National Bureau of Soil Survey and Land Use Planning

(Indian Council of Agricultural Research)

Amravati Road, Nagpur 440 033
Maharashtra, India

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Concept : Dr. Dipak Sarkar
Compilation and Editing : Dr. S. Chatterji
Dr.T. Bhattacharyya
Dr. T.K. Sen
Dr. P. Chandran
Dr. S.K. Ray
Dr. G.P. Obi Reddy
Ms. Pushpanjali

Word Processing : Shri D.K. Nandanwar
Ms. Wasudha Khandwe

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डा. एस. अय्यप्पन
सचिव एवं महानिदेशक
Dr. S. AYYAPPAN
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 114

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 114
Tel: 23382629, 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

FOREWORD

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

The mounting demographic pressure on land is leading to degradation of land resources threatening food, livelihood and environmental security of the country. The problem is getting compounded further because of diversion of prime agricultural lands to industrial and urban sectors. Concerns in soil resource conservation, soil pollution and land degradation have compelled us to rethink with particular reference to increased demands for lands. This suggests that surveys and monitoring of soil resources has to be carried out henceforth with more specific purposes. National Bureau of Soil Survey & Land Use Planning (NBSS&LUP), Nagpur has to develop cutting-edge technologies for resource mapping at watershed to regional level, resource information management in GIS framework and application of remote sensing technology in monitoring land use, land cover changes, degradation of resource base, and sophistication in data processing and analytical techniques relevant to land evaluation land use planning and monitoring of resources in changing scenario of climatic change.

It is expected that the analytical approach and forward looking concepts presented in the *'Vision 2030'* document will prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

(S. Ayyappan)

Dated the 30th June, 2011
New Delhi

Preface

It is with great pleasure that I am presenting the **Vision 2030** document of National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), that reflects the collective understanding, aspirations and determination of its staff to become world leaders in the field of Soil Survey and Land Use Planning.

In the earlier Vision documents of the NBSS & LUP, we gave a detailed account of what we shall do without really trying to ascertain what our stakeholders expect us to do. While preparing the **Vision 2030** document, sincere efforts were made in connecting our programmes to their needs and expectations. This was done through a participatory and consultative process that covered stakeholders from the jurisdiction of all the Regional Centres of the Bureau and that of the Headquarters. I am extremely pleased at the eagerness and commitment that was exhibited by the stakeholders during the consultative process.

The **Vision 2030** document articulates the strategies to overcome the challenges it would face in the next two decades in Soil Survey, Land Use Planning and allied work areas, and utilize the opportunities that would emerge in the form of new concepts, tools and techniques.

Despite the seemingly long time in which the **Vision 2030** will be implemented, its realisation will depend on the actions and measures that we undertake as a R **T** & D organization through adoption of viable strategies.

I thank Dr. S. Ayyappan, Secretary, DARE and Director-General, ICAR, for inspiring the Bureau to undertake this important task. My thanks are also due to Dr. A.K. Singh, Deputy Director General (NRM), ICAR, and Dr.P.S.Minhas, Assistant Director General (Soils), ICAR for providing much needed support during the preparation of the document. I would like to express my gratitude to the Chairman and members of the Research Advisory Committee of the Bureau for giving valuable inputs in preparing the document. I also take this opportunity to thank all the Heads of the Divisions and Regional Centres and I/C of different sections for providing valuable suggestions from time to time during the preparation of the document. I take this opportunity to put on record the genuine pains taken by the members of the Editorial Committee in preparing the document. The sincere involvement of the stakeholders during its preparation is also gratefully acknowledged.

Since the **Vision 2030** will serve as the guide for all research and development efforts, the commitment and dedication of my colleagues at the Bureau to its realization is of paramount importance. I, therefore, call upon them to rise to the occasion and take up the challenge of elevating the Bureau to serve the society and the nation with dedication.

30 June 2011 **(Dipak Sarkar)**

Nagpur Director

Preamble

The life sustaining ability of soil is recognized world over. The entire mankind owes its existence to soil but most unfortunately, it is the least cared, most neglected and misused natural resource. As a result, the soils are degrading faster than our imagination and certainly faster than ever before. Their functional capacity is declining too. Proper handling of this finite, non renewable resource is, therefore, of fundamental and paramount importance to a country's overall development. It thus becomes imperative that we manage our soils for their long term productivity, sustainability and health. But then, the soils are not the same everywhere. Their nature and extent vary too and information thereon is key to their optimum and sustainable use. Soil survey provides such information.

It is also known that there can be no fixed guidelines formulated for land use planning owing to the varied biophysical conditions and socio-economic set ups. Research in land use planning, hence, becomes all the more complex. The role of the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) in accomplishing these extremely important tasks thus becomes indispensible.

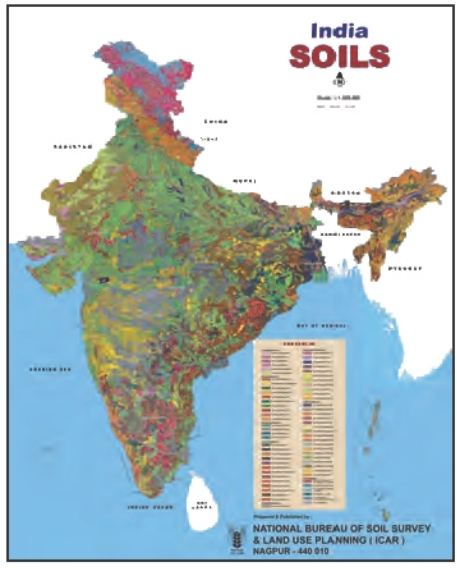
There has been genuine realisation that soil resources of the country are to confront serious challenges and threats in future. The challenges include, among others, shrinking land resources as a result of country's galloping population and their degradation, depleted nutrient stock, deterioration in their quality, changing climate and its impact on soils and land use, land use conversion and non-judicious planning for optimum and sustainable land use. Alongside, there will of course, opportunities emerging in the form of new concepts, tools and techniques.

