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Research Paper :

Automatic generation of land capability map using remote sensing and geographic information system techniques

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ABSTRACT

The research study area covers Malegaon watershed of Nasik District. This study was undertaken to generate thematic maps and to design and develop a package in Geographic Information System (GIS) for automatic generation of land capability map using Arc Macro Language (AML). The satellite data of IRS-1B (LISS-II) of 11^{th} November 1993, 30^{th} January 1994 and 8^{th} May 1994 of the study area were used for generating various thematic maps such as landuse/land cover, soil, hydrogeomorphology and slope. The land capability map was developed automatically in GIS using AML by assuming and standardizing the soil parameters. On the basis of standardization, the parameters of the soil were assigned with the appropriate weightages by program. The spatial and non-spatial data of the soil were taken into consideration for generation of the layer.

Key words : Thematic maps, Arc macro language, Graphic user interface menu

A sound and complete farm-conservation plan, requires an inventory of the land, which is most conveniently recorded on a map and a farm business available facilities. Thus it is necessary to know the carrying capacity of each land. Land capability is referred as suitability of the land based on inherent characteristics of the soil, associated land features, and climatic conditions that limit their safe use under agriculture, forestry etc. in sustainable manner. The method recognizes the whole land into eight classes from class - I to class - VIII, in which class-I to class-IV are suitable for cultivation, while the class-V to class-VIII are not suitable for cultivation.

Remote Sensing and Geographic Information System (GIS) are the most handy and accurate tools to identify the various earth resources and its potentials. Using Remote Sensing techniques, various resource maps can be generated and with the help of GIS these maps can be further analyzed to derive composite maps with various information on different layers. Finally, with their integration derive new maps like land capability and land suitability.

Mohanty (1994) detected the changes in land use pattern using sequential aerial photographs of 1974 and 1989 and compared with SPOT data of 1988 with the help of 'USEMAP' GIS software package. He suggested that in order to know the trend of development and land use patterns, analysis of sequential aerial photographs and satellite imagery of different years is useful tool. Rao *et al*. (1997) undertook a study in Neelkanthpuram Watershed with the objective of generating action plans for sustainable development of land and water resources through the integration of information on soils, land use/ land cover, slope, hydrogeomorphology etc. using GIS approach. Pandit *et al.* (1999) carried out a case study of Nasik district (Maharashtra) using remote sensing and GIS based integrated watershed development. Murthy *et al.* (2000) planned village level action plans for land and water resources development, which required higher scales for planning. The action items for plan implementation were either area specific or local specific and to identify the end beneficiaries. This study was undertaken to generate thematic maps and to design and develop a package in Geographic Information System (GIS) for automatic generation of land capability map.

METHODOLOGY

Study area:

The study area covered the Malegaon watershed of Nasik Tehsil, which is located in the south-western part of Nasik district (Maharashtra) and lies between $72^{0}28'$ to $73^{0}37'$ E Longitude and $20^{0}00'$ to $20^{0}05'$ N Latitude. The watershed area was 5022.97 ha. Physiographically, the area can be divided into alluvial plain, undulating upland, plateau plain, high plateaus, foot slope followed by the hill slopes. The general elevation ranges from 538 m to 1245 m above MSL. The general slope of the area is from north-west to south-west. The study area has subtropical, semi-arid monsoon climate with average annual rainfall of 1100 mm and mean maximum and minimum temperatures of 34^{0}C and 10^{0}C.

Data used:

The satellite data of IRS-1B (LISS-II) of path number 30 and row number 54 covering Nasik tehsil were collected for the three date of pass *viz.*, 11th November 1993, 30th January 1994 and 8th May 1994. For the generation of thematic/derived maps, both digital data on Computer Compatible Tape (CCT) as well as geocoded outputs on 1:50,000 scale were used. Topographic map and Soil survey report from All Indian Soil and Land Use Survey for the part of the study area were used as collateral data.

Generation of thematic maps:

The thematic maps on 1:50,000 scales were generated using the remote sensing technique (EASI/PACE software version 6.3) both interactive digital and visual techniques. The informations collected during the field investigations were used for preparation of thematic maps.

