :110-120.

Maske, S.P., Anil kumar, K.S., Hegde Rajendra, Ramesh kumar, S.C., Srinivas, S. and Naidu, L.G.K. (2012). Rainfall probability analysis for crop planning – a case study of Kuttanagere micro-watershed. *Mysore Journal of Agric. Sci.* **46** : 683-686.

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Obi Reddy, G.P., Nagaraju, M.S.S., Ramteke, I.K. and Sarkar, Dipak (2012). Terrain characteristics for soil resource mapping using IRS-P6 data and GIS – A case study from basaltic terrain of central India. *Journal of the Indian Society of Remote Sensing* **41**:331-343. (*DOI: 10.107/s12524-012-0240-5*).

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Pal, D. K., Bhattacharyya, T., Chandran, P., and Ray, S. K. (2012) Linking minerals to selected soil bulk properties and climate change: A review, *Clay Research* 31 : 38-69.

Pal, D.K., Bhattacharyya, T., Sinha, R., Srivastava, P., Dasgupta, A.S., Chandran, P., Ray, S.K. and Nimje, A. (2012). Clay minerals record from late Quaternary drill cores of the Ganga Plains and their implications for provenance and climate change in the Himalayan foreland, *Palaeogeography, Palaeoclimatology, Palaeoecology* **356-357**: 27-37.

Patil, N. G. and Chaturvedi, Arun (2011). Surrogate prediction of saturated hydraulic conductivity of seasonally impounded soils. *Journal of Soil Salinity and Water Quality* **3** : 30-36.

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Patil, N.G. and Rajput, G.S. (2011). Pedotransfer functions to predict soil moisture constants in shrink–swell soils of Haveli tract in Jabalpur district of Madhya Pradesh. *Hydrology Journal* **34** : 135-144.

Reza, S.K., Baruah, U. and Sarkar Dipak (2012). Mapping risk of soil phosphorus deficiency using geostatistical approach: A case study of Brahmaputra plain, Assam, India. *Indian Journal of Soil Conservation*, **40** : 65-69.

Reza, S.K., Baruah, U. and Sarkar, Dipak (2012). Spatial variability of soil properties in Brahmaputra plains of North-Eastern India: A geostatistical approach. *Journal of the Indian Society of Soil Science*, **60** : 108-115.

Reza, S.K., Baruah, U. and Sarkar, Dipak (2013). Hazard assessment of heavy metal contamination by the paper industry, North-Eastern India. *International Journal of Environmental Studies,* **70** : 23-32. (*DOI:10.1080/00207233.2012.746810*).

Reza, S.K., Pal, S. and Singh, S. (2012). Rock phosphate-enriched pressmud compost: Direct effect in pearl millet (*Pennisetum glaucum* L.) and residual effect in mustard (*Brassica juncea*) in a Typic Haplustept. *Journal of the Indian Society of Soil Science*, **60** : 138-144.

Satyavathi, P. L. A., Raja, P., Ray, S. K., Anantwar, S. G. and Bhaskar B. P. (2012) Elemental composition and mineralogy of silt and clay fractions of cracking clay soils of semi arid and arid parts of Gujarat, India, *Clay Research* **31** : 12-26.

Sharma, R. P., Pandey, A. K. and Singh, R. S. (2012). Aggressive action to reduce CO_2 emissions: Burning practice of paddy straw now sequestering carbon. *Noto-are Agriculture,* ISSN 1941-2681. (*http://www.notoare.com/16424734*).

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Singh, D., Bhaskar, B. P., Baruah U., Sarkar, Dipak, and Vadivellu, S. (2013). Economic appraisal of rice based cropping sequences in major soil series of upper Asom. *Indian Journal of Agricultural Sciences* **83** : 326–330.

Singh, S.K., Kumar, Mahesh, Pandey, C.B., Sarkar, Dipak, Ghosh, Anupam, Mukhopadhya, S. (2012).Soil properties between irrigation and cropping sequence in *Thar* desert of Rajasthan, India. *Journal of Arid Land Research and Management*. (DOI: *10.1080 /15324982.2012.719577*)

Surya, Jaya N, Singh, S.P. and Jat, R.S. (2012). Suitability assessment of soil resources for micro level crop planning – A case study. *Journal of Soil and Crops* **22** : 297-301.

Surya, Jaya N. and Singh, S.P. (2012). Characterization, classification and management needs of Indo-Gangetic Alluvial Plains in Karnal district of Haryana. *Agropedology* **22** : 50-55.

Velmourougane, K., Venugopalan, M.V., Bhattacharyya, T., Sarkar, Dipak, Pal, D. K., Sahu Apeksha, Ray, S. K., Nair, K. M., Prasad Jagdish and Singh, R. S. (2013). Soil dehydrogenase activity in agro-ecological sub regions of black soil regions of India. *Geoderma* **197-198**: 186-192.

Velmourougane, K., Venugopalan, M.V., Bhattacharyya, T., Sarkar, Dipak, Pal, D. K., Sahu Apeksha, Chandran, P., Ray, S. K., Mandal, C., Nair, K. M., Prasad Jagdish, Singh R. S. and Tiwary, P. (2013). Urease activity in various agro-ecological sub-regions of black soil regions of India. Procedings National Academy of Science, India, Section B - Biol. Sci. *DOI 10.1007/s40011-013-0162-1*.

Verma, T.P., Singh, S.P., Ram Gopal, Dhankar, R.P., Rao, R.V.S. and Tarsem Lal (2012). Characterization and evaluation of soils of Trans Yamuna area in Etawah district, Uttar Pradesh for sustainable land use. *Agropedology* **22** : 26-34.

Vishal, M.K., Aishwath, O.P., Singh., R., Mehta, R.S., Mishra, B.K., Obi Reddy, G.P. and Nirmal Kumar (2013). Spatial and Temporal assessment of area, production and productivity of cumin in Rajasthan. *International Journal of Seed Spices* **3**: 70-76.

Reports/Bulletins

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Sonitpur District. NBSS & LUP Report No. **1041 (A)**.

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Darrang District. NBSS & LUP Report No. **1041 (B).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Goalpara District. NBSS & LUP Report No. **1041 (C).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Kokrajhar District. NBSS & LUP Report No. **1041 (D).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Bongaigaon District. NBSS & LUP Report No. **1041 (E).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Barpeta District. NBSS & LUP Report No. **1041 (F).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Nalbari District. NBSS & LUP Report No. **1041 (G).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Marigaon District. NBSS & LUP Report No. **1041 (H).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Nagaon District. NBSS & LUP Report No. **1041 (I).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Lakhimpur District. NBSS & LUP Report No. **1041 (J).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Dhemaji District. NBSS & LUP Report No. **1041 (K).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Tinsukia District. NBSS & LUP Report No. **1041 (L).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Karbi-Anglong District. NBSS & LUP Report No. **1041 (M).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Chirang District. NBSS & LUP Report No. **1041 (N).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Bagsa District. NBSS & LUP Report No. **1041 (O).**

Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning: Udalguri District. NBSS & LUP Report No. **1041 (P).**

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10 Participation of scientists in seminars, symposia, conferences, workshops, trainings and meetings in India and abroad

Seminars/Symposia/Conferences

- In India

17th Annual Convention and National Symposium organized by Clay Mineral Society of India held at NBSS & LUP, Regional Centre, Kolkata during April 27th - 28th 2012

Dr. (s) S.K. Singh, T.H. Das, D.C. Nayak, A.K. Sahoo, S.K. Gangopadhyay, K. Das, K.D. Sah, S. Mukhopadhyay, Mrs. T. Banerje, S. Dharamurajan, Ramesh Kumar S.C., M. Ramesh, S. Thayalan and K.M.Nair

The Third National Conference on Agro-Informatics and Precision Agriculture (AIPA 2012) Conference 1st to 3rd August, 2012 at IIIT, Hyderabad organized by Indian Society of Agricultural Information Technology (INSAIT)

Dr. S. Srinivas

One day Seminar on "Nutrient Management in Crops for Sustainable Agriculture – Present Status and Future Needs" in collaboration with International Plant Nutrition Institute (IPNI) – Asia and Africa Programme, Gurgaon at NBSS & LUP, Kolkata on 24th August, 2012

Dr.(s) S.K. Singh, T.H. Das, D.C. Nayak, A.K. Sahoo, S.K. Gangopadhyay, S. Ghoshal Chaudhuri, K.D. Sah, T. Chattopadhyay, S. Mukhopadhyay, Mrs. T. Banerjee and R. Srinivasan

National Seminar of Indian Society of Soil Survey and Land Use Planning organized by Indian Society of Soil Survey and Land Use Planning, Nagpur during October 12th -13th 2012 held at NBSS & LUP (ICAR), Nagpur

Dr.(s) Dipak Sarkar, G.S.Sidhu, S.K. Singh, R.S.Singh, L.G.K.Naidu, A. Natarajan C.S.Walia K.M.Nair, S.Thayalan, T.H. Das, D.C. Nayak, A.K. Sahoo, Dr. S.K. Gangopadhyay, S. Ghoshal Chaudhuri, K. Das, T. Chattopadhyay, T.P.Verma, R.K.Naitam, R.S. Meena, R.P.Sharma, S.C. Ramesh Kumar, M. Ramesh, (Mrs.) Jaya N. Surya

3rd International Agronomy Congress on "*Agriculture Diversification, Climate change management and livelihoods*" at New Delhi during 26th -30th November 2012

Sh. Ashok Kumar

77th Annual Convention & National Symposium of ISSS organized by Indian Society of the Soil Science held at Punjab Agricultural University, Ludhiana during December 3rd – 6th 2012

Dr.(s) G.S.Sidhu, C.S. Walia, T.K. Sen, Jagdish Prasad, S. Chatterji, D.C. Nayak, Anil Kumar, K.S., S.K. Mahapatra and Mrs. Jaya N. Surya

Karnataka Land Policy and its impact on Land Use at National Conference on "Approach to National Land Use Policy" held at Heritage Village resort, Menesar, Haryana on 8th December 2012

Dr. S.C. Ramesh Kumar

34th IIG Meet and National Conference on Natural Resource Management and Decentralized Planning held at Thiruvananthapuram, organized by CESS and Institute of Indian Geographers during 13th-15th Dec 2012

Sh. M. Ramesh

5th Annual Conference of Karnataka Science and Technology Academy, Bangalore held at Bangalore during 19th and 20th December 2012

Dr.(s) Rajendra Hegde, A. Natarajan, K.V. Niranjana and L.G.K. Naidu

100th Indian Science Congress 2013 organized by Indian Science Congress Association during 3-7th January, 2013 held at University of Calcutta.

Dr.(s) Dipak Sarkar, S.K. Singh, T.K. Sen, D.C. Nayak, A.K. Sahoo, S.K. Gangopadhyay K. Das and S.K. Mahapatra

XIth Agricultural Science Congress on Agricultural Education-Shaping India's Future organized by Orisha University of Agricultural Technology, Bhubaneswar during 7th – 9th February, 2013 held at OUAT, Bhubaneswar.

Dr.(s) Dipak Sarkar, S.K. Singh, A.K. Sahoo and K. Das

DST sponsored Management Development Programme on "Decision support Systems and Technologies" from 25th February to 1st March 2012 at Indian Institute for Foreign Trade (IIFT), New Delhi.

Dr. V. Ramamurthy

Farmers First national seminar held at Bangalore, organized by CSWRTI, Dehradun during 14th - 16th March 2013

Dr. K.V. Niranjana

National Seminar on Recent Trends in Geographical Research organized by Foundation of Practicing Geographers during March 30th – 31st 2013 held at Foundation of Practicing Geographers, Kolkata.

Dr. (Mrs.) T. Banerjee

Workshops

National Workshop on Integrated Land Use Planning for Sustainable Agriculture and Rural Development organized by National Institute of Rural Development (NIRD), Hyderabad during June 18th - 20th 2012 at NIRD, Hyderabad

Dr.(s). Rajeev Srivastava, Ramamurthy, A. Natarajan, S.C. Ramesh Kumar, A.K. Sahoo and Rajendra Hegde

Workshop at IIHR, Bangalore for the finalization of Package of Practices for Horticultural crops in Karnataka organized by University of Horticultural Sciences, Bagalkote during 25th and 26th June 2012

Dr. Rajendra Hegde

Three days workshop on ''Preparing winning research project proposals" at NAARM during 22nd -24th November, 2012

Dr. S. Srinivas

National Workshop on Natural Resource Management in Backward districts in India, on 20th -21st Feb 2013 organized by NBSS&LUP, Nagpur.

Dr. L.G.K. Naidu

National workshop on "Geospatial Technique for Natural Resource Management" at NAARM, Hyderabad during 20th -23rd February 2013

Dr.(s) Dharumarajan and S. Srinivas

Workshop on "Preparation of year wise 3 years plan with larger plan outlay in respect of RKVY and its sub schemes BGREI for the year from 2013-14 to 2015-16" organized by Department of Agriculture, Govt. of West Bengal at Agriculture Training Centre, R.K. Mission, Narendrapur on 25th March 2013.

Dr.(s) A.K. Sahoo and K. Das

Workshop of NAIP (Component 4) held during 25-26 March, 2013 at New Delhi to review the work progress of the subproject on "Georeferenced soil information system for land use planning and monitoring soil and land quality for agriculture".

Dr. P. Tiwary

A meeting of Regional Committee No. VIII of the Indian Council of Agricultural Research (ICAR) was presided by Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR, Shri S. Damodaran, Minister for Agriculture, Government of Tamil Nadu inaugurated the meeting. The following reports of NBSS & LUP, Regional Centre were released by the Honorable Agricultural Minister and Hon'ble Director General, ICAR.

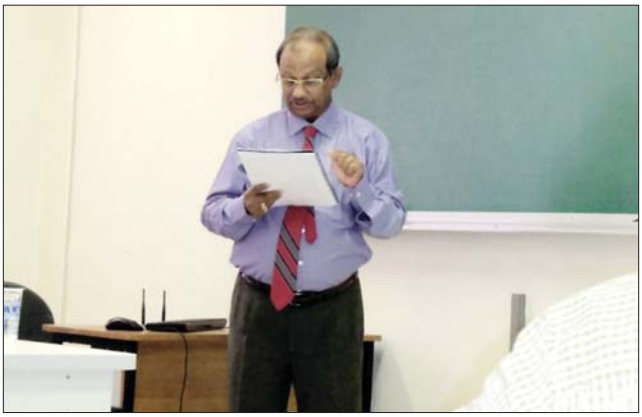
a. Detailed land resources inventory of D Nagenahalli village for integrated development under NICRA, IIHR KVK, Hirehalli.

b. Delineation of Agro-ecological zones of Tamil Nadu, NBSS & LUP, Publ., No 1039

Abroad

Second Workshop under Indo-Brazilian Cooperation in Bio-energy by Govt. of Brazil

Dr. Dipak Sarkar, Director participated the Second Workshop under Indo-Brazilian Cooperation in Bio-energy as a member of Indian Delegation held during 18-20 April 2012 at FEQ-UNICAMP auditorium, Sao Paulo, Brazil presented a paper entitled "**Land Use Planning/Modelling Possibilities for Sugarcane in India**".



