CASE STUDY

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LAND CAPABILITY CLASSIFICATION IN A PART OF NARMADA BASIN

NATIONAL INSTITUTE OF HYDROLOGY
JALVIGYAN BHAWAN
ROORKEE - 247 667 (INDIA)

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PREFACE

In Humid regions, agricultural land are subject to excessive erosion due to water and unsuitable topography. In the regions, ravines or gullies are found near river or stream courses. The ravines extend upto few meters to several kilometers. Skeletal soils are found in hills. Gravelly to fine textured soils are found near river banks. At several locations, deep clays are found. Land capability classification is done in an area in humid region. Land capability classification is a systematic classification. The classification considers properties that decide the ability of the land to produce common cultivated crops and pasture plants virtually on permanent basis. This classification is made primarily for agriculture purposes and it enables the farmer to use the land according to its capability and to treat it according to its need.

In the present study, land capability classification is carried out considering several of soil characteristics and associated land features. The major soil characteristics considered are texture, depth, permeability and salinity of the soil. The important associated land characteristics are: Landuse, slope of the land and erosion etc.

GIS Integrated Land and Water Information System (ILWIS) is used in this study. Results obtained in this study are useful to various government agencies and researchers working in this area. The existing criteria of the land capability have been used in this study and have been carried out in GIS ILWIS.

This study was carried out in Remote Sensing Application division at National Institute of Hydrology, Roorkee. Shri D.S.Rathore and Shri S.K.Jain, Scientist 'C' carried out this study.

(S.M.Seth)

DIRECTOR

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ABSTRACT

Bargi project is a major multipurpose water resources project in Narmada basin in Upper Narmada. The project provides irrigation to area in Jabalpur and Narsinghpur districts of Madhya Pradesh. Land capability mapping is very important for proper management of agricultural lands. The command area of Bargi left bank canal is selected for land capability mapping. The area lies between latitudes 22°52'N to 23°26.5'N and longitudes 78°45'E to 79°54'E. The areal extent of the command is 307302 Ha.

An approach given by Dhruvnarayan V.V. (1993) is selected in this study for land capability classification. The map is prepared in different physiographic unit in the command. Various input maps of physiography, landuse/ cover and soil are prepared using IRS LISS II FCC data of pre and post monsoon dates. The maps from satellite data are checked using ancillary data such as topographic maps and soil data. The maps are input in a GIS ILWIS (Integrated Land and Water Information System) using digitizing tablet. The maps are overlaid and statistics for the area are generated using GIS ILWIS.

CHAPTER 1. INTRODUCTION

A large part of land area in our country is under cultivation. Proper management of vast agricultural area in the country is necessary for its sustained use. It is essential to know the capability of land for cultivation. In different physiographic regions different management practices are used. Thus, physiographic regions form inherent mapping units. For selecting a management practice in a land area, it is very essential to have a hazard map. Such a map is obtained by sub classifying land capability in a region according to hazard. The area having various hazards are put to different management practice. A land-capability class is decided by limitations in land-use. Land-capability classes are not enough for planning and execution of works. For practical purposes, it is necessary to know the kind of limitation and the hazard involved. Various hazards to which a land is exposed and which limit uses of land for cultivation are: soil, wetness, climate and erosion.

Land capability classification is a systematic classification. Land properties which decide the ability of the land to produce common cultivated crops and pasture plants virtually on permanent basis, are considered. This classification is made primarily for agriculture purposes and it enables the farmer to use the land according to its capability and to treat it according to its need. Land is arranged in various capability classes by considering several of soil characteristics and associated land features and environmental factors (climate). The chief soil characteristics to be considered are texture, depth, permeability, salinity and alkalinity of soil. The important associated land features are slope of land, effect of past erosion or susceptibility to erosion, natural soil drainage, frequency of overflow etc.

The idea of land capability classification has been developed in the USA for soil conservation on farm lands (Klingbiel and Montogomery, 1961). This idea has been adopted in India also by the All-India Soil and Land-Use Survey Organisation for similar purpose. Land is arranged in various capability classes. Many soil characteristics are considered are: texture, depth, permeability, salinity and alkalinity of soil and subsoil. The important associated land features are: slope of land, effect of past erosion, natural soil drainage, frequency of overflow etc. All the above information is available in a standard soil survey report and can be interpreted to classify the land.

Land capability classification is needed to enable the user of land to decide the proper landuse for optimum production without the risk of soil erosion.

Physiography is very important in a land capability classification. The management practice varies according to the physiography of the land area. In hill terrace cultivation or contour cultivation is done. This reduces the erosion of the fertile and precious top soil. In hills, the cultivation also is done in valleys. The piedmont region contains coarser soil texture and deep ground water tables. The regions are normally put under dry land farming. The alluvial lands are normally with mild to rolling slopes, variable textures and fertile soils. The regions are normally put under dry land farming and irrigated farming. The land possesses in general low to moderate erosion hazard. The region posses suitable land capability class.

The soil hazards in land capability classification are rock exposure or stoniness, wetness, texture, type, electrical conductivity and permeability. The stoniness possesses difficulty in tillage operations. Wetness restricts supply of oxygen to plants through plant roots. The wetness also creates another soil hazard namely salt affected soils. The salt affected soils reduce moisture availability to plants and infiltration to the soils. The areas need to be put under tolerant crops and to be treated. The further creation of salt affected lands in an area after treatment requires proper management practices. The texture and type of soil, control nutrient supply to the soils and possess different erosion hazards. Coarser soils are more prone to erosion due to granular structure. The permeability in the soil controls the supply of moisture from rains to the soil.

CHAPTER 2.0 REVIEW OF LITERATURE

The idea of land capability classification is originated in United States of America. In a land capability classification the land is classified in eight classes. The classes are designated with Roman numerals I to VIII. First four classes are suitable classes. The last four classes are non suitable classes. (Dhurva Narayan V.V., 1993).

Classification Scheme

The land is divided into eight capability classes I to VIII. These 8 classes are grouped in two land-use suitability groups, viz. (i) land suited for cultivation and other uses (Class to IV) and (ii) land not suited for cultivation but suitable for other uses (Class V to VIII).

Class I land is the best and the most easily formed land. It has no hazard or limitation for use. In the Class VIII land, nothing of economic value can be produced. The class may need protection and management to conserve other more valuable (Table 2.1).

Soil and water conservation farm practices suited for Class-I to IV lands are given in Table. Each class of land may need one or more of the practices, depending upon the prevailing conditions of farming. Soil and water conservation practices suited for Class V to VII lands are given in Table 21. Each class of land may need one or more of the above practices depending upon the prevailing conditions.