Vision 2030 of the NBSS & LUP envisions the key challenges and opportunities in its Research Training & Development (RT&D) activities in the next two decades and articulates strategies that will be required to overcome the challenges and utilize the opportunities. The Bureau ensured enhanced participation of its stakeholders in developing the vision and is also committed to involving them while implementing the strategies and programmes to realise it.

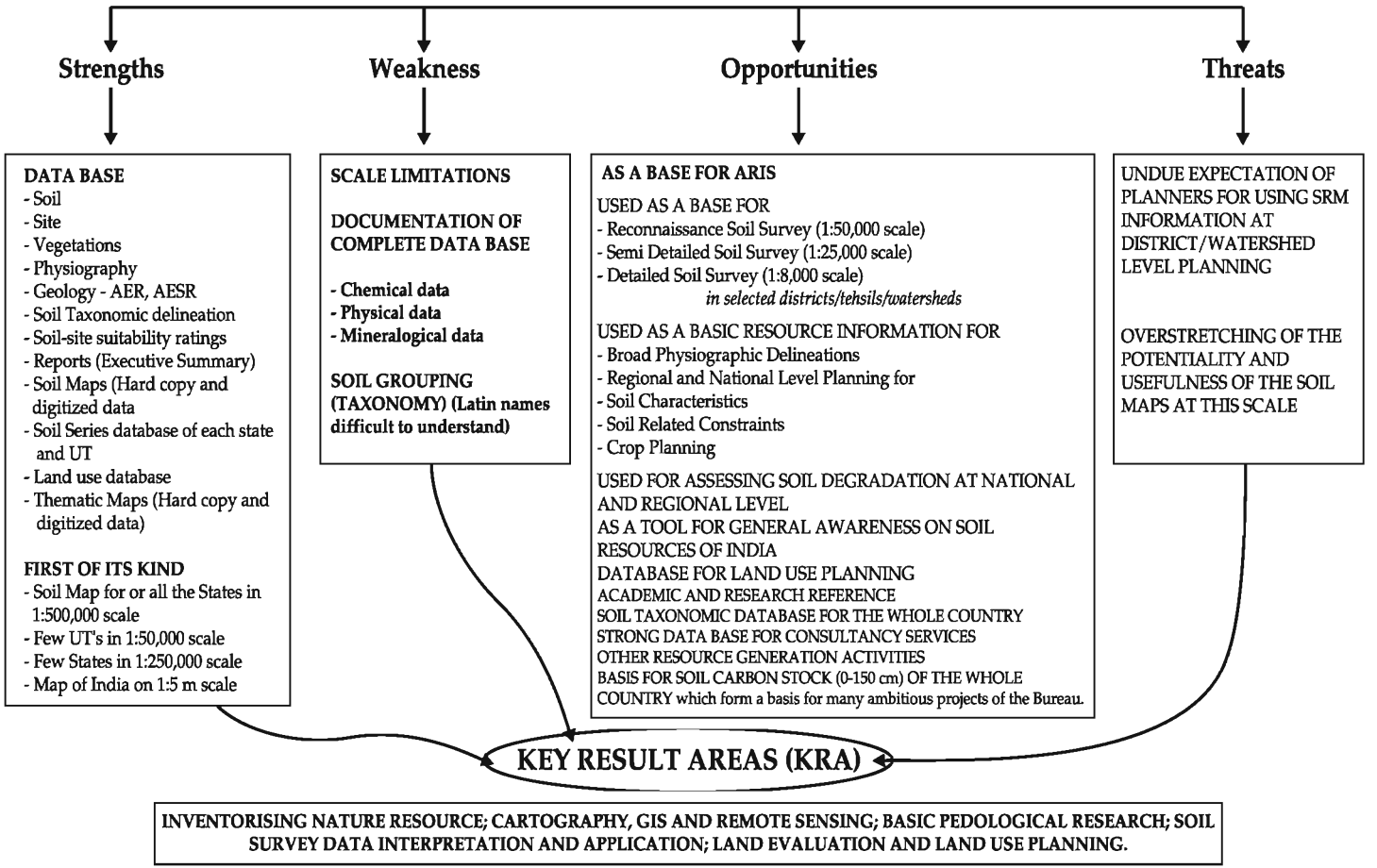
Contents

Soil Resource Inventorisation and Land Use Planning Scenario

No developmental plan in a country can be successful unless it is based on knowledge and understanding of the nature and extent of soils that is provided by soil resource inventorisation. The beginning of soil resource inventorisation in the country dates back to the second quarter of the 20th century when a few resource oriented surveys were carried out in the river valley projects in some parts of the country. Later, the Imperial (now Indian) Council of Agricultural Research sponsored the All India Soil Survey Scheme in 1943. This scheme examined and collated the available soil survey information and the related analytical data which could be suitably projected on the Soil Map of India. A soil map was prepared in 1943, portraying the different climatic types on the basis of N.S. quotients by adopting colour and texture as units of classification; these were correlated with four major climatic zones, namely, arid, semi-arid, humid and perhumid. Soil Survey received recognition as a **National Priority** in 1947. Later in 1954, the map of 1943 was revised by IARI, New Delhi (1" = 70 miles) with twenty broad soil classes, which underwent further revision in 1964 and 1970. Soil resource maps of different states and Union Territories of India were prepared by National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) (will hereafter be referred as 'Bureau'), affiliated to the Indian Council of Agricultural Research (ICAR) on 1 : 250,000 scale and generalized on 1 : 500,000 scale during the 90s'. A soil map of India was later compiled on 1 : 1 M scale (NBSS & LUP, 2002).