Visually interpreted land use/land cover map was prepared by carrying out the supervised classification. Physiographic cum soil map was prepared in the category of soil series map. The soil series in the study area were Wadholi, Mahirawani, Adgaon, Dhondegaon, Illunja, Nasalgaon, Talegaon, Manoli, Talyachiwadi, Kotamgaon and Masrul. The hydrogeomorphological map was prepared based on visual interpretation of the satellite data of three years and Survey of India (SOI) topographical maps (1:50,000). The slope map was prepared from topographic map using digital elevation model (DEM).

Assumptions for the development of arc macro language (AML):

An AML was used to design and develop a package in GIS for automatic generation of land capability map. In order to prepare the accurate land capability map, it is necessary to study the physical properties of the soil, which plays an important role in land capability classification. The terms or parameters such as depth, texture, erosion, slope and permeability which are the basic and important parameters in land capability classification were assumed while generating the land capability map.

Standardization of the parameters:

The land capability classification was carried out and customized on the basis of depth, texture, erosion, slope and permeability. Therefore, it was necessary to prepare the algorithm based on the standardization for each of these parameters so as to allocate the capability classes. Land allocation in a particular capability class was done on the basis of standardization of the above parameters, which showed the kind of limitations that can be accepted for a particular class. Thus, the standardization of these parameters was carried out based on the standard recommendations given by United State Department of Soil Conservation Service (SCS) to assign the class of the land capability for each class of land (Suresh, 2004). The standardization was also helpful in preparing the weightagesfor these factors.

Customization of the procedure using AML:

Graphic user interface (GUI) menus:

GUI menus provide structure to the complex processes or operations. A carefully designed GUI menu helps an end user by grouping individual operations and arranging them in a manner that is logical and consistent with the actions that need to be performed. GUI menus can be prepared by using the different types of AML widgets such as button, check box, choice, display, forminit, input etc. Using these ARC/INFO AML widgets, four GUI menus were prepared for automatic generation of the land capability map. Menu-I is the main menu and consists of the buttons for database integration, display and querry, LCAP generation, quit and help (Fig. 1). Menu-II consists of the database integration (Fig. 2). Menu-III was prepared for the display and querry (Fig. 3) and menu-IV consists of the LCAP generation (Fig. 4).

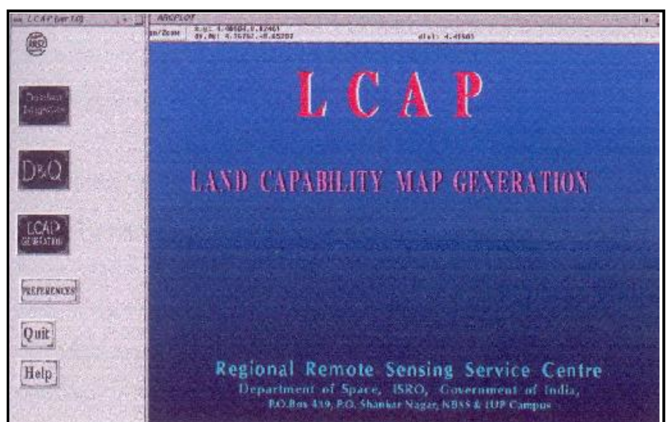

Fig. 1 : LCAP-MAIN Menu

GIS integration and analysis:

Using the ARC/INFO, GIS integration and analysis were carried out for the generation of the land capability map. The land capability map generation was automated using AML through GUI.