Land capability sub classes

Land capability subclasses are assigned based on hazard to a land area. The sub classes are created for hazards namely soil, erosion, wetness and climate. The sub categories are assigned first letters of the hazard category namely S, E, W and C. This sub class designation suffixes to class designation. Soils having stones, gravels critical values of electrical conductivity, exchangeable sodium percentage and pH limits its use for agriculture. Wetness in an area affects the agricultural activities when the water table remains close to plant's roots round the year. In arid and semiarid climates, the landuse is limited due to insufficient supply of moisture in the root zone. This insufficient supply of water in root zone is caused due to torrential rains and higher rates of evapo-transpirations. Wetness is a hazard in soils. It causes salt affect in soils. The waterlogged soils are found slightly to moderately salt affected. Sodic soils affect infiltration characteristics. The soil particles get dispersed in sodic soils due to water. The dispersed particles clog soil pores affected infiltration causes stagnation of water. (Dhurva Narayan V.V., 1993, Varshney R.S., 1994, Sugumaran R. et.al, 1994, Sidhu P.S. et. Al., 1991). Four kinds of hazards are recognised at the subclass level. Within a land-capability class, the subclass is, therefore, decided by the kind of limitation or hazard. The land capability subclasses are given below:

e = Erosion hazard-when vulnerability of the soil to erosion is the main problem in its use
w = Wetness -when excess water is the main problem
c = Climates-when climate (e.g. temperature or lack of moisture is the main problem)
s = Soil-when limitation of nature of soil (e.g.shallow soil, salinity) is the main probl

For the land capability classification various factors are to be generated. Some work on land capability classification is done with conventional techniques. A few works have been carried out using GIS approach. The GIS approach is very much important for such type of studies. In this chapter a literature review is given for land capability classification. A review of certain parameters is included.

Khybri (1979) suggested a land capability classification for the Himalayan region keeping in view the socioeconomic, agroclimatic conditions and erosion problems of the region. It was also suggested that for steeper slopes, soil depth and land slope have to be considered. This is needed, particularly, for the construction of bench terraces on such slopes. Accordingly, land capability rating table for the Himalayan region has been developed.

Phadnawis et al. (1990) considered effect of climate on soil damage, limitations in use, productive capacity and soil depth. The author has also discussed effect of past erosion on permeability, waterholding capacity. This revealed that the land capability classification is a pre requisite in landuse planning.

Singh B.M (1994) has given land capability classification for watershed management in the Himalayan terrain. He concluded that for Himalayan terrain having unique geomorphic features and land use characteristics, land capability rating needs special consideration. Study in erosion has led to a land classification of these areas. Three major landuses are recognized and they are cultivation, forest and pastures. Each land use is further divided into optimum suitability and marginal suitability class to identify areas of potential development.

Rao et al. (1994) carried out land capability classification of Bharatpur district using All India Soil & Landuse Survey (AIS&LUS) classification system. The different parameters considered in this classification include soil, drainage, slope and erosion. A matrix consisting of the different land parameters on one side and eight classes of capability on the other side was generated. In the matrix, class-I are best capable land and class-VIII are the least capable land.

Dubey O.P. et al. (1988) mapped erosion prone area considering rock, soil type, slope and landcover. Use of satellite data and aerial photographs was made for preparing landcover map and grouping the rock-soil classes according their erodibility. Slope analysis was carried out on contoured map and on digital elevation model. A semi automatic method for erosion mapping was developed and tested in a part of Himalayan. Venkataranam (1994) identified four erosion classes: nil to slight, moderate, severe to very severe and very severe based on the length and degree of slope, landuse/ landcover and soil characteristics as revealed by remotely sensed data and with the aid of ancillary data. Sridhar V. and I.V.Muralikrishna (1994), carried cut a study on soil erosion using IRS-1B, LISS II data at 1:50,000 and toposheets. Various maps such as landuse/ landcover, slope and isohyetal maps were prepared by visual interpretation. By the superimposition of the four base maps, the final maps showing of erosional zones are prepared.

Widely used predictive equations for erosion is used by Saha S.K. et al. (1992), Choudhary et al. (1992) and Narayan P. et al. (1993). Saha S.K. et al. (1992), have undertaken a study to decide priority of subwatersheds. The study is carried out in a part of song river watershed, eastern doon valley, based on soil loss estimates using IRS- IA- LISS II data. The USLE has been applied. The results indicated that out of total fifteen subwatersheds, nine subwatersheds belong to high to very high priority classes. This category covered 36.2% of the watershed. The erosion rate ranged from 50.5 to 225.4 t/ha/yr. Rest subwatersheds covering 63.8% area of the watershed was classified as low to moderate priority categories(average estimated soil loss between 7 to 17.7t/ha/yr). Soil loss has been calculated using' Wishchmeier and Smithes' soil loss equation in hill-slope followed by pediment area (Choudhary et al., 1992). There is insignificant soil lose in flat areas. Narayan P. et al. (1993) prepared a soil erosion map of West Bengal. The soil erosion in West Bengal ranges from 5 to 40 t/ha/yr. Small erosion occurs in deltaic and dense forest regions. High erosion rate occurs in western parts of Chhotanagpur plateau and hilly regions having open forest in Darjeeling, Jalpaiguri and Kooch Bihar. About 10% of the area of the state revealed severe erosion(>20t/ha/yr) needing immediate attention to treat the area with soil conservation measures on priority. The area under moderately several(15-20t/ha/yr) and moderate erosion classes(10-15t/ha/yr) are about 6 and 13 percent respectively. Slight to moderate erosion occurs in 70% area of West Bengal. The erosion rate in the area is less than 10t/ha/yr. Map will prove a handy tool for identifying priority areas for developing landuse plans and devising conservation strategies for effective resources management. This study has been done at greater scale.

Waterlogged areas can be mapped using methods: (Varshney R.S., 1994)

1. Visual survey of salt appearance
2. Ground water data
3. Soil survey for soil characteristics upto 3 m depth
4. Clay band formation in the subsoil

USSL (United States Salinity Laboratory) has given criteria for defining salt affected areas. According to these criteria the salt- affected area can be classified in three types based on soil electrical conductivity, exchangeable sodium percentage and soil pH. The salt affected soils are designated as saline, non saline alkali or sodic and saline-alkaline or sodic (Agarwal R.R. et. Al., 1982).