SWOT OF RESOURCE INVENTORY (1:250,000 scale)



INVENTORISING NATURE RESOURCE; CARTOGRAPHY, GIS AND REMOTE SENSING; BASIC PEDOLOGICAL RESEARCH; SOIL SURVEY DATA INTERPRETATION AND APPLICATION; LAND EVALUATION AND LAND USE PLANNING.

Land use planning activities undertaken during the 60s and 70s in the country largely concentrated on land capability classification in selected watersheds / command areas. It was in the 80s that crop specific soil suitability assessment was undertaken in a number of land use planning research projects. However, these efforts considered only the biophysical factors. It was not before 2001 that a mega project (World Bank aided) was undertaken on 'Land Use Planning for Management of Natural Resources' which involved integration of biophysical and socioeconomic information in developing various land use options for the selected operational units in different agro ecosystems of the country. Since then, a series of land use planning projects have been undertaken at various levels involving multicriteria approach of using biophysical factors, socioeconomic setups and environmental impact. Stakeholders' participation needs to be ensured during both, planning and implementation processes.

Soil survey is followed up by an important activity of 'Soil Correlation' undertaken to establish soil series. This activity needs the active involvement of various soil survey departments of the state governments and soil survey units of state agricultural universities. For land use plan implementation and also for finalizing land use policy, the services of different land use boards are made use of. Focused Research, Training and Development (RT&D) endeavors along with institutional framework and policy support will be required to match with the emerging scenario in soil resource inventorisation, land use planning and other allied RT & D activities of the Bureau.

Soil Resource Inventorisation

Soil resource inventorisation is the mandate of foremost importance. A SWOT analysis of such an important mandate becomes essential to give a proper shape and direction to all future resource inventory programmes (one such for 1:2,50,000scale is presented). Keeping in view the present need and emerging scenario, it needs to be re-oriented and be largely demand driven. For the inventorisation of soil resources to be holistic, it should be multi-faceted and multi-institutional. Increased use of sophisticated remote sensing techniques is needed to enhance the speed of inventorising soil resource, minimize the survey cost per unit area and also save manpower.

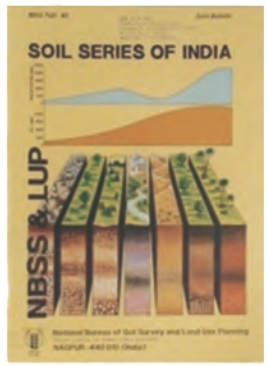
Detailed soil resource mapping of the arable areas of the country for farm level planning and diversified land use planning at village and watershed levels will have to be given top priority in next 1-2 decades. The future programmes in soil resource inventorisation will also focus on the priority districts of the country depending upon the proneness to drought, flooding and other natural calamities, socio-economic status of the districts, etc.; the

watersheds on 1:4000 to 1:15,000 scales, keeping in view the scenario of climate change and efficient utilization of soil and water to the maximum, degraded / potentially degraded areas and developing strategies for their rehabilitation and the villages in order to cater to the needs of the farmers on nutrient status and other parameters for better plant growth.

Remote Sensing and Geographical Information System (GIS) Applications

The Bureau started using satellite remote sensing data in soil mapping in 1986, with the availability of Landsat Imagery. Remote sensing techniques were used in satellite image interpretation for delineating physiographic units for preparing soil resource maps for different states of India and Union Territories. The use of remote sensing data in soil resource mapping got impetus with the availability of Indian Remote Sensing (IRS) satellites and Cartosat data products. The methodologies for mapping soils on 1: 50,000, 1: 25,000 and 1: 12,500 scales, using IRS 1 C LISS-III and PAN data were also developed. This was followed by the preparation of soil degradation map of the country (1 : 4M scale) by using Global Assessment of the Status of Human-induced Soil Degradation (GLASOD) methodology. The Bureau has been the pioneer in the country in the study of spectral reflectance properties of soils and creation of their spectral library.

The Bureau has emerged as a leading user of GIS in managing the soil resource data, an activity it first undertook in 1989. The GIS-aided analysis of spatial and non-spatial data generated through Soil Resource Mapping project was the first major activity. In course of time, GIS laboratory kept upgrading the hardware and software depending on the changing needs of the institute and developments in the GIS world. In the last two decades, many projects of regional and national importance that involved GIS applications were completed. They are, to name a few, Development of Indian National Agricultural Research Information System, Design and development of soil resource database (1:250,000 scale at state level), and harmonisation of data set on degraded and wastelands of the country.



Documentation of established soil series of the country

Soil Genesis Research

Research on genesis and transformation of minerals will continue to be a major basic research activity to get insight into the weathering stage of minerals formed under different agro-ecological regions and subregions of the country. The concepts developed will be useful to predict the transformation

of minerals in soils developed on different geomorphic surfaces and their nutrient supplying capability.

Soil Correlation and Agro-technology Transfer

Soil correlation undertaken to establish Benchmark soils in the country will continue to be a major activity. These Benchmark soils are important for carrying out research and transferring developed technologies to soils under similar agro-eco environment.

Taxonomy Rationale

Many of the differentiating criteria in Soil Taxonomy (USDA) are based on the moisture regimes, climatic conditions and soil characteristics of temperate regions. Many of these criteria do not fit well for the soils under tropical and subtropical regions. With the availability of vast knowledge base of Indian soils developed under varied agro climatic regions, efforts will continue to develop soil taxonomy rationale for the classification of Indian soils.

