Soil Survey and Land Use System Approach for Planning of Sustainable Land Management

A Case Study of Ananthapur District, India

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1. Introduction

India is a country of splendid diversity of soil, climate, food, clothing and culture. The stability in the sector of food security, fiber and shelter provisions and animal wealth has been threatened due to ever-increasing population pressure and indiscriminatory use of land resources. It is also well recognized all over the world, specially in the developing countries that inappropriate land use leads to decline of soil productivity and ultimately to poorer quality of life. Though India has overcome the situation of food shortage and increased its production from less than 100 million tons per year in the early sixties to 195 million tons per year in this decade, the goal of self sufficiency in the dynamic socio-economic framework in a sustainable nature needs urgent attention and scientific guidance. This can be achieved through sustainable land management. In the last two decades many fora discussed the need for sustainable land use (Edward et al 1990, Singh et al 1990).

The implementation of SLM is based on individual values supplied by farmers who are concerned about more production and income generation and institutional values like development of technology for efficient cropping, crop protection, water use efficiency etc. In this paper the role of institutional values has been highlighted through the case study of developing a plan for sustainable land use in Ananthapur District, India.

The objectives of the study are:

- To identify and evaluate the land and water resources
- To develop a sustainable land use plan based on resource inventory data and socio-economic scenario.

1.1 Brief description of the study area

Ananthapur District is situated in the western part of the Deccan Plateau and forms the southern most part of the Rayalseema Region of Andhra Pradesh. The District is situated within geographical co-ordinates $13^{o}14'$ and $15^{o}15'$ N and $76^{o}50'$ and $78^{o}30'$ E, occupying an area of 19,130 sq. kms. It is the largest District of Andhra Pradesh

accounting for 6.9 per cent of the total geographical area of the state. The District has 16 administrative blocks with 340 villages, inhabited mostly by farmers. The total number of cultivators is 561 thousand of which 490 thousand are small or marginal farmers. Animal resources are summarized hereafter.

	Nos.
Bullock	3,08,800
Cows	79,466
Buffaloes	88,590
Sheep	8,79,500
Goats	2,75,100
Poultry	9,40,940

The land : man ratio is 0.6 ha/man and the cattle equivalent is 0.24 ha/cattle.

2. Agro-Ecological Properties

Delineation of the agro-ecological units in the District is important for crop planning as soil characteristics and length of growing period co-determine the choice of crops for a particular area. The annual rainfall sum, in the District ranges from 500 to 700 mm with an average of 562 mm; the District is drought prone.

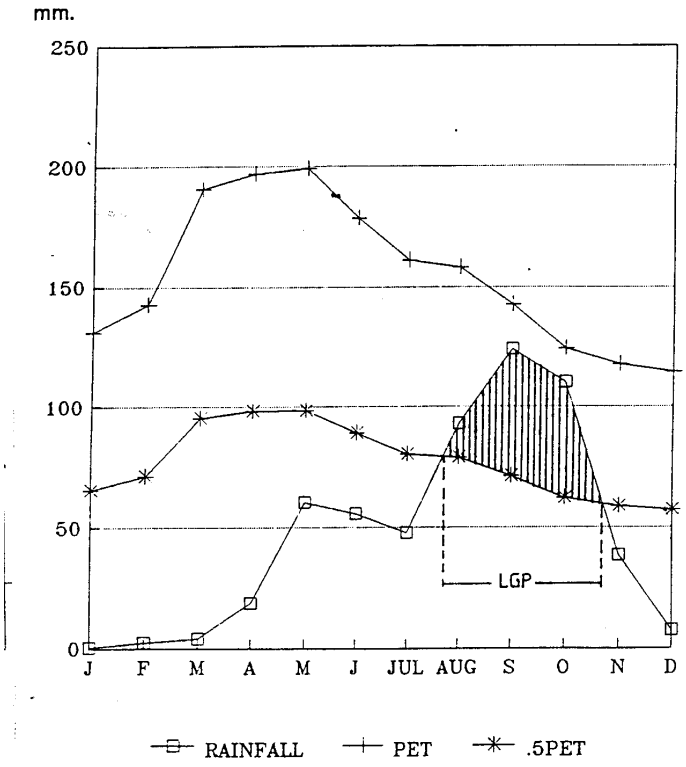

Figure 1. Water balance of the Ananthapur District

The mean annual temperature is 27.6°C and the mean summer and mean winter temperatures fluctuate between 31.2°C and 24.3°C. Climatically the District is in the transition from semi-arid to arid; the average length of the growing period is 70 to 90 days with an exceptional 110 days in some small areas. The available water capacity is low to medium. Figure 1 presents the water balance diagram.