Landuse/ cover e.g. salt affected areas and urban areas are mapped by Sidhu P.S. 19991 and Kumar S. et al., 1989. Sidhu P.S. has observed salt affected area with high calcium carbonate content on the surface. The soils have been developed in loamy sand, loam and sometime on sandy loam. The salt affected area has been seen in FCC in white tone and mixed red and white patches. Areas are classified as severely salt affected (Uncultivated) and salt affected in patches (Cultivated). Other category identified is salt affected and waterlogged. The salt affected area has shown a decline due to improved drainage and arresting of floods. This mapping has been done in Punjab. The urban areas: residential has been found in dark cyan color, coarse texture and mixed with different street pattern. The mapping is done with SPOT data in Bombay metropolitan region (Kumar S. et al., 1989).

Kudrat M. et. Al., 1993 have done physiographical classification of a watershed in Himalayan foothills. The physiographic units delineated as hill, upper and lower piedmont and mountains. They made subclasses in hill physiography based on fores cover type and density. Upper and lower piedmonts were classified based on density of forest cover namely dense forest cover and area partly covered with forest. The mountains are classified based on density and type of forest cover and scrubs. (Kudrat M. et. Al,). Singh B.D.(1987) has delineated piedmonts: upper and lower in Punjab near Siwaliks. Piedmonts alluvial plains are formed from coalescing of alluvial fans. (Thornbury W.D., 1986).

Singh B.D. (1987) has used FCC and black and white single band imageries in physiographic mapping. Piedmonts: upper and lower have shown respectively light yellow to light bluish color and medium bluish to brown color on FCC. Band 5 (Landsat MSS) has also been used. The boundaries are clearly defined for piedmonts in imageries. Hills have been observed in dark brown color and are having sparse tree cover. Valleys are seen in light color.

Spectral reflectance study from various soils has shown that entisol recorded created soil reflectance as compared to vertisol due to differences in particle size distribution, soil color and moisture content in the soil. The moisture content had significant affect among all the factors (Govardhan V., 1991). The particle-size and soil-reflectance relationship is inverse of moisture-content and soil-reflectance relationship (Govardhan V.; Sinha A.K., 1987) The spectral reflectance decreases with a increase in particle size. The change is more in small particle sizes (Govardhan V., 1991).

Table 2.1. Land-capability Class (Dhurva Narayan, 1993)

Class	Characteristics and recommended land use
I	These are deep productive soils, easily worked on nearly level land, not subject to overland flow, near slight risk of damage when cultivated,use of fertilizers and lime, cover crops,crop rotations required to maintain soil fertility and soil structure.
II.	These are productive soils on gentle slopes, moderate depth, subject to occasional overland flow, mayrequire drainage, moderate risk of damage when cultivated, use crop rotations, water control systems or special tillage practices to control erosion.
III.	Soils are of moderate fertility on moderatelysteepslopes, subject to more severe erosion, subject to severe risk of damage but can be used for crops provided adequate plant cover is maintained, hay or other sod crops shouldbe grown instead of row crops.
IV.	These are good soils on steep slopes, subject tosevere erosion, withsevere risk ofdamage but may be cultivated occasionally if handled with great care, keep in hay or pasture but a grain crop may be grown once in 5 or 6years.
V.	Land is too wet or stony for cultivation but of nearly level slope, subject to only slight erosion ifproperly managed, should be used for pasture or forestry butgrazing should be regulated to prevent plant cover from being destroyed.
VI.	These are shallow soils on steep slopes, used forgrazing and forestry, grazing should be regulated topreserve plant cover, if the plant cover, if the plant coveris destroyed, use should be restricted until cover is re-established.
VII.	These are steep, rough, eroded land with shallowsoils,also includes droughtly and swampy land, severe risk of damage even when used for pasture or forestry, strictgrazing or forest management must be applied.
VIII.	Very rough land, not suitable even for woodland or grazing, reserve for wildlife, recreation or watershedconsideration.

CHAPTER 3.0 DESCRIPTION OF STUDY AREA

For the present study Bargi left bank canal command area has been selected for carrying out land capability classification (Fig.3.1). Bargi dam is located near Bijora village. The dam is 43 kms from Jabalpur, the head quarters of Jabalpur district. The Bargi left bank canal takes off from the left flank of Bargi Dam and runs upto the Shakkar river covering a distance of 137.2 km. The command area under Bargi LBC lies in Jabalpur and Narsinghpur districts. The geographic location of the area is: latitudes 22°52'N and 23°26.5'N and longitudes 78°45'E and 79°54'E. In the west the extent of the command is up to the confluence of the Shakkar and the Narmada river limits the boundary in the south. The command extends up to the proposed Patan Branch Canal in the east.

Climate

The project area is covered by tropical type of climate having considerable variations in rainfall, temperature and humidity. The changes weather and climate is the direct result of changes of pressure and movement of air currents from the Indian Ocean to Bay of Bengal and Arabian Sea. The year has three distinct seasons-the wet season (mid-June to October), the winter season (November to February) and the hot weather (March to mid-June).

Rainfall

Rainy season in the command area extends June to October under the influence of the South-West monsoon. The command area also receives some rainfall during January and February from the North-East monsoon. July and August are the heaviest rainy months. Normally, the rainfall ceases by the end of September. However, in most years October receives good rainfall. There is a considerable variation in rainfall.

The rain gauge stations are at Jabalpur, Patan, Narsinghpur, Gotegaon and Mohapani. The average annual rainfall, however varied from 888 mm to 2043 mm. average annual rainfall of Narsinghpur raingauge station for the same period is 1246 mm. Jabalpur raingauge receives about 92 per cent of the annual rainfall in the monsoon months. Narsinghpur raingauge station receives 95 per cent of yearly rainfall in monsoon months.

Temperature

The command area lies in the hot region of the country. The temperature begins to rise rapidly from March till May that is generally the hottest month. Monsoon sets in second week of June. This causes an appreciable drop in day temperature. From mid-November onwards both day and night temperature decreases rapidly. December and January are the cloudiest months of the year. In winter cold waves effect the area in the wake of western disturbances passing across North India. The minimum temperature drops to about the freezing point.

Maximum summer temperature of Jabalpur recorded in May 1954 is 44.7°C. In winter, the temperature ranges between 35.3°c and 7.4°C. Maximum and minimum summer and winter temperatures have been recorded at Narsinghpur station.

Humidity

The project area lies in hot zone. The variation in humidity is quite large. The maximum relative humidity at Jabalpur was 94.0 per cent recorded in August 1960 and the minimum relative humidity was 10.0 per cent recorded in May 1948. The maximum relative humidity recorded at Narsinghpur was 93 per cent in August 1963 and the minimum was 17 per cent in March 1963.

