MORPHOMETRIC ANALYSIS IN THE WGK-5 SUB-WATERSHED OF WAINGANGA RIVER BASIN IN MAHARASHTRA USING REMOTE SENSING & GIS

Aanchal Singh Chouhan [1]

[1]Assistant Professor, Dept of Agriculture Technology, Sardar Patel University, Balaghat, (M.P.), India

---***---

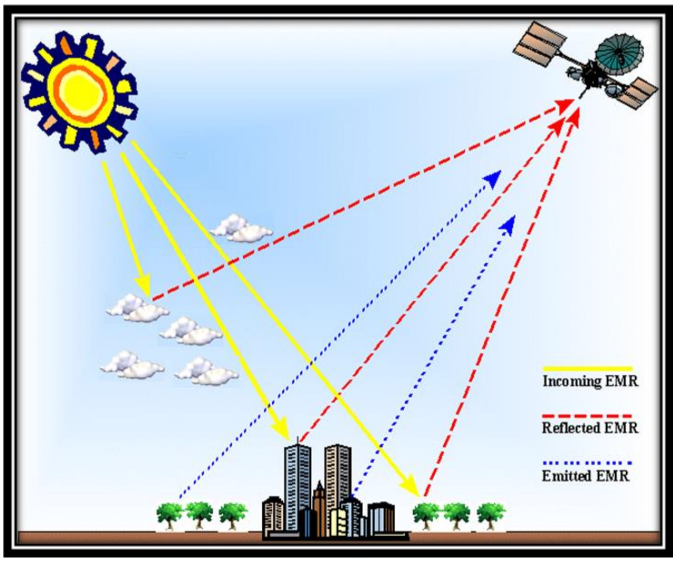
Abstract - *The morphometric analysis of river basin helps to explore the interrelationship between hydraulic parameters and geomorphologic characteristics. The study has been conducted in the Upper Tons basin of Northern Foreland of Peninsular India. The river basin has been characterized using the topographical maps, CARTOSAT satellite image integrated using the GIS techniques. The drainage density analysis indicates lower values in the north-eastern regions and thus these regions can be categorized as better ground water potential zone. There are in total 10 sub-watersheds which have been delineated; SW-4 has maximum drainage density (4.75), stream frequency (5.61) and drainage texture (26.64) followed by SW-6–10. The prioritized sub-watershed numbers SW-4 and SW-6–10 need conservation practices because of their high erodibility and run-off. SW-1–3 and SW-5 regions have better permeable bed rocks and hence good for water harvesting. The areal parameter indicates elongated shape of basin and moderate to steeper ground slope. The results are supported by extensive field survey. This study can be applied for soil and water management, as well as disaster prevention from similar type of drainage basins.*

Key Words: GIS, GPS, LIDAR, VNIR, AIS, LUS Satellites, Space Shuttle, morphometric analysis, upper tons basin cartosat, dem, remote sensing.

1. INTRODUCTION

1.1 REMOTE SENSING

Remote sensing is the art and science of recording, measuring, and analyzing information about a phenomenon from a distance. Humans with the aid of their eyes, noses, and ears are constantly seeing, smelling, and hearing things from a distance as they move through an environment. . In remote sensing, the sensors are not in direct contact with the objects or events being observed. The information needs a physical carrier to travel from the objects/events to the sensors through an intervening medium. In a more restricted sense, remote sensing usually refers to the technology of acquiring information about the earth's surface and atmosphere using sensors onboard airborne(aircraft, balloons) or space borne (satellites, space shuttles) platforms.



1.2 RESOLUTION

In computers, resolution is the number of pixels(individual points of color) contained on a display monitor, expressed in terms of the number of pixels on the horizontal axis and the number on the vertical axis. The sharpness of the image on a display depends on the resolution and the size of the monitor. The same pixel resolution will be sharper on smaller monitor and gradually lose sharpness on larger monitors because the same number of pixels are being spread out over a larger number of inches.