Generation of AML for land capability classification:

For the generation of AML, the standardization of the assumed soil parameters is very important. The soil

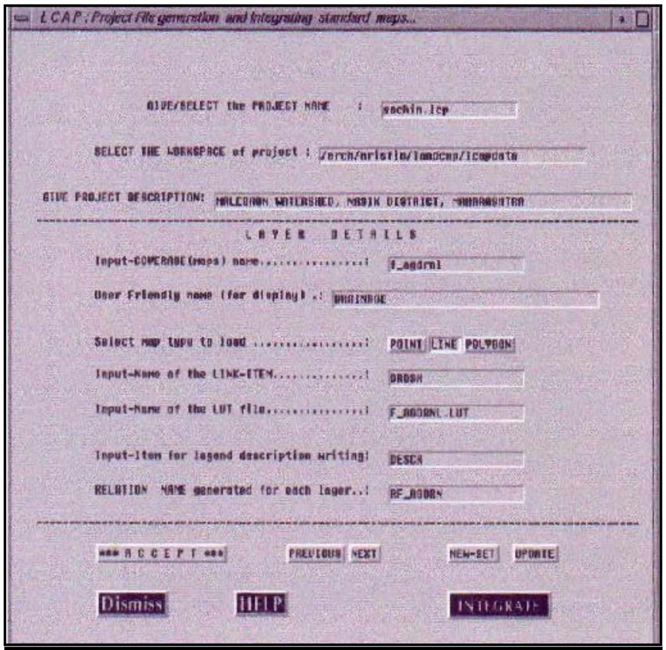

Fig. 2 : Database Integration Menu

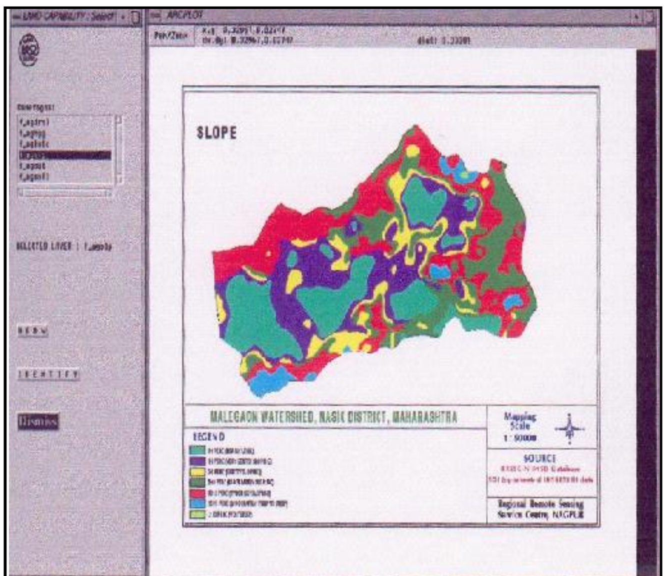

Fig. 3 : Display and Querry Menu

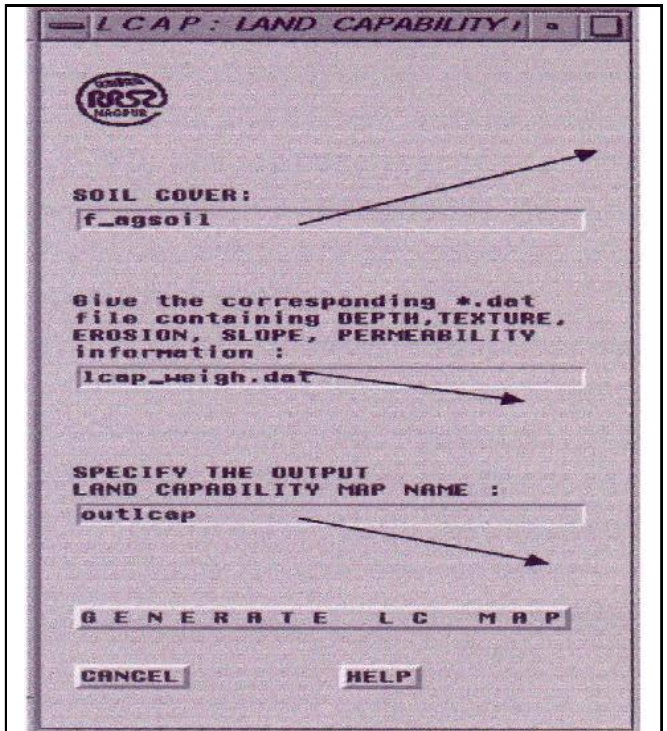

Fig. 4 : LCAP Generation Menu

is the dominant factor in the land capability classification. Therefore, the spatial and non-spatial data of the soil were taken into consideration for generation of the layer for automatic generation of the land capability map, the input parameters were the soil codes and their corresponding data file in *.dat format (INFO files). With the help of the available information about the soil, the parameters *viz.*, depth, texture, erosion, slope and permeability were standardized as per their categories based on USDA recommendations. Based on the standardization of the parameters, the criterion for land capability map generation was prepared (Table 1).

