# Soil Resource Inventory of India Using Remote Sensing Technique for Sustainable Agriculture

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## Abstract

Landsat MSS and terrain data are used for soil inventory. Soil-site suitability is determined for a number of crops with the aid of data on soils and climate and crop requirements to arrive at a sustainable land use proposal for the Rajkot area (Gujarat, India).

## 1. Introduction

Soils are a vital natural resource on whose proper use depends the life-supporting systems of a country and the socioeconomic development of its people. Being a component of the lithosphere and biosphere system, soils provide food, fiber, fodder and fuel-wood for meeting the basic human needs. However, the capacity of a soil to produce is limited and the limits to production are set by its intrinsic characteristics, agroecological settings, and use and management (FAO 1993).

With the ever-increasing human and animal population, demand on soils for food production has been increasing. It has been estimated that India's human population (920 m) would cross one billion mark by the turn of the century and would stabilize around 1.5 billion by the middle of the next century (Fig. 1). This would imply that per capita cultivable land holding will decline from 0.3 ha (in 1951-52) to 0.14 ha (by 2000 AD; Fig. 2). The food production, no doubt increased from 52 M tonnes (in 1950's) to almost 185 M tonnes (in 1990's), especially there was an increase during 1960's and 1970's periods of green revolution. But that has been largely as a result of expansion in cultivable area and high inputs of fertilizers, irrigation and hybrid cultivars.

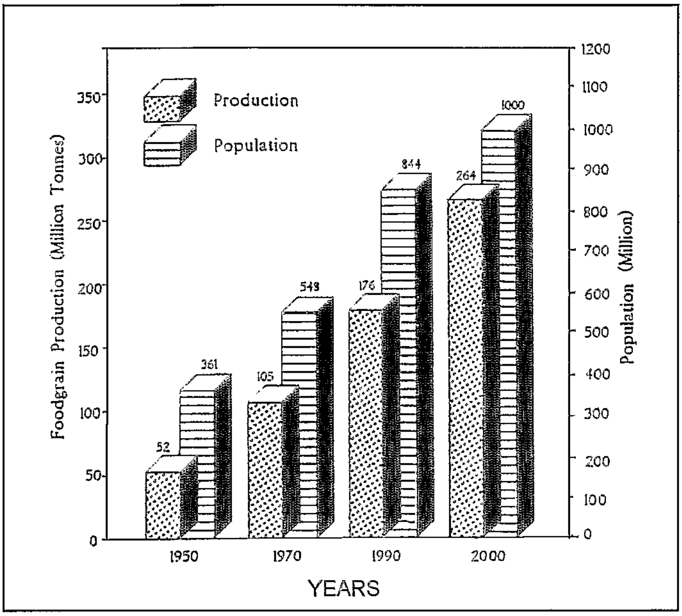


**Figure 1.** Foodgrain production and population growth in India.

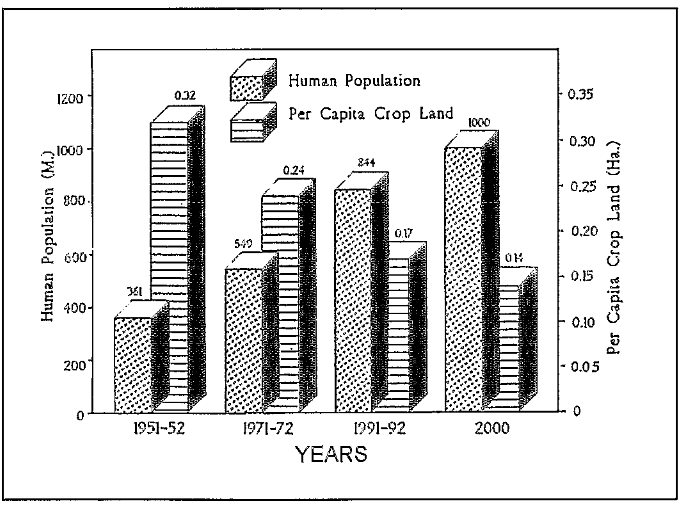


**Figure 2.** Per capita availability of crop land in India.

The significant growth of agriculture has been at the cost of decline in soil quality and risk of soil degradation (ABROL and SEHGAL, 1992). Today there are increasing evidences to support that a majority of our soil resources are under different degrees of degradation and are getting further deteriorated at an alarming rate with risk of jeopardising food security system (SEHGAL and ABROL, 1994).