Topography

The elevation above mean sea level of the command area varies from 365 m to 397 m in Jabalpur district. In Narsinghpur district, the elevation ranges from 313 m to 380 m. The topography of the command area in Jabalpur district is mostly undulating and rolling. At some places deep gullies and ravines are also formed. The general topography of Narsinghpur district is flat due to Heavily system of cultivation, which is prominent in Gotegaon block, local differences in elevation are small. In the plain area, the slope ranges from 0 to 3 per cent. The steeper slopes up to 15 per cent are observed in the area where the topography is undulating and rolling.

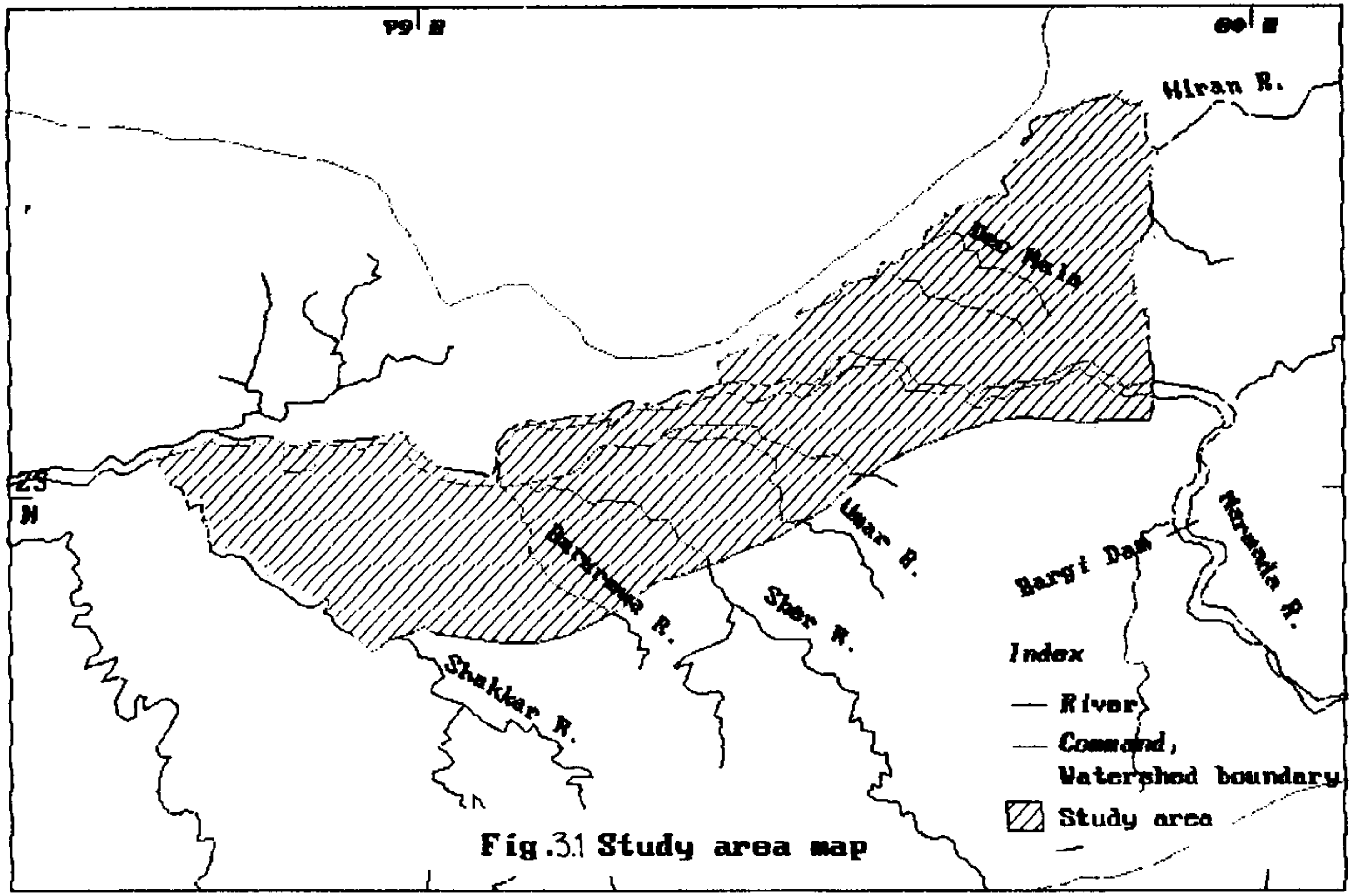


Fig.3.1 Study area map

CHAPTER 4.0 STATEMENT OF THE PROBLEM

In the present study, land capability classification will be carried out considering several of soil characteristics and associated land features. The major soil characteristics considered are texture, depth, permeability and salinity of the soil. The important associated land characteristics are: Landuse, slope of the land and erosion etc.

Land capability classification has been made for Bargi left canal bank command area. A review of literature for land capability classification has been made in chapter two. No work for the study area in question has been carried so far. In the present study remotely sensed data and ancillary data are used in GIS environment.

CHAPTER 5.0 DATA AVAILABILITY AND METHODOLOGY

5.1 DATA AVAILABILITY

GROUND WATER

Ground water data are available for Bargi command. Data are available for pre monsoon, post monsoon and Rabi seasons (Ground Water Survey Circle, Bhopal, Water Resources Department, Government of M.P.). The data are arranged district-wise. The data are available for years from 1984 to 1992. Depth of well in pre monsoon dates is more than 3.5 m in the wells in the command.

SOIL

Soil survey

Detailed soil survey is carried out in the command. In the detailed soil survey the soils are classified in 5 Phases (Table 5.1)

Table 5.1 Soil survey phases

Phase	Location
I	North of Umar Nala and Sher river and south of Narmada river
II	South of Deo Nala, north of Narmada river and east of Hiran river
III	North of Deo Nala
IV	West of Phase I area and east of Barureva river
V	West of Phase IV, no permanent boundary in the west

Classification

Soil in Jabalpur and Narsinghpur districts are classified respectively as medium and deep black under broad classification of Indian soils. In detailed soil survey, the soils are mixed yellow and black soils. In Narsinghpur district the soils are deep to very deep. The soils are dark yellowish brown to light yellowish brown in undulating and rolling topography. Near the banks of rivers the soils are yellow.

Texture

The soils are of coarser texture and skeletal along the banks of river and nallas. The textures of soil in the catchment are as follows:

1. clay
2. sandy clay loam
3. clay loam
4. clay and clay loam
5. sandy clay loam and clay loam
6. clay loam and clay

pH

Phase I area's soils are slightly acidic to moderately alkaline. Larger areal extent is neutral followed by medium alkaline followed by slightly acidic and moderately alkaline. There are 9 and 19 villages respectively with strongly acid and strongly alkaline pH. In zone-II, soils are in general alkaline. The larger areal extent is of mildly alkaline, neutral and moderately alkaline. In phase-III and -IV the larger areal extent is of moderately alkaline followed by mildly alkaline followed by neutral. There are 15 villages where pH is strongly alkaline in Phase III. In phase-V larger area extent is of mildly alkaline, followed by moderately alkaline followed by neutral.