TYPE OF RESOLUTION:

1. Spectral Resolution.
2. Spatial Resolution.
3. Radiometric Resolution
4. Temporal Resolution.

1.3 APPLICATIONS OF REMOTE SENSING DATA

- Doppler radar is used by local law enforcements' monitoring of speed limits and in enhanced meteorological collection such as wind speed and direction within weather systems in addition to precipitation location and intensity.

- Laser and radar altimeters on satellites have provided a wide range of data. By measuring the bulges of water caused by gravity, they map features on the seafloor to a resolution of a mile or so.
- Light detection and ranging (LIDAR) is well known in examples of weapon ranging, laser illuminated homing of projectiles. LIDAR is used to detect and measure the concentration of various chemicals in the atmosphere, while airborne LIDAR can be used to measure heights of objects and features on the ground more accurately than with radar technology.

- Chlorophyll strongly absorbs radiation in the red and blue wavelengths but reflects green wavelengths. Leaves appear "greenest" to us in the summer, when chlorophyll content is at its maximum. In autumn, there is less chlorophyll in the leaves, so there is less absorption and proportionately more reflection of the red wavelengths, making the leaves appear red or yellow (yellow is a combination of red and green wavelengths).
- Soil has very different characteristics in the VNIR. The increase of reflection with wavelength in the visible is consistent with the human eye's observation that soils can have a red or brown color to them.

Remote sensing can be used for many other applications in several different areas, including:

1. Geology and Mineral exploration
2. Hazard assessment
3. Oceanography
4. Agriculture and forestry
5. Land degradation
6. Environmental monitoring
7. Natural Disaster Management
8. Crop Estimation
9. City & Town Planning etc.

How data is recorded: The detection of the electromagnetic energy can be performed either photographically or electronically: The photographic process uses chemical reactions on the surface of light-sensitive film to detect and record energy variations. An image refers to any pictorial representation, regardless of what wavelengths or remote sensing device has been used to detect and record the electromagnetic energy.

Data Analysis- In order to take advantage of and make good use of remote sensing data, we must be able to extract meaningful information from the imagery. Much interpretation and identification of targets in remote sensing imagery is performed manually or visually, i.e. by a human interpreter. Recognizing targets is the key to interpretation and information extraction. Observing the differences between targets and their backgrounds involves comparing different targets based on any, or all, of the visual elements of tone, shape, size, pattern, texture, shadow, and association. If a two-dimensional image can be viewed stereoscopically so as to simulate the third dimension of height, visual interpretation will be much easier.

When remote sensing data are available in digital format, digital processing and analysis may be performed using a computer. Digital processing may be used to enhance data as a prelude to visual interpretation. Digital processing and analysis may also be carried out to automatically identify targets and extract information completely without manual intervention by a human interpreter.

Digital image processing may involve numerous procedures including formatting and correcting of the data, digital enhancement to facilitate better visual interpretation, or even automated classification of targets and features entirely by computer. In order to process remote sensing imagery digitally, the data must be recorded and available in a digital form suitable for storage on a computer tape or disk.

2. GEOGRAPHIC INFORMATION SYSTEM (GIS)

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. Sometimes used for geographical information science or geospatial information studies to refer to the academic discipline or career of working with geographic information systems and is a large domain within the broader academic discipline of Geoinformatics. What goes beyond a GIS is a spatial data infrastructure, a concept that has no restricted boundaries.