Dr. Dipak Sarkar, Director, NBSS&LUP presenting his research paper in the Indo-Brazilian Cooperation Workshop at Sao Paulo, Brazil

International workshop at the Joint Research Centre of the European Commission - JRC in Ispra (Varese), Italy during March 18-22, 2013

Dr. T. Bhattacharyya

Dr. Rajendra Hegde, participated in the following seminars / conference / symposium / workshop

International seminar on "Agricultural Productivity, sustainability: the future we want: organized by National Institute of Advanced Studies (II Sc), Bangalore during 8th and 9th Jan 2013 at Bangalore. He served as the Rapporteur of one of the session and presented the proceedings.

National seminar on "The present status, prospects and constraints in rice production in India" organized by and at National Institute of Advanced studies, Bangalore on 3rd August 2012.

Golden Jubilee celebrations of CIFRI, Hessarghatta, Bangalore on 14th April 2012. The Hon'ble Director General, (ICAR) and other officials of ICAR participated in the event.

Session on "International Training capabilities of NBSSLUP on: Land resources inventorization" for the 11 officials of developing countries brought by NIRD, Hyderabad under an International training program (3rd August 2012).

National workshop on "Innovative policies, programs and projects related to agricultural development in India" organized by and at National Institute of Advanced studies, IISc, Bangalore on 10th August 2012.

3rd National Research Conference on "Climate Change" organized by Indian Climate Research Network at Centre for Oceanic and Atmospheric studies, Indian Institute of science, Bangalore on 3rd - 4th November 2012.

2nd National Bio-diversity Conference at Indian Institute of Science organized by Indian Institute of Science during 7th and 9th December 2012.

5th Annual Conference of Karnataka Science and Technology Academy, Bangalore held at Bangalore during 19th and 20th December 2012 and presented a research paper.

Golden Jubilee celebrations and Krishimela of IISR (ICAR) Cardamom Research centre, Appangala, Kodagu, Karnataka on 20th - 22nd December 2012, Hon'ble Director General, ICAR was the Chief Guest.

National Seminar on "Crop Improvement and adaptive strategies to meet challenges of Climate change on 22nd and 23rd February 2013 at UAS, Bangalore.

Radio talk on "Union Budget 2013-14: Analysis of budgetary allocation on Agriculture and rural development sectors- aspirations and allocations on 28th February 2013, AIR Bangalore.

Pre-launching workshop on Sujal-3 was held on 30th November 2012 at Karnataka Watershed Development Department.

Dr.(s) L.G.K. Naidu, A. Natrajan, K.M.Nair, Ramesh Kumar, Anil Kumar, S. Srinivas, V. Ramamurthy and Rajendra Hegde, Consortium partners from state of Karnataka. Commissioner-watershed, Director-watershed, Director-Horticulture, Director-KSRSAC, consortium partners- IISc Bangalore, UAS Dharwad, UAS Bangalore, UAS Dharwad, UHS Bagalkot and other Districts officials of watershed department.

Brainstorming session on- Drought mitigation and drought management-leverage of policy in state and central govt. programs" organized by NAAS, UAS(B) GKVK: Dryland research Project and CRIDA on 5th December 2012.

Dr.(s) L.G.K. Naidu, V. Ramamurthy and Rajendra Hegde

One day workshop on Sujal-III horticultural component on 16th November 2012. A presentation on "Need and Utility of detailed soil resources database' by Dr.Natrajan for the effective implementation of sujala-III.

Dr.(s) Av Natarajan and Rajendra Hegde

KVK-Industry interaction workshop held at Zonal Project Director (ICAR) Zone 8, Bangalore on 25th January 2013

Dr.(s) L.G.K.Naidu and Rajendra Hegde

Workshop on "Hydrological Monitoring under Sujal-III at I.I.Sc., organized by Dr.Shekar Muddu, Assoc. Prof, I. I. Sc.

Dr.(s) A.Natrajan and Rajendra Hegde

17th Annual Convention and National Symposium on Application of Clay Science : Agriculture, Environment and Industry, 27-28 April, 2012 at NBSS&LUP, Regional Centre, Kolkata. Presented a paper on "Soil and Land Quality – Use of Georeferenced Soil Information System" and also worked as Co-chairman in Technical Session 4: Fertilizers, Ceramics and Pharmaceuticals and Rapporteur in the Plenary Session.

T. Bhattacharyya

A User's interaction meet was organized at Dept. of Soil & Water Conservation, Kohora, Karbi-Anglong district of Assam on 03rd August, 2012. Dr. U. Baruah, Head and Principal Scientist, Dr. D. Dutta, Principal Scientist, Dr. S.K Reza and Dr. S. Bandyopadhyay, Scientists of NBSS & LUP, RC, Jorhat participated in the meeting and interacted with the stake-holders.

Dr.U. Baruah, Head and Principal Scientist attended the Foundation Day Celebration of NBSS & LUP held on 23th August, 2012 at Nagpur.

Dr. U. Baruah attended the 18th Annual Convocation of Assam Agricultural University, Jorhat, Assam on 12.11.2012.

A Farmers' Interaction Meet was organized on 13.02.2013 at Bhomoraguri Missing Gaon, Pub Teok Circle, Jorhat in conjunction with *Ali-Ail-Ligang* festival of Missing Tribals. Dr. K.M. Bujarbaruah, Hon'ble Vice Chancellor, Dr. Girin Hazarika, Director of Research, AAU, Jorhat, Dr. Dipak Sarkar, Director, NBSS&LUP (ICAR), Nagpur, Dr. T.H. Das, Principal Scientist, Regional Centre, Kolkata and other dignitaries participated in the Meet.

Dr. S. Bandyopadhyay, Scientist of the Centre, participated in one day vetted Workshop on District Level Contingency Planning of Assam State, held at ICAR Complex for NEHR, Barapani, Meghalaya on 18.04.2012.

Dr. S. Bandyopadhyay, Scientist of the Centre, participated in the National Symposium on "Application of Clay Science: Agriculture, Environment and Industry" by Clay Mineral Society of India, organized by IARI and NBSS & LUP on 27-28th April, 2012.

Dr. U. Baruah, Dr. D. Dutta and Dr. S. Bandyopadhyay participated in the National Seminar on Managing Land Resources for Sustainable Agriculture, organized by ISSLUP, NBSS & LUP (ICAR) on 12-13th October, 2012.

Participated and displayed maps and data products of the Regional Centre, Jorhat in the Farmer's Day on 06.11.2012 at Regional Experimental Research Station of AAU at Titabar, Jorhat.

Nirmal Kumar attended national workshop on "Foresight and Future Pathways of Agricultural Research through involvement of Youth in India" on 1st and 2nd March, 2013 at NASC complex, New Delhi.

Obi Reddy, G.P. attended NSDI Metadata Workshop from 6th to 8th February, 2013 at NSDI, New Delhi.

Nirmal Kumar attended NSDI Metadata Workshop from 6th to 8th February, 2013 at NSDI, New Delhi.

Nirmal Kumar and Sunil Meshram attended NKN first annual workshop at IIT Bombay from 31st October to 2nd November, 2012.

Meetings attended

Name of the scientist	Meeting attended	Venue and date
Dr. Rajeev Srivastava	Meeting of Heads of Division/Regional centers, Project Coordinators and Directors with Secretary, DARE and DG, ICAR.	NASC complex, Delhi on 12th March 2013.
	Meeting on NAIP project "Development of soil reflectance methods and low cost sensors for variable rate inputs in precision farming"	PAU, Ludhiana during January 16-17, 2013 and 1st to 2nd November 2012.
	Review meeting of AICRP on Integrated Farming Systems	NASC complex, New Delhi held during August 30 to September 1st 2012.
Dr. (s) L.G.K.Naidu, A.Natrajan and Rajendra Hegde	Karnataka State soil survey co-ordination committee meeting	NBSSLUP, Bangalore on 19th April 2012.
Dr. (s) G.S.Sidhu, L.G.K. Naidu, U. Baruah, T.Bhattacharyya, R.Srivastava, R.S. Singh, S.K. Singh, A.Chaturvedi, P. Chandran, Mrs. C. Mandal and G.P. Obireddy	Meeting of Head of Division/ Regional Center/Section of NBSS&LUP with Director	NBSS&LUP, Nagpur on 13th March 2013.
Dr. (s) L.G.K.Naidu and A.Natarajan	Interface meeting of ICAR Institutes with State developmental Departments.	CRIDA. Hyderabad on 20th April 2012.
Dr. R.S. Singh, Principal Scientist & Head, Regional Centre, Udaipur	The Scientific Advisory Committee meeting	Vidya Bhavan Krishi Vigyan Kendra, Udaipur on May 11th 2012
Dr. R.S. Singh Principal Scientist & Head T.P. Verma, Sr.Scientist and Dr. B.L.Tailor, Technical Officer, Regional Centre, Udaipur	Interactive meeting with Stake holders for preparation of land use plan of Chanavada Watershed (villages Paduna & Jabla) with Er. Madan Chajed, Executive Engineer, Watershed Development, Zila Parishad, Udaipur, Er. Pradip Somani, Asst. Engineer Watershed development, Zila parishad, Dr. P.K.Singh, Associate professor Dept. of soil and water Engineering, College of Technology & Engineering, MPUA&T, Udaipur, local Panchayat Sarpanch & local stake holders.	NBSS&LUP, Regional Centre Udaipur on 6th June 2012
	Stakeholder's meeting and discussion on land use plan of Chanavada watershed under the project "Land use planning of Chanavada watershed in Girwa tehsil, Udaipur district (Raj.) for integrated development" Stakeholder's meeting and discussion on land use plan of Chanavada watershed under the project "Land use planning of Chanavada watershed in Girwa tehsil, Udaipur district (Raj.) for integrated development"	NBSS&LUP, Regional Centre Udaipur on 1st November 2012.

Dr. (s) A. Natarajan and Rajendra Hegde	Meeting for working out the modalities of implementing the action plan and bringing out a comprehensive publication on watershed development.	Director office Karnataka State Watershed Development Department, Bangalore on 11th May 2012
Dr. (s) A.Natrajan and Rajendra Hegde	Meeting to decide purchase of software for IWMP program of Karnataka state watershed development department	Regional Centre, Bangalore on 19th May 2012
Dr. V. Ramamurthy	Meeting for Rubber Research Institute collaborative project.	Rubber Research Institute, Kottayam on 23th May 2012
	Mid-term workshop of the project "Soil based plant nutrient management plan for Agro-ecosystems of Kerala project"	Thiruvanthapuram on 24th May 2012.
Dr. (s) L.G.K. Naidu Natarajan and Rajendra Hegde	Meeting called by Karnataka Development Commissioner: Sri Kaushik Mukherjee, Commissioner, watershed department, Director, Karnataka state watershed development department, Executive Director(Sujala-3), Special officer, National Rainfed Agriculture Authority, New Delhi, Commissioner, Horticulture, for working out the modalities of implementing Sujala-3 watershed development Program	Karnataka Development Commissioner office Bangalore on 27th July 2012.
Dr. (s) L.G.K. Naidu, A.Natarajan and Rajendra Hegde	Meeting with Commissioner, watershed department, Director, Karnataka state watershed development department, Director of Research of all SAU's of state for preparing plan and implementation of model watershed development program in all the districts on the models of Motganalli watershed.	Karnataka Development Commissioner office, Bangalore on 1st August 2012.
Dr. Rajendra Hegde	25th meeting of Executive Committee of KSRSAC, Bangalore.	KSRSAC, Bangalore on 22nd August 2012.
Dr. L.G.K. Naidu	Meeting at with Commissioner, Watershed Development, GoK, Executive Director, Sujala-III for finalizing the ToR for Sujala-III project.	Regional Centre Bangalore on 8th October 2012.
Dr. (s) L.G.K. Naidu and Rajendra Hegde	Meeting with Dr.Prabhuraj, Director, KSRSAC on the generation of Digitized Cadastral maps and supply of Cartosat imagery for the sujala-3 watersheds	Bangalore on 26th October 2012.
Dr. Rajendra Hegde	4th Annual Governing body's meeting of KSRSAC.	Chief Secretary office, GoK on 9th November 2012
Dr. U. Baruah	18th Annual Convocation of Assam Agricultural University, Jorhat, Assam 2.	Assam Agricultural University, Jorhat, on 12th November 2012
Dr. (s) L.G.K. Naidu, Natarajan and Rajendra Hegde	Meeting with Vice Chancellor, UAS, Bangalore, Director of Research, UAS Bangalore, Dean UAS, Bangalore, HoD of Soil science, UAS Bangalore regarding the execution of Sujala-III project.	Bangalore on 15th November 2012