PERMEABILITY

Soil permeability data are available for 51 stations. The permeability classes are specified as moderate and rapid, slow and very slow.

EC

EC data are available from 1:2 dilution EC tests. The EC in the command is in general below 1 mhos/cm. In Phase-II, there are 18 villages where EC is between 1 to 2 mhos/cm. In Phase IV, EC in one village is approximately 2 mhos/cm.

Calcium carbonate and effervescence tests

Data on calcium carbonate content and effervescence tests are available for the command area.

Satellite and Topographic data

IRS LISS II FCC paper prints and IRS LISS I CCT is available for the study area. Topographic maps 55/I,J,M, N at a scale of 1:250,000 are available for the study area. The satellite data IRS LISS II FCC in the form of paper prints at 1:250,000 scale is available. Their path/row numbers are 25-52 A1 2.04.89,18.11.89, 26-52 A1 ,13.04.89, 06.10.89, 26-52 B1,13.04.89, 06.10.89

5.2 METHODOLOGY :

In the present study GIS approach has been adopted. Integration which is one most persistent and pervasive buzzwords in the field of GIS, is used. Integration, in a GIS context, is the synthesis of spatial and non spatial information within the frame work of an application. Criterion for analysis can be dividing into two categories (i) Statement criterion (ii) Table criterion. In statement criterion relationship of the parameters is a statement and is mundane definition of the criterion. Table criterion approach lays down all possible combinations of relationships and thus provides a total solution from the data set. The table criterion is a matrix of parameters and the solution class categories.(Rao et al.,1994). In the present study Table criterion approach has been adopted..

5.3 GIS SOFTWARE USED:

The GIS software used in this study is ILWIS (Integrated Land and Water Information System). It was developed at the Computer Centre of International Institute of Aerospace Survey and Earth Sciences (ITC) Enschede, The Netherlands. ILWIS provides a user with state of art GIS capabilities. It merges GIS procedures with image processing. Software is microcomputer based. It is a raster GIS but uses modules for raster to vector conversion and vice versa (Valenznela 1988).

A conversion program imports remote sensing data, tabular data raster maps, and vector files. Analog data can be transferred into vector format by means of digitizing program.

GIS modelling is executed by the map calculation. Map calculation includes modelling language. 'Map calculation' also uses mathematical functions and macros. It integrates tabular and spatial data bases. Tabular and spatial data bases can be used independently and on an integrated base. Calculation, queries and simple statistical analysis can be performed by table calculator.

In ILWIS the user interface is provided by user-friendly menu. The ILWIS programs can also execute by entering command at DOS prompt while ILWIS is active, by using DOS batch files and using ILWIS response files at the DOS prompt.

5.4 MAP PREPARATION

The process of data base creation for the basin in ILWIS involved collection of relevant available data, including these data into digital format, digitization error checking and correction, polygonization of segment files and finally conversion of data found in vector structure to raster format. Original source maps have been digitized using a digitizing tablet linked to a personal computer through ILWIS and related attribute data have been entered at the key board.

Errors involved in digitization and editing the error:

Manual cartographic digitizing, due to its tedious process often involves errors. Therefore, the segments should be checked for errors. The most common possible errors that are likely to occur during digitization are over and under shooting of the lines, failure to snap lines together at nodes, omission of lines and points incorrect feature coding, incorrect location of features etc. The errors were checked and corrected by the facilities available in ILWIS under VECTOR-digitize module.

Polygonization

After each segment file was checked and corrected, polygon files for soil,landuse,physiography,slope and erosion were created by the polygon generator program. The polygons for any given polygon file were assigned identification name and colour values. It is worth to note that polygon features attributes labels are normally entered only after the topology of the digitized data has been checked and corrected if necessary. In the GIS package used program facilities are also available to automatically create polygon information file containing the areas and perimeters of different polygons. Area and perimeter calculations are done by an interactive in built program.

Vector to Raster Conversion

In spatial variability, overlay operations are easily and efficiently implemented in a raster model. All maps encoded in vector structures were converted into raster structure.

Generation of maps

In preparation of a land capability map following maps are required as input

1. Physiographic map
2. Soil maps
   - Texture
   - Class
   - Permeability
   - Electrical conductivity
3. Landuse/cover map 4. Slope map
5. Erosion map
6. Wetness

Physiographic map, soil maps and land use/ cover maps are generated using IRS LISS II FCC paper prints. Visual interpretation technique is used for preparing various maps from satellite data. For visual interpretation of satellite data, interpretation keys are prepared. The maps are checked using ancillary data such as topographic maps, reports giving data such as permeability, texture, EC etc., ground water well data etc. In landuse cover maps forest cover and urban areas are delineated. In physiographic map, hills are separated from alluvial area using shadow and rough texture in hills as criteria. In a soil map, clay, fine, coarse and gravelly sandy soils are separated due to their tone and texture. Clayey soils exhibited smooth texture and black tone. Fine, coarse and gravelly sandy soils showed varying texture from smooth to rough and bright tone. The tone varied for light to very bright for fine textured soils and gravelly soils. Salt affected area in a landuse/ cover map exhibited mottled texture and cyan to black color. Urban areas showed cyan color and association of road or rain communication lines. Dense and sparse forests have exhibited dark red to light red colours and smooth to coarse texture respectively.

Slope Map

Because sufficient contours were not available for the study area therefore, spot heights were taken from Survey of India, toposheets at a scale of 1:50,000. This data was digitized in the ILWIS system for further analysis. In ILWIS interpolation is available using different technique from point data. Elevation data that represent the topography of the watershed were interpolated to create digital elevation model (DEM). DEM represents the continuous variation of relief over the area. In DEM the altitude value of a given location or point can be identified reading in the value of the grid cell (or pixel).

The elevation data have been gathered and transformed into the altitude matrix (DEM), using standard procedures. This makes production of terrain parameters maps, like slope, easier. Slope, the most important terrain parameter, is defined by a plane tangent to the surface as modeled by DEM at any given point and comprises two components: gradient, the maximum rate of change of altitude, aspect and the compass direction of the slope (Burrough, 1986). In the present study, ILWIS standard filter method has been used and described below :

East - west and south - north gradients were calculated applying standard ILWIS first derivative filters (dfdx and dfdy) on digital elevation model. Slope was obtained from these derivatives by applying standard slope function (Eq).