Database Management System

The Bureau has developed soil resource maps (at different scales) at country, state and district levels (for some districts). The available soil map information is not utilized to its optimum due to non-availability of digitized soil information system compatible with the users. Therefore, it is of necessary to collate all the available geo-referenced information in systematic order through developing of a Soil Information System, which can be retrieved, monitored, modified and used for different purposes.

The Bureau is currently engaged in developing database on soils, climate, land use in SOTER-GIS environment and linking the information in a map to prepare soil and other thematic maps. This baseline database can be utilized for understanding many other processes occurring in the soils and also for modelling purposes, soil quality research, soil carbon stock studies, etc. Efforts will be made to dovetail the existing and future soil resource information systems with traditional local names of the soils to facilitate their better utility at farmers' level.

Agroecological Regionalisation

The Bureau prepared a 20 Agro-ecological region (AER) map (Sehgal et al.,1992) and a 60 agro-ecological sub region (AESR) map (Velayutham et al., 1999) for regional land use planning. Currently, efforts are being made to refine the existing AESR map through the use of measured or Pedo-transfer

Functions (PTFs) -estimated values of Plant Available Water Capacity (PAWC) and saturated Hydraulic Conductivity (sHC) in LGP calculations.

Soil Quality vis-à-vis Pedology

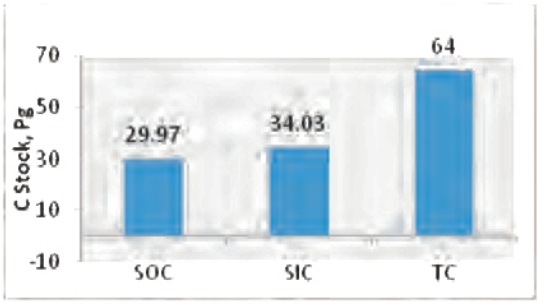
A soil may be of very high quality for one function and at the same time may perform very poorly for some other functions. Therefore, the quantification of its fitness is made difficult by the wide range of soil uses. Nevertheless, there is linkage between pedology and soil quality because genetic properties dictate the range in which a dynamic property occurs and undergoes changes due to diverse soil management practices. Therefore, efforts would be made to identify the key soil parameters as quality indices to understand the use potentials of the soils.

Soil Degradation

Of the total geographical area of 329 m ha, 121 m ha area (as per reconciled database) of ICAR-(ICAR-NAAS, 2010) NAAS, 2010 has been reported as suffering from different kinds (and extent) of degradation problems. Efforts will be undertaken on identifying soil categorywise (alluvial, red, black, etc.) area under degradation. Also, the Bureau has the responsibility to generate information on the area of arable land that has been degraded or converted to different non-agricultural uses.

Carbon Stock and its Sequestration

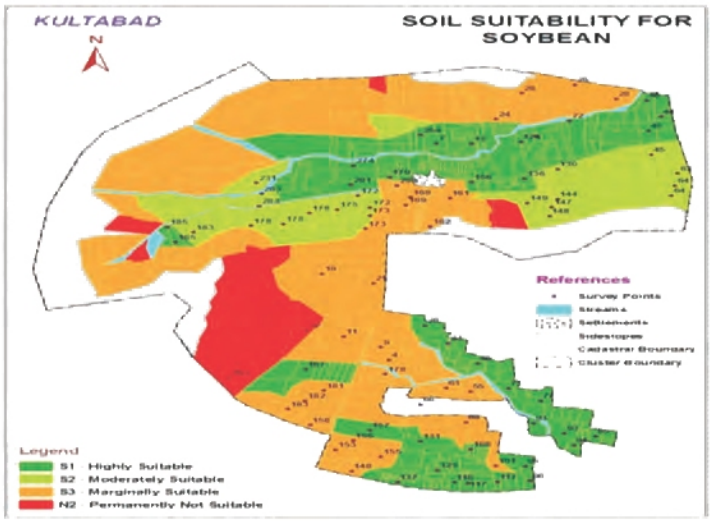
Soil organic carbon is an important parameter influencing quality of a soil. Estimation of soil carbon stock assumes particular significance in view of the growing concern of global warming and deterioration of soil quality. The total carbon stocks in Indian soils at 150 cm depth is up to 64 petagrams (1 pg = 10 to the power of 15 g) (Bhattacharyya et al., 2000) which is low and hence its sequestration is of immense importance. The Bureau is making efforts to identify various agricultural measures of C sequestration in soils. Research is also aimed at quantifying C-sequestration potential of various current and alternate land use systems in different bioclimatic regimes.



Distribution of Carbon Stock in Indian Soils (0-150 cm depth)

Land Evaluation and Land Use Planning

The Bureau in the past developed suitability criteria for major crops in order to evaluate soils for alternate land uses. These criteria need refinement taking into account the species/ varietal adaptability in different agro-eco systems, the yield and management levels, etc. so that the rating obtained thereof become more specific and realistic. Use of sophisticated and highly effective land evaluation tools such as crop simulation models, fuzzy logic and multiple goal linear programming, will be increasingly made use of for generating realistic land use options. The principal goals, information generated and data available (or required) and methodologies are different for land use planning at different scales. Land Use Planning at different scales involve use of various tools such as (a) at micro-watershed/ farm level (PRA), Linear Programming and Scenario Analysis, (b) at district level (Growing Period Zonation, Modelling, Linear Programming Land Management Unit-Linear Programming), (c) at state level (Agro-eco Zones, Model, Scenario Analysis) and (d) at country level (Scenario Analysis, Linear Programming and Efficient Economic Zonation). All future land use planning programmers will focus on using appropriate tools. Currently the focus is on adopting interdisciplinary approach to land use planning and involving the stakeholders in the planning and implementation processes.



