International Journal of Agricultural Engineering, Vol. 3 No. 1 (April, 2010) : 147-152

Research Paper :

Development of thematic maps for a watershed using remote sensing and geographic information system

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Accepted : *March, 2010*

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ABSTRACT

The research study was undertaken to generate various thematic maps for Malegaon watershed of Nasik district. The base maps such as watershed boundary, drainage network were prepared with the help of Survey of India topographical map. The satellite data of IRS-1B (LISS-II) of 11th November 1993, 30th January 1994 and 8th May 1994 of the study area were used for generating various thematic maps such as land use/land cover, soil, hydrogeomorphology and slope map. The land use/land cover map indicates that 35.07% was *Kharif* cultivated land and 4.32% was the double crop land. The watershed area consisted of eleven soil series, most of them were cultivable. The hydrogeomorphology map showed that 77.18% area of the watershed has moderate ground water potential. The slope map showed that about 50% of the land was slope less than 5% that should undergo cultivation.

Key words : Thematic map, Watershed, Remote sensing

A thematic map focuses in a specific idea or theme. A thematic map illustrates a particular subject and contrasts the general map, in which the variety of geological and geographical phenomena regularly appear together. Thematic maps also emphasize spatial variation of one or a small number of geographic distributions. These distributions may be physical phenomena such as climate or human characteristics such as population density and health issues. Thematic maps serve three primary purposes. First, they provide specific information about particular locations. Second, they provide general information about spatial patterns. Third, they can be used to compare patterns on two or more maps. A thematic map is a map that emphasizes a particular theme or special topic such as the average distribution of rainfall in an area. They are different from general reference maps because they do not just show natural features like rivers, cities, political subdivisions and highways. Instead, if these items are on a thematic map, they are simply used as reference points to enhance one's understanding of the map's theme and purpose.

Remote sensing and GIS are the handiest and accurate tools to measure the various earth resources and their potentials. Using satellite based remote sensing various resources maps can be generated and using GIS tools these maps can be further analysed to derive a composite maps with numerous information, which finally derives new maps like land capability and land suitability maps.

Mohanty (1994) made an attempt to detect 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. Das *et al.* (1997) conducted the study for groundwater exploration and development in Keonjhar district of Orrisa. In this study, air borne and space borne data were used for qualitative evaluation of groundwater resources. 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.

METHODOLOGY

The information provided by the satellites in combination with other sources of information can be integrated through GIS to quantify the various parameters for efficient management of land and water resources in

watershed.

Study area:

The study area covers 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 covers an area of 5022.97ha. The general elevation ranges from 538 m to 1245 m above mean sea level. 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 34^0C and 10^0C.

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 was used as collateral data.

Hardware and software:

The workstations of International Business Machines (IBM) RS6000 and SILICON Graphics SGI-O2 were used as hardware in this study. EASI/PACE version 6.3 was used for digital image processing of remotely sensed data. For Geographic Information System**,** ARC/INFO software was used.

Generation of base maps:

The various base maps such as watershed boundary, drainage network and contour maps were prepared using the satellite data and topographic map. Later, these maps were converted into digital maps through the process of digitization using on screen digitizer available in EASI/ PACE software.

Generation of thematic / derived maps:

Land use / land cover map:

The classification of image was done for preparation of land use/land cover map. The supervised classification was carried out for the satellite data of November 1993, January 1994 and May 1994. In supervised classification, the identity and location of some of the land cover types, such as urban, agricultural wetland and forest are known through a combination of fieldwork, maps and personal experience.

Soil map:

Soil mapping of the study area was carried out to study characteristics, qualities and classes of the different soils, their location and spatial distribution. IRS-1B (LISS-II) data of November 1993, January 1994 and May 1994 was used along with the available soil map of the area for the generation of the soil map. Based on the image characteristics, soil map information and collateral information like land use and vegetation, a tentative relationship among image interpretation units, physiography and soils was developed and soil map was prepared.

The soil map was prepared in the category of soil series map by considering the soil parameters depth, texture, slope, erosion etc. The soil series are described particularly by the name of the region in which they are found mainly in abundance. The soil series in the study area were Wadholi, Mahirawani, Adgaon, Dhondegaon, Illunja, Nasalgaon, Talegaon, Manoli, Talyachiwadi, Kotamgaon, Masrul.