Based on the criterion, the soil category of the study area was assigned with the appropriate weightages for calculating land capability classes. Assigned weightages to the soils in the study area are shown in the Table 2.

Table 1 : Criterion table for land capability analysis

Parameter	Land capability classes							
	I	II	III	IV	V	VI	VII	VIII
Depth (cm)	Greater than 90	45 to 90	22.5 to 45	7.5 to 22.5	Less than 7.5	Less than 7.5	Less than 7.5	Rock
Texture	Sil, Cl, l, Sl, Si, SCl	Sil, Cl, Sl, SCl, SiCl	SC, SiC, C, lS	G, S	Sil, Cl, l, Sl, Si, SCl	Sandy	Sandy	-
Erosion	None to moderate	Moderate	Moderate to severe	Severe	Severe to very severe	Very severe	Very severe to excessive	Excessive
Slope (%)	0 to 1	0 to 1	1 to 3	3 to 5	5 to 10	5 to 10	10 to 15	Greater than 15
Permeability	Moderate	Mod. Slow to rapid	Slow to rapid	Slow to rapid	-	Slight	Slight	-

Table 2 : Assigned weightages to the soils in the study area based on United State Department of Soil Conservation Service (SCS) recommendations

Soil Series	Map symbol	Depth	Texture	Erosion	Slope	Permeability
Wadholi	6	3	2	3	3	2
Mahirawani	8	4	4	4	3	2
Adgaon	9	3	3	3	2	2
Dhondegaon	10	4	4	4	3	2
Illunja	11	7	6	7	7	7
Nasalgaon	12	4	2	2	3	3
Nandgaon	13	3	8	7	8	7
Talegaon	14	7	6	7	7	7
Manoli	15	2	2	4	3	3
Talyachiwadi	19	4	6	4	7	7
Kotamgaon	20	4	6	3	3	5
Masrul	21	7	6	4	3	5
Rock outcrop	99	7	7	7	7	7

RESULTS AND DISCUSSION

The results obtained from the present investigtion are presented below :

Land capability map:

The soil in the study area existed in association with the other soil categories. If the association was of three-soil category, the active weightages of the soil class was assigned based on the percentage weightages of 60-30-10 proportions. If the association existed as three-soil category as 6-9-10, then 6 is the soil-code, 9 is the ASS1-code and 10 is the ASS2-code. If the association was of two-soil category as 8-12, the active weightages of the soil class was assigned as 70-30 proportions. In two-soil category association (8-12), 8 is the soil-code and 12 is the ASS1-code.

The final weightages for the parameters were calculated as illustrated below:

Soil-category 6-9-10:

Available percentages were 60-30-10, respectively.

The weightages are assigned by taking the original values of the parameters in the study area and comparing with the United State Department of Soil Conservation Service (SCS) recommendations (Suresh, 2004). Assigned weightages of depth for category 6 is 3, for 9 is 3 and for 10 is 4.

(60 X 3) + (30 X 3) + (10x 4) = 310

Depth = 310/100 = 3.1

The actual depth weightage was calculated by multiplying the map symbol depth by proportionate percentage of association and adding all and dividing by 100. Thus, in this way the texture, erosion, slope and permeability values were calculated for each association. Based on the assumption and calculation, the final weightages for each soil class was computed (Table 3).

Finally the weightages of all the soil were added and averaged. The average value was categorized in their respective land capability classes with the aggregation given in Table 4. The flow diagram of LCAP program is shown in Fig. 5.