The sustainability of some cropping systems based on high-inputs has been showing signs of fatigue. For instance, rice-wheat or cotton-based cropping systems in the Indo-

Gangetic Plain, where the crop productivity has either plateaued or is showing a declining trend (Fig. 3).

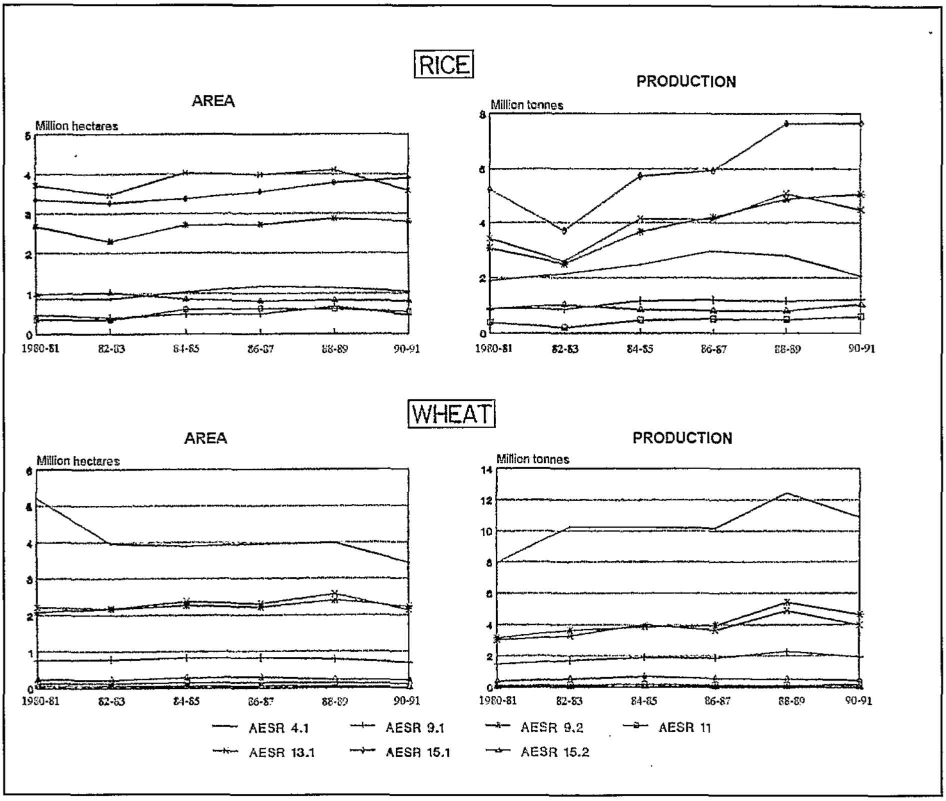


**Figure 3.** Trends in area and production for rice and wheat in different agro/eco subregions in the Indo-Gangetic Plain, India.

Such cropping systems are being adopted because of the market demand resulting in replacement of old, stable systems without paying attention to sustainability.

The increased irrigation facilities motivated farmers to adopt rice-wheat rotation disregarding the time-tested, highly-effective system of crop rotation as well as the practice of green manures and without giving any consideration to the nature of soils (Ustipsamments/Ustochrepts, generally with a sandy phase).

The rice-wheat cropping system although helped in increasing productivity, yet is becoming a constraint to sustain the yields from either of the two crops despite high inputs (up to 400 kg nutrients $ha^{-1}$). This is because of the rise in ground-water-table that brings salts to the surface (in SW Sectors) and receding groundwater-table (at the rate of 1 $m.yr^{-1}$) in the central sectors of Punjab, resulting in depleting water resource and change in land use (SEHGAL *et al.*, 1986).

The question before us is **"Are these gains sustainable with the constraints posed by shrinking and depleting of resource base?"**

The United Nations Conference on Environment and Development (UNCED), popularly called "Earth Summit", held in Rio de Janeiro, Brazil (June, 1992) focused the world attention on the harmful impact of development on the Earth's life-supporting system. The UNCED's Agenda 21 emphasised seven issues related to land use for sustainable production and efficient use of natural resources, especially soils and water. Nobel Laureate Norman BORLAUG advanced the concept of land sparing techniques through the application of modern technologies. He argues that the USA in 1990 could harvest 600 Mt from 119 M ha of land area which is 2 times more production from some 10 M ha less land when compared with 1960's level of production. Further, comparing the impressive gains in land savings that China and India have made through application of modern techniques, he argues that if the cereal productivity of 1961 had prevailed in 1992, China and India would have needed three and two folds more land area to equal their 1992 harvests, respectively (BORLAUG and DOWSWELL, 1994). In India, however, the cultivable land area has been marginally increasing because of mounting population pressure, but its production trend is almost stabilizing. These are matters of great concern as far as sustainability is concerned. Hence India has to look for both production and protection of its basic resources, i.e. soils (SEHGAL, 1995).