Suitability map of soils of Kultabad cluster,
Aurangabad district, Maharashtra for soybean.

Soil Survey and Land Use Planning Research System

The Soil Survey and Land Use Planning Research System in India is handled largely by the Bureau. It accomplishes its mandate through its 3 research divisions at the Headquarters (at Nagpur) and 5 regional centres (Bangalore, Delhi, Kolkata, Jorhat and Udaipur). The regional centres undertake the region specific mandated activities.

The Bureau has received national and international recognition for developing cutting-edge science and technology in soil resource mapping, use of geoinformatics in soil resource mapping at different scales, soil genesis and classification, carbon dynamics modelling, multicriteria land evaluation and land use planning.

Mandate

- To conduct soil survey and mapping of the soils of the country to promote scientific and optimal land use programmes in collaboration with relevant institutions and agencies.
- To conduct and promote research in the National Agricultural Research System in the areas of Pedology, Soil survey, Remote sensing applications, Land degradation, Land evaluation and Land use planning, 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 Bureau, through its journey over the last 4 decades, has every reason to feel proud of its tremendous accomplishments in the domains of research, training and development. These are numerous and include, among others, publication of Soil resource Map of the country on 1:1 million scale and its different states (on 1:500,000 scale), ; development of new concepts in genesis of soils; publication of a 20-Unit Agro-ecological and a 60-Unit Agro-ecological sub-region map of the country prepared by the Bureau has proved immensely useful in national and regional level land use planning; cost effective and time efficient use of remote sensing data in mapping of soils at various levels; establishment of 265 benchmarks soil series (till date) through

soil correlation which were subsequently put into the National Register; generation of reliable estimates of degraded land in the country, estimation of carbon stock in the Indian soils and; development of land use options for different operational units spread over 5 agro-eco systems, namely, Rainfed, Irrigated, Arid, Hill & Mountain and Coastal. Besides, it has also generated qualified and skilled manpower in soil survey, micromorphology, geoinformatics applications, land use planning and land resource management through its training programmes of international standards and Post Graduate teaching and research programme.

The Bureau has identified different stakeholders for pursuing its research and development programmes interfacing its activities with State Agricultural Universitites, ICAR institutions, NGOs and other research organizations through a multidisciplinary approach that would facilitate better understanding of soil and land use problems and their redressal.

NBSS and LUP 2030

Of the Natural Resource Management (NRM) institutes of ICAR, the Bureau is one among the foremost shouldering the responsibility of inventorising soil resources of the country using modern sophisticated tools and techniques, generating reliable information on nature and extent of degraded soils, conducting research in pedology, remote sensing applications, land evaluation and land use planning. It aspires to function in next two decades as National Research, Training and Development system that would be contemporary, relevant, competitive and strongly connecting to stakeholders' needs and expectations.

Vision

Become a national custodian of country's land and soil resources and land use related database, so as to support scientific and judicious land use planning.

Mission

Spread knowledge/awareness on land and soil resources for its preservation, conservation, increasing productivity and ensuring sustainability.

Focus

The Bureau in the past had always lived up to the expectations and aspirations of the nation and now given a clear vision coupled with a motivated workforce, its RT&D endeavours will largely concentrate on the following key areas.

- Development of methodology to conduct detailed soil survey and mapping at watershed and village levels using latest remotely sensed data products.
- Coordination of soil surveys conducted by different agencies and users' meet.
- Correlation of soils at different categoric levels.
- Development of soil classification rationale.
- Development/Refinement of agro-ecological inventory on the basis of land resource database.

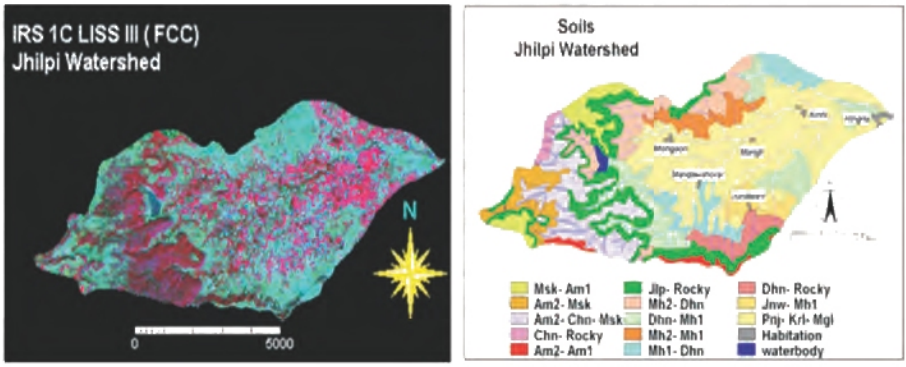
- Applied and basic research in pedology, remote sensing applications and land evaluation for land use planning.
- Assessment of carbon and other nutrient dynamics
- Identification of potential of carbon sequestration in soils and land use system.
- Assessment of land degradation for resource conservation.
- Development of National Land Resource Database towards preparation of appropriate land use options.
- Land quality assessment and monitoring the changes.
- Human Resource Development related training programmes in soil survey and mapping, remote sensing and GIS applications. Watershed characterization, land evaluation and land use planning. PG education in Land Resource Management (LRM) in collaboration with SAUs of the respective regions of the country.
- Execution of consultancy projects in the specialized fields.