Dr. (s) L.G.K. Naidu and A.Natarajan	23rd meeting of Regional Committee No. VIII of the Indian Council of Agricultural Research (ICAR) was presided by Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR, Shri S. Damodaran, Minister for Agriculture; Government of Tamil Nadu inaugurated the meeting	Bangalore on June 15th - 16th 2012
Dr. L.G.K. Naidu, Dr. Natarajan and Dr. Rajendra Hegde	Meeting with Commissioner for Agriculture, GoK regarding the utility of soil resources database for the execution of Bhu-Chethana, strengthening of soil fertility evaluation services, Sujal-III program.	Bangalore on 15th November 2012.
Dr. L.G.K. Naidu, Dr. A Natrajan, Dr. Rajendra Hegde	Meeting on the pre-launching workshop on Sujala-3 was held at centre. Participants: Sri G. Satish, Executive Director and CCF, Karnataka watershed Dept, Dr. Dr. Ramohan Rao, Dr. Laxman, Deputy Director of Agriculture, Training Unit, watershed dept, Mysore, Sri Karibasappa, Asst Directoir of Agriculture, Training Unit, watershed dept, Mysore, Sri Ashok Kulkarni KWDD.	Bangalore on 28th November 2012.
Dr. Natarajan and Dr. Rajendra Hegde	Meeting with Dr. Ramakrishna Parama Prof Soil science and other scientists from UAS (B) on finalization of ToR on Sujala-3 project. The same was finalized and sent to Watershed department.	Bangalore on 10th December 2012
Dr. L.G.K. Naidu and Dr. A. Natarajan	Meeting with Principal Secretary, Department of Agriculture on use of Land Resource Information in Planning and implementing Agricultural Developmental Schemes in Andhra Pradesh. Also met Commissionaire of IWMP, Govt, of A.P. and handed over Muttala watershed, Atmakur mandal, Anatapur District as model report for developing watersheds.	Bangalore 2nd and 3rd of January 2013
Dr. A. Natarajan and Dr. Rajendra Hegde	Meeting with Dr.G. Satish IFS, Executive Director, and Chief Conservator of Forests, Karnataka watershed Development Department for finalizing the ToR of the Sujala-3 project.	Bangalore on 11-1-2013
Dr. L.G.K.Naidu	Attended KSRSAC Executive meeting to discuss on-going projects of KSRSAC and also organizing KGIS one day workshop.	Bangalore on 19th January 2013
Dr. Natarajan, Dr. Ramamohan Rao and Dr. Rajendra Hegde	Meeting to finalize the final technical workshop of Sujala-III to be held soon. The meeting was called by the Executive Director & Chief Conservator of Forests, Karnataka Watershed Development Department	Regional Centre, Bangalore on 1st -2-2013
Dr. S.K. Singh	Quinquintial Review Team Interaction meeting	NBSS & LUP, Nagpur on 14.10.2012
	Quinquintial Review Team (QRT) meeting	NBSS & LUP, Kolkata 27-28 October, 2012
	Heads meeting	NBSS & LUP, Nagpur on 13.03.2013
	Core Group meeting of LRI project	NBSS & LUP, Nagpur on 19.02.2013
	Interactive meeting of NRM Division of ICAR	NASC, New Delhi on 12.03.2013

Dr. T.H. Das	Core Group meeting of LRI project	NBSS & LUP, Nagpur on 19.02.2013
Dr. A.K. Sahoo	Quinquintial Review Team (QRT) meeting	NBSS & LUP, Kolkata 27-28 October, 2012
	Core Group meeting of LRI project	NBSS & LUP, Nagpur on 19.02.2013
	Review meetings of Network project on "Land use planning at district level"	NBSS & LUP, Nagpur on 20.02.2013
	9th CIC and 6th CAC meeting of NAIP GeoSIS (C-4)	NBSS & LUP, Nagpur 4-5 March, 2013
Dr. S.K. Gangopadhyay	Meeting with Director, Agriculture Dr. (Mrs.) Yasoda Pradhan and other Joint Directors of Sikkim at Gangtok, Sikkim in connection with the collection of soil samples under the project "Mapping of Nutrient Status in Soils of Sikkim State towards Land Use Planning"	Gangtok, East Sikkim from 28.02.2013 to 03.03.2013
Dr. S. Ghoshal Chaudhuri	Millennium Alliance Meet of FICCI as an Expert invited by the Director, organized by Technology Development Board, Deptt. of Science of Technology, Govt. of India	Hotel Hindusthan International, Kolkata on 01.11.2012
Dr. T. Chattopadhyay	Meeting with Joint Director, West Sikkim on "Mode of collection of soil samples under the project "Mapping of Nutrient Status in Soils of Sikkim State towards Land Use Planning"	Geyzing, West Sikkim from 30.10.13 to 06.11.2013
Dr. S.K. Singh Dr. T.H. Das Dr. D.C.Nayak, Dr. A.K. Sahoo Dr. S.K.Gangopadhyay Dr. S.Ghosal Chaudhury Dr. K. Das, Dr. K.D. Sah Dr. T. Chattopadhyay Dr. S. Mukhopadhyay Dr. (Mrs.) T. Banerjee Dr. R. Srinivasan	7th Prof. Pran Kumar De Memorial Lecture on "Does the stability of soil carbon depend on microbial diversity" by Prof. William Horwath, Department of Land, Air and Water Resources, University of California, Davies, USA in collaboration with Indian Society of Coastal Agricultural Research, Canning Town, Indian Society of Soil Science, Kolkata Chapter and Indian Society of Soil Survey & Land Use Planning, Kolkata Chapter.	NBSS & LUP, Kolkata on 17.09.2012
Dr. S.K. Singh Dr. T.H. Das Dr. D.C. Nayak Dr. A.K. Sahoo Dr. S.K.Gangopadhyay Dr. S.Ghosal Chaudhury Dr. K. Das Dr. K.D. Sah Dr. T. Chattopadhyay Dr. S. Mukhopadhyay Dr. (Mrs.) T. Banerjee Dr. R. Srinivasan	14th Dr. N.S. Randhawa Memorial Lecture organized by Indian Society of Soil Science, New Delhi	NBSS & LUP, Kolkata on 28.09.2012

All Scientists of the NBSS&LUP (ICAR)	Institute Research Council (IRC) meeting	NBSS & LUP, Nagpur 14-16 March 2013
Dr. Jagdish Prasad	Stakeholder's Meet "Implementation of Vidarbha Irrigation Intensive Development (VIIDP), a project on "Improving cotton productivity and breaking yield barriers	CICR on 15th May 2012
	Review meeting for Khamaria Farm, Jabalpur	Nagpur 28th May 2012
	M.S. Swaminathan Research Foundation, Chennai followed by tour (12-13 June, 2012) to Wardha and Amravati with them to two KVKs, Science for villages for agri-nutrition.	NBSS&LUP, Nagpur on 11th June 2012
	Meeting Science – Sustainable Development and Innovation, Indian Science Congress	Nagpur 24th June 2012
	3rd IMC meeting of NIASM, Baramati	NIASM, Baramati on 16th March 2013.
Dr. S.K. Ray	Field correlation trip to Goa under the project "Soil Correlation of India"	Bangalore Regional Centre from 23rd to 25th January 2013.
	17th Annual Convention and National Symposium on Application of Clay Science Agriculture, Environment and Industry, and presented paper on "Soil micromorpholgoical investigation to infer changes in bulk density *vis-à-vis* determination of pores" and also acted as rapporteur in a session.	NBSS&LUP, Regional Centre, Kolkata 27-28 April 2012
Dr. T. Bhattacharyya	Meeting convened by the Dy. Director General (NRM) with the presence of Heads of Divisions and Regional Centres of NBSS&LUP in presence of NRM Directors of ICAR Institutes	12th March 2013.
	Compulsory training course on "Development of clean development mechanism projects under land use, land use change and forestry : theory and practices and their relevance to forestry sector" for Indian Forest Service (IFS) Officers	Amity University, Noida, U.P. on 7th November 2012.
	Session for the Review meeting of the Programme Advisory & Monitoring Committee (PAMC) of National Programme of Carbon Sequestration (NPCS) Research by DST-IS-STAC	Andhra University, Vishakhapatnam, A.P. on 19-20th July 2012
	IPNI Research Cooperators' Meet, 2012. Co-chaired Session 2, three papers were delivered from CIMMYT, ILRI	IISS, Bhopal during 14-15th May 2012.
Dr. G. P. Obi Reddy	National Organizing Committee meeting	NSDI-12 at New Delhi 20th November 2012.
	AICRP review meeting on 'Integrated farming systems'	PDFSR, Modipuram at New Delhi on 31st August 2012.
	Institute Management Council (IMC) meeting	Indian Institute of Soil Science, Bhopal on 17th August 2012.

	7th EC meeting of NSDI	NRSC, Hyderabad on 12th July 2012.
	GI Policy Roundtable Meeting'	Bangalore from 19th to 20th June 2012.
	"Human Resource Development in Remote Sensing and GIS in Natural Resource Management"	NNRMS Standing Committee on Training and Technology at ISRO HQ, Bangalore on 13th June 2012.
	Geographic Information Committee (LITD 22) Meeting	New Delhi on 7th June 2012.
Dr. G.S.Sidhu	EFC Meeting chaired by the Director General, ICAR during 27-28 April, 2012.	
	Audit Para Meeting chaired by the Director General, ICAR	on 2nd May 2012.
	Meeting in Ministry of Environment & Forestry chaired by Mrs Maharishi, Secretary, MOEF	MOEF, New Delhi on 15th May 2012.
	Meeting on Land Use Planning of Haryana under chairmanship of DDG (NRM)	ICAR, KAB-II on 28th May, 2012.
	Meeting on NAIP	ICAR, KAB-II on 12-13 June, 2012.
	Meeting on NAIP (CIC &CAC)	NBSS&LUP, Nagpur on 18-19 July, 2012.
	Meeting of Regional Committee V of ICAR	CSSRI, Karnal on 24th July, 2012.
Dr. S.K. Mahapatra	Executive Committee Meeting of the Indian Society of Soil Science	IARI, New Delhi on 23rd June, 2012
	Meeting of Formulation of Draft Project Proposal on 'Nitrogen, Phosphorous and carbon budgets with reference to climate change in the Ganga Basin'	NASC complex, New Delhi on 25th March, 2013.
Dr. (s) G.S.Sidhu, Tarsem Lal, C.S.Walia, and S.K. Mahapatra, Dharam Singh, Jaya N. Surya and Sh. Ashok Kumar	QRT Meeting under the Chairmanship of Dr. S.K. Sanyal, Vice Chancellor, BCKV, West Bengal	Regional Centre Delhi on 1st August, 2012.
Dr. (s) G.S.Sidhu C.S.Walia S.K. Mahapatra	Executive Committee of Clay Mineral Society of India under the chairmanship of Dr. Dipak Sarkar, Director	NBSS&LUP, at Regional Centre Delhi on 1st September, 2012
Dr. G.S.Sidhu	Meeting in Ministry of Environment & Forestry chaired by Mrs Maharishi, Secretary, MOEF,	New Delhi on 6th September, 2012.

	Meeting of NCR Planning Board,	New Delhi on 12th & 27th September, 2012.
	RAC and QRT	NBSS&LUP, Nagpur on 14th & 15th October, 2012.
	Regional Committee V of ICAR at IARI	New Delhi during 14-15 December, 2012
	Meeting with the Director (Extension), YSPHUF, Nauni (H.P.) to discuss about formulation, implantation and monitoring of tribal sub-plan project	New Delhi on 5th November, 2012.
	Meeting on NAIP (CIC &CAC) at NBSS&LUP	Nagpur during 4-5 March, 2013.
	Meeting of LRI Project at NBSS&LUP	Nagpur on 19th February, 2013.
	Meeting of the Heads of NRM Division under ICAR at complex	NASC New Delhi during 11th -12th March, 2013.
	Heads Meeting	NBSS&LUP, Nagpur on 13th March, 2013.
Dr. C.S.Walia	Stake holders meeting workshop "National Mission on sustainability Himalayan eco sysem (NMHSE)	IHBT, Palampur (H.P.) during 6-7 October, 2012.

11 Consultancy, Patents, Commercialisation of Technology

The Bureau is undertaking characterization of soils for micro and macro-nutrients and their mapping in Sikkim, Kerala, three NICRA villages in northern states of Uttar Pradesh and Himachal Pradesh and three districts of Jharkhand namely Dumka, Jamtara and Hazaribag on a consultancy mode. All the samples are geo-referenced. Important soil nutrient maps, such as, organic carbon, available nitrogen, phosphorus and potassium, micro nutrients and other thematic maps are being prepared and supplied to the sponsoring agencies. These maps and reports are used by the concerned agricultural departments for input supply regulations and creating awareness among the farmers to use the precious fertilizers according to the soil/crop requirements. Another consultancy project entitled "Land resource inventory and GIS database for farm planning" was undertaken. Detailed soil survey of the seven blocks of coastal region of West Bengal is under progress. The information generated will be useful for farm level planning.

12 Meetings Organized

Institute Research Committee (IRC) Meeting

Institute Research Committee (IRC) meeting of the Bureau was held during 14th – 16th March 2013 at Hqrs., Nagpur to discuss work progress in research projects.

A technical session of IRC in progress

Research Advisory Committee (RAC) Meeting

Research Advisory Committee (RAC) meeting was held on 15th October 2012 under the Chairmanship of Dr. M. Velayutham, ex-Director, NBSS&LUP to discuss the ongoing research programmes and the future action plan for the XII plan.

RAC meeting in progress

Quinquennial Review Team (QRT) Meeting

The QRT team under the Chairmanship of Prof. S.K. Sanyal, Vice-Chancellor, BCKV visited the Regional Centre Bangalore (7th September 2012), Kolkata (18th August 2012), Jorhat (21st August 2012) and Udaipur (3rd August 2012) to review the research programmes of the centres and the facilitates developed during the last five years. The team had interaction with the scientists and all the staff at these centres. The QRT meeting of the Regional Centre, Jorhat was held on 21st August, 2012. Prof. M.S. Kuhad chaired the meeting. Dr. A.N. Sigh, Dr. C.J. Thampi, Dr. P. Chandran, Dr. U. Baruah,

Dr. D. Dutta, Dr. S.K. Reza, Dr. S. Bandyopadhyay and Dr. Shelton Padua participated in the session. Dr. U. Baruah, Head, Regional Centre, Jorhat presented the overall progress of the centre.

QRT team visits to Research Laboratory at Regional Centre, Bangalore

Joint RAC – QRT Meeting

A joint meeting of RAC and QRT was conducted, NBSS&LUP attended a joint meeting of RAC and QRT held on 14th October 2012 at Nagpur to cross-learn from the experience of both the committees to give a clear direction to the Institute for way forward. Dr. M. Velayutham Chairman, RAC, Prof. S.K. Sanyal, Chairman, QRT, other members of RAC including Director Dr. Dipak Sarkar and members of QRT attended the meeting. Dr. Dipak Sarkar, Director brought out the research highlights, mapping programme and micro-watershed plans and also presented flagship and platform projects and future programmes of the Institute during the 12th Plan period.

Joint meeting of RAC and QRT in progress

Institute Management Committee (IMC) Meeting

Institute Management Committee (IMC) Meeting of the Bureau was held on 11th December 2012 at Nagpur to discuss the scientific, technical and administrative matters for the period March 2012 to December 2012.

A view of the IMC meeting

Monthly Interaction Meeting

As per the directive from ICAR, a monthly meeting of Scientists and Technical Officers is organized regularly at the HQrs, Nagpur alongwith presentation by one of the scientists of the Institute on a theme based on Mandate. One such interaction meeting was held on 23rd July 2012 in which Dr. Pramod Tiwari, Scientist delivered a talk on "**Development and Evaluation of Decision Support System for integrated water resources management**".