SLOPE := (SLOPE(DX,DY)/u)*100

u is the size of the pixel

The slope map prepared from this method did not produce good results. A slope map was collected from Project authority. The map collected was made from the contour interval of 1 m. The map is accurate. This map was digitized. A polygon map of the different slope classes was made. In this way a slope map was stored in ILWIS. The slope map with different classes is shown in Fig. 5.1

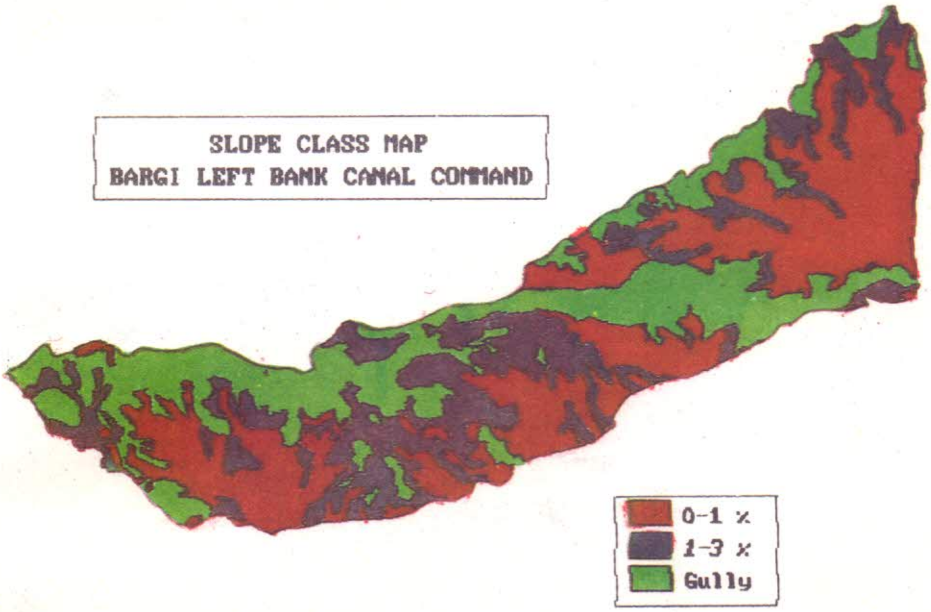
Soil Erosion Map

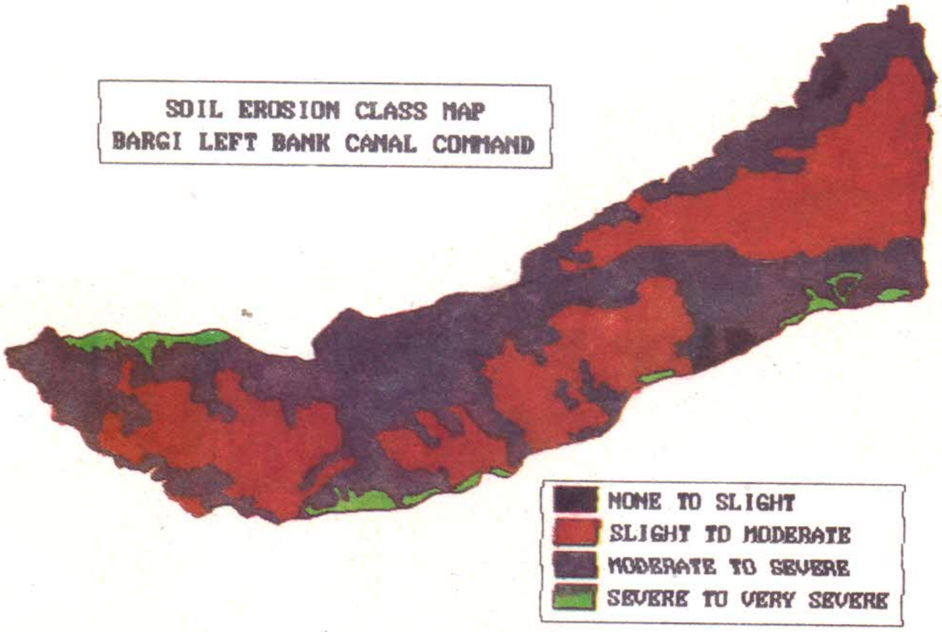
For preparation of soil erosion map, a map collected from Narmada Water Development Authority and IRS LISS II data was used. Soil erosion map of the study area is shown in Fig. 5.2.

Land capability subclass map

New derivative data files are made using attribute map or overlay operations. Almost all the factors required were generated by both methods: (i) Overlay of source data layers and (ii) through linkage between attribute data and spatial data.

Land capability maps are prepared for soil and erosion hazards. The soil and erosion hazard factors are reclassified according to land capability class. 'Reclassification' is a GIS operation. After reclassification the maps are overlaid. Final map is prepared retaining land capability class and limiting factor of soil or erosion in capability of land. This is again done with 'reclassification' GIS operation. The subclasses are grouped to create a land capability class map. Statistics are generated for land capability classes in each soil survey zone. Statistics are also prepared for total command area. A land capability map gives capability of land for agricultural purposes. Thus, areas with dense forest cover and urban landuse/cover are excluded from land capability map.


SLOPE CLASS MAP
BARGI LEFT BANK CANAL COMMAND
0-1 %
1-3 %
Gully


SOIL EROSION CLASS MAP
BARGI LEFT BANK CANAL COMMAND
NONE TO SLIGHT
SLIGHT TO MODERATE
MODERATE TO SEVERE
SEVERE TO VERY SEVERE

CHAPTER 6.0 ANALYSIS AND RESULTS

All the parameters required for the analysis for land capability classification have been generated and stored in GIS. The parameters generated are soil characteristics such as soil texture, permeability, conductivity, slope of land, soil erosion and gully erosion. These parameters were then classified according to the land capability classification criterion given by Tejwani (1976). Now all these parameters were overlaid in GIS and a land capability map has been generated. Within a land capability class, the sub class is determined by hazard. In this study two types of hazard viz. erosion and soil hazard has been considered.

Physiography

Physiography of the region is mapped by visual interpretation of IRS LISS II FCC. Hills have been observed in mixed red and yellow, white color and coarse texture, dark red, smooth and medium texture. Other photo interpretation characteristics observed in shadow. Alluvium has yellow, dark brown color and medium to coarse texture; mixed yellow and dark brown, mixed red and brown, yellow, mixed light blue, blue, black, cyan and red color, coarse texture and patchy pattern. Hill and alluvium have 4209 and 307682 Ha. areal extent. The percent areas are respectively 1.3 and 98.7.