## 2. The need

In order to address the question of sustainability, Kanwar in his presidential address to the 12th Congress of Internatitonal Society of Soil Science (1982) put forth the slogan **"Save the soil and save humanity"** and stressed the need for assessing and mapping of our basic resources (soil and climate) to understand their potential and constraints and to develop management strategies to achieve sustainability. This is feasible by promoting the increased use of soil survey and climatic resource database (SEHGAL, 1987).

## 3. Background

The establishment of the National Land Resource Conservation and Development Commission and of Land Use Boards at the Centre and State levels is an index of political will and administrative support by the Government of India for the scientific care and management of our soil resources for sustainable agricultural production.

The present 1:7 m scale soil resource map of India showing delineations of Suborder association (NBSS, 1985) although an achievement for broad understanding of soils, yet it does not serve the purpose of land use planning because of the limiting scale and level of information contained therein.

At the national seminar on Soil Resource Mapping of India, the major recommendation emerged was to undertake soil resource mapping of all the states at 1:250,000 scale in cooperation with the Soil Survey Staff from different states, with NBSS & LUP as a nodal agency. The question before the House was whether to compile the existing information or generate a new soil resource map based on latest know-how and technology. It was argued that it will take five years to collate the existing information on soils from different States in order to generate a soil resource map on 1:1 m scale. On the other hand it might take about 6-7 years for generating a soil resource map of all the States on 1:250,000 scale with a further possibility of reducing this map to 1:1 m scale for the country as a whole. Based on the discussion, it was decided that a new initiative ought to be taken, involving Soil Survey Staff of different states and of the NBSS to work hand in hand in order to generate soil resource maps of each state on 1:250,000 scale. Since most of the Soil Survey Staff in different states is working under the control of the bureaucrats, it became necessary to communicate and convince the Directors; Secretaries, Ministers and/or Governors of different States briefing them about this new initiative and convincing them of the need for ascertaining the potential and problems of the state's soil resource base for perspective land use planning. Once motivated each State signed a Technical Memorandum of Understanding (TMOU) with the Director of NBSS & LUP for undertaking the gigantic task of mapping soil resources on 1:250,000 scale on cooperative basis.

In order to create uniformity in mapping and laboratory analyses, Field and Laboratory Manuals (SEHGAL and SAXENA, 1995; SARMA *et al.*, 1987) were written and training was given to the State Soil Survey Staff imparted at their respective State Headquarters. These training programmes became very handy to built teacher-taught relationship, motivate staff and maintain uniformity in different states and also at the national level. The Soil Survey Staff, thus trained, was deployed to undertake joint field operations to accomplish the task of Soil Resource Mapping (SRM). The mapping included two field reviews: mid-field and post-field for correlating and classifying soils.

The soil samples representing different mapping units were collected and analysed for mandatory and optional properties and SRM prepared. Based on the master soil map, several thematic maps, such as soil erosion, salinity, texture, water holding capacity, pH, organic matter, soil-site suitability for different crops, land degradation, etc. were prepared, using GIS methodology. These maps are proving to be very useful in rationalising land use towards agricultural production on sustainable basis.

## 4. Geographic setting

India, situated between 08°04' to 37°06' N and 68°07' to 97°25' E, occupies a total geographical area 329 M ha. It has three distinct physiographic units, viz. (i) triangular plateau of Peninsula (in the Deccan and south Vindhyas); (ii) mountain region of Himalayas, known as the Extra Peninsulara; (iii) Indo-Gangetic plain of the Punjab, and Bengal separating the two above-mentioned areas.

Based on the combination of a number of climatic elements, such as rainfall, temperature, potential evapotranspiration, coupled with the altitude aspect and with vegetation, a bioclimatic map of India, using a water balance approach, has been produced (SEHGAL *et al.*. 1990).