Dr. Pramod Tiwari, Scientist delivering a talk in monthly meeting of scientists and technical officers at HQrs., Nagpur

User Interaction Meeting organized

A **User's Interaction Meet** was organized at Dept. of Soil & Water Conservation, Kohora, Karbi-Anglong district of Assam on 3rd August 2012. Dr. U. Baruah, Head and Principal Scientist, Dr. D. Dutta, Principal Scientist, Dr. S.K Reza and Dr. S. Bandyopadhyay, Scientists of NBSS & LUP, RC, Jorhat participated in the meeting and interacted with the stake-holders.

User's Interaction Meet organized in Bhomoraguri Missing Gaon Pub-Teok, Jorhat district

A **Farmers' Interaction Meet** was organized at Regional centre, Jorhat on 13th February 2013 at Bhomoraguri Mising Gaon, Pub Teok Circle, Jorhat in conjunction with *Ali-Ail-Ligang* festival of Missing Tribals. Dr. K.M. Bujarbaruah, Hon'ble Vice Chancellor, Dr. Girin Hazarika, Director of Research, AAU, Jorhat, Dr. Dipak Sarkar, Director, NBSS&LUP (ICAR), Nagpur, Dr. T.H. Das, Principal Scientist, Regional Centre, Kolkata and other dignitaries participated in the Meet.

IJSC Meeting

IJSC meeting held at Regional Centre, Bangalore

The Institute Joint Staff Council (IJSC) meeting was organized at Regional Centre, Bangalore under the Chairmanship of Dr. Dipak Sarkar, Director on 29th June 2012.

13 Workshops/Seminars/Summer and Winter Schools/Farmer's Day and Other Events and Activities

Workshops

CMSI Workshop

Seventeenth annual convention of Clay Mineral Society of India and National Symposium on Application of clay science; in Agriculture, environment and industry was organized at NBSS&LUP Regional Center Kolkata during 27th - 28th April, 2012. The Clay Mineral Society of India, New Delhi and International Plant Nutrition Institute, South Asia Programme, Gurgaon were the sponsors of this symposium. A number of research papers were presented on the chosen themes in the symposium.

A view of the inaugural session of symposium at Rabindra Okkura Bhavan, Salt Lake

A workshop on "**Soil fertility Management–Project Outputs and Way forward"** was conducted on 24th and 25th May 2012 at Thiruvananthapuram under the project "Soil based Plant Nutrient Management Plan for Agro-Ecosystems of Kerala". Sri K.P. Mohanan, Honorable Minister for Agriculture, Govt. of Kerala inaugurated the 2 days programme. Dr. Dipak Sarkar, Director, NBSS & LUP delivered the key note address and Dr. K. M. Nair, Principal Scientist presented an overview of results of soil analysis project.

A NAIP Workshop was organized on '**Natural Resources Management in Backward Districts of India'** was organized at NBSS&LUP, Nagpur during 21-22 February, 2013.

Dr. Dipak Sarkar, Director delivering the key note address during the workshop

Seminar / Symposium

National Seminar (ISSLUP)

Two days National Seminar on "**Managing Land Resources for Sustainable Agriculture**" was organized by Indian Society of Soil Survey and Land Use Planning during 12th & 13th October 2012 at Nagpur. There were three memorial lectures, three technical sessions and poster presentations. Dr. A. K. Singh, Deputy Director General (NRM) was the Chief Guest, Dr. C.D. Mayee, Former Chairman ASRB, New Delhi presided over the function, Dr. M. Velayutham, Former Director NBSS&LUP, Dr. S.M. Virmani, Former Principal Scientist, ICRISAT (Guest of Honour) and Dr. R.G. Dani, Vice-Chancellor, Dr. PDKV, Akola were Guest of Honour. About 125 delegates from different parts of the country were participated in the seminar.

Dr. Dipak Sarkar, Director and President, ISSLUP addressing the audience in the ISSLUP National Seminar in presence of (from R to L) Dr. Raviprakash Dani, VC, Dr. PDKV, Akola, Dr. A.K. Singh, DDG (NRM), ICAR, N. Delhi, Dr. C.D. Mayee, Ex Chairman, ASRB, N. Delhi, Dr. M. Velayutham, Ex Director, NBSS&LUP, Dr. S.M. Virmani, Guest of Honour and Dr. T.K. Sen, Organizing Secretary ISSLUP

- The Regional Centre, Kolkata organized one day Seminar on **"Nutrient Management in Crops for Sustainable Agriculture – Present Status and Future Needs"** in collaboration with International Plant Nuturition Institute (IPNI) – Asia and Africa Programme, Gurgaon at the Regional Centre, Kolkata on 24th August, 2012.

Krishi Vigyan Mela/Kisan Mela/Farmer's Day

- Staff of regional centre, Kolkata participated in the **2nd India Crop Summit 2012** during 17th - 18th September, 2012 at Netaji Indoor Stadium, Kolkata and displayed research activities based on soils of Eastern States.
- Staff of Regional Centre Delhi participated in "***PUSA KRISHI VIGYAN MELA -20013"*** held at IARI, New Delhi, during March 6-8, 2013 and displayed various maps, publications & highlighting activities of the Bureau besides interaction with scientists, farmers and other visitors. Leaflets highlighting the mandate, activities, and achievements of the institute (both in Hindi and English) were distributed amongst the visitors Inaugurated by Sh. Sharad Pawar, Hon'ble Minister of Agriculture, Govt. of India. Many Dignitaries, Scientists, Farmers, Students & others visited the stall.

NBSS & LUP participated in Pusa Krishi Vigyan Mela

Science Exhibition

- NBSS&LUP, Nagpur organized an exhibition at Raman Science Centre from 9th to 13th January, 2013, National Expo (AGROVISION, 2013) at Reshimbagh from 24th to 27th January, 2013 and Rashtriya Nimboovargiya Kisan Mela at NRCC, Nagpur from 22nd -23rd February, 2013 under the supervision of Dr. Jagdish Prasad with active participation of NBSS&LUP staff.
- **Workshop on Agro-Vision 2013:** Institute's activities were explained to the farmers and general

public at Rashimbagh, Nagpur during 24th to 27th January 2013.

- **Zonal Workshop (East Zone) on Financial, Accounting and Auditing Matters including Financial Management System & Management Information System:** The workshop was organized by Regional Centre, NBSS&LUP, Kolkata on 24th January, 2013 at its campus under the Chairmanship of Mr. P.K. Pujari, Addl. Secretary & FA, ICAR; Mr. Devendra Kumar, Director (Finance), ICAR; Mr. G.P. Sharma, Dy. Director (Finance), ICAR, Mrs. Rashmi Rao, Dy.Director (Finance), ICAR; Mr. S.K. Pathak, Dy. Director (Finance), ICAR; Dr. Dipak Sarkar, Director, NBSS & LUP (ICAR), Nagpur; Mr. G.C. Prasad, Sr. Finance & AO, NBSS & LUP (ICAR), Nagpur and Dr. S.K. Singh, Pr. Scientist & Head were also present in the workshop. Twenty four FAO, Asst.FAO from ICAR Institutes of Eastern India also participated in the workshop.

Staff, NBSS & LUP (ICAR), Regional Centre, Kolkata exhibiting research publications during India Crop Summit 2012

Hindi Workshops

The annual Hindi workshop was organised at Regional Centre, Bangalore on 29th June 2012. Dr. Dipak Sarkar, Director, NBSS & LUP inaugurated the function. Dr. Baruah, Dr. L.G.K. Naidu, Dr. T.K. Sen, Dr. Jagdish Prasad, Shri.Mahadev, Dr. Sahoo, and Smt. Hayat and staff of the Regional centre participated in the workshop.

Release of Hindi version of Soil survey Scientific Terminology booklet at inaugural function

- First Hindi Karyashala on "*Patra Lekhan Evam Tippani*" was organized on 18th Feb, 2013 for the Technical and Administrative staff.
- Second Hindi Karyashala on '*Vartni Ka Mankikaran*" was organized at Regional Centre, Delhi on 5th June, 2012, for Scientists.
- Third Hindi Karyashala on "*Anuvad Ki Vyaharik Kathinaiya*" was organized at Regional Centre Delhi on 29th August, 2012 for the Technical Officers, Administrative and Technical Assistants staff.
- Fourth Hindi Karyashala on "*Rajbhasha Miya Adhiniyam ki Jankari Evam Tippanih*" was organized at Regional Centre Delhi on 11th December, 2012 for the Field & Technical Assistants and Administrative staff.

Other Events

The renovated ICAR Guest House located at Krishi Kunj, Nagpur was inaugurated by **Dr. S. Ayyappan, Secretary DARE and DG, ICAR** Govt. of India on **24th November 2012** in presence of Dr. C.D. Mayee, ex -Chairman, ASRB, New Delhi, Dr. Swapan Kumar Datta, DDG (CS) ICAR, Dr. R.G. Dani, Vice-Chancellor, PDKV, Akola, Dr. Dipak Sarkar, Director, NBSS&LUP (ICAR), Dr. K.R. Kranthi, Director, CICR (ICAR), Dr. V.J. Shivankar, Director, NRCC (ICAR).

Dr. Ayyappan appreciated the efforts made by ICAR Institutes located in the city namely, NBSS&LUP, CICR and NRCC. The facility has been developed for comfortable stay for all ICAR employees in the country

as well as officials from State Agricultural Universities (SAU's) and State Agricultural Department and other Govt. organizations.

Inauguration of Guest House at Krishi Kunj, Nagpur by the hands of Dr. S. Ayyappan, Hon'ble DG, ICAR & Secretary DARE, New Delhi. From Left Dr. C. D. Mayee, Ex-Chairman, ASRB, New Delhi, Hon'ble Dr. S. Ayyappan, Secretary DARE and Director General, ICAR, New Delhi, Dr. R. G. Dani, Hon'ble Vice Chancellor, PDKV, Akola, Dr. Dipak Sarkar, Director, NBSS & LUP, Nagpur and Dr. V.J. Shivankar, Director, NRCC

The foundation stone laying ceremony of the Training Hostel at Regional Centre, NBSS&LUP, Jorhat, Assam was held on 4th April 2012 by Dr. Bujarbaruah Hon'ble Vice-Chancellor, Assam Agricultural University, Jorhat. This facility shall be utilized for conducting training on different needs of the NE Region. It was laid by Dr. K.M. Bujarbaruah, Hon'ble V.C., Assam Agricultural University (AAU) in presence of Dr. Dipak Sarkar, Director, NBSS&LUP (ICAR). Dr. Girin Hazarika, Director of Research, Heads of different departments of AAU and other staff members of AAU were also present in the function.

Hon'ble V. C., AAU, Jorhat inaugurating the Foundation Stone of the Training Hostel at Regional Centre, NBSS&LUP Jorhat and Dr. Dipak Sarkar Director, NBSS & LUP look on.

Foundation Day Celebration

The **NBSS&LUP** celebrated its Foundation Day on **23rd August 2012** at Hqrs., Nagpur with great fervor and enthusiasm. On this occasion, **Dr. Dipak Sarkar,** Director of the Bureau narrated the past, present and future of the Bureau with emphasis on its road map, achievements and projects in pipeline as per pressing demand of the country. ex-Directors, Heads of Regional Centres and Divisions and other staff were felicitated on this occasion. **Dr. C.D. Mayee,** ex -Chairman ASRB (ICAR), New Delhi and Chief Guest of the function delivered Foundation Day Lecture on "**Management of Natural Resources for Achieving the Second Green Revolution**". He stressed for 2nd Green Revolution and self sufficiency in food production and also highlighted the deteriorating ecosystem due to faulty packages of practices. He put a challenge to the scientists to combat the threat of climate change and ways to revert it by developing appropriate genotypes and marker assisted selection. He also stressed upon convergence of knowledge from different faculties in achieving the livelihood security and nutritional quality of food. The Guest of Honor **Sh. B. Venugopal Reddy,** IAS the Divisional Commissioner of Nagpur Division pointed out that drought and flooding situation in Vidarbha and administrative problems for tackling these situations. He stressed upon *in-situ* conservation of rainwater and recharging of aquifer so that we can increase the area under irrigation and/ or to provide live saving irrigation to crops.

Sh. B. Venugopal Reddy, IAS Divisional Commissioner and Guest of Honor felicitating one of the ex employees of the Bureau during Foundation Day Ceremony in presence of Dr. C.D. Mayee, ex - Chairman, ASRB and Chief Guest of the function and Dr. Dipak Sarkar, Director, NBSS&LUP, Nagpur

- The Regional Centre, NBSS&LUP, Kolkata organized 7th Prof. Pran Kumar De Memorial Lecture on **"Does the stability of soil carbon depend on microbial diversity"** by Prof. William Horwath, Department of Land, Air and Water Resources, University of California, Davies, USA in collaboration with Indian Society of Coastal Agricultural Research, Canning Town, Indian Society of Soil Science, Kolkata Chapter and Indian Society of Soil Survey & Land Use Planning, Kolkata Chapter on 17th September, 2012 at the Regional Centre.

Other Important Activities

The following activities were undertaken at Bhomoraguri Missing Gaon, Pub Teok Circle" under the TSP programme.

- 47 nos. of farm families under *Miching* tribe were surveyed for their socio-economic status covering 120 bigha of land.
- Two Shallow Tube Wells (STW) along with pump sets were installed as micro-irrigation for *Rabi* crops.
- Around 15 bigha of land was covered for cultivation of *Rabi* crops (*viz.,* mustard, potato, cabbage and brinjal).
- 15000 seedlings of *F1 hybrid* of cabbage and 8000 seedlings of *F1 hybrid* of brinjal were planted and 3 q of *Kufri Jyoti* potato were also sown.
- 24 nos. of piglets were supplied to two Self Help Groups (SHG) for piggery.
- 1 no. of Honey bee hive with 5 No. of bee colony frames (*Mellifera* sp.) was supplied for Apiculture.

