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Soil resources of Gujarat and their suitability for banana (*Musa paradisiaca L*) cultivation: A case study of Jhagadia, Bharuch district of Gujarat, India

R.P. Sharma[1]*, R.K. Naitam[1], B. Dash[1], G. Tiwari[1], A. Jangir[1] and Sanjay Arora[2]

[1]*NBSS&LUP, Regional Centre, University Campus, Bohara Ganeshji Road, Udaipur-313001, Rajasthan, India*
[2] *ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow-226002, Uttar Pradesh, India*
**Corresponding author Email: rpsharma64@yahoo.com*

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ABSTRACT

Land resources inventory (LRI) provides information about morphological and physico-chemical characteristics of soils, their problems, and potentials for best utilization under a given set of agro-climatic conditions. A detailed soil survey was carried out in Jhagadia block of Bharuch district Gujarat to evaluate the soil suitability for banana production. The area highly suitable for bananas is demarcated in the form of a map. The information is useful for the sustainable management of natural resources and boosts the production of quality banana crops in the Narmada River basin region. Such a scientific land use plan can support India's geo-smart food production system.

Keywords: Land resource inventory, banana, Narmada basin, geo-smart food production

INTRODUCTION

An evaluation of the land resources for alternative kinds of use requires a survey to define and map the land units together with the collection of descriptive data on land characteristics and other relevant resources. Land resources inventory (LRI) provides information about morphological and physicochemical characteristics of soils, their problems, and potentials for best utilization under a given set of agro-climatic conditions (Sharma *et al.*, 2018). It produces maps of the specified location at a larger scale with the extent and distribution of various soil groups. However, block development is supposed to be more than just soil and water management. It should be an integrated approach to improve rural livelihoods, including human resource development, pasture development, agriculture development, livestock management, and rural energy management (Sharma *et al.*, 2018). It should aim to develop all resources for humans in existing nature in one ecosystem. National Bureau of Soil Survey and Land Use Planning, Nagpur has initiated various projects on land resource incentivization for farm planning in different agro-ecological regions of India (NBSS&LUP 2011-12). Recently LRI study has been completed for Chikarsinkere Hobli, Maddur taluk, Mandya district of Karnataka, Lakhan Majra block, Rohtak district of Haryana, Katonigaon, Titabar block, Jorhat district of Assam, Chinchura - Mogra and Polba-Dadpur Block, Hugli District of West Bengal, Bhadesar Tehsil, Chittaurgarh district of Rajasthan (NBSS&LUP 2011-12). Initially, the Bureau has undertaken a pilot study of six blocks for LRI in Gujarat state representing different agro-ecological sub-regions (Sharma *et al.*, 2019b, Jangir *et al.*, 2019). Later it was started in southwest Gujarat, mainly representing the west coast physiographic region (Sharma *et al.*, 2020, Jangir *et al.*, 2019). The study was extended to all 60 agro-ecological sub-regions of India with the support of its five regional centers in association with agriculture departments of state governments. Such studies are considered fruitful for land use planning and sustainably managing natural resources.

The Bharuch district has been divided into eight Talukas, Bharuch, Anklesvar, Jambusar, Jhagadia, Valia, Vagra, Amod, and Hansot. Jhagadia block is situated in the Bharuch district on the banks of the Narmada River. The soil quality/health has recently deteriorated due to urbanization, industrialization, intensive use of land resources, or high input agriculture. We should use natural resources as per their potential and constraints for sustainable production. Hence, up-to-date and reliable information at an appropriate scale is a requirement for proper natural resource planning. However, the soil information at a large scale is lacking, particularly in the Jhagadia block of Bharuch district, Gujarat. The proposed study attempts to fill this information gap in the Jhagadia block of Bharuch district, Gujarat. The objectives of the detailed soil survey are (i) to characterize and map the soil resources in Jhagadia taluka, Bharuch district, Gujarat, and to assess for banana suitability.