Based on the soil moisture and temperature databases of over 700 meteorological stations in India, soil moisture and temperature regime maps have been produced (SEHGAL and MANDAL, 1993 and 1994). The maps show that a large portion of India is under hyperthermic temperature regime and ustic moisture regime.

## 5. Methodology

A 3-tier approach (SEHGAL and SAXENA, 1995), comprising image interpretation, field (ground) survey, including soil analysis, and cartography, which takes advantage of recent advances in image interpretation techniques and provides greater efficiency at the reconnaissance level of mapping than the conventional methods, was used. For classifying soils, the USDA Soil Taxonomy (Soil Survey Staff, 1975), was used.

- The false-colour composites produced by a combination of bands 1,2 and 4 were used for visual interpretation of 1:250,000 Landsat MSS data for delineating major landforms. The subdivisions were accomplished by the regional physiography, as expressed by the integrated effects of geology, terrain, and environmental conditions. Further subdivisions were made on the basis of landscape elements together with tone and texture, singly or in combination. Field observations were made for checking and finalizing the physiographic boundaries. This was followed by transfer of physiographic boundaries on to the topographic base map (on 1:250,000 scale) using optical reflecting projector.
- The field surveys were undertaken to collect soil-site characteristics in sample strips (5-8 on each topographic-sheet, cutting across most of the photomorphic units) for the identification and correlation of soil units with physiographic units (Table 1).
- The soil samples representing master pedons, benchmark soils and other grid samples, were analysed for various properties (mandatory and optional) and the soil mapping units were refined and/or modified.
- The Cartographic work, preparing the final soil map at the level of associations of soil families with phases, was based on the physiographic delineations supported by extensive and intensive field studies and soil analysis.

**Table 1.** Physiography soil relationship, Rajkot area.

| Map unit | Physiography | Soil description | Soil classification |
|---|---|---|---|
| 1. | Gently sloping pediment with dykes | Moderately shallow to shallow, moderately well drained clayey soils, slightly eroded | Vertic Ustochrepts<br>Lithic Ustorthents |
| 2. | Rolling pediment with stony waste | Very shallow, well drained, clayey soils, severely eroded | Rock outcrops (60%)<br>Lithic Ustorthents |
| 3. | Very gently sloping alluvial plain | Very shallow, well drained clayey (dissected) soils, severely eroded | Lithic Ustorthents<br>Lithic Ustochrepts |
| 4. | Gently sloping alluvial plain | Moderately deep, well drained, clayey soils, slightly eroded | Typic Chromusterts<br>Vertic Ustochrepts |
| 5. | Very gently sloping alluvial plain (dissected) | Shallow to moderately deep, well drained clayey soils, moderately eroded | Lithic Ustochrepts<br>Vertic Ustochrepts |
| 6. | Very gently sloping alluvial plain with narrow valleys | Moderately shallow, moderately well drained clayey soils, slightly eroded | Vertic Ustochrepts<br>Typic Chromusterts |
| 7. | Nearly level low lying coastal plain (dissected) | Deep, poorly drained clayey soils very severe salinity | Typic Halaquepts |
| 8. | Very gently sloping alluvial plain | Moderately deep, poorly drained clayey narrow valleys soils, severe salinity, strong sodicity | Typic Chromusterts<br>Vertic Ustochrepts |

## 6. Soil resource inventory

Remote sensing is now widely used as a tool for preparing landform/physiographic maps which help in preparing soil resource maps as physiography and soils are known to be well related and the approach has been developed since 1970's (GOOSEN, 1967 and SEHGAL *et al.,* 1973). Remotely sensed data became an important tool in soil surveys at medium (1:100,000 to 1:250,000 scale) and small (1:250,000 to 1:1 m scale) (HARRISON, 1980; KARALE *et al.,* 1983). Recently, digital processing has been successfully applied in soil resource mapping, evaluation of crop condition, erosion processes, etc.

In the present endeavour of preparing a charter of soil resources, the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) initiated a gigantic task of preparing soil resource maps of different states (on 1:250,000 scale) by undertaking visual interpretations of the remotely sensed data and by know-how (SEHGAL *et al.*, 1988). A 370-sheets soil resource map (SRM) of India (state-wise) has been prepared and databases about each mapped unit generated for use by different organisations. The basic mapping unit is the "association of soil families", which is the most important category determining plant growth. An example of one district soil map (in Gujarat State) is given (Fig. 4).