- Regional Centre, Kolkata conducted ARS/NET Examination 2012 of ASRB on 24.02.2013 at Bharatiya Vidya Bhavan, Salt Lake, Kolkata

Scientific services/extension activities

Radio talks

1. Dr. G.S.Sidhu, Principal Scientist & Head, Krishi Darshan, Hindi National News – Importance of Soil Survey for Land Use Planning, telecasted on 14th June, 2012.
2. Dr. Rajendra Hegde gave a radio talk on "Sunflower cultivation" by AIR Bangalore (Farm &Home section) April 2012.
3. Dr. Rajendra Hegde: gave a radio talk on "Water and nutrient management in paddy cultivation" All India Radio, Bangalore. (28-6-2012).
4. Dr. Rajendra Hegde gave a live radio interview on FM-Rainbow, Bangalore on "Economical, ecological and agricultural importance of sand & specific issues related to sand in Karnataka(2-8-2012).
5. Dr. Rajendra Hegde gave a Radio interview on "Improved method of organic manure preparation" broadcasted from AIR Gulberga, Karnataka (13-9-2012)
6. Dr. Rajendra Hegde gave a radio talk on "Fertilizer types and their use in Indian Agriculture" from AIR, Bangalore (Farm & Home program on 16-11-2012).
7. Dr. Ramamurthy gave radio talk on importance of soil survey and soil management was broadcasted on 2nd Oct. 2012 by FM 90.8
8. Dr.V. Ramamurthy gave radio talk on "Management of soils of H.D. Kote" was broadcasted on 1st November 2012 by FM 90.8
9. Rajendra Hegde gave a radio interview on "Soil and water conservation concepts and practices (14-3-2013), AIR Bangalore.
10. Rajendra Hegde gave a radio talk on "Union Budget 2013-14: Analysis of budgetary allocation on Agriculture and rural development sectors-aspirations and allocations. (28-2-2013), AIR Bangalore

Services rendered (Extension)

- NBSS & LUP, Regional Centre, Bangalore shared the copy of final report on "Detailed land resources inventory of D Nagenahalli village for Integrated development under NICRA, IIHR KVK Hirehalli with the Vice Chancellors of all SAUs of Karnataka

- Advice given on organic banana cultivation to two farmers form Kanakapura(23-8-2012).
- Provided the information on various projects handled to HRC in response to a RTI application
- Submitted a compendium of all the developments and documents pertaining to the Sujala-3 project to Director as per his directions
- Dr. Rajendra Hegde gave a live radio interview on FM-Rainbow, Bangalore on "Economical, ecological and agricultural importance of sand & specific issues related to sand in Karnataka (2-8-2012)
- Dr. Rajendra Hegde served as the external evaluator of M.Sc. (Agri) thesis of UAS(D) on " Nutrient ratios of N&P on ground nut productivity
- Dr.A. Natarajan visited DDG's office, New Delhi to facilitate the operationalisaion of the LRI project during the 12th plan period
- Soil information of Chikkamagalur provided to GKVK, Chikmagalur District
- Soil map of Bangalore (Rural) and Karnataka State LGP, drought and fertility maps supplied to Horticulture Research Station, GKVK, Bangalore
- 5 maps of Tamil Nadu and Karnataka was supplied to executive engineer, National Water Development Agency, Irrigation Division, Bangalore
- Provided Land Resource information of Bangalore rural district to KVK Hadonahalli, UAS, Bangalore for rendering farm advisory services and Technology transfer.
- YSR District Land Resources information i.e. Soil map, fertility maps were given to ADA, YSR District, who accompanied progressive farmers.
- Soil map along with soil texture, Soil depth maps for Shimoga, Chikkamagalur, Haveri, Dakshin Kannada and Hasan Districts were supplied to college of Agriculture, Shimoga.
- NAIP workshop on "Natural Resources Management in Backward Districts of India" 21st & 22nd February, 2013.
- Farmers meet cum Workshop on 19 March 2013 and CAC & CIC Members meeting & visit to Aurangabad clusters.
- Farmers rally cum agriculture exhibition on 20 March2013 at Lagadwal, Sakri cluster, Dhule District attended by 800 farmers and farm women from surrounding villages.

Appendix 1

Ongoing and Completed Projects

ONGOING INSTITUTIONAL PROJECTS

Inventorying Natural Resources

1. **Soil resource inventory for developing geo-database and land use planning in Patnagarh sub-division of Bolangir district, Orissa.**

   K.D. Sah, K. Das, Tapati Banerjee and S.K.Singh

2. **Soil resource inventory and land evaluation of Rohtas district, Bihar (1:50,000 scale) for land use planning.**

   D.C. Nayak and S.K. Singh

3. **Soil resource inventory and land evaluation of Aurangabad district, Bihar (1: 50,000 scale) for land use planning**

   S.K. Gangopadhyay, K. Das and S.K. Singh

4. **Influence of land use and management on soil properties in Mahanadi basin of Bolangir district in Odisha**

   Tapati Banerjee, K.Das, K.D.Sah and S.K.Singh

5. **Soil Resource Inventory of IARI Farm, New Delhi**

   S.K. Mahapatra, C.S.Walia, Tarsem Lal and G.S. Sidhu

6. **Land resource inventory for farm planning in Jhalarapatan block of Jhalawar district of Rajasthan**

   R.S. Meena, T.P.Verma, R.K.Naitam and R.S.Singh

7. **Soil Resource Inventorisation for developing geo-database towards land use planning in Bolangir subdivision in Bolangir district, Odisha**

   K. Das, D.C. Nayak, S. Chatterji, K.D. Sah, Tapati Banerjee and S.K. Singh

8. **Identification and characterization of benchmark soils of Odisha for agro-technology transfer**

   S.K. Singh, K.D. Sah, K. Das, A.K. Sahoo and D.C. Nayak

9. **Soil resource inventory and land evaluation of Chittaurgarh district for land use planning**

   T.P. Verma, R.S. Meena and R.K. Naitam

10. **Correlation of soil series of India**

    T. Bhattacharyya, R. Srivastava, J. Prasad, P. Chandran, S.K. Ray, B.P. Bhaskar, J.D.Giri, L.G.K. Naidu, A. Natarajan, K.M. Nair, K.S. Anil Kumar, G.S. Sidhu, C.S.Walia, S.K. Mahapatra, U. Baruah, S.K. Reza, A.K.Sahoo, D.C. Nayak, K. Das, S.K. Singh, T.H. Das, D.Dutta, R.S. Singh, T.P.Verma and R.K. Naitam

11. **Correlation of soil series of India and their placement in the National Register: Southern States (Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Goa, Puducherry and Lakshadweep)**

    L.G.K. Naidu, A. Natarajan, K.M. Nair and K.S. Anil Kumar

12. **Correlation of soil series of India and their placement in the National Register – Northern States**

    G.S. Sidhu, S.K. Mahapatra and C.S. Walia

13. **Correlation of soil series of India and their placement in the National Register for the Western region (Gujarat & Rajasthan)**

    R.S. Singh, T.P. Verma and R.K. Naitam

14. **Correlation of soil series of North-Eastern States (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura)**

    U. Baruah and S.K. Reza

15. **Correlation of soil series of Eastern States (Bihar, Jharkhand, Orissa, Sikkim, Andaman & Nicobar Islands and West Bengal)**

    A.K. Sahoo, D.C. Nayak, K.Das, S.K. Singh, T.H. Das, S.K. Gangopadhyay, K.D. Sah, S. Mukhopadhyay and T. Banerjee

16. **Soil resource inventory of Shimla district (part) of Himachal Pradesh for horticulture plantation**

    C.S. Walia, J.N. Surya, T. Lal and G.S. Sidhu

17. **Land resource inventory for farm planning in Lakhan Majra block of Rohtak district, Haryana** (subproject of main project- Land resource inventory for farm planning in different agro-eco-regions of India)

    Jaya N. Surya, T. Lal, Dharam Singh, S.K. Mahapatra and G.S. Sidhu

18. **Land resource inventory of Katonigaon Panchayat of Mariani circle, Jorhat** (subproject of main project- Land resource inventory for farm planning in different agro-eco-regions of India)

    S.K. Reza, S. Bandyopadhyay and Utpal Baruah

19. **Land resource inventory of East Lahing Gaon panchayat of East Jorhat development block, Jorhat district, Assam** (subproject of main project- Land resource inventory for farm planning in different agro-eco-regions of India)

    S. Bandyopadhyay, S.K. Reza and U. Baruah

20. **Land resource inventory for farm planning in Gotu and Puinan village clusters, Polba-Dadpur Block, Hugli District, West Bengal** (subproject of main project- Land resource inventory for farm planning in different agro-eco-regions of India)

    S. Dharumarajan, T. Banerjee and S.K. Singh

21. **Land resource inventory for farm planning in different agro - ecological regions of India sub project: Bhadesar Tehsil (cluster of 10 villages) in Chittaurgarh district (Rajasthan).** (subproject of main project- Land resource inventory for farm planning in different agro-eco-regions of India)

    T.P. Verma and R.S.Singh

22. **Land use planning of Chanavada watershed in Girwa tehsil, Udaipur district, Rajasthan for integrated development**

    R.K. Naitam and T. P. Verma

23. **Study of crop moisture availability of soils during post – kharif period in Shibsagar district of Assam**

    D. Dutta., S.K. Reza and U. Baruah

24. **Land resource inventory of Durgada Nagenahalli village, Kortagere taluk, Tumkur district, Karnataka for integrated development under NICRA project**

    A.Natarajan, Rajendra Hegde, S. Srinivas and K.S. Anil Kumar

25. **Land resources of Muttala village, Atmakur mandal, Anantpur district for integrated Watershed Management**

    S. Dharumarajan, M. Lalitha, S. Srinivas, ANatrajan and L.G.K.Naidu

Remote Sensing, GIS and Cartography

26. **Area prioritisation for land use planning in some selected blocks of Bankura, Puruliya and West Medinipur districts - a remote sensing and GIS approach**

    S. Mukhopadhyay and S.K.Singh

27. **Development of Indian Soil Information System (ISIS) – A Geoportal**

    G.P. Obi Reddy, C. Mandal, Rajeev Srivastava, T. Bhattacharyya, L.G.K.Naidu, G.S.Sidhu, Utpal Baruah, S.K. Singh, R.S. Singh and Nirmal Kumar

28. **Assessment and mapping of spatial variability of soil properties in basaltic terrain for precision agriculture using VNIR spectroscopy and geo-statastical techniques.**

    M.S.S. Nagaraju, N.G.Patil, Nirmal Kumar and Rajeev Srivastava

29. **Development of district soil information system (DSIS) on 1:50,000 scale (50 Districts)**

    G.P. Obi Reddy, C. Mandal, Rajeev Srivastava, T. Bhattacharyya, L.G.K. Naidu, G.S. Sidhu, Utpal Baruah, S.K. Singh, R.S. Singh, Nirmal Kumar and Dipak Sarkar

30. **Natural resource assessment using RS and GIS – a case study in Badajorenala micro watershed in Utkal plain of Orissa**

    K. Das, S.K. Singh and Tapati Banerjee

31. **GIS modeling to predict land productivity potential (LPP) for major crops in Wardha district of sub-humid (dry) region, Eastern Maharashtra.**

    Nirmal Kumar, G.P. Obi Reddy and S. Chatterji

32. **Assessment of spatio-temporal variability of major crops in different states of India for land use planning: A GIS based approach**

    Malathi Bommidi, G.P. Obi Reddy, Nirmal Kumar and S.N. Goswami

33. **Documentation and storing maps and photographs – concept of digital map library**

    C. Mandal, D.K Mandal, Jagdish Prasad, T. Bhattacharyya, R. Srivastava and D. Sarkar

Basic Pedological Research

34. **Geomorphological analysis and study on landform-soils-land use relationships in Karnataka**

    S. Thayalan, A. Natarajan, K.M. Nair, K.S. Anil Kumar, L.G.K. Naidu, S.C. Ramesh Kumar, and V. Ramamurthy

35. **Geomorphometric and hydrological evaluation of micro watershed in Chhotnagpur plateau, West Bengal for sustainable utilization of soil and water resources**

    Tapati Banerjee, S.K. Singh K. Das and S. Dharuamarajan

36. **Water retention characteristics and saturated hydraulic conductivity of dominant soil series of Yavatmal district, Maharashtra**

    P.L.A. Satyavathi, P. Tiwary, S.K. Ray, P. Chandran, B.P. Bhaskar, Jagdish Prasad and T. Bhattacharyya

37. **Geochemical characterization for reconstruction of physical and chemical properties of shrink-swell soils of Yavatmal district, Maharashtra**

    B.P. Bhaskar, Dipak Sarkar, T. Bhattacharyya and P.L.A.Satyavathi

38. **Studies on soil minerals and their genesis in selected benchmark spots representing different agro-eco subregions of India**

    P. Chandran, S.K. Ray, K. Karthikeyan. T. Bhattacharyya, Jagdish Prasad, B.P. Bhaskar , P.L.A. Satyavathi, P. Tiwary, C. Mandal, L.G.K Naidu, G.S. Sidhu, S.K. Singh, U. Baruah, R.S. Singh, K.S. Anil Kumar, D.C Nayak C.S. Walia, S.K. Reza, R.K. Naitam and D. Sarkar

39. **Nano-clay minerals of typical shrink swell soils: their separation and characterization**

    K. Karthikeyan, S.K. Ray, P.Chandran, T. Bhattacharyya, P. Tiwary and Jagdish Prasad

40. **Revising methods for the determination of available potassium content in shrink-swell soils of India**

S.K. Ray, P. Chandran, K. Karthikeyan, T. Bhattacharyya, J. Prasad and D. Sarkar

Soil Survey Data Interpretation and Applications

41. **Soil microbial biomass Carbon and Nitrogen in selected soil series of north-eastern region as affected by different land uses and varied agro-ecological conditions**

T. Chattopadhyay, S.K. Reza and U. Baruah

42. **Interpretation of soil nutrient database for site-specific fertilizer recommendation in different land use systems of West Bengal**

S.K. Singh D.C. Nayak, A.K. Sahoo, S. Mukhopadhyay, Tapati Banerjee and K.Das

43. **Estimating available water content of soils of selected villages in Aurangabad, Dhule and Gondia districts of Maharashtra**

N.G. Patil, T.K. Sen, S. Chatterji and A. Chaturvedi

44. **Assessment of heavy metal pollution and its mapping in soils of contaminated areas of Morigoan, Dibrugarh and Tinsukia districts of Assam**

S.K. Reza, S.K. Ray and Utpal Baruah

Land Evaluation and Land Use Planning

45. **National Network Project on district level land use planning and policy issues under different agro-ecosystem of the country**

A. Chaturvedi, V. Ramamurthy, S.K. Mahapatra, S. Bandyopadhyay, A.K. Sahoo, T.K. Sen and R.S. Singh

46. **Development of district level land use plan for Almora district, Uttrakhand under Hill and Mountain ecosystem**