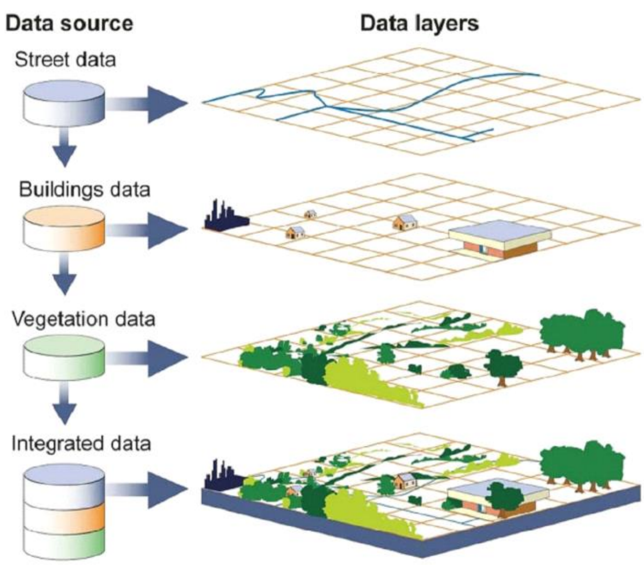


Fig. : Gio Information System

GIS is a broad term that can refer to a number of different technologies, processes, and methods. It is attached to many operations and has many applications related to engineering, planning, management, transport/logistics, insurance, telecommunications, and business. For that reason, GIS and location intelligence applications can be the foundation for many location-enabled services that rely on analysis and visualization. "Geographic Information Systems are computer based tools for mapping and analyzing features and events on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps" (Monroe County, 2008).

Thus, the use of GIS is needed to collect data, store, manage, analyze and produce useful information. In other words, the process of GIS is to input sets of raw data to produce useful output information. CAS relies on the input of accurate historical records and utilizes the functionality of GIS to produce predictions and response plans for this natural phenomena.

3. PROJECTIONS COORDINATE SYSTEMS

Coordinate systems enable geographic datasets to use common locations for integration. A coordinate system is a reference system used to represent the locations of geographic features, imagery, and observations, such as Global Positioning System (GPS) locations, within a common geographic framework.
Each coordinate system is defined by the following:

- Its measurement framework, which is either geographic (in which spherical coordinates are measured from the earth's center) or plan metric (in which the earth's coordinates are projected onto a two-dimensional planar surface)
- Units of measurement (typically feet or meters for projected coordinate systems or decimal degrees for latitude-longitude)
- The definition of the map projection for projected coordinate systems
- Other measurement system properties such as a spheroid of reference, a datum, one or more standard parallels, a central meridian, and possible shifts in the x- and y-directions
- Several hundred geographic coordinate systems and a few thousand projected coordinate systems are available for use. In addition, you can define a custom coordinate system.

4. OBJECTIVE OF MORPHOMETRIC ANALYSIS

The morphometric analysis of the drainage basin and channel network play an important role in understanding the geo-hydrological behavior of drainage basin and expresses the prevailing climate, geology, geomorphology, structural antecedents of the catchment. Morphometric analysis of a drainage basin expresses fully the state of dynamic balance that has been attained due to dealings between matter and energy. The morphometric analysis of river basin helps to explore the interrelationship between hydraulic parameters and geomorphologic characteristics.

5. MORPHOMETRIC PARAMETERS:

The morphometric parameters of the Mandovi River basin have been broadly classified into two categories, namely basic parameters and derived parameters.
Basic Parameters
1. Basin Area (A): Basin area is the area of the catchment of the watershed of a channel network as projected onto a horizontal plane. The size of the basin affect the total volume of rainwater received, the total runoff produced and thus the stream discharge.
2. Basin Length (Lb): Basin length of a watershed is the aerial distance between the watershed outlet and the farthest point on the perimeter of the watershed (Gregory and Walling, 1973).

3. Basin Perimeter (P): Basin perimeter is the length of the watershed boundary that encloses the catchment area. It is used in conjunction with the basin area to give a measure of the departure of the basin from a true circle and in conjunction with relief to give a measure of the general steepness of the basin.

4. Main Stream Length (SL): The main stream length is the length of the main stream having maximum length measured along the stream course. The time of concentration is always maximum along this stream.