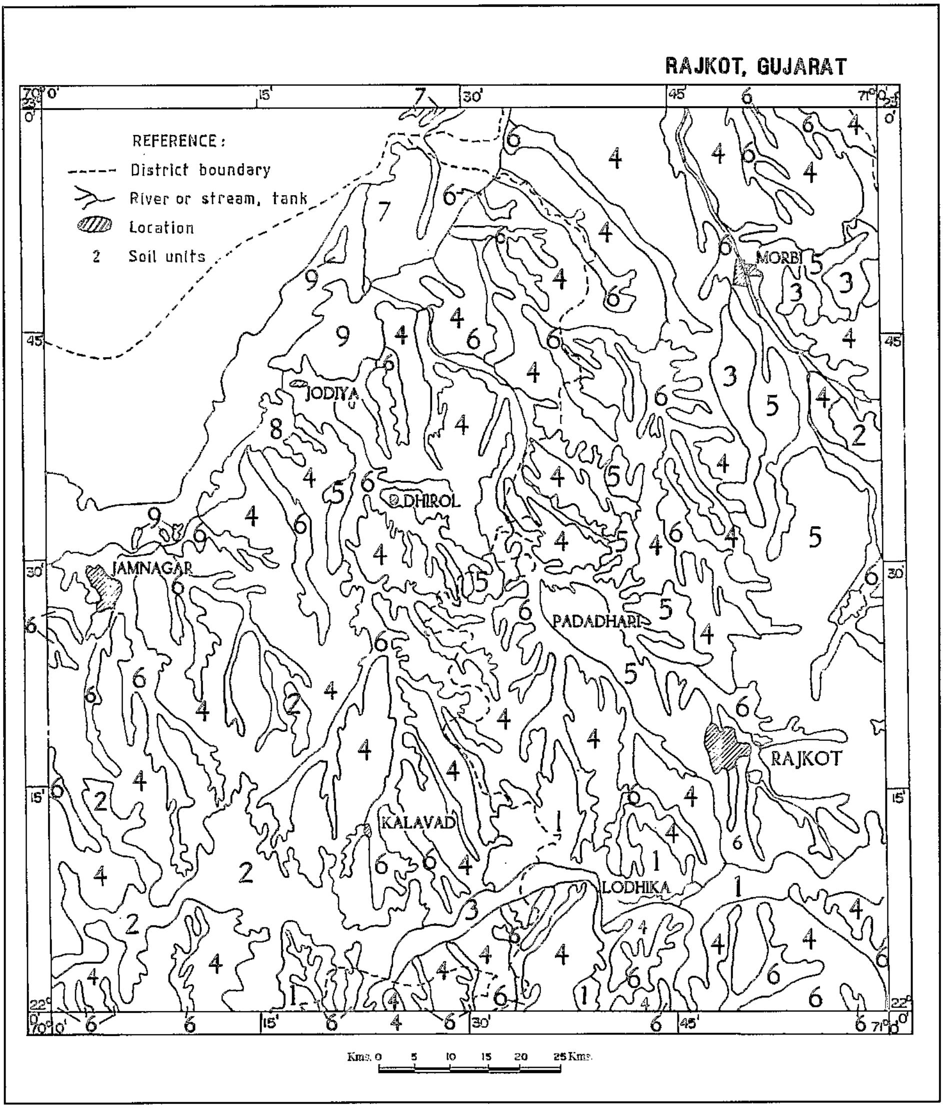


**Figure. 4.** District soil map (Gujarat State). Legend: 1 Vertic Ustocrepts; 2 Lithic Ustorthents; 3 Lithic Ustorthents; 4 Typic Chromusterts; 5 Lithic Ustochrepts; 6 Vertic Ustochrepts; 7 Typic Halaquepts; 8 Typic Chromusterts.

The nature and properties of the studied soils show major characteristics and their constraints (Table 2). The data show that not two soils are alike and most soils have varying constraints. For instance, one such soil is classified as Salic Chromustert, fine, montmorillonitic, calcareous hyperthermic. The interpretations of its various elements are given in table 3.