Harnessing Science

The Bureau through the scientific knowledge and expertise gained over years, would strive to develop research programmes using new science that would be evolving along with the tools, methods, techniques and approaches that would be emerging in the next two decades in addition to using the appropriate conventional ones. This will help in developing cutting edge technologies for resource mapping at different levels, characterization of the extrapolation domains of the agricultural technologies, resource information management in GIS framework and applications of remote sensing technology in monitoring land use/ land cover changes and degradation of resource base, data processing and analysis relevant to soil resource inventory and characterization, land evaluation and land use planning.

Geoinformatics Applications

The technology of remote sensing is continuously evolving and will be able to address emerging challenges in resource inventory and land use planning with improvement in satellite data resolution and increased availability of multi temporal data. Large scale soil resource inventory and mapping at block/village level using Cartosat-I, Cartosat-II and other data products like RapidEye, QuickBird, GeoEye, etc. in conjunction with the ground surveys will help in development of strong database of soil resources. The digital soil mapping techniques are very effective in predicting some of the soil properties.



Remote sensing applications in soil resource mapping

The assessment (and mapping) of soil moisture availability in time and space plays a pivotal role in crop planning. The potential of emerging microwave data will be tapped for the same.

Remote sensing techniques have proven potential to predict properties of soils and their variability to enable users employ such information in decision making. The spectral library approach provides a framework for linking soil information with future hyper-spectral remote sensing data and will be used for improved spatial prediction of soil properties. Updation of soil maps with new information through use of high resolution remote sensing data will be required to improve their quality.

GIS and remote sensing applications hold immense potential in spatio-temporal analysis of land use and cropping systems, assessment of prime agriculture areas and understanding their inter-relationships at AER/AESR level that may help in increasing optimum utilization of soil. GIS based models help in integrating the bio-physical and socio-economic parameters in generating site-specific land use plans. Interfacing of GIS and GPS technologies in conjunction with the farm level soil resource mapping is of much use in precision farming.

GIS aided robust exploratory spatial decision support systems will be a potential tool for effective and proper land use planning. The geospatial database generated in GIS holds immense potential in modelling different aspects of land resources in characterization of use potential of land parcels.

Software Development and Applications

Development and applications of softwares for varied uses have become an important activity because these tools help in understanding the concept, methodology and workability of different ideas. Keeping this and anticipated generation of huge database in next two decades in view, softwares will be developed for their use in soil resource inventory, soil genesis and correlation studies and decision support system for facilitation of agro-technology transfer, monitoring soil quality and land use planning, including multifunctional land use planning.

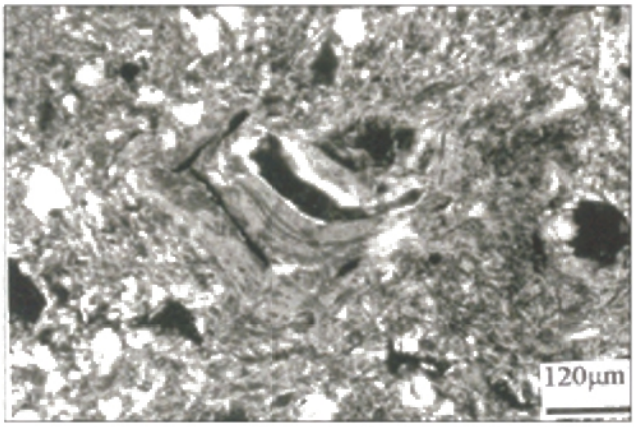
Pedometrics in Soil Survey

Conventional soil survey methods have in the past been criticized, perhaps justifiably, for being too qualitative in character. Quantitative techniques for spatial prediction in soil survey are developing apace, which will be used in future to describe, classify and study the spatial distribution patterns of soil in a more objective way. The methods are collectively categorized in the relatively new field of Soil Science known as 'pedometrics' (Burrough et al., 1994). Some of the pedometric techniques, namely, fuzzy logic, geostatistics (like ordinary kriging) and hybrid techniques, namely,

cokriging, universal kriging and regression kriging could be useful tools for soil survey in future.

Soil Micromorphology

Application of micromorphology will see a considerable expansion in geo-scientific investigations in next two decades. Micromorphological studies not only provide more concise and descriptive information about the soil resources of the country and their formation but also provide evidence of climate change, polygenesis and tectonics. (Srivastava and Prakash, 2002)



Evidence of clay illuviation in calcareous soils

Potential of Nanotechnology Applications

Nanotechnology has potential to bring a revolutionary breakthrough in natural resources management in decades to come (Abdul-Kalam, 2007). Nanominerals, such as clay, offer a controlling mechanism in management of soils and environment clean up. Their characterisation is important to provide database for research in natural resources management. The Bureau, in addition to using the technology for characterising nanominerals, will tap its potential in studies on weathering of soil minerals and soil development, to name a few.

Soil Quality Assessment and Monitoring

Evaluation of soil quality assumes particular significance in view of the alarming problem of land degradation and the changing climate. Systematic evaluation of pedological data base holds key to identification and quantification of physical, chemical and biological soil quality indicators and monitoring changes due to land use dynamics and soil degradation,

generation of integrated soil quality index, generation of soil quality indicator maps, identification of threshold values of soil quality indicators under diverse conditions.

Soil Carbon (Organic and Inorganic) Dynamics and its Sequestration

Mapping of soil carbon in Benchmark soils (through estimation of its stock) under different land use and management systems and cropping patterns and identification of sequestration potential using various C-models constitute the key components of contemporary and future research in soil carbon dynamics and its sequestration.