Water logging

The IRS LISS II FCC of pre monsoon period are interpreted. No area is interpreted as water logged in the command.

Soil classification

Yellow (alluvial) soils are mapped using pre monsoon data (Fig. 6.1). Yellow skeletal soils has bright yellow color. Yellow coarse soils has medium yellow color. Yellow fine soils has mixed light, black and light red color and patchy pattern. Yellow soil occurs near river or Nalla course. The photo texture is coarse. A clear boundary exists between yellow and black soils in the FCC. The boundary is not visible in post monsoon date FCC.

Landuse/ cover map

Main landuse (Fig. 6.2) in the area is agriculture. The urban area is delineated in post monsoon image. The area has dark cyan color, coarse texture and transportation network. Forest area is delineated in both pre and post monsoon FCC. Dense forest has dark red and dark brown color. The texture varies from smooth to medium. Sparse forest area has mixed yellow and red, brown color. The texture is coarse. Salt affected area is mapped using pre monsoon date IRS LISS II FCC. Salt affected area has mixed black and white tone and coarse texture. Salt affected cultivated area has patchy pattern. The salt affected area is not checked either from ancillary data or field visit. Other categories are checked using topographic maps.

Land capability map

There are 13 land capability sub classes identified (Fig.6.3). Land capability map with respect to soil properties and land capability map with respect to erosion factor are used as input map.

Areal statistics

1. For Phase area

The are five phases in the study area (Table 6.1 to 6.4). Five statistics tables are generated for each map. Statistics are generated for phase areas for different maps.

2. For command area

Statistics are also generated for command area for all the maps for which phase area statistics are generated (Tables 6.1 to 6.6)

Discussions

The majority of the area in the command is under black soil. Thus major area is classified in category IVS in the study area. Erosion occurs near the banks of the river and nallas and in piedmonts. Thus the areas are classified in categories IV and VI depending on severity of erosion. Near the banks of river and nallas, some area is under skeletal soils. These areas are classified in category VS, since they possess stoniness in the soil. Other areas near the bank of river and Nallas are having suitability class II and III. In these areas different degree of erosion occur. Soil grades from coarse to fine texture. Such areas are better suitable than other areas for agricultural activities.

Area under yellow (alluvial) soils from IRS LISS II FCC are of larger extent than area obtained from field survey data (Rahangdale S.R. et. al,1983,85,87,88 & 89) in all Phases except Phase II. In phase II, the yellow (alluvial) soil area obtained from satellite data is 50% of the area under yellow soil from field data. In phases: III,IV and V the yellow soil area is obtained three times in satellite data as compared to that in field data.

Very small area is mapped as salt affected area in the command. The area mapped could not be checked from ancillary data, since all relevant soil properties were not decided from ancillary information. However, the salt affected areas did not change the land capability map for the command as this area has been mapped as clay soils which already rank low in the suitability classes for land capability.

Table 6.1 Soil texture statistics
Area in ha and in parenthesis area in percentage

Phase	I	II	III	IV	V	Total
skeletal	651 (1.0)	0 (0)	436 (0.9)	2147 (3.7)	956 (1.0)	3755 (1.2)
coarse	468 (0.7)	476 (0.8)	436 (0.9)	3430 (5.9)	1219 (1.3)	6032 (1.9)
fine	6146 (9.8)	2904 (5.3)	4772 (10.7)	10753 (18.6)	3164 (3.5)	28169 (9.1)
clay	54954 (88.3)	51009 (93.7)	39102 (88.2)	41187 (72.6)	83518 (93.9)	273937 (89.1)

Table 6.2 Landuse statistics
Area in ha and in parenthesis area in percentage

Phase	I	II	III	IV	V	Total
fore_dens	2187 (3.5)	225 (.4)	0 (0)	211 (.3)	2584 (2.9)	5207 (1.6)
fore_spar	2 (.004)	0 (0)	0 (0)	305 (.5)	3978 (4.4)	4285 (1.3)
urban	25 (.04)	0 (0)	14 (.03)	57 (.09)	31 (.03)	127 (.04)
salt_cul	0 (0)	388 (0.7)	0 (0)	328 (0.5)	0 (0)	716 (.2)
salt_uncl	0 (0)	0 (0)	0 (0)	57 (0.1)	17 (0.01)	74 (.02)

Table 6.3 Land capability sub class statistics
Area in ha and in parenthesis area in percentage

Phase	I	II	III	IV	V	Total
S	35684 (57.3)	47554 (87.4)	41707 (94.1)	42267 (73.4)	64353 (72.4)	235111 (76.5)
E	20555 (33.0)	45303 (9.7)	385 (0.8)	10844 (18.8)	16316 (18.3)	61731 (20)
SE	3767 (6.0)	1308 (2.4)	2204 (4.9)	4138 (7.1)	5572 (6.2)	17276 (5.6)

Table 6.4 Land capability sub class statistics with forest (dense) area and urban area subtracted
Area in ha and in parenthesis area in percentage

Phase	I	II	III	IV	V	Total
S	35684 (59.4)	47554 (87.7)	41707 (94.1)	42267 (73.8)	64353 (74.6)	235111 (77.8)
E	20555 (34.2)	5303 (9.7)	385 (0.8)	10844 (18.9)	16316 (18.9)	61731 (20.4)
SE	3767 (6.2)	1308 (2.4)	2204 (4.9)	4138 (7.2)	5572 (6.4)	17276 (5.6)

Table 6.5 Land capability statistics
Area in ha and in parenthesis area in percentage

Phase	I	II	III	IV	V	Total
IIS	28 (.04)	0 (0)	8 (0.2)	0 (0)	2 (.003)	39 (.01)
IIE	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	242 (.07)
IISE	0 (0)	425 (0.7	68 (0.1)	334 (0.5)	133 (.1)	973 (.3)
IIIS	3544 (5.6)	1739 (3.1)	2656 (5.9)	4723 (8.2)	645 (.7)	13523 (4.4)
IIIE	282 (0.4)	77 (0.1)	385 (0.8)	2284 (3.9)	191 (.2)	9864 (3.2)
IIISE	2164 (3.4)	708 (1.3)	2136 (4.8)	3227 (5.6)	1616 (1.8)	10067 (3.2)
IVS	30517 (49.0)	45546 (83.7)	39042 (88.1)	35341 (61.4)	62368 (70.1)	216146 (70.3)
IVE	8 (.01)	0 (0)	0 (0)	37 (0.06)	139 (.1)	202 (.06)
IVSE	1602 (2.5)	174 (0.3)	0 (0)	576 (1)	3818 (4.2)	6234 (2)
VS	348 (0.5)	0 (0)	0 (0)	1605 (2.7)	765 (.8)	2719 (.8)
VIS	0 (0)	2 (.005)	0 (0)	0 (0)	0 (0)	2 (.001)
VIE	20264 (32.5)	5226 (9.6)	0 (0)	8522 (14.8)	15985 (17.9)	51421 (16.7)
VIII	1245 (2.0)	265 (0.4)	0 (0)	596 (1)	571 (.6)	2679 (.8)