S.K. Mahapatra, Jaya N. Surya and G.S. Sidhu

47. **Development of district level land use planning for Jorhat district, Assam under rainfed eco-system**

S. Bandyopadhyay, S.K. Reza and U. Baruah

48. **Development of district level land use plan for Nadia district in West Bengal under irrigated ecosystem**

A.K. Sahoo, D.C. Nayak and T. Banerjee

49. **Development of district level Land Use Plan for Gondia district, Maharashtra- A sub project of network project on district level land use planning.**

T.K. Sen, S. Chatterji, T.N. Hajare, S.N. Goswami, N.G. Patil, P.N. Dubey, A. Chaturvedi and Dipak Sarkar

50. **Development of district level land use plan for Bundi district (Rajasthan) under arid and semi arid ecosystem.**

R.S. Singh and R.K. Naitam

51. **Land evaluation for rainfed Bt cotton in soils of Nagpur district, Maharashtra using soft computing techniques**

S. Chatterji, T.K. Sen N.G. Patil, T.N. Hajare and A. Chaturvedi

52. **Dynamics of land use and its impact on soil properties in Jalandhar district, Punjab state**

G.S. Sidhu, Jaya N. Surya, Tarsem Lal and Dharam Singh

53. **Alternate Land Use options for Chhata tehsil of Mathura district towards sustainable crop production and livelihood security.**

Ashok Kumar, S.K. Mahapatra, Tarsem Lal and G.S. Sidhu

54. **Evaluation of management practices for different sustainable cropping systems in major soil series of Shikohpur village in Haryana**

Dharam Singh, S.K. Mahapatra, Tarsem Lal and G.S. Sidhu

55. **Land use planning of Buraka micro watershed in Mewat district of Haryana under irrigated ecosystem for integrated watershed development**

S.K. Mahapatra, C.S.Walia, Tarsem Lal, Jaya N. Surya and G.S. Sidhu

56. **Land use dynamics in rural urban interface of NCR for regional planning – a case study of NCT-Delhi and Haryana sub-regions**

Tarsem Lal, Jaya N. Surya, Ashok Kumar and G.S. Sidhu

57. **Land use planning of Khuskarani, Birbhum district, West Bengal for integrated development**

T.H. Das, S. Mukhopadhyay and S.K. Singh

58. **Land Use Planning of Diring-Thanglong Micro-watershed of Karbi-Anglong and Golaghat Districts of Assam under Hill and Mountain Ecosystem for Integrated Development**

S. Bandyopadhyay, D. Dutta, S.K. Reza and U. Baruah

59. **Land use planning of Tirumale sub-watershed in Magadi taluk, Ramanagara district, Karnataka for integrated development**

Rajendra Hegde and Associates

60. **Natural Resources and Land Use Issues in Backward Districts of India**

A.Chaturvedi, N. G. Patil and T. N. Hajare

61. **Human resource development in post-graduate education and research in land resource management (LRM)**

T.K. Sen and Associates

62. **Capacity Building in the Area of Remote Sensing & GIS Applications in Natural Resources Management**

G. P. Obi Reddy, L.G.K. Naidu, Rajeev Srivastava, G.S. Sidhu, Utpal Baruah, S.K. Singh, R.S. Singh and Dipak Sarkar

Completed Projects (Institutional)

1. **Assessment of land and soil resources of Malappuram district of Kerala at 1;50,000 scale for land use planning**

K.S. Anil Kumar, L.G.K. Naidu, S. Thayalan, K.M. Nair, Rajendra Hegde, S.C. Ramesh Kumar and S. Srinivas

2. **Assessment of land resources for growing horticultural crops in selected districts of Tamil Nadu under the National Horticultural Mission Project**

A Natarajan, V. Ramamurthy, S. Thayalan, S. Srinivas, K.V. Niranjana, M. Ramesh, D.H. Venkatesh and L.G.K.Naidu

3. **Land resources inventory and GIS database for farm planning in 10 blocks of Tamil Nadu**

A Natajan and Associates

4. **Land resource inventory for farm planning in different agro-ecological regions of India**

A Natarajan, Jaya N. Surya, R.S. Meena S.K. Reza, S. Bandyopadhyay, S. Dharmarajan, Pushpanjali, K. Karthikeyan, T.P. Verma and Dipak Sarkar

5. **Land resource inventory for farm planning in Chikarsinkere Hobli, Maddur taluk, Mandya district, Karnataka**

R.S. Meena, A.Natarajan, S. Thayalan, S.C. Ramesh Kumar, V. Ramamurthy and S. Srinivas

6. **Soil resource mapping of Sultanpur district of Uttar Pradesh for perspective land use planning**

C.S.Walia, Jagat Ram, Tarsem Lal, G.S. Sidhu, R.P. Dhankar and S.P. Singh

7. **Prediction of soil fertility parameters through Visible and Near Infrared (VNIR) soil reflectance data of West Bengal**

Rajeev Srivastava, M.S.S. Nagaraju, D.C. Nayak and S.K. Mukhopadhyay

8. **Comparative assessment of large scale mapping through conventional survey and remote sensing techniques- A case study in Parsori watershed, Katol tehsil, Nagpur district, Maharashtra state**

   J.D. Giri, M.S.S. Nagaraju, D.S. Singh and Rajeev Srivastava

9. **Detailed soil mapping in basaltic terrain for land resources management using Cartosat-1 data**

   M.S.S. Nagaraju, J.D. Giri, Nirmal Kumar, D.S. Singh, S.N. Das and Rajeev Srivastava

10. **Development of district level land use plan for Mysore district, Karnataka state**

    V. Ramamurthy, K.M. Nair, S.C. Ramesh Kumar, S. Srinivas, L.G.K.Naidu and S.Thayalan

EXTERNALLY FUNDED PROJECTS: ONGOING

National Agricultural Innovation Project (NAIP)

1. **Georeferenced soil information system for land use planning and monitoring soil and land quality for agriculture**

   T. Bhattacharyya, Dipak Sarkar, S.K.Ray, P Chandran., D.K. Mandal, Jagadish Prasad, C Mandal., G.S. Sidhu, A.K. Sahoo, K.M. Nair, R.S. Singh, T.H. Das, M.V. Venugopalan, A.K. Srivastava, Mausumi Raychaudhuri, K. Velmourougane, K.K. Rajeev Srivastava, T.K. Sen, Sushmoy Chatterji, G.P. Obireddy, N.G. Patil, S.K. Mahapatra, K. Das, A.K. Singh, S. Srinivas, S.K. Reza and P. Tiwary

2. **Efficient land use based integrated farming system for rural livelihood security in Aurangabad, Dhule and Gondia districts of Maharashtra.**

   Arun Chaturvedi, T.N. Hajare, N.G. Patil, T.K. Sen, S. Chatterjee, S.N. Goswami, M.S.S. Nagaraju, B.P. Bhaskar and G.P Obireddy

3. **Development of soil reflectance methods and low cost sensors for variable rate inputs in precision farming (NAIP-Component 4)**

   Rajeev Srivastava and Dipak Sarkar

DST Sponsored

4. **Delineation of potential areas for commercially important medicinal and aromatic plants in different agro-ecological zones of Karnataka using GIS tools**

   V. Ramamurthy, L. G. K. Naidu, K.S. Anil Kumar and S. Srinivas

5. **Influence of organic and inorganic carbon sequestration on soil and land quality in selected benchmark spots of India (DST-IS-STAC)**

   T. Bhattacharyya, P. Chandran, P. Tiwary, S.K. Ray, C. Mandal and D. Sarkar

6. **Assessment of environmental and economic input of the new agricultural policy of Karnataka in land use, land productivity and rural livelihood.**

   S.C. Ramesh Kumar, K.S. Anil Kumar and S. Srinivas

Other Externally Funded Projects (State Agril. Depts./CSIR/ISRO/NRSC)

7. **Assessment and mapping of some important soil parameters including macro and micro nutrients for the thirteen (13) priority districts of Assam state (1:50,000 scale) towards optimum land use planning.**

   Utpal Baruah, D. Dutta, T. Chattopadhyay, S.K. Reza and S. Bandyopadhyay

8. **Assessment and mapping of some important soil parameters including macro and micro nutrients for the state of Nagaland (1: 50,000 scale) towards optimizing land use planning.**

   S. Bandyopadhyay, D. Dutta, T.H. Das, S.K. Reza, S. Padua and Utpal Baruah.

9. **Land resource inventory and GIS database for farm planning in coastal region of West Bengal**

   S. K. Singh, A. K. Sahoo, K. Das, K. D. Sah, D. C. Nayak, S.K.Gangopadhyay, S. Mukhopadhyay and Tapati. Banerjee

10. **Assessment and mapping of some important soil parameters including macro and micro nutrients at block levels of Dumka, Jamtara and Hazaribag districts for optimum land use plan**

    A.K. Sahoo, D.C. Nayak, S. Mukhopadhyay, T. Banerjee and S.K. Singh

11. **Mapping of nutrient status in soils of Sikkim state towards land use planning**

    T.H. Das, D.C.Nayak, A.K.Sahoo, S. Mukhopadhyay, S.K.Reza, S. Bandyopadhyay, U.Baruah, S.K.Singh and D.Sarkar

12. **Soil based plant nutrient management plan for agro-ecosystems of Kerala**

    K.M. Nair, S. Thayalan, S.C. Ramesh Kumar, V. Ramamurthy, K.S. Anil Kumar, S. Srinivas, P. Chandran, L.G.K. Naidu and Dipak Sarkar

13. **Soil fertility assessment and soil health monitoring in traditional Rubber growing areas of Kerala, Tamil Nadu and Karnataka**

    K. S. Anil Kumar, S. Thayalan, K.M.Nair, V. Ramamurthy, S.C. Ramesh Kumar and Sunil Maske

14. **Modeling impact of climate change on soil quality and land use in arid, semi-arid and sub-humid regions of Karnataka for agricultural sustainability (C-MMACS-CSIR)**

    V. Ramamurthy, K.M. Nair, L.G.K. Naidu and D. Sarkar

15. **Preparation of district wise contingency crop plan for Maharashtra and Madhya Pradesh**

    D.K. Mandal, S.N. Goswami, C. Mandal, Jagdish Prasad, M.S.S. Nagaraju and J. D. Giri

16. **Assessment of salt-affected soils of Tamil Nadu and its impact on crop productivity**

    A Natarajan, Lalitha, M., S. Dharumarjuan, R. Vasundhara and L.G.K. Naidu

17. **Fallow lands of Tamil Nadu - – causes, effects and measures to arresting the march of fallows**

    S. Dharumarajan, M. Lalitha, R.Vasundhara, A Natrajan and L.G.K. Naidu

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

    V. Ramamurthy, L.G.K. Naidu, K.M. Nair, S.C. Ramesh Kumar and Chandrakala

Externally Funded Projects: Completed

1. **Assessment of quality and resilience of soils in diverse agro-ecosystems (NAIP)**

   T. Bhattacharyya, **D. Sarkar,** P. Chandran, S.K. Ray and C. Mandal

2. **Nutrient Indexing and soil fertility assessment of Kole lands**

   K.M. Nair, K.S. Anil Kumar, S. Srinivas, L.G.K. Naidu and Dipak Sarkar

3. **Soil and land capability map for land use planning of Dzongu farm, North Sikkim district, Sikkim**

   S.K. Reza, Utpal Baruah and Dipak Dutta

4. **Changes in soil carbon reserves as influenced by different ecosystems and land use in India (ICAR Network project on Climate Change)**

   T. Bhattacharyya, P. Chandran, M.V. Venugopalan, S.K. Ray, C. Mandal, D. Sarkar and P. Tiwary

Appendix 2

Distinguished Visitors

Headquarters, Nagpur

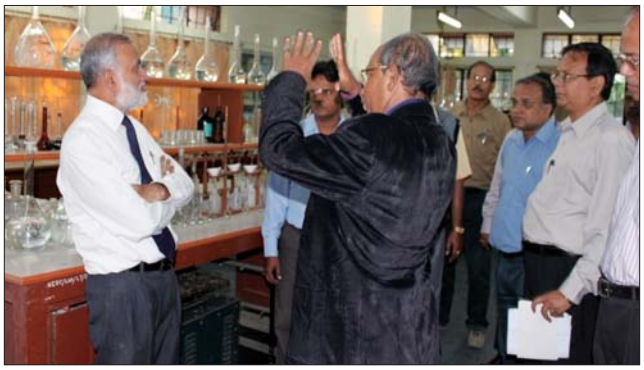
- Dr. H.A. Kwajaffa, Chairman, and Dr. Touba Bediwgar, Member National Cotton Association, Nigeria alongwith their Team on 2nd November 2012.

Dr. Dipak Sarkar, Director interacting with members of National Cotton Association, Nigeria

- Prof. S.K. Sanyal, Vice Chancellor, BCKV, Mohanpur, West Bengal and Chairman QRT, NBSS&LUP
- Dr. M. Velayutham, Chairman, RAC, NBSS&LUP
- Prof. M.S. Kuhad, EX Registrar, HAU, Hisar and Member, QRT, NBSS&LUP
- Dr. A.N. Singh, Member, QRT, NBSS&LUP
- Dr. C.J. Thampi, Ex Head, Regional Centre, NBSS& LUP, Kolkata and Member, QRT, NBSS&LUP
- Dr. S.M. Virmani
- Prof. Sanjay K. Dwivedi, IGKV, Raipur alongwith 26 students of B.Sc. (Ag.), final year.
- Library Science students (Post Graduate) of Department of Library & Information Science, RTM Nagpur University, Nagpur visited the library for their project work.

Regional Centre, Jorhat

- **Dr. S. Ayyappan, the Hon'ble Director General, ICAR and Secretary, DARE, Govt. of India** on 11th November 2012.



Visit of Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR interacting with Director Dr. Dipak Sarkar and scientists at Regional Centre, Jorhat

- Dr. A.K. Gogoi, Zonal Project Director, Zone-III, ICAR Research Complex, Barapani
- Prof. M.S. Kuhad, Chairman, QRT team visited on 21.07.2012.
- Dr. A.N. Singh, Member, QRT team on 21.07.2012.
- Dr. C. J. Thampi Member, QRT team on 21.07.2012.
- Dr. T. Lotha, Deputy Director, Directorate of Soil Conservation, Govt. of Nagaland
- Dr. S. Chetri, Joint Director, Directorate of Soil Conservation, Govt. of Nagaland.
- Dr. K.M. Bujarbaruah, the Vice Chancellor, AAU visited on 04th April 2012.
- Dr. A.K. Gogoi, Zonal Project Director, Zone-III, ICAR Research Complex, Barapani visited on 11.11.2012.