Benchmark Soil Information System (BeMSIS)

Development of Benchmark Soil Information System (BeMSIS) is the most vital aspect towards working for soil information system and its application. Digitized format of the data is necessary for its dissemination and further use. Various other contemporary technical inputs such as geo-statistical analysis (e.g. krigging), pedotransfer functions, taxo transfer rules employed in a GIS environment help in developing an effectively useful BeMSIS.

Potential Quantitative Land Evaluation Techniques

Multi-criteria land evaluation system involving the analysis of physical suitability and also the socio-economic viability and the environmental impact will be used to make land evaluation more effective and wholesome. The multi-criteria evaluation integrated in GIS has the potential of being applied in many situations for optimal land use allocation. A web-based economic land evaluation system (WELES) developed by the Bureau for planning suitable land use is also an appropriate tool for predicting land performances in economic terms.

The land evaluation system must provide continuous land suitability maps, that are necessary for the subsequent land use allocation. So, the matching procedure used in the land evaluation exercises must be based on fuzzy logic, or on some other continuous suitability functions.

Anticipatory and Participatory Land Use Planning

Anticipatory tools, such as, scenario building, crop simulation modelling and GIS-crop model interfacing are helpful in anticipating and exchanging perspectives about the future of land use planning.

Simulation crop models used either in isolation or as interface with remote sensing and GIS tools to give spatial dimensions are very effective

anticipatory tools to predict the yield of a crop in order to take several strategic decisions at macro and micro level.

Participatory land use planning approach involving use of participatory rural appraisal (PRA) tool is effective in farm level land use planning (Velayutham et al., 2002). The experience gained and success achieved in the participatory land use studies undertaken in a rural village using PRA tools in the Vertisol belt of central India (Nagpur area) could form the starting point for many more such studies in the future, through identification of domains having similar problems and potentials for replications to enable transfer the land use options developed at this site.

Participatory land use planning in Asalpani (Tola) village, Gondia district, Maharashtra

The Bureau is equipped with gigantic database generated through a number of NATP and NAIP projects and other agronomic trials including farming system analysis and could utilize the information for development of optimum land use models for various agro-ecological and socio-economic settings of the country. Such models are helpful at suggesting alternative land use for increasing agricultural production and ensuring livelihood. Land use planning models developed through integration of multi-criteria evaluation techniques and mathematical programming such as Interactive Multiple Goal Linear Programming (IMGLP) offer wide scope for generating viable land use options at different levels.

Strategy and Framework

The following 7-point strategy would be adopted to accomplish the vision and the goals of the Bureau and to enhance efficiency and effectiveness of the research resources (See Annexure-1).

- **Develop demand driven soil resource inventory of disadvantaged districts, command areas, prioritized watersheds, villages and farming systems.**

- To create a soil resource database for its subsequent application in varied fields.
- To inventorise soil resources at watershed scales keeping in view the scenario of climate change and utilization of soil with proper care and water to the maximum.
- To conduct detailed soil survey of arable areas for farm and watershed level planning and degraded/potentially degraded soils and developing strategies for their rehabilitation and effective utilization.
- To develop National Portal on soils by detailed survey and mapping for farm level land use planning/ land use alternatives.
- To map the soils for major macro and micro nutrients status as per requirements of developmental agencies. To also monitor for changes frequently and revise the maps. This detailed information on soil and land resources may also help for the planners to regulate the input supply to the particular area as per the requirements of the crops grown and soils.

- **Integrate soil resource inventory with other natural resources inventories to prepare a comprehensive land resource inventory.**

- Keeping in view the proposed programme of the Government of India, the soil resources inventory developed by the Bureau will be a part of a comprehensive land resource inventory through its integration with natural resources inventory to enable facilitate monitoring of land resources and planning for their efficient use.
- To prepare comprehensive resource inventory of the priority districts of the country depending upon the proneness to drought, flooding and other natural calamities, socio-economic status of the districts, etc.

■ **Pursue basic and strategic research in soil resources**

- Conduct research on soil genesis to understand different steps of weathering for predicting inherent source of plant nutrients and estimate future input requirement and develop models of soil formation under Indian situation.
- Evaluate physical, chemical and biological soil database for identification of indicators of soil quality, its quantification and monitoring its changes, due to land use dynamics and soil degradation.
- Estimate nature and extent of degraded soils in the country and regularly reconcile the database with the ones generated by other agencies.
- Assess change in soil carbon status in Benchmark soils under different land use systems / cropping pattern management systems and carbon sequestration potential of soils and land use systems.
- Suggest measures to improve total factor productivity and more importantly the total natural resources productivity of the country.
- Ascertain the trade-offs between the storage of organic matter in the soil (to counter climate change effects of gaseous emissions) and its use to drive nutrient cycling, crop production and other ecosystem services.

■ **To prepare blue prints for efficient land use planning at different levels.**

- Involve stakeholders including very much the farmers in the very process of land use planning and take into consideration their varied interests resulting in conflicts that need to be balanced through compromise on best possible use to resolve.
- Ensure interdisciplinary land use planning that demonstrates a certain change of paradigm from the traditional mono-disciplinary scientific study of soils to an interdisciplinary study of integral land use systems leading to quantified prescriptions for optimal utilization.
- Strengthen land use planning programmes through strong linkages with state governments, state agricultural universities and ICAR institutes.
- Develop collaborative projects with state land use boards and state government departments on land use policy issues.

- **Facilitate development of repository of soil and land resources database to facilitate their exchange with national and international agencies.**
- To align Indian soil databse with international databases like SOTER.
- To facilitate exchange of database with national and international agencies.