Soil Resources of Jhagadia

A detailed land resource inventory (LRI) has been prepared for the Jhagadia block at a scale of 1: 10,000. Jhagadia taluka is located between 21°34′44″ to 21°46′07″ N latitude and 73°03′49″ to 73°23′46″ E longitude in Bharuch district, Gujarat. Geomorphologically, the study area varied from flat to hilly topography, having variable slopes from northeast (NE) to southwest (SW). The regional slope takes a tilt from southeast to northwest, shifting drainage channels and courses of the Narmada River over some time. The southeastern part of the block is hilly terrain with moderately dense forest. The major geology of the area is quaternary alluvium, and the quaternary basin of the Gujarat plain is a result of differential basement topography formed due to the reactivation of tertiary basement faults bounded within the Sathpura highland and the Aravalli highland surfaces. The alluvium is derived from the basaltic parent material of the Amarkantak plateau, Anuppur district of Madhya Pradesh (Merh, 1995). The Jhagadia block belongs to the agro-ecological subregion (AESR) 5.2, a Hot semi-arid ecoregion with medium and deep black soils, LGP 90-120 days (Velayutham *et al.,* 1999) and characterized by *ustic* soil moisture regimes and *hyperthermic* soil temperature regimes.

The study area is well known for commercial production of banana, sugarcane, and other fruits and vegetables crops. Visual interpretation of LISS-IV data indicated that the block was characterized as the lower alluvial plain, middle alluvial plain, upper alluvial plain, lower pediment, and upper pediment. The landform, slope, and land-use/land-cover maps were integrated into ArcGIS, and an LEU map with 30 LEU units was prepared.

Jhagadia block covers 61,003 ha of area. The block was delineated into five landforms, and the soils were classified into nine series with 21 mapping units. The soils representing the Jarsad series were developed on the lower alluvial plain of the block. Jarsad soils are very deep, imperfectly drained, brown to very dark grayish brown, and classified as *fine, mixed, hyperthermic, and Typic Haplustepts.* The soils representing the Motipura series were developed on the middle alluvial plain of the block. Motipura soils (*Fine, smectitic, hyperthermic, Typic Haplusterts*) are very deep, moderately well to well-drained, dark greyish brown to very dark greyish brown soils on very gentle to moderate slope in the middle alluvial plain with silty, silty clay and clayey surface texture and slight to moderate erosion.

The soils representing Andharkachhala (*Clayey skeletal, mixed, hyperthermic, Lithic Haplustepts*), Haripara (*Fine, smectitic, hyperthermic, Typic Haplusterts*), Moretalab (*Clayey skeletal, mixed, hyperthermic, Vertic Hapludalfs*) and Shir (*Fine, mixed, hyperthermic, Vertic Haplustepts*) series were developed on upper alluvial plain of the block. All soils are deep (Haripara, Moretalab) to very deep (Shir) except those of Andharkachhala. Andharkachhala soils are shallow, somewhat excessively drained, dark greyish brown to very dark greyish brown, and affected by very severe erosion. Soils of the Andharkachhala series have low productivity potential whereas the remaining series of the upper alluvial plain has moderate to high productivity potential.

The soils representing the Amalzar and Tavdi series were developed on the lower pediments of the block. Amalzar soils are slightly deep, moderately well drained, very dark greyish brown with clay loam to sandy clay loam surface texture, moderate erosion, and classified as *Fine, mixed, hyperthermic, vertical haplustepts*. Tavdi soils are very deep, well to somewhat excessively drained, very dark greyish brown with sandy clay loam surface texture and slight to moderate erosion (*Fine, mixed, hyperthermic, Typic Haplustepts*). The upper pediment landform represents the soils of the Kadwali series. Kadwali soils are very shallow to shallow, somewhat excessively to excessively drained, dark brown with clay to clay loam surface texture, and very severe erosion and classified as *Loamy, mixed, hyperthermic,* *and Lithic Haplustepts*. It has low productivity potential.

The majority of soils of the Jhagadia block are neutral (pH 6.6-7.3) to moderately alkaline (pH 7.9-8.4) in reaction but partly slightly acidic (6.1-6.5) to moderately acidic (pH 5.6-6.0). Out of 73.9 per cent cultivated area of the block, 52.6 per cent of soils are high in organic carbon content. More than 12 per cent TGA of Jhagadia is affected by severe to very severe soil erosion, and more than 50 per cent of TGA is moderately well to well drained. Part of the soils of the upper alluvial plain and pediments also have the problem of slight to moderate surface stoniness. Most soils are deep to very deep and moderate to high in soil moisture storage capacity and are capable of maintaining the survival of crops from water stress.