Hydrogeomorphology and ground water potential map:

The hydrogeomorphological map was prepared based on visual interpretation of IRS-1B (LISS-II) data of three years and SOI topographical maps. The geomorphic units were classified based on the origin of the landforms and the geological process acting upon it. Further, the units have been separated based on relief altitude and structural information. The hydrogeomorphology map has been refined and updated with the field investigation.

Slope map:

The digitized contour information was used for preparation of slope map. Slope map gave the idea about the topography of the land and its cultivability. The contours of 20 m were digitized from topographic map on 1:50000 scale. By using, ARC command TOPOGRID DEM (Digital Elevation Model) in grid was generated. A slope map on 1:50000 scale was generated from the DEM-grid. Later, the slope map was corrected for peaks and sinks and generalized. The Look Up Table (LUT) file with per cent slope range and corresponding slope code was prepared in ARC/INFO. The information of the DEM-grid was then divided into the per cent slopes using slope code from the LUT file through the ARC command 'LATTICEPOLY'.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been summarized under following heads:

Base maps:

The base map contains the drainage network information and was ordered using Strahler Method of nomenclature. The highest order of drainage that flows through the watershed was 5th order (Fig. 1). The drainage pattern was dendritic and flows from west to southwest direction as a part of Godavari catchment.

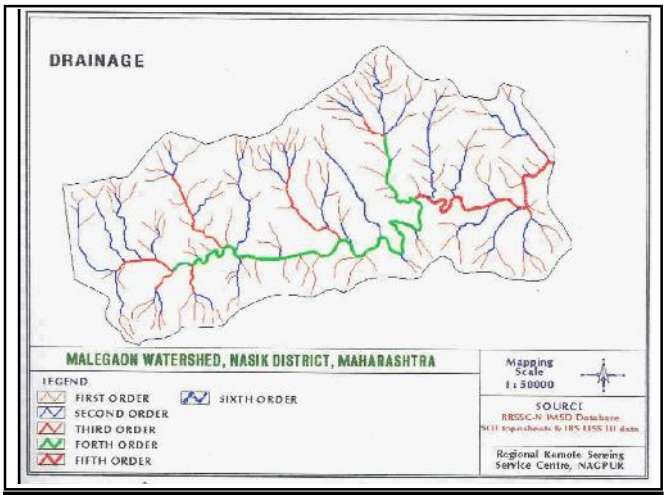

Fig. 1 : Drainage map

Thematic maps:

Land use / land cover map:

The land use/land cover map was classified considering nine classes (Fig. 2). The results were validated with the ground truth data. Table 1 indicates the areas under different classes of land use/land cover. The results, which were found in the land use map, were justified with the IMSD project report available at RRSSC, Nagpur and were found to be similar to each other (Anonymous, 1996 and Pandit *et al.*, 1999).

Soil series map:

The soil map was prepared in the soil series category (Fig. 3). Table 2 shows the area covered under different soil series of the study area. It is seen from Table 2 that about 62 per cent of soil was cultivable. However, Table 1 shows that 40 per cent soil was cultivated and 45 per cent was either scrub or wasteland. Thus most of the scrub and fallow lands were on the cultivable soils. Thus, in land resource development plan soil factor plays an important role. The results were justified with the IMSD project report and found to be matching with each other (Anonymous, 1996 and Pandit *et al.*, 1999).

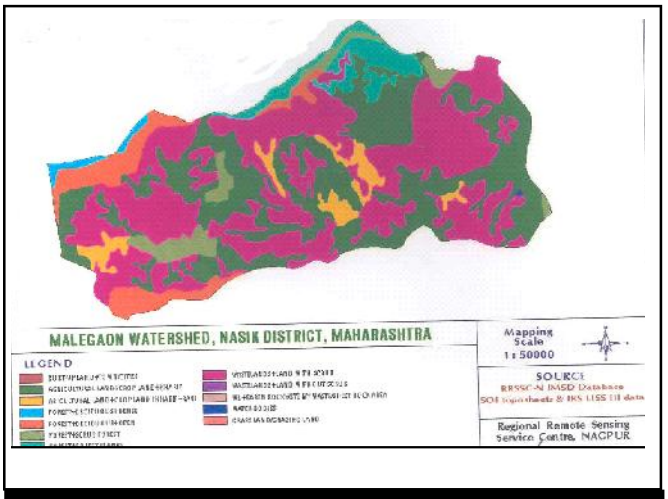

Fig. 2 : Land use / land cover map

Hydrogeomorphology and ground water potential map:

Based on the geological, geomorphological and ground truth data, qualitative assessment of ground water potential has been analyzed in the area. The hydrogeomorphological setup of the area was broadly

Table 1 : Areas under different classes of land use/land cover

Sr. No.	Land use/land cover	Area (ha)	Percentage of the total area
1.	Agricultural land: crop land + *Kharif*	1761.16	35.06
2.	Agricultural land: crop land + *Kharif* + *Rabi*	216.35	4.31
3.	Forest + deciduous + dense	44.23	0.88
4.	Forest + deciduous + open	343.62	6.84
5.	Forest + Scrub forest	217.18	4.33
6.	Forest + forest blank	267.85	5.33
7.	Waste lands + land with scrub	2169.58	43.19
8.	Water bodies	2.18	0.04
9.	Others	0.82	0.02
	Total	5022.97	100.00

Table 2 : Area covered under different soil series

Sr. No.	Soil series	Soil type	Cultivability	Area (ha)	Percentage of the total area
1.	Wadholi -Adgaon - Dhondegaon	Fine loamy mixed isohyperthermic typic ustorthent	Cultivable	961.30	19.14
2.	Mahirawani-Nasalgaon	Loamy skeletal mixed isohyperthermic typic ustorthent	Cultivable	1356.37	27.00
3.	Adgaon-Dhondegaon	Fine montmorillonitic isohyperthermic vertic ustorthent	Cultivable	98.50	1.96
4.	Dhondegaon-Nasalgaon-Manoli	Fine montmorillonitic isohyperthermic typic ustorthent	Cultivable	599.70	11.94
5.	Illunja-Nasalgaon-Nandgaon	Loamy skeletal mixed isohyperthermic typic ustorthent	Un-cultivable	1216.92	24.23
6.	Nasalgaon-Kotamgaon-Masrul	Fine loamy mixed isohyperthermic typic ustorthent	Cultivable	26.64	0.53
7.	Illunja-Nandgaon	Loamy skeletal mixed isohyperthermic typic ustorthent	Un-cultivable	58.62	1.18
8.	Talegaon-Illunja-Rock	Loamy skeletal mixed isohyperthermic typic ustorthent	Un-cultivable	3.33	0.06
9.	Talyachiwadi-Rock	Fine montmorillonitic isohyperthermic vertic ustorthent	Un-cultivable	141.27	2.81
10.	Dhondegaon-Nasalgaon-Kotamgaon	Fine montmorillonitic isohyperthermic typic ustorthent	Cultivable	76.04	1.51
11.	Talyachiwadi-Talegaon	Loamy skeletal mixed isohyperthermic typic ustorthent	Un-cultivable	484.28	9.64
		Total		5022.97	100.00

divided into three major units namely, structural origin, denudational origin and fluvial origin. After the classification of hydrogeomorphology classes (Fig. 4), the area statistics of the hydrogeomorphology classes were computed in GIS and given in Table 3. The results were justified with the IMSD project report and found to be matching with each other (Anonymous, 1996 and Pandit *et al.*, 1999).

Slope map:

The slope information is very important for planning of the land resource development work. Table 4 shows the slope categories and the area under each category found in the study area. The slope map is shown in the