The land capability classes of the study area includes

Table 3 : Final weightages to the soil parameters

Sr. No.	Soil association	Depth	Texture	Erosion	Slope	Permeability	Sum	Sum/5	Land capability class
1.	6-9-10	3.1	2.5	3.1	2.7	2.0	13.4	2.68	III
2.	8-12	4.0	3.4	3.4	3.0	2.3	16.1	3.22	IV
3.	9-10	3.3	3.3	3.3	2.3	2.0	14.2	2.84	III
4.	10-12-15	3.8	3.2	3.4	3.0	2.4	15.8	3.16	IV
5.	11-12-13	5.7	5.0	5.5	5.9	5.8	27.9	5.58	VI
6.	12-20-21	4.3	3.6	2.5	3.0	3.8	17.2	3.44	IV
7.	11-13	5.8	6.6	7.0	7.3	7.0	33.7	6.74	VII
8.	14-11-99	7.0	6.1	7.0	7.0	7.0	34.1	6.82	VII
9.	19-99	4.9	6.3	4.9	7.0	7.0	30.1	6.02	VII
10.	10-12-20	4.0	3.6	3.3	3.0	2.6	16.5	3.30	IV
11.	19-14	4.9	6.0	4.9	7.0	7.0	29.8	5.96	VI

Table 4 : Land capability class according to average weightages

Sl. No.	Aggregation classes	Land capability class
1.	≤1	I
2.	>1?2	II
3.	>2?3	III
4.	>3?4	IV
5.	>4?5	V
6.	>5?6	VI
7.	>6?7	VII
8.	>7?8	VIII

Table 5 : Area under different land capability classes

Sl. No.	Class	Cultivability	Area (ha)	Percentage of the total area
1.	III	Cultivable	1059.80	21.10
2.	IV	Cultivable	2058.75	40.99
3.	VI	Uncultivable	1701.20	33.87
4.	VII	Uncultivable	203.22	4.04
	Total		5022.97	100.00

class-III, class-IV which are cultivable whereas class-VI and class-VII are uncultivable (Fig. 6). Table 5 indicates the areas under different land capability classes of the study area. The soil series according to land capability class is presented in Table 6. The results, which were found in the land capability map, were justified with the IMSD project report available at RRSSC, Nagpur