3. Agricultural Scenario

The District has the largest cropped area in the state and about 87 per cent of the cropped area is rainfed. Major crops grown in the District include: groundnut, sorghum, paddy, sunflower, sugarcane and pigeon pea. The present land utilization status is given in the following table below and summarized in Fig. 2.

Land Utilization

	('000 ha)
Geographical area	1913
Net area sown	966
Sown more than once	29
Gross cropped area	995
Net area irrigated	135
Irrigated more than once	27
Gross area irrigated	178

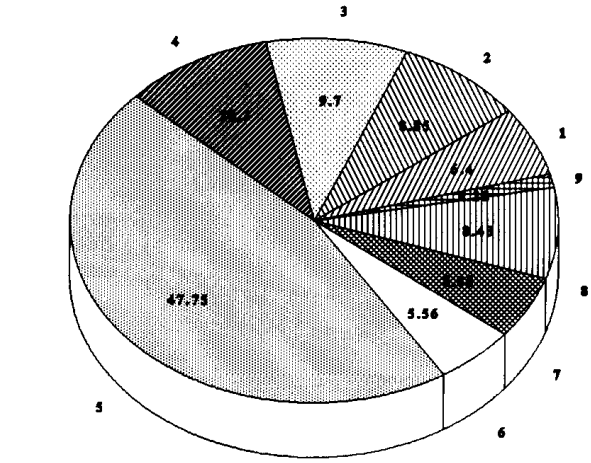

Figure 2. Present area use under different types of land use in the Ananthapur District.

Irrigation

Net irrigated area	134914 ha
Irrigation by canals	33,259 ha
Irrigation by tanks	10,376 ha
Irrigation by wells	88,673 ha
Irrigation by other	2,616 ha

4. Crop Performance

The crop areas, crop production and yield rates have been studied. These are presented in the table below.

Crop	Area	Production	Yield
	('000 ha)	('000 tonnes)	(kg/ha)
Rice :			
Total	59	151	2567
Kharif	29	62	2155
Rabi	30	89	2965
Sorghum :			
Total	39	41	1064
Kharif	11	14	1238
Rabi	28	27	1064
Ragi :			
Total	11	19	1650
Kharif	10	17	1653
Rabi	1	2	1625
Groundnut :			
Total	723	497	689
Kharif	679	464	665
Rabi	44	33	1383

5. Methodology

The methodology followed starts with a soil resource inventory comprising image interpretation, field survey and laboratory work

- Visual image interpretation were carried out visually using LISS II data for base map generation with physiographic delineation and land use studies.
- Soil resource survey were carried out following thorough traversing and site selection for profile study in selected landforms to study morphological properties and information on site conditions. Apart from this data on crops, cropping system, socio-economic features etc were collected from farmer's and other local sources.
- Soil analysis were carried out to determine the physical and chemical properties of soils following standard procedures as outlined by Sarma et al (1987).
- GIS activity using SPANS software included digitisation of soil map and processing in GIS and generation of thematic maps generation using `reclassification' techniques and map analysis for statastical information on various themes.

6. Results And Discussion

Soils of the District - Their characteristics and classification

The District is past of under the south Deccan Plateau, in the Rayalseema region. This land is characterized by hills and ridges, rolling, undulating and gently sloping lands and very gently sloping plains. The soils on the different landforms have been classified as per soil taxonomy (USDA, 1992).

The hills and ridges are moderately steep to steep, rocky and bouldery, with soil in patches. The soils are shallow to very shallow, somewhat excessively drained, gravelly clay to gravelly loam and very severely to severely eroded. They are classified as (Lithic/Paralithic) Ustorthents and Ustropepts; in places Paleustalfs and Haplustolls are mapped in ustic areas. The aridic areas have (Lithic) Ustic Torriorthents and (Lithic) ustic Haplocambids.

Rolling lands have shallow to moderately deep, well drained, gravelly clay to gravelly loam and loamy soils, calcareous and non-calcareous, and moderately to severely eroded. They are classified as (Lithic) Ustropepts and (Lithic) Rhodulstalfs in ustic areas and as (Paralithic) Ustic Haplocambids and Ustic Haplargids in aridic areas.

Undulating lands have deep to moderately deep and shallow, well drained to moderately well drained, clay to gravelly loamy soils and in places calcareous, cracking clay soils. The soils are moderately to severely eroded and are classified as (Paralithic) Ustropepts, Haplustalfs, Rhodustalfs, (Vertic) Ustropepts and Haplusterts in Ustic and (Ustic and Ustertic) Haplocambids and (Aridic) Haplusterts in aridic areas.

Gently sloping lands have deep to moderately deep and very deep, moderately eroded, well drained to moderately well drained, gravelly clay to loam and calcareous, cracking clay soils. The soils are classified as Rhodustalfs, Paleustalfs, Haplustalfs, (Vertic) Ustropepts and Haplusterts in ustic and Ustic Haplargids and Ustic Haplocambids in aridic areas.