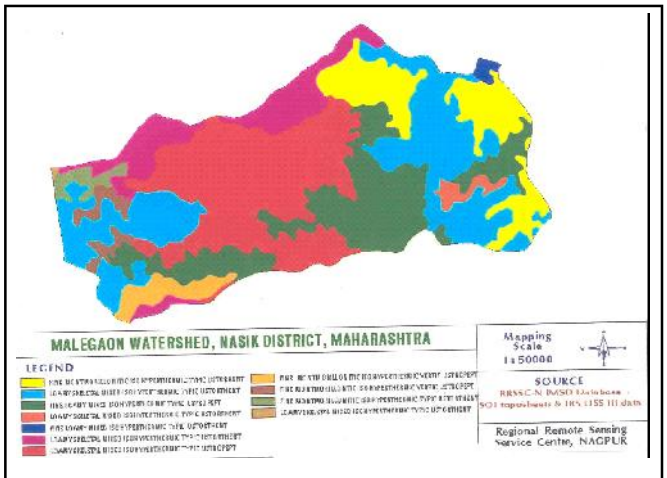

Fig. 3 : Soil series map

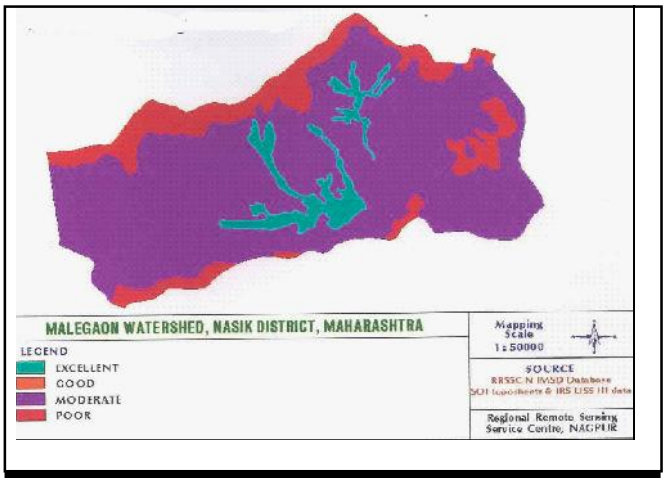

Fig. 4 : Hydrogeomorphology and ground water potential map

Table 3 : Area under different hydrogeomorphology and ground water potential categories

Sr. No.	Hydrogeomorphology	Ground water potential	Area (ha)	Percentage of the total area
1.	Fluvial origin VF	Excellent	353.62	7.04
2.	Dissected plateau-A	Poor	792.82	15.78
3.	Dissected plateau-B	Moderate	3876.53	77.18
		Total	5022.97	100.00

Table 4 : Slope categories and the area under each category

Sr. No.	Slope category	Area (ha)	Percentage of the total area
1.	Nearly level (less than 1%)	1022.19	20.35
2.	Very gentle sloping (1-3%)	1047.23	20.85
3.	Gently sloping(3-5%)	498.58	9.93
4.	Moderately sloping (5-10%)	1009.85	20.10
5.	Strongly sloping (10-15%)	1251.20	24.90
6.	Moderately steep to steep (15-35%)	187.40	3.73
7.	Very steep sloping (more than 35%)	6.52	0.14
	Total	5022.97	100.00

Fig. 5.

Table 4 reveals that about 50 per cent of land was having slope less than 5 per cent, which should undergo cultivation. Whereas, for the topography having slope of about 45 per cent, conservation practices are necessary for cultivation purpose and on the remaining piece of land different plantations should be taken. The obtained results were similar to the results in IMSD project report (Anonymous, 1996 and Pandit *et al.*, 1999).

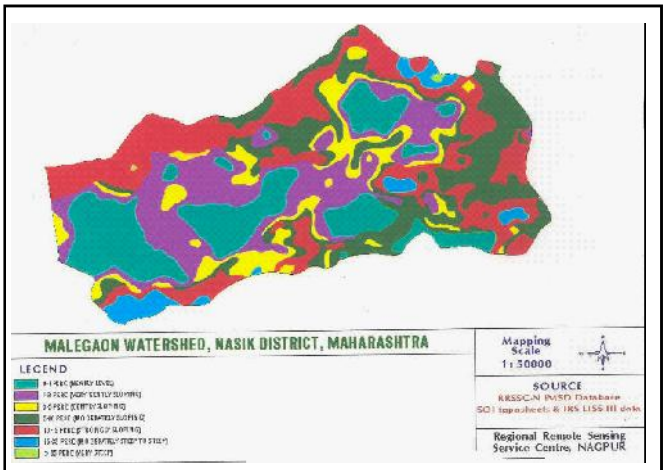

Fig. 5 : Slope map

Conclusion:

– The Remote Sensing and GIS techniques can be effectively used for the development of various thematic maps such as land use/land cover, soil series, hydrogeomorphology, slope, drainage etc.

– The land use/land cover map indicates that 1761.57 ha (35.07%) was *Kharif* cultivated land and 216.76 ha (4.32%) was the double crop land.

– The watershed area consists of eleven soil series in which most of them were cultivable.

– The hydrogeomorphology unit's class found in the study area were fluvial origin VF, DPT-A and DPT-B.

About 50 per cent of land was having slope less than 5 per cent, which should undergo cultivation. Whereas, for the topography having slope of about 45 per cent, conservation practices are necessary for cultivation purpose and on the remaining piece of land different plantations should be taken.

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