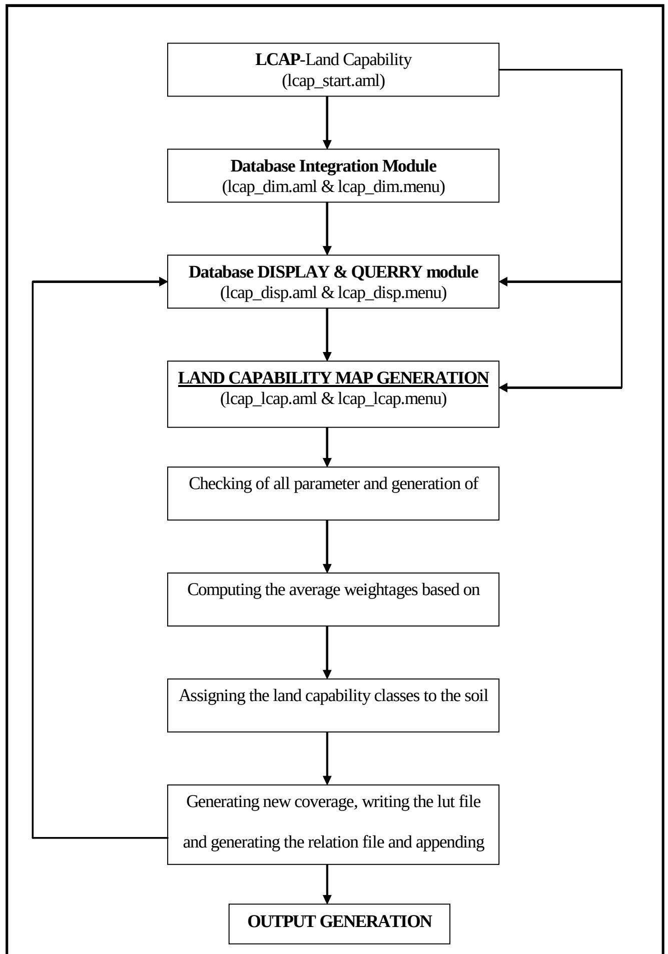

Fig. 5 : Flow diagram of LCAP program

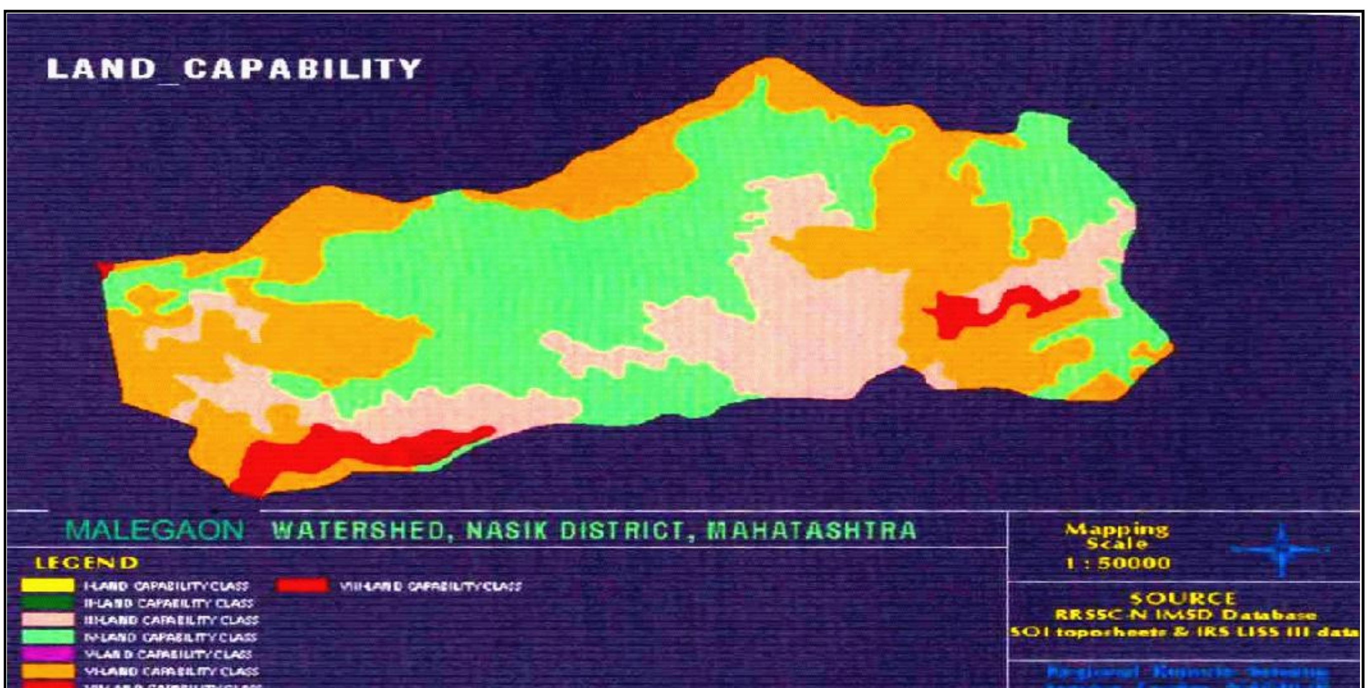

Fig. 6 : Land capability map

Table 6 : Soil series according to land capability class

Sl. No.	Land capability classes III	IV	VI	VII
1.	Wadholi	Mahirawani	Illunja	Nandgaon
2.	Adgaon	Dhondegaon	Masrul	Talegaon
3.		Kotamgaon		Talyachiwadi
4.		Nasalgaon		

and were found to be similar to each other (Anonymous, 1996 and Pandit *et al.*, 1999).

Conclusion:

– The land capability classes developed with the help of GIS integration were class-III, class-IV, class-VI and class-VII.

– The two soil series comes under the class-III and class-VI whereas four soil series comes under class-IV and three soil series comes under class-VII.

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