The soils of the block have been divided into three land capability classes viz. II, III, and IV. The major limiting factors in the block are topography, depth, drainage, AWC, and surface stoniness. The soils of the block have been grouped into three irrigability classes, which are further subdivided into six sub-classes based on the limitations of soils and site characteristics. According to suitability assessment criteria, the soils were assessed for the fitness of major crops growing in the region. Sugarcane is suitable in 43.9 per cent, moderately suitable in 8.2 per cent, and marginally suitable in 13.1 per cent of TGA. The evaluated suitability classes of bananas showed that the 13.4 per cent area of the block is highly suitable, 32.9 per cent area is moderately suitable, and 18.9 per cent area is marginally suitable. Similarly, the soils were evaluated and mapped for cotton, pigeon pea, and wheat crops. Soils of the area are grouped in eight LMUs for sustainable or alternate land use options.

The reported soil survey data are useful for other purposes like installation of soil drainage systems, amelioration of soils, and any other agricultural land use planning after consulting the experts of line departments.

Land Evaluation for Banana:

Land evaluation of the identified soil mapping units was carried out through land capability classification (LCC), land irrigability classification (LIC) (AIS&LUS, 1970), and crop suitability evaluation (FAO, 1976; Sys *et al.,* 1991, 1993; Naidu *et al.,* 2006).

The FAO panel for land evaluation (FAO, 1976) defined the concept of land utilization types and suggested land classification for specific uses. The classification is presented in four categories: orders, class, subclasses, and units. There are two orders, "S" for suitable and "N" for unsuitable land, reflecting the kind of suitability. The suitable order (S) is further subdivided into three classes. (S1, S2 and S3) reflecting the degree of suitability within the order. The unsuitable (N) order has two classes (N1 & N2). The sub-classes reflect the kind (s) of limitation or the main kinds of improvement measures required within a class. These limitations are climate (c), topography (t), wetness (w), salinity (n), soil fertility (f), and physical soil limitation (s).

Soil suitability assessment criteria for Banana

Banana is one of the major fruit crops of the country. It is a good source of minerals and vitamins. It contains more than 20 per cent carbohydrates, which is a rich source of energy. Banana is moisture and heat-loving plant and cannot tolerate frost or arid conditions. Banana is mainly grown in Tamil Nadu. West Bengal, Kerala, Maharashtra, Gujarat, Karnataka, Assam, Andhra Pradesh and Bihar. Though some inferior types of bananas are grown in the Himalayas, their commercial production is mainly limited to tropical conditions, such as those prevailing in central, southern, and northeastern India. Banana is a predominantly tropical crops. The optimum temperature for foliar growth is 26-28 °C and for fruit growth 29-30 °C. Leaf area production is highest at 33 °C day and 26 °C night temperatures, with pseudo stem growth at 21- 24 °C. Temperature <20 °C affects growth and rate of fruit maturation. Temperature below 16 °C in subtropics can cause fruit deformation and temperatures of 37 °C or higher may cause leaf scorch. Banana fruits increase in girth up to a temperature of 29 °C. The growth almost stops at a temperature of <10°C or >38 °C.

Wind velocity of 40 km per hour or above causes breakage or uprooting of pseudo stems and is a major reason for crop loss. The rainfall of 50 mm per month represents a level below which the plant is affected seriously by a deficit of water, while 100 mm rainfall per month may be taken as 'satisfactory'. Bananas can be cultivated from sea level to 1500 m MSL and under rainfed conditions at an elevation of 500-1500 m. It can be grown on a wide range of soils, having good internal drainage, adequate fertility, and moisture sufficiency. Ideal soils described for banana cultivation are level (0-1% slope), silty loam or fine sandy loam soils that have gravel content of 5 per cent or less, deep (>120 cm depth), with angular blocky structure and pH 5.5-7.0. The clay content should be <40 per cent with a water table deeper than 120 cm. Banana tolerates a pH range of 4.5-8.0, but excellent growth can be obtained in very slightly acid to mildly alkaline soils. A soil that is not too acidic, rich in organic matter, high in nitrogen content, adequate phosphorus, and potash is preferable. Soils derived from limestone are ideal. Coarse sands, heavy compact clays, silts, poorly drained soils with compact subsoils, and saline soils with salt percentage >0.05 are unsuitable. Acid soils cause the Panama disease.