Table 6.6 Land capability statistics with dense forest and urban area subtracted
Area in ha and in parenthesis area in percentage

Phase	I	II	III	IV	V	Total
IIS	28 (.04)	0 (0)	8 (.01)	0 (0)	2 (.003)	39 (.01)
IIE	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	242 (.08)
IISE	0 (0)	425 (0.7)	68 (.1)	334 (.5)	137 (.1)	973 (.3)
III S	3544 (5.9)	1739 (3.2)	2656 (5.9)	4723 (8.2)	645 (.7)	13523 (4.4)
IIIE	282 (0.4)	77 (.1)	385 (.8)	2284 (3.9)	191 (.2)	9864 (3.2)
IIISE	2164 (3.6)	708 (1.3)	2136 (4.8)	3227 (5.6)	1616 (1.8)	10067 (3.3)
IVS	30517 (50.8)	45546 (84)	39042 (88.1)	35341 (61.7)	62368 (72.3)	216146 (71.5)
IVE	8 (.01)	0 (0)	0 (0)	37 (.06)	139 (.1)	202 (.06)
IVSE	1602 (2.6)	174 (.3)	0 (0)	576 (1)	3818 (4.4)	6234 (2)
VS	348 (0.5)	0 (0)	0 (0)	1605 (2.8)	765 (.8)	2719 (.9)
VIS	0 (0)	2 (.005)	0 (0)	0 (0)	0 (0)	2 (.001)
VIE	20264 (33.7)	5226 (9.6)	0 (0)	8522 (14.8)	15985 (18.5)	51421 (17)
VIII	1245 (2.0)	265 (.4)	0 (0)	596 (1)	571 (.6)	2679 (.8)

Fig.6.1 Soil texture and color map

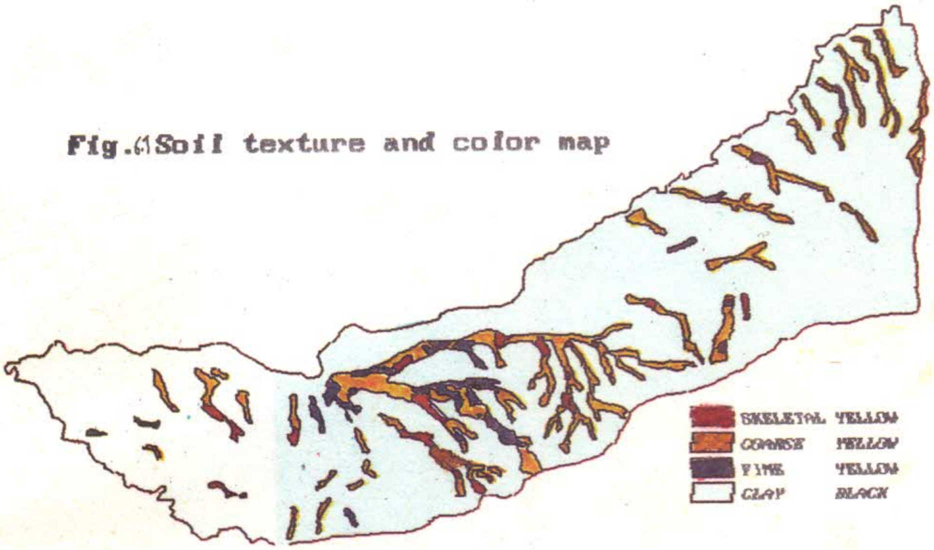


Fig.6.2 Landuse/ cover map

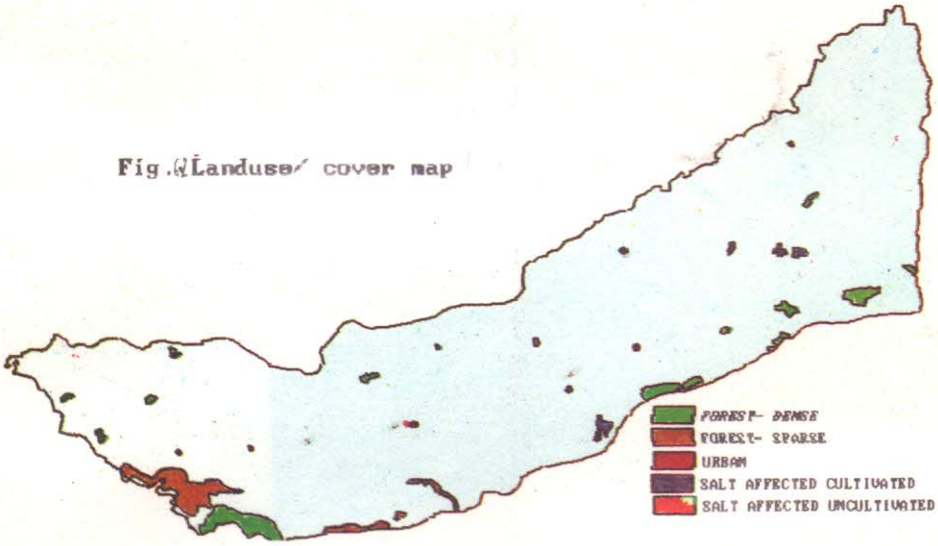


Fig. 6.3 Land capability map

CHAPTER 7.0 CONCLUSIONS

GIS is very effective tool in lar capability classification. In the study the variables, e.g soil texture, type, slope, electrical conductivity, soil erosion and gully formation affecting the use of land for agriculture activity are useful. Overlaying of these large number of variables is facilitated by GIS overlay operations.

Many variables useful in land capability can be mapped by visual interpretation technique of satellite data. These variables are landuse/ cover, physiography and soil. Agriculture area and urban categories are clearly interpreted visually. Yellow (alluvial) soil are mapped by visual interpretation technique. The various maps thus prepared are input to GIS and analysed further, for land capability classification in a part of Narmada basin. Small scale maps give synoptic detail of the area. Such maps help in taking broad management decision. A suitable practice of land and water management has to be adopted in hazard areas using this map.

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DIRECTOR : Dr. S.M.Seth

HEAD : Dr. V.K.Choubey

STUDY GROUP

Mr. D.S.Rathore, Sc.'C'

Mr. Sanjay Kumar Jain, Sc.'C'