5. Total Relief (H): Total relief is the difference between the highest elevation and the lowest elevation in the watershed

6. METHODOLOGY

Following steps are used in methodology:

1. Firstly we Download the latest Land sat 8 image of study area.
2. After Download the image with the help of Image processing software ERDAS 2013 we perform layer stacking and mosaicing process.
3. The exact boundary of the study area has been extracted by the process of subset Image.
4. After sub -setting the image, the whole area is classified. Classification is performed in two ways:

a) Supervised
b) Unsupervised

The supervised classification is avoided because the reason is that it requires training site selection for all classes & when computation is done, the intermixing of pixels may occur. It will ultimately affect the accuracy of result.
It is better to take the advantage of unsupervised classification.

5. The whole area is classified on the basis of spectral values.
6. The classified image is recoded into various classes like open area, dense urban, urban, suburban, villages, Road, water body, river, grassland, agriculture etc.

7. After Unsupervised Classification of Image prepare Habitation layer.
8. Preparation of River and Drainage layer by manual editing.
9. After digitized feature doing the ordering of drainage.
10. When completing the ordering of drainage then create water -shad delineation.
11. With the help of morphometric analysis formula doing the calculation of drainage.
12. Ofter quantitative calculation of drainage by the help of results determines the information of study area.

7. ANALYSIS PARAMETER

A systematic description and analysis of a drainage basin require measurement of linear aspect of drainage network and areal aspect of the drainage basin . The parameters computed include stream orders and stream numbers, cumulative length and stream orders, mean cumulative length and stream orders, stream length ratio, bifurcation ratio, drainage density, stream frequency, form factor, circulatory ratio, elongation ratio, constant of channel maintenance, relative relief, percentage of slope, and relief ratio. The statistical methods were also applied to validate data and to obtain further precise results. The various aspects were studied for their inter-relationship which helps to depict the nature of the sub-catchments. The parameter of the present study area measured by using following parameters are presented .