Area suitable for Banana

Soils of Jhagadia block, distributed in various mapping units, were evaluated for suitability for banana crops. The suitability analysis (Table 1 and

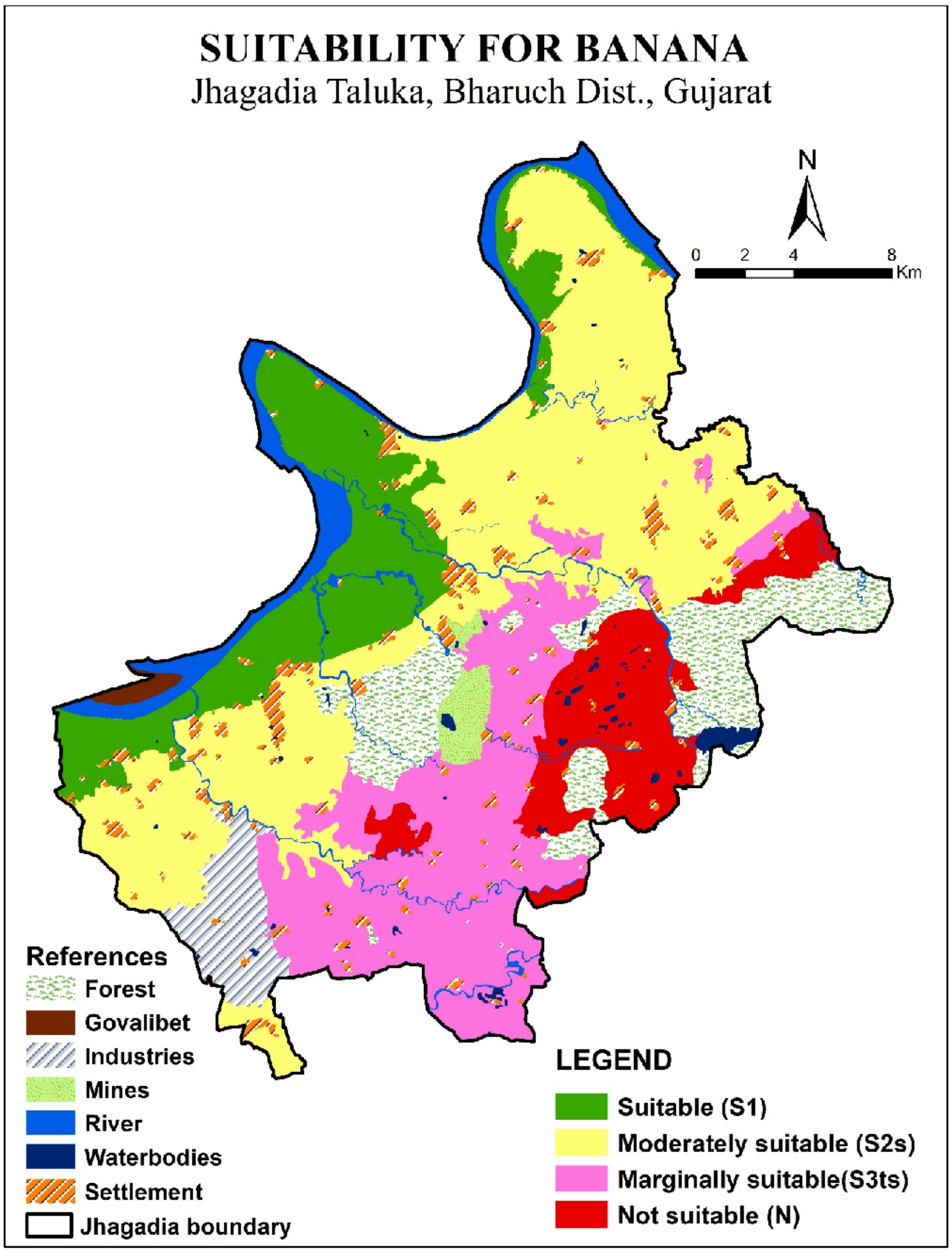

Fig. 1. Soil-site suitability map for the banana in Jhagadia block of Bharuch district, Gujarat.