Regional Centre, Bangalore

- 35 B. Tech third year students and teachers of UAS, Bangalore on 21st May 2012
- 54 B.Sc (Agri.) students and teachers of Agricultural College, Kasargod, Kerala on 6th March 2012
- Dr. Jay Anand, Scientist, M.S. Swaminathan Research Foundation, Chennai on June 2012
- 11 Land development officers from different countries visited Regional Centre on 3rd August 2012
- Visit of NIRD trainees to NBSS&LUP, Regional Centre, Bangalore on August 2012
- Sujala Project Team comprising 15 scientists to the regional centre on 21st September 2012

Visit of NIRD trainees to Regional Centre, Bangalore, August 2012

ToR (Sujala-3) meeting held at Regional Centre, Bangalore

Students from Sudarshana Vidyamandir School Jayanagar, Bangalore visited Regional Centre, Bangalore

- 45 B.Sc (Agri.) final year students of Agriculture College, Ranchi, Birsa Munda University, Ranchi, Jharkhand and three faculty members in September 2012
- Mr. M.S. Goudar, IFS, Commissioner, Karnataka State watershed Development Department on 8th October 2012.
- Dr. Shekar Muddu, Associate Professor (Civil Engineering), Indian Institute of Science, Bangalore on 5th January 2013.
- Mr. Vishvanath Hotagi, IFS, Conservator of Forests, Govt. of Madhya Pradesh on 2nd January 2013.
- Mr. R. M. Patil, Ex Minister, Karnataka & Chairman, BIRD KVK, Belgaum on 23rd January 2013.
- Dr. H. Venkatesh, Senior Manger (R&D), De-V-Gen, Seed Company Hydrabad on 5th January 2013.
- Dr. P. K. Mishra, Director, CSWRTI (ICAR), Dehradun on 23rd January2013.
- 34 Students (M.Sc & Ph.D) and 3 faculty members (Natural Resources Management and Environmental Sciences) of Doon University, Dehradun on 22nd January 2013.
- 43 B.Sc. (Agri.) students and 3 teachers from Kerala Agricultural University on 5th March 2013.
- 40 students (10th Std.) and teachers from Sudarshana Vidyamandir School Jayanagar Bangalore on 21st March 2013.
- Dr S.G. Patil, Dean Education, UAS, Raichur on 12th February 2013.

Regional Centre, Kolkata

- Professor William Horwath, Department of Land, Air and Water Resources, University of California, Davies, USA.
- Prof. Sukumar Aditya, (Retd.) Prof. of Applied Chemistry, Calcutta University
- Dr. S.K. Ghosh, Past President of CMSI
- Prof. K.V. Raman, Former President, CMSI and Former Member, ASRB, New Delhi
- Prof. S.K. Sanyal, Chairman, QRT, NBSS & LUP (ICAR), Dr. M.S. Kuhad. Former Registrar, Haryana Agricultural University, Hisar, Haryana and Member, QRT, Dr. A.N. Singh, Former Director, UPRSAC, Lucknow, Uttar Pradesh and Member, QRT, and Dr. C. J. Thampi, Former Head, NBSS&LUP, Regional Centre Kolkata, Former Commissioner Land Use Board, Kerala and Member, QRT
- Dr. J. Krishnamurthy, Member Secretary, NNRMS SC-T
- Dy. Director (US & U), EOS, ISRO, Deptt. of Space, GOI, Bangalore
- Mr. P.K. Pujari, Addl. Secretary & FA, ICAR, New Delhi
- Mr. Devendra Kumar, Director (Finance), ICAR; New Delhi
- Mr. G.P. Sharma, Dy. Director (Finance), ICAR, New Delhi
- Mrs. Rashmi Rao, Dy.Director (Finance), ICAR; New Delhi
- Mr. S.K. Pathak, Dy. Director (Finance), ICAR; New Delhi
- Dr. D.K. Pal, Ex-Principal Scientist, NBSS & LUP, Nagpur
- Dr. M.S. Kuhad. Former Registrar, Haryana Agricultural University, Hissar, Haryana and Member, QRT, NBSS & LUP (ICAR)
- Dr. A.N. Singh, Former Director, UPRSAC, Lucknow, Uttar Pradesh and Member, QRT, NBSS & LUP (ICAR)

Regional Centre, Udaipur

- Prof. S.K. Sanyal,Vice Chancellor, BCKV, Kalyani, W.B. and Chairman, QRT, NBSS & LUP (ICAR)
- Dr. M.S. Kuhad. Former Registrar, Haryana Agricultural University, Hissar, Haryana and Member, QRT, NBSS & LUP (ICAR)
- Dr. A.N. Singh, Former Director, UPRSAC, Lucknow, Uttar Pradesh and Member, QRT, NBSS & LUP (ICAR)
- Dr. C. J. Thampi, Former Head, NBSS&LUP, Regional Centre Kolkata, Former Commissioner Land Use Board, Kerala and Member, QRT, NBSS & LUP (ICAR)

Appendix 3

Important Committees

Institute Research Committee (IRC)

1.	Dr. Dipak Sarkar, Director	:	Chairman
2.	Heads of Divisions/Regional Centres	:	Members
3.	All Principal Investigators	:	Members
4.	Dr. P. Chandran, Principal Scientist & In-charge, PME Cell	:	Member
5.	Dr. T. Bhattacharyya, Pr. Scientist and Head, Div. of SRS	:	Member Secretary

Research Advisory Committee (RAC)

1.	Dr. M. Velayutham	:	Chairman
2.	Prof. S.C. Mukhopadhyay	:	Member
3.	Dr. U.C. Sharma	:	Member
4.	Dr. T. Ravishankar	:	Member
5.	Dr. S.S. Magar	:	Member
6.	Dr. T. Bhattacharyya, Pr. Scientist and Head, Div. of SRS	:	Member Secretary

Institute Management Committee (IMC)

1.	Dr. Dipak Sarkar, Director	:	Chairman
2.	Dr. Rajeev Srivastava, Pr. Scientist & Head, Division of RSA	:	Member
3.	Dr. V. Ramamurthy, Pr. Scientist, Regional Centre, Bangalore	:	Member
4.	Dr. M.V. Venugopalan, Pr. Scientist, CICR, Nagpur	:	Member
5.	Dr. A.K. Biswas, Pr. Scientist & Head, Soil Chemistry, IISS, Bhopal	:	Member
6.	Shri B.D. Phansal, Chief Administrative Officer	:	Member Secretary

Quinquennial Review Team (QRT) (2007-2012)

1.	Dr. S.K. Sanyal	:	Chairman
2.	Dr. C.J. Thampi	:	Member
3.	Dr. A.N. Singh	:	Member
4.	Dr. M.S. Kuhad	:	Member
5.	Dr. P. Chandran	:	Member Secretary

Project Monitoring and Evaluation Committee (PMC)

1.	Dr. Dipak Sarkar	:	Chairman
2.	Dr. Rajeev Srivastava	:	Member
3.	Dr. T. Bhattacharyya	:	Member
4.	Dr. Mrs. C. Mandal	:	Member
5.	Dr. T.K. Sen	:	Member
6.	Dr. G.P. Obi Reddy	:	Member
7.	Dr. P. Chandran	:	Member Secretary

Appendix 4

Lectures Delivered by Scientists

Name and designation of the Scientist	Topic	Date and Venue
Dr. Dipak Sarkar, Director, NBSS&LUP (ICAR), Nagpur	"Land Use Planning / Modeling – Possibilities for Sugarcane in India" in connection with Indo – Brazilian Cooperation Workshop in Bio-energy	Sao Paulo, Brazil during 18–21 April 2012
	"Site Specific Nutrient Management (SSNM), – An Unique Approach towards Managing Soil Fertility" in connection with Workshop on Soil Fertility Management	Kerala State Planning Board, at Mascot Hotel, Thiruvananthapuram during 24th & 25th May 2012
	"Land Resource Inventory for Land Use Planning" in connection with training programme entitled Application of Remote Sensing and GIS for Watershed Management under TSP Plan	Bhubaneswar, Odisha during 25.07.2012 to 08.08.2012 in collaboration with the Odisha Watershed Development Mission, Bhubaneswar.
	30th Prof. J.N. Mukherjee ISSS - Foundation Lecture on "21st Century Challenges and Opportunities of Pedological Research Towards Land Resource Management For Sustained Agriculture" in connection with 30th Prof. J.N. Mukherjee ISSS - Foundation Lecture	77th Annual Convention of the ISSS, 5-8 December, 2012 , PAU, Ludhiana, Punjab.
	Plenary Lecture on "Managing Degraded Lands in India towards Ensuring Food Security –The Greatest Challenge of 21st Century"	First International Conference on "Bio-resource and Stress Management". During 6-9th Feb. 2013, Science City, Kolkata
Dr. R.S. Singh, Principal Scientist & Head, Regional Centre, Udaipur	High Science tools in watershed plan (introduction to remote sensing and GIS), presented in one day training programme on *Planning and design of engineering structures in watershed management* programme for 25th middle level official engaged in implementing IWMP.	22nd May 2012, CSWCR&TI Research Centre, Kota

Dr. B.L. Tailor, Technical Officer, Regional Centre, Udaipur	Watershed characterization and practical on remote sensing &GIS, in One day training programme on *Planning and design of engineering structures in watershed management* programme for 25th middle level official engaged in implementing IWMP.	22nd May 2012 CSWCR&TI, Research Centre, Kota
Dr. C.S. Walia, Principal Scientist Regional Centre, Delhi	Remote Sensing Applications for Soil Mapping, Faculty and students of GIS, Centre of Excellence for NRDMI.	5th June 2012 Kumaun University, NT Campus, Almora
	'Soil resource mapping using remote sensing data' during short course training on "*Sustainable Management for Ecological Agriculture*" under CAFT.	22nd October 2012, PAU, Ludhiana
Dr. V. Ramamurthy, Principal Scientist Regional Centre, Bangalore	Tribal Sub Plan (TSP) activities of the institute.	23rd August 2013, NBSS&LUP, Nagpur Foundation day celebration
Dr. T. Bhattacharyya Principal Scientist & Head, Division of Soil Resource Studies	Project report on "Predicting soil carbon changes under different cropping systems in soils of selected benchmark spots in different bioclimatic systems in India"	19-20th July, 2012 of DST-IS-STAC at Andhra University, Vishakhapatnam, A.P.
	"Carbon stock in Indian soils and its usefulness for prioritisation for carbon sequestration"	13th September, 2012 IISS, Bhopal on the occasion of Model Training Course (MTC)
	"Estimation of Carbon Stock and its Changes in Indian Soils"	20th September, 2012, Dr. PDKV, Akola
	"Estimation and measurement soil carbon stock"	7th November, 2012, in Amity University, Noida, Uttar Pradesh
	Hi-tech intervention in citriculture on "Carbon sequestration, carbon modelling and carbon trading under annual versus perennial crop production"	May 7-27, 2012 NRCC, Nagpur under ICAR sponsored summer school
Dr. Rajendra Hegde Principal Scientist Regional Centre, Bangalore	"Essentiality of detailed land resources database for all the land based rural development programs" during the ICAR Winter school on Integrated Farming Systems"	13th December 2012, UAS, Raichur
Dr. Jagdish Prasad, Principal Scientist, Division of Soil Resource Studies	Awareness of Natural Resources for Sustainable Development, to officials of Haryana Agricultural Management and Extension Training Institute.	25th June 2012, HAMETI, Haryana
	"Watershed development for sustainable production of citrus", presented for training programme on *Integrated Crop Production and Post-Harvest Management in Citrus* during 8-15 January, 2013.	10th January 2013, NRCC, Nagpur
	Concept and methodology in soil survey" to 4th March, 2013), held at NBSS&LUP	18th February, 2013 to the training officials of Remote

		Sensing and GIS Applications in Natural Resource Management (12th February to 4th March, 2013) NBSS&LUP, Nagpur
Dr. Arun Chaturvedi Principal Scientist and Head, Division of Land Use Planning	Report of NAIP sub-project "Efficient Land Use Based Integrated Farming System for Rural Livelihood Security in Aurangabad, Dhule & Gondia Districts of Maharashtra".	June 5th - 6th 2012, CIRCOT, Mumbai.
	Report of NAIP sub-project "Efficient Land Use Based Integrated Farming System for Rural Livelihood Security in Aurangabad, Dhule & Gondia Districts of Maharashtra".	15th -16th March 2013 Annual Review Workshop at BHU, Varanasi
Dr. P. Chandran Principal Scientist, Division of Soil Resource Studies	Concepts for developing Soil Information System in SOTER	NNRMS sponsored training "Remote Sensing and GIS Applications in Natural Resource Management during 12th February to 4th March, 2013), held at NBSS&LUP, Nagpur
Dr. S. K. Singh, Principal Scientist and Head, Regional Centre, Kolkata	Soil Fertility Mapping: Needs and Utility	Fertilizer Association of India during 5th – 7th April 2012, Odisha University of Agriculture and Technology (OUAT) Bhubaneswar
	Livelihood and Environmental Security through Resource Conservation in Eastern Region of India (LESRC-2012)	Patna on 24th November, 2012
	Soil Nutrient balance in the state of West Bengal	NBSS & LUP (ICAR), Nagpur on 24th August, 2012.
	"GPS and GIS based Nutrient Mapping of West Bengal" in the Golden Jubilee Seminar on "Advances in Agricultural Research towards Food Security and Environmental Sustenance"	Palli Shiksha Bhavan, Viswa Bharati, Sriniketan on 2nd September 2012.
Dr. G.P.Obi Reddy, Senior Scientist and Incharge, GIS Section	'Application of Remote Sensing in Land Resource Management' TSP sponsored training programme on "Application of Remote Sensing and GIS in Land Resource Inventory towards Land Use Planning"	NBSS&LUP, Regional Center Jorhat at Aizwal, Mizoram on 15th February, 2013.
	'*GPS and its use in Natural Resource studies*' in TSP sponsored training programme on "Application of Remote Sensing and GIS in Land Resource Inventory towards Land Use Planning"	NBSS&LUP, Regional Center Jorhat at Aizwal, Mizoram on 16th February, 2013.
	"Design of spatial database and its management"	NNRMS (ISRO) sponsored training programme Division of Remote Sensing Applications, NBSS&LUP, Nagpur from 12th February to 4th March, 2013

	"Spatial Interpolation Techniques for Interactive Mapping"	NNRMS sponsored training programme on "RS and GIS applications in Natural Resource Management" at Regional Centre, NBSS&LUP, Kolkata on 1st December, 2012.
	'Advances in spatial database management in GIS'	NNRMS sponsored training programme on "RS and GIS applications in Natural Resource Management" at Regional Centre, NBSS&LUP, Kolkata on 30th November 2012.
	"Remote Sensing and GIS in assessment of spatio-temporal variability of land use systems" in NAIP sponsored training program on "Forecast modeling in crops using weather and Geoinformatics"	IASRI, New Delhi on 30th August, 2012.
	"Geospatial applications in land resource management and land use systems analysis" in ICAR sponsored Summer School	IASRI, New Delhi on 26th July, 2012.
Shri Nirmal Kumar, Scientist, GIS Section	'Introduction to GIS' in NNRMS (ISRO) sponsored training programme	Division of Remote Sensing Applications, NBSS&LUP, Nagpur from 12th February to 4th March, 2013
	'*Introduction to Microwave remote Sensing*' in NNRMS (ISRO) sponsored training programme	
	'Remote sensing applications in land use land cover classification'	
	'Digital terrain analysis'	
Shri Nirmal Kumar and Obi Reddy, G.P	"An introduction to GIS and its applications in natural resource management"	NNRMS (ISRO) sponsored training programme NBSS&LUP, Regional Center, New Delhi on 17th January, 2013.