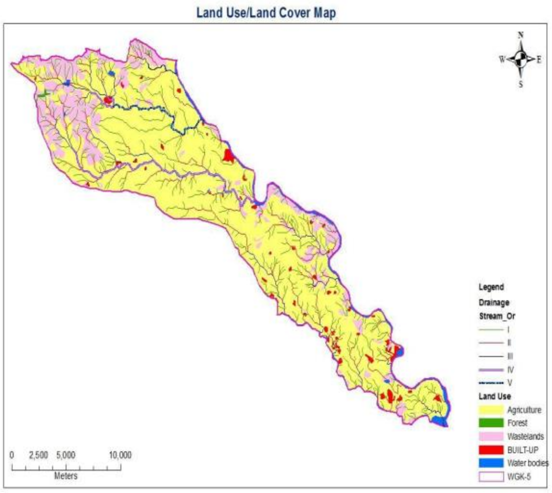


Fig.: Land use and land cover map

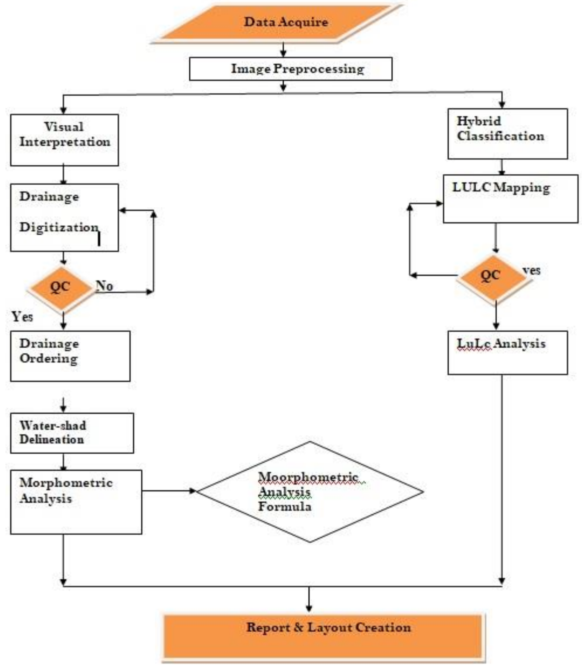


Fig. : Flow Chart

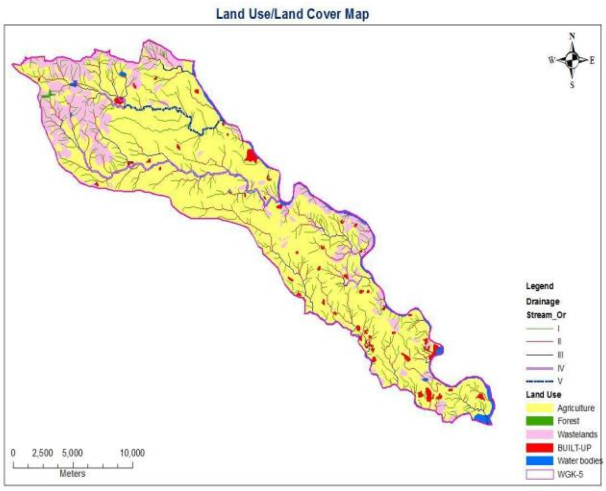


Fig. : Land used/land cover map

8. Result & Discussion

Morphometric parameters are relevant and useful to identify various hydraulic characteristics of drainage basin i.e. patterns, shape, stage of stream, permeability of bed rock, health of streams, as well as help to correlate with lithological characteristics. In the present study region most common patterns are dendritic to sub-dendritic.

In the present study area, dendritic pattern is the most dominant type, generally those streams which originated from the Vindhyan scarps follow dendritic pattern, while the stream that comes from Kaimur hills follows barbed and parallel patterns. The theoretically minimum bifurcation ratio is 1.86 and generally natural drainage systems have Rb