Table 1. Suitability for Banana

Sl. No.	Suitability class	Mapping units	Area (ha)	% of TGA
1	Suitable (S1)	6-7	8,145	13.4
2	Moderately suitable (S2s)	4, 12-19, 21	20,043	32.9
3	Marginally suitable (S3ts)	1-2, 5, 10-11, 20	11,560	18.9
4	Not suitable (N)	3, 8-9	5,307	8.7

Fig. 1) showed that 8.7 percent of the total geographical area of the block is not suitable for the cultivation of banana crops due to the problems of severe erosion, shallow soil depth, slight to moderate stoniness, and undulating topography. However, 13.4 per cent of the area is suitable, 32.9 per cent of the area is moderately suitable, and 18.9 per cent of the area is marginally suitable. Presently, the farmers are planting tissue culture seedlings of bananas and are engaged in producing good-quality bananas in mapping units 6 and 7.

Conclusions

Based on the degree and extent of limitations and potentials of land resources of the Jhagadia block, soils were evaluated for suitability of the Banana crop. We conclude that 13.4 percent of the area is highly suitable and 32.9 percent is moderately suitable for banana production. The area for banana cultivation delineated in the map should be used to boost productivity and production in Gujarat state. The findings of the present study may be used for up-scaling the research in adjoining blocks or districts situated on the west coast physiographic region of Gujarat.

References

AIS&LUS, (1970). *Soil Survey Manual*, All India Soil Land Use Survey Organization, Indian Agricultural Research Institute, New Delhi.

Food and Agriculture Organization (FAO), (1976). *A Framework for Land Evaluation*. Soils Bulletin 32, Rome.

Jangir A., Tiwari G., Sharma R.P., Dash B., Chandran P., Singh R.S., and Singh S.K., (2019) Land resource inventory of Bharuch taluka, Bharuch district, Gujarat on 1:10000 scale using geospatial techniques for optimal agricultural land use planning. NBSS&LUP Publ. No. 1123; NBSS&LUP, Nagpur, pp. 1-74.

Merh, S.S. (1995). *Geology of Gujarat*, Geological Society of India. Bangalore.

Naidu, L.G.K., Ramamurthy, V., Challa, O., Hegde, R. and Krishnan, P. (2006). Soil Site Suitability Criteria for Major Crops. *NBSS Publ. No.129*, NBSS & LUP, Nagpur.

National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), (2011-12). Annual Report 2011-12., Nagpur-440033, India.

Sharma R.P., Singh R.S., Naitam R.K., and Singh S.K. (2019a). Technique of Large Scale Soil Mapping using Remote Sensing Satellite Data in Basaltic Terrain of Peninsular Region in the Northwest Gujarat, India. *Journal of the Indian Society of Soil Science,* 67 (2), 151-159. DOI: 10.5958/0974-0228.2019.00016.1

Sharma R.P., Jangir A., Tiwari G., Dash B., Naitam R.K., Nirmal Kumar, Singh R.S., Singh, S.K. and Chandran, P. (2020). Land Resource Inventory of Jhagadia Taluka, Bharuch District, Gujarat on 1:10000 Scale for Optimal Agricultural Land Use Planning, Using Geospatial Techniques. NBSS Publ. No. 1138, NBSS&LUP, Nagpur, pp.1-150.

Sharma, R.P., Singh, R.S., Rao, S.S., Singh, S.K., Chandran, P., Singh, T.P., Singh, R. and Tailor, B.L. (2019b) Land Resource Inventory of Dholka Taluka, Ahmadabad District, Gujarat on 1:10000 Scale for Optimal Agricultural Land Use Planning, Using Geospatial Techniques. NBSS Publ. No. 1127, NBSS&LUP, Nagpur, pp.1-145.

Sharma, R.P., Singh, R.S., Singh, S.K. and Arora, S. (2018). Land Resource Inventory (LRI) for development of sustainable agricultural land use plans using geospatial techniques: A case study of Pata Meghpar village, Jamnagar district, Gujarat. *Journal of Soil and Water Conservation,* 17(1), 15-24. DOI: 10.5958/2455-7145.2018.00003.6

Sys, C., Van Ranst, E. and Debaveye, J. (1991). *Land Evaluation*, Part II. In: *Methods in Land Evaluation*. Agricultural Publications No.7, GADC, Brussels, Belgium.

Sys, C., Van Ranst, E., Debaveye, J. and Beernaert, F. (1993). *Land Evaluation*, Part-III. *Crop Requirements*. Agricultural Publications No.7, GADC, Brussels, Belgium.

Velayutham, M., Mandal, D.K., Mandal, C. and Sehgal, J. (1999). Agro-Ecological Subregions of India for Planning and Development. Nagpur, India. *NBSSLUP Publ.* **35**, 372.