- **Enhance quality of human resource in soil survey, geo-informatics and land use planning through training and teaching.**
- To equip human resource with the latest knowhow of soil survey tools and techniques, involving use of Remote Sensing, GIS and GPS and land use planning through expert faculty for skill enhancement.
- Improve quality of Post Graduate education and research programme in Land Resource Management to prepare students to meet future challenges.

- **Facilitate accelerated dissemination of improved technologies, knowledge and information.**
- Evolve methods to link research, training and development system with stakeholders including farmers for accelerated adoption through information and communication technology and transfer of digital data.
- Develop a 'Georeferenced National Soil Resource Information System' to facilitate dissemination and decision making.
- Create state-of-the-art scientific facilities in laboratories and infrastructure.
- Link research and development system with society by improving science communication. Awareness and sensitization programmes would be developed on importance of soil and its sustainability for addressing the issue of food and nutrition security.

Epilogue

Visioning what the Bureau will be in 2030, is in itself, a very complex task that will need a thorough and rational understanding of its relevance in the ICAR system, in particular, and the society in general and the challenges it would face and the opportunities that would emerge in the next two decades.

The challenges it will need to overcome include, among others, the shrinking soil and land resource base and their fast degradation, their deterioration in quality and declining productivity, and improper use of soil and water resources. We cannot afford, therefore, to misuse, overuse, underuse or abuse these precious resources(soil and water). Concerted efforts will also have to be made to utilize the opportunities that would emerge in the form of new science, tools and techniques.

The vision 2030 document of the Bureau presents an account of these challenges and opportunities and also the strategies to realise the vision. The Bureau is committed to bring in a rational change in its work programmes and strategies to accommodate needs and expectations of its stakeholders and the farmers. Since a vision not followed by an action remains a dream, the Bureau is committing to itself, the ICAR and the society its firm resolve in undertaking sincere and dedicated efforts towards realising the vision

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Annexure 1: Strategic Framework

Goal	Approach	Performance measure
• Inventorise soil resources at different levels	Standard soil survey methodology along with remote sensing land GIS tools	Soil resource database and maps at different levels.
• Establish benchmark soils	Soil correlation	Benchmark soil series
• Develop soil taxonomy rationale	Pedological investigations	Indian soil classification system
• Investigate processes and formation of soil formation.	Micromorphology, Radiology, Electron Microscopy and Soil analysis	Insights into soil formation processes
• Redefine Agro-ecological subregions for effective regional land use planning	Use of updated soil and climatic database	Revised agro -ecological sub-region maps
• Develop Indian Soil Resource Information System	Soil resource inventorisation, characterization, evaluation and documentation	Spatial Indian Soil Resource Information System
• Facilitate soil-based agro-technology transfer	Pedological investigations on Benchmark soils	Number of technologies transferred
• Identify recommendation domains for technology developers	Information retrieval from database	No. of technology transfers facilitated
• Assess nature and extent of soil/land degradation	GLASOD and ASSOD* techniques/RUSLE** technique	Soil/land degradation maps.
• Assess soil/land quality and mo nitor changes	Conventional and modern methods involving use of mathematical tools, spectral library and soil quality softwares	Soil quality indicators and their threshold values
• Estimate carbon and other nutrients stock in soils	Carbon and other nutrients dynamics modelling	Soil carbon and other nutrients database (current and potential) and maps and quantified information on carbon sequestration potential of various soils

*Regional Assessment of the Status Human-induced Soil Degradation in South and Southeast Asia
** Revised Universal Soil Loss Equation

• Assess climate change impact on soils and land use	Use of simulation techniques	Quantified information on impact of climate change on soils and land use and sequestration potential of various land use systems.
• Formulate regional mitigation strategies to combat climate change	Use of simulation techniques	Mitigation strategies
• Evaluate land for land use allocation	Multi-criteria land evaluation (LE) approach of determining physical suitability, socio-economic viability and environmental impact and use of various modern LE tools namely, crop simulation models, mathematical programming, fuzzy logic, export system, and web-based LE techniques	Land use suitability classes and maps. (land utilization system)
• Develop optimum land use plans for villages, watersheds, command areas, districts and states	New/refined methodology for land use planning at different levels, use of participatory resource appraisal simulation land use models and expert systems for diverse conditions and problems.	Site-specific land use options
• Develop land use plans for rural livelihood security	Participatory resource appraisal	Livelihood indices
• Assess impact of land use dynamics	• Soil and socio-economic resources characterization • Quantification through metric of regional climate change potential. • Change in physical properties of the land surface	Change in soil properties and socioeconomic indicators
• Develop IT -based Decision Support System for sustainable land resource management/ land use planning at different levels	Use of land use models, computer programming, and geo -informatics in DSS designing	Decision Support System for land use planning

• Improve skills and quality of human resources to address emerging challenges	Modernize Post Graduate Teaching and Research Systems in collaboration with SAUs, capacity strengthening through national/international training in soil survey, micromorphology, geo-informatics applications, land evaluation, development and implementation of land use plans	Qualified and skilled manpower in soil survey, land evaluation, micro-morphology, geo - informatics and land use planning
• Develop linkages with national and international organizations in different areas of work and on data sharing	• Developing Linkage mechanism • Establishing international centres (centre of excellence) • Developing national policy on sharing of digital data and maps	Linkages developed
• Prepare for catering to the emerging needs (challenges) of science and society	• Establishing new state-of-the art laboratories such as soil microbiology laboratory • Linking soil survey to soil testing through establishment of Krishi Vigyan Kendras(KVKs) at Hqrs and regional centres to facilitate increased use of organizational outputs by the farming community	Comprehensive databases for soil quality research Closer and stronger linkages with the farming community