**Table 2.** Soil-site characteristics of the dominant soils of the mapping units.

| Soil map unit | Soil classification | Rain-fall (mm) | Slope | Soil characteristics | | | | | | Major constraints |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Drainage | Tex-ture | Depth (cm) | Ero-sion | Salinity | Sodicity | |
| 1. | Vertic Ustochrept Lithic Ustorthent | 555 | <3 | Mod. well | Clay | 50-75 | e1 | Nil | Nil | Drainage, depth, erosion |
| 2. | Lithic Ustorthent Rock outcrops | 555 | 8-15 | Well | Clay | 10-25 | e3 | Nil | Nil | Slope, depth, erosion |
| 3. | Lithic Ustorthent Lithic Ustochrept | 555 | 3-5 | Excessive | Clay | 10-25 | e3 | Nil | Nil | Slope, depth, erosion |
| 4. | Typic Chromustert Vertic Ustochrept | 555 | <3 | Well | Clay | 75-100 | e1 | Nil | Nil | Erosion, slope |
| 5. | Lithic Ustochrept Vertic Ustochrept | 555 | <3 | Well | Clay | 25-50 | e2 | Nil | Nil | Depth, erosion |
| 6. | Vertic Ustochrept Typic Chromustert | 555 | <3 | Mod. well | Clay | 50-75 | e1 | Nil | Nil | Drainage, depth |
| 7. | Typic Halaquept Lithic Ustorthent | 555 | <3 | Very poor | Clay | 100-150 | e2 | Very severe | Nil | Drainage, salinity |
| 8. | Typic Chromustert Vertic Ustochrept | 555 | <3 | Imperfect | Loam | 75-100 | e1 | Severe | Severe | Drainage salinity and sodicity |

**Table 3.** Interpretations of Salic Chromustert at different categoric levels.

| Category | Soil name | Interpretations or inferred properties |
|---|---|---|
| Order | Vertisol | Cracking-clay soils with high swell-shrink potential; have high exchange capacity and base status. |
| Suborder | Ustert | Ustic soil moisture regime suggesting soils (in control section) remaining dry for >90 cumulative days and their use is limited to 1 crop per year. |
| Greatgroup | Haplustert | Suggest non hydromorphic conditions due to higher chroma values within 1 m of the surface. |
| Subgroup | Salic | Suggest high salinity within 75 cm of the surface causing physiological drought conditions. |
| Family | Fine mont-morillonitic hyperthermic | Percent clay 35-60; high cation exchange and moisture holding capacity; and >40% montmorillonitic type of clay minerals. The soils are calcareous and have MAT (soil) of more than 22°C with wide variability of mean summer and winter temperatures. |

The name of the taxon also indicates what properties it cannot have. Thus Vertisols cannot have the properties of Aridisols (dry throughout), Histosols (organic soils), Alfisols, Oxisols, Mollisols or Inceptisols. Similarly, at lower categoric levels, Usterts cannot have the properties of Torrerts, Uderts, Xererts. At Greatgroup level, Haplusterts cannot have the attributes of Saliusterts. In conclusion, one may say that each soil has its own characteristic properties, use potential, rationalising use and capability, essential for sustained use.

# 7. Land evaluation for crop planning

The process of evaluating land for alternative uses (field crops, irrigation, etc.), as per its capability, forms a prerequisite for land use planning (SYS *et al.*, 1991). It is well established that each plant species thrives well on specific soil and under specific climatic conditions for its optimum growth (SEHGAL, 1988).

The goal of any cropping system research is to develop an efficient cropping system that maximises the productivity without degrading the resource base, i.e. soil and water. This is feasible through identification of crop adaptation zones for maximum productivity based on soil climatic requirements for photosynthesis and phenological development, both of which bear relationship to yield (Fig. 5).

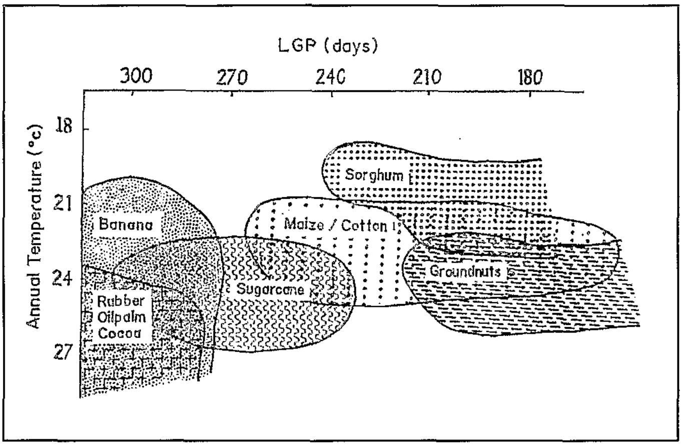


**Figure 5.** Land use as a function of thermal regime and length of growing period in the tropical areas (FAO, 1991).

By correlating soil-site characteristics with crop yield data, soil-site suitability models for different crops are developed. These, when programmed properly, can yield suitability maps for different crops.