Very gently sloping plains have deep to very deep, moderately well drained, calcareous, cracking clay soils with slight to moderate erosion. These soils are classified as (Vertic) Ustropepts and (Chromic) Haplusterts.

The soils are in general neutral to strongly alkaline with loam to clay near the surface and clay in the subsoil. The CEC is ‘high’ and organic carbon and phosphorus contents is low. The potassium content is high to medium.

7. Thematic Maps

Several thematic maps have been derived from the basic soil survey data. The attributes chosen were those that influence plant growth through soil-water-air-plant relationships. These interpretative maps help land users to develop an action plan for conserving soils, ameliorating degraded soils and for using soils in line with their capability.

7.1 Slope

In Ananthapur District, about 47 per cent of the area have very gentle (1-3%) slope. Another 23 per cent area has gentle (3-8%) slopes and 12 per cent of the area moderately steep (15-30% slope) where soil conservation measures, such as contour cultivation and plantation on bunds, are needed to protect the soils from the vagaries of erosion.

7.2 Soil Depth

Very deep soils occur only in pockets where the soil depth is more than 150 cm, whereas deep soils (100-150 cm) cover in about 14 per cent of the area. Moderately deep (75-100 cm) and moderately shallow (50-75 cm) soils occur in 47 and 4 per cent of the total area, respectively.

7.3 Particle Size Class

The soil textural class influences soil water retention, infiltration, drainage conditions. Out of 13 particle size classes, loamy skeletal, coarse loamy, loamy fine loamy and clayey soils occur in the District. Loamy, skeletal soils cover about 13 per cents the extent of clay skeletal soils is about 35 per cent of the total District area.

7.4 Available Water Capacity

Soil texture, soil depth and soil mineralogy are soil characteristics which determine the available water capacity (AWC) of soils and as such are of great significance for plant growth. It is observed that about two thirds of the area have a low to very low AWC (upto 100 mm/m) and another 20 per cent has a medium (100-150 mm/m) AWC. About 10 per cent of the area has a high AWC (150-200 mm/m).

7.5 Land Capability

Land capability classification is a broad grouping of soils based on their limitations. It serves as a guide to assess the suitability of land for cultivation, grazing and other uses.

The study of the area reveals that potential evapotranspiration exceeds precipitation. The low water holding capacity of the soils constrains moisture availability to crops. There are only a few weeks in the rainy season when rainfall probability is >40 per cent (after sowing of the crops in the 38th to 40th week). Rama Rao *et al* (1994) found that monsoon forecasting during the southwest monsoon season, reaches the level of 55 per cent.

The soils suffer from various physical limitations such as: coarse texture, gravelliness and shallowness. An appreciable area consists of rock outcrops. The fertility of the soil is low with low nutrient retention suggested by a low CEC. In places, salinity and high contents of calcium carbonate also cause problems for land use.

Land capability classification suggests that 50 per cent of the lands are class III land with limitations of climatic conditions, soil and erosivity; class IV lands occupy 20 per cent of the area where careful management practices are to be adopted.

The land evaluation studies showed that only 6 per cent of the District have no or slight problems and are rated highly suitable for common crops, whereas 20 per cent has been rated as moderately suitable and likely to produce 20 per cent less than the productive zone. The study also shows that part of northern Ananthapur is suitable for sorghum cultivation whereas the central part is mostly marginally suitable with fringes that are moderately suitable. However, it is observed that the suitability for groundnut cultivation is moderate in most of the south-central part of the District. The northern and

eastern parts of the District are marginally suitable. The southeastern part of District is unsuitable for groundnut cultivation.

The thematic maps generated using GIS give an indication of the spatial nature of land capability concerned land attributes as used to assess the various degrees of limitation. Similar studies were carried out to assess land suitability of the Puruliya District in West Bengal for rainfed rice cultivation. (Maji and Krishna 1996).

The overall situation of the District is described by: -

- Low rainfall
- Erratic rainfall
- 87% of the area under cultivation
- Low level Farming Technology
- Poor soil fertility
- Soil constraints such as shallow soils, rock outcrop etc.
- Depletion of the ground water level
- Less forest and vegetation cover
- Human and Animal population pressures
- Poor marketing and transport network

8. Conclusion

The following recommendations are made:-

- Good soils are suitable for normally grown crops with better Agro-technology.
- Crop planning per agro-climatic unit should consider the probability of soil water availability
- Forestry, Agroforestry, Silvipasture and Arid Horticulture may be encouraged in soils having capability class IV and above.
- Small-scale water harvesting (ponds, wells) must be practiced for life saving irrigation of crops.
- Sericulture may prove to be an opportunity for women and landless labour to increase their income.
- Planning must take agriculture, forestry, silvi-pasture and small-scale industry into considerations.

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