Appendix 5

Personnel (Managerial Position) (as on 31.03.2013)

DR. DIPAK SARKAR
DIRECTOR

Dr. Rajeev Srivastava Principal Scientist (Pedology) and Head	:	*Division of Remote Sensing Applications*
Dr. T. Bhattacharyya Principal Scientist (Pedology) and Head	:	*Division of Soil Resource Studies*
Dr. T.K. Sen Principal Scientist (Pedology) and In-charge Head upto 23.11.2012 (F/N) **Dr. A. Chaturvedi** Principal Scientist (Geography) and Head w.e.f. 23.11.2012 (A/N)	:	*Division of Land Use Planning*
Dr. L.G.K. Naidu Principal Scientist (Pedology) and Head	:	*Regional Centre, Bangalore*
Dr. G.S. Sidhu Principal Scientist (Pedology) and Head	:	*Regional Centre, Delhi*
Dr. Utpal Baruah Principal Scientist (Geography) and Head	:	*Regional Centre, Jorhat*
Dr. S.K. Singh Principal Scientist (Pedology) and Head	:	*Regional Centre, Kolkata*
Dr. R.S. Singh Principal Scientist (Pedology) and Head	:	*Regional Centre, Udaipur*
Dr. (Mrs) C. Mandal Principal Scientist (Geography) and In-charge	:	*Cartography Unit*
Dr. G.P. Obi Reddy Senior Scientist and In-charge	:	*Geographical Information System Unit (GIS)*
Dr. P. Chandran Principal Scientist (Pedology) and In-charge	:	*Prioritization, Monitoring and Evaluation (PME) Cell*
Dr. (Mrs.) Jiji Cyriac Technical Officer (T-6) and In-charge	:	*Library and Documentation Unit*
Dr. N.C. Khandare Technical Officer (T-9) and In-charge	:	*Sale and Publication Unit*
Sh. S.K. Arora Printing Officer (T-9) and In-charge	:	*Printing Section*
Sh. Suresh Kumar Chief Administrative Officer upto 01.08.2012 **Sh. B.D. Phansal** Chief Administrative Officer from 02.08.2012	:	*Administration*
Sh. O.P. Nagar Senior Finance and Accounts Officer upto 21.08.2012 **Sh. G.C. Prasad** Senior Finance and Accounts Officer w.e.f. 21.08.2012 (F/N)	:	*Finance and Accounts*
Mrs. Bhanu Narayanan Administrative Officer	:	Administration

Appendix
6

Staff related general information

Visits Abroad

Second Workshop under Indo-Brazilian Cooperation in Bio-energy by Govt. of Brazil

Dr. Dipak Sarkar, Director participated in the Second Workshop under Indo-Brazilian Cooperation in Bio-energy as a member of Indian Delegation held during 18-20 April 2012 at FEQ-UNICAMP auditorium, Sao Paulo, Brazil presented a paper entitled "Land Use Planning/Modelling Possibilities for Sugarcane in India".

International workshop at the Joint Research Centre of the European Commission - JRC in Ispra (Varese), Italy during March 18-22, 2013

Dr. T. Bhattacharyya, Principal Scientist and Head, Division of Soil Resource Studies participated in International workshop at the Joint Research Centre of the European Commission - JRC in Ispra (Varese), Italy

New entrants /Promotions

- Dr. Lalitha, Scientist joined Regional centre, Bangalore on 14th May 2012 after her training at NARM, Hyderabad
- Dr. Shelton Padua, Scientist joined in the Regional Centre on 1st June 2012.
- Sh. Sumit Sindhu, Assistant joined on 14th September 2012 at Regional Centre Delhi.
- Ms. Bedantika Dutta joined as Assistant on 6th October 2012 in NBSS & LUP, Regional Centre, Kolkata .
- Miss Nisha Sahu, Scientist joined at GIS Section, NBSS&LUP, Nagpur on 9th November, 2012.
- Dr. S. Ramachandran, Scientist joined in the Regional Centre on 10th December 2012.
- Dr. Tarsem Lal promoted to Principal Scientist with effect from 27th July1998.
- Sh. K.M. Pal, promoted to the next higher grade, Technical Officer (T-7-8) with effect from 1st January 2010.
- Sh. K.K. Bhardwaj, promoted to the next grade Technical Officer (T-5) with effect from 3rd February 2012.
- Sh. D.B. Thombre, Skilled Supporting Staff promoted to the next financial upgradation Rs. 2400/- (MACPS) with effect from 7th April 2012.
- Sh D.B. Thombre, Skilled Supporting Staff transferred from Regional Centre Delhi to NBSS&LUP, Nagpur with effect from 8th February 2013
- Dr. S.K. Reza promoted to Scientist (Senior Scale) on 12th June 2012.
- Sh. Vas Dev promoted to the next grade, Field Asstt (T-1-3) with effect from 19th August 2012.
- Mr. M. Das promoted to PA on 06th December 2012.
- Mr. B.V. Gogoi promoted to AAO on 09th November 2012.

- Mr. P. K. Das promoted to Assistant on 26th March 2013
- Mr. D.P. Dutta promoted to T-6 w.e.f. 31st March 2013.
- Dr. T.P. Verma Scientist (Sr. Scale) promoted to Sr. Scientist w.e.f. 6th August 2003
- Dr. S.S. Rao Sr. Scientist promoted to Principal Scientist w.e.f. 1st January 2009.
- Sh. Devi Lal Oad, T-3 promoted to T-4 w.e.f. 13th June 2011.
- Sh. Naola Ram Ola, T-4 promoted to T-5 w.e.f. 14th June 2011

Transfers

- Dr. R.P. Sharma, Scientist joined Regional Centre, Udaipur on 9th April 2012 on transfer from Indian Institute of Vegetables Research (IIVR), Varanasi.
- Mr. Bheem Raj Meena Driver (T-I-3) transferred from Regional Centre, Udaipur to Regional Centre, Bangalore on 1st June 2012.
- Mr. Sohan Lal Sharma, Field Asstt. (T-1) joined on 20th June 2012 on transfer from Regional Centre, Kolkata to Regional Centre, Udaipur.
- Smt. Girija Rangari, AAO was transferred from Regional Centre NBSS&LUP, Udaipur to HQ, NBSS&LUP, Nagpur on 18th August 2012.
- Mr. Jitendra Singh Rao, T-1 joined on 5th September 2012 on transfer from Regional Centre, NBSS&LUP, Jorhat to Regional Centre, Udaipur.
- Mrs. Malathi Bommidi, Scientist, GIS Section, NBSS&LUP, Nagpur got transferred to ZPD-V, Hyderabad on 6th December, 2012.

Staff Retirement on Superannuation

- Sh. Amarjit Singh, Technical Officer (T-5) retired on superannuation on 30th April 2012 from Regional Centre Delhi.
- Sh. Binoy Kumar Saha, Personal Assistant, Sh. B.N. Bag, Driver (T-5) retired on superannuation.
- Sh. Mrinal Naskar, SSS retired on superannuation

Deceased

- Sh. Ramaji Giri, Driver (T-2) expired on 29/07/2012 at Regional Centre Delhi

Appendix 7

RFD – Related Information

Annual (April 1, 2012 to March 31, 2013) Performance Evaluation Report in respect of RFD 2012-2013 of RSCs i.e. Institutes

Name of the Division : Natural Resource Management Division
Name of the Institution : National Bureau of Soil Survey and Land Use Planning (ICAR), Nagpur
RFD Nodal Officer : Dr. T. K. Sen, Principal Scientist

Sr. No.	Objective(s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target / Criteria Value					Achievements	Performance		Per cent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw Score	Weighted Score		
1.	Soil resource inventorisation at different scales	25	Soil survey and mapping	Soil resource maps at different levels developed	No.	25	5	4	3	2	1	5	100	25	125.0	-
2.	Optimization of land use	20	Land use planning	District level land use plans developed	No.	20	2	1	-	-	-	2	100	20	200.0	-
3.	Human resource development	13	Capacity building	Trainings/ workshops conducted	No.	8	4	3	2	1	-	4	100	8	133.3	-
				Students awarded degree (in a collaborative programme with Dr. PDKV, Akola)		5	4	3	2	1	-	4	100	5	133.3	-
4.	Identification and establishment of Benchmarks soil series	12	Soil correlation	Benchmark soil series Identified and established	No.	12	10	9	8	7	6	9	90	10.8	100.0	The final meeting of the correlation committee for identification and establishment of the remaining 1 soil seriescould not be held.

cont....

5.	Assessing soil fertility	10	Soil nutrient mapping	Soil nutrient maps at different levels developed	No.	10	15	14	12	11	9	15	100	10	107.1	-
6.	Organisation, cataloguing and creation of datasets on soils in GIS environment	8	Georeferencing of soil observation sites (points)	Georeferenced soil observation sites (points) of Black Soil Region	No.	4	417	375	333	292	250	417	100	4	111.2	-
				Georeferenced soil observation sites (points) of Indo-Gangetic plain	No.	4	425	382	340	298	255	425	100	4	111.2	-
7.	Efficient Functioning of the RFD System	3%	Timely submission of RFD for 2012-13	On-time submission	Date	2%	Mar. 23 2012	Mar. 26 2012	Mar. 27 2012	-	-	Feb. 03, 2012	100	2	100.0	-
			Timely submission of Results for 2012-13	On-time submission	Date	1%	May 1 2013	May 2 2013	May 3 2013	-	-	April 20, 2012	100	1	100.0	-
8.	Administrative Reforms	5%	Implement ISO 9001	Prepare ISO 9001 action plan	Date	1%	May 1 2013	May 2 2013	May 3 2013	-	-	May 30, 2012	100	1	100.0	-
				Implementation of ISO 9001 action plan	Date	2%	Mar. 25 2013	Mar. 26 2013	Mar. 27 2013	-	-	-	-	-	-	ISO 9001 could not be implemented due to delayed initiation in processing and subsequent delay in receiving quotations from bidders on expression of interest.
			Implement mitigating strategies for reducing potential risk of corruption	% of implementation	%	2%	100	95	90	-	-	109	100	2	114.7	-
9.	Improving Internal Efficiency / responsiveness / service delivery of Ministry / Department	4%	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2%	100	95	90	-	-	100	100	2	105.3	The excess achievement was due to more frequent implementation of some of the mitigating strategy.
				Independent Audit of implementation of public grievance redressal system	%	2%	100	95	90	-	-	100	100	2	105.3	-

Total Composite Score: 96.8

Procedure for computing the Weighted and Composite Score

1. Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score / 100
2. Total Composite Score = Sum of Weighted Scores of all the Success Indicators

- + Soil Series of Chhatisgarh State, NBSS Publ.85, 2001.
- + Soil Resource Atlas of Betul District (M.P.), NBSS Publ.86, 2001.
- + Soil Based Agro-Technology Transfer in Sukli (Distt. Nagpur), NBSS Publ.87, 2001.
- + Soils of Hugli District for Optimising Land Use, NBSS Publ.88, 2001.
- + Soil Series of West Bengal, NBSS Publ.89, 2001.
- + Soil Resource Atlas of Dhar Dist. (M.P.), NBSS Publ.90, 2001, 100p, ISBN:81-85460-68X.
- # Soil Series of Himachal Pradesh, NBSS Publ.91, ISBN: 81-85460-69-8.
- + Soil Series of Goa, NBSS Publ.92, ISBN:81-85460-70-1.
- + Soil Resource Atlas of Ratlam Distt. (M.P.), NBSS Publ.93.
- + Soils of India, (1:1 M Scale, 11 Sheets Maps) NBSS Publ.94, ISBN:81-85460-72-8.
- + Soil Resource Atlas of Bilaspur Distt. (Chhattisgarh), NBSS Publ.95. ISBN:81-85460-73-6.
- + Soil Series of Rajasthan, NBSS Publ.96. ISBN:81-85460-75-2.
- + Soil Erosion of Tripura: A model for soil conservation and crop performance, NBSS Publ.97. ISBN:81-85460-76-0.
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- + Soil Resource atlas of Jorhat Distt. (Assam). NBSS Publ.107. ISBN:81-85460-85-x
- + Salt affected soils, Etah Distt. (UP). NBSS Publ.108.ISBN:81-85460-86-8
- + Soil series of Nagaland. NBSS Publ.109.ISBN:81-85460-87-6
- # Soil Resource Information & land use planning of Chhattisgarh. NBSS Publ. 110. ISBN:81-85460-88-4
- + Soil Series of Tripura. NBBS Publ. 111.ISBN:81-85460-89-2
- + Soil Series of Delhi. NBSS Publ. 112.ISBN:81-85460-91-4
- + Land use planning of Udaipur distt. Soil resource & agro-ecological assessment. NBSS Publ. 113. ISBN:81-85460-92-2
- + Soil Erosion in Andhra Pradesh. NBSS Publ. 114.ISBN:81-85460-93-0
- # Economic land evaluation for sustainable land management of Rajanukunte watershed, Karnataka. NBSS Publ. 115. ISBN:81-85460-94-9
- + Soil resource atlas of Wardha distt. Maharashtra. NBSS Publ. 116. ISBN:81-85460-95-7
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  (For order, contact: M/s Kalyani Publishers, 1/1 Rajinder Nagar, Ludhiana-141 008.

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