An attempt was made to evaluate the soil-site suitability of the soils of Rajkot (Gujarat) for different crops grown under rainfed conditions in the area, by matching the soil-site characteristics of each mapped polygon as per the soil resource inventory database (Table 2) with the soil and climatic requirements of each crop (Table 4) at different limitation levels. Soil-site suitability for some rainfed crops, such as pearl millet, groundnut, sorghum and cotton were prepared (Table 5) following the criteria proposed (SEHGAL *et al.*, 1989).

Depending on the suitability of the soil units for a set of crops, optimum cropping patterns have been suggested (Table 6) taking into consideration the present cropping system and the socioeconomic conditions of the farming community.

**Table 4.** Soil-site requirements of different crops at various degrees of limitations (0-3*).

| Characteristics (Site and Soils) | | Pearl millet 0 | Pearl millet 3 | Sorghum 0 | Sorghum 3 | Groundnut 0 | Groundnut 3 | Cotton 0 | Cotton 3 |
|---|---|---|---|---|---|---|---|---|---|
| Slope (%) | | 1-3 | > 15 | < 3-8 | < 1 | 8-15 | < 1 | 3-8 | |
| Erosion | | - | - | e0 | e2 | e0 | e2 | e0 | e3 |
| Drainage | | Well | Imperfect somewhat excessive | Well | Imperfect | Well | Imperfect | Well | Imperfect |
| Texture | | F. loamy | Sandy | F. loamy | Sandy (c. sand) | Loam | Loamy sand, sand | Fine, f. loamy | Sandy (fine) |
| Coarse fragments | Fine | | | | | | | 3 | 35-55 (ske) |
| Coarse fragments | | 3 | 35-55 | - | 35-55 | - | 35 | | |
| Coarse fragments | V. Fine | | | | | | | 15 | 55-75 (ske) |
| Soil depth (cm) | | 100 | 25-10 | 100 | 25-50 | 100 | 25-50 | 100 | 50-25 |
| $CaCO_3$ (%) | | 100 | 35-50 | 3-20 | 45-75 | 10 | 35-50 | 10 | 40-60 |
| Gypsum (%) | | 0-3 | 10-20 | 0-3 | 10-20 | - | - | - | - |
| Salinity E.C. | | Nil | 4-8 | 2 | 8-15 | - | 4-8 | 4 | 15-25 |
| ESP | Med. Coarse tex. | | | 10 | 25-40 | | | 10 | 25-40 |
| ESP | | 5 | 25-50 | | 9.2-9.5 | 5 | 15-25 | | |
| ESP | Fine texture | | | 5 | 15-25 | | | 5 | 10-25 |
| Rainfall (mm) | | 600-750 | 400-300 | 800-1000 | 400-550 | 800-950 | 400-500 | 1000-1250 | 650-700 |
| Rainfall during growing season | | 550-600 | 250-300 | 750-900 | 350-500 | 700-850 | 400-300 | 900-1100 | 625-500 |
| Length of growing period season | | 100-110 | 80-70 | 120-150 | 100-90 | 150-210 | 90-750 270-300 | 150-210 | 280-330 |
| Mean temperature growing season | | 25-27 | 18-20 | 26-32 | 22-20 | 26-22 | 34+ 14-10 | 26 | 22-20 |
| Mean max. temp. growing season | | 30-32 | - | 28-31 | 35+ | 36 | 40-42 | 34 | - |
| Mean min. temp. growing season | | 23-24 | - | 21 | 12-15 | 18 | 10-6 | - | - |
| Mean R. H. | | 70-75 | 60 | 60-70 | 40+ | 50-70 | - | - | - |

* Key: 0-No limitation; 3-Severe limitation (marginal soils).

**Table 5.** Soil suitability for climatically-adopted crops of the area.

| Map unit | Dominant soil (subgroup) | Soil suitability for crops* Pearl millet | | Sorghum | | Groundnut | | Cotton | |
|---|---|---|---|---|---|---|---|---|---|
| | | P | I | P | I | P | I | P | I |
| 1. | Vertic Ustochrept | S2 | S1 | S2 | S1 | S2 | S2 | S3 | S2 |
| 2. | Lithic Ustorthent | N2 | N2 | N2 | N1 | N2 | N2 | N2 | N2 |
| 3. | Lithic Ustorthent | N1 | S3 | N2 | N2 | N2 | N2 | N2 | N2 |
| 4. | Typic Chromustert | S2 | S1 | S2 | S1 | S2 | S1 | S3 | S1 |
| 5. | Lithic Ustochrept | S2 | S2 | S2 | S2 | S3 | S2 | N1 | S3 |
| 6. | Vertic Ustochrept | S2 | S1 | S2 | S1 | S2 | S2 | S3 | S2 |
| 7. | Typic Haplaquept | N2 | N2 | N2 | N2 | N2 | N2 | N2 | N2 |
| 8. | Typic Chromustert (saline and sodic) | N1 | S3 | N1 | S3 | N1 | S3 | N1 | S3 |
| 9. | Salt pan | N2 | N2 | N2 | N2 | N2 | N2 | N2 | N2 |

* Suitability class : P-Present; I-Improved.

**Table 6.** Suggested land use for Rajkot area, Gujarat.

| Map unit | Major constraints | Present land use | Suggested land use and management practices |
|---|---|---|---|
| 1. | Drainage, depth, erosion | Pearl millet, sorghum | Suited for pearl millet and sorghum; moderately suited for groundnut and cotton with improved management practices. |
| 2. | Slope, depth, erosion and rock outcrops | Barren rock outcrops | Not suited for arable crops; afforestation; soil and water conservation measures to be adopted. |
| 3. | Slope, depth, erosion | Barren, pearl millet in patches | Marginally suited for pearl millet; afforestation and pasture development; soil and water conserva tion measures to be adopted. |
| 4. | Erosion, slope | Cotton, sorghum, pearl millet | Suited for climatically adopted crops with improved management practices. |
| 5. | Depth, erosion, | Groundnut, sorghum | Moderately suited for pearl millet, sorghum and groundnut with improved management practices; soil and water conservation measures to be adopted. |
| 6. | Drainage, depth | Cotton, sorghum | Suited for pearl millet and sorghum; moderately suited for groundnut and cotton with improved management practices. |
| 7 | Drainage, salinity / sodicity | Wasteland | Not suited for arable crops; can be used for growing salt tolerant grasses and shrubs for protecting the ecosystem. |
| 8. | Drainage, salinity / sodicity | Cotton, sorghum | Suited for salt tolerant arable crops with sodicity reclamation measures. |
| 9. | Salt pan erosion | Wasteland | Not suitable for arable crops; protection of ecosystem recommended. |

The delineation and evaluation of soil map units, which provide a complete set of information on the edaphic situations, prove to be a tool for optimising land use on sustainable basis. This can help in stabilising the cropping system zones in the country, where intensive research efforts are made for generating appropriate crop production techniques and for transfer of technology.

## 8. Future strategies

Meeting the basic needs of ever-growing population and achieving sustainable development are the most relevant challenges for the 21st century. The scientific community has to focus attention on issues sensitive to Agenda 21 of the UNCED, which include:

- There is continuing need to increase agriculture production while safeguarding the natural resource base. Future research must be related to sustainable production and environmental protection with a slogan **"Production and Protection."**

- There is need to assess and monitor land resource bases, through mapping, using remote sensing and GIS technologies. For achieving this the following issues need implementation as measures for long-term planning:

  - Developing standards for uniformity in mapping and data reliability to meet needs at national/global level.
  - Digitization of maps and automation for efficient storage of database and its retrieval.
  - Assessing risk of land degradation for taking preventive measures.

In order to have a sustainable approach in managing the natural resource across eco-environments, there is need to knit soil resource mapping with land use planning through land evaluation in a continuum.

## Conclusion

For meeting the challenges of increasing population and stagnating agricultural production, an inventory of the soil resource base is a prerequisite not only to understand their potential and constraints, but also plan towards sustained agricultural production. The soil resource maps serve as a base for monitoring changes in soil quality. Remote sensing techniques greatly enhance our ability to monitor such changes more efficiently and in a cost-effective manner.

The short and long-term measures are needed to fulfil our obligation to the motherland and to the growing population by conserving our resource for increased agricultural production and to leave a better heritage for the future generations to avoid the question: **"Here is the land, but where is the soil ?"**

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