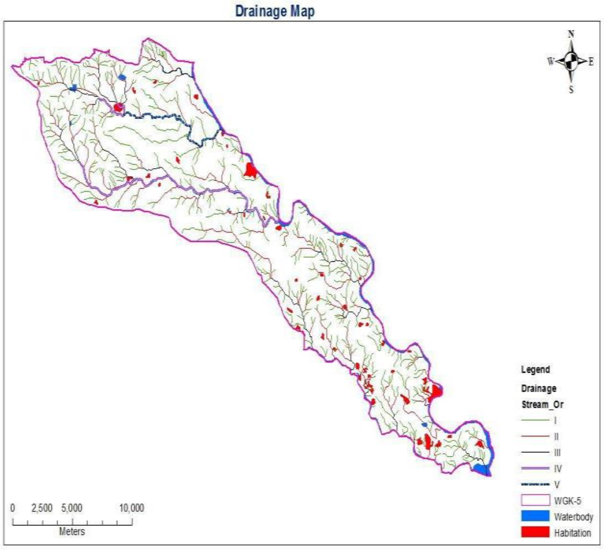


Fig. : Drainage Map

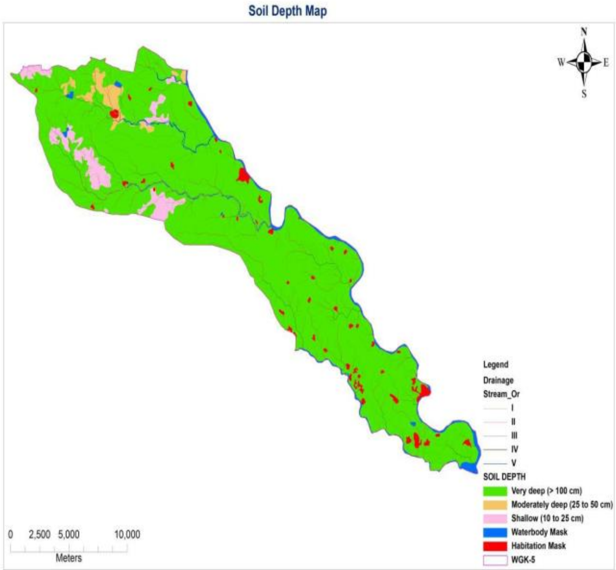


Fig. : Solid Depth Map

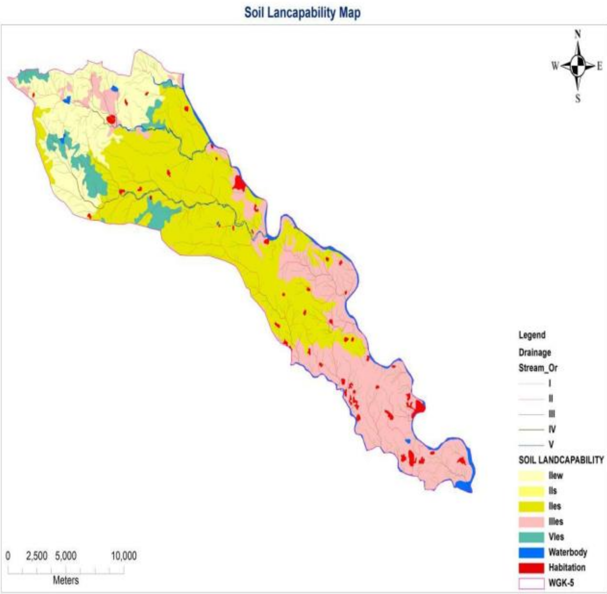


Fig. : Soil lancapability map

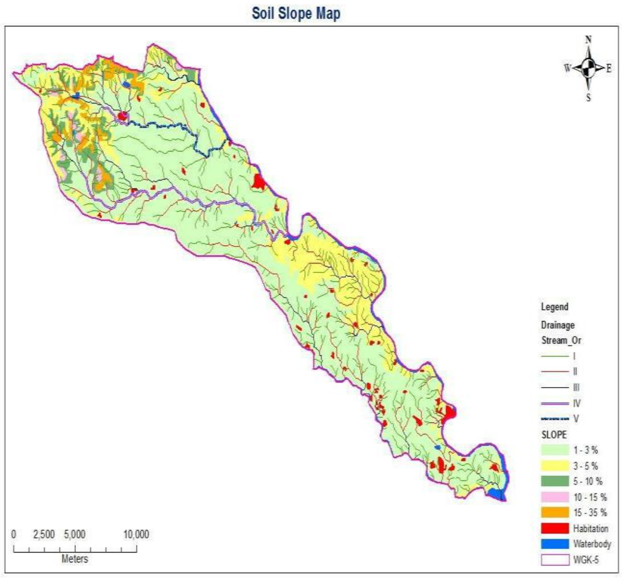


Fig. : Soil Slope Map

values between 3.0 and 5.0. If Rb value is low (between 2.0 and 3.0), it indicates plain terrain, permeable and soft rock. The average Rb of upper Tons basin is 4.47 which indicate hilly region, moderate ground slope, high run-off and moderate permeability of bed rocks. With the help of stream length ratio we can determine discharge of surface flow and erosional stage of the basin. the highest value indicates that the area drained by the fifth-order stream is enough permeable, gradients are gentler than in the area drained by the lower-order streams. A river basin has several branches of rivers, the selection or determination of the hierarchal position of stream segments within that basin is known as stream ordering. In the present study, the drainage density of the whole basin is 0.35 per km. Drainage density helps in analyzing a numerical measurement of land scape dissection and run-off potential. The high stream frequency indicates greater surface run-off and steep ground surface. Drainage frequency of the whole Upper Tons basin is 3.59 per km^2.The value of form factor varies between greater than zero to one (in perfect circular shape). A higher F_f value implies high peak flow in shorter duration, while lower value of Ff indicates lower peak flow of longer duration. Also, the low F_f value indicates elongated shape of drainage basin. The Ff of upper Tons basin is 0.417 which indicates elongated shape of the basin.

Table: Table of Result

S.N	Stream order	Stream number	Stream Length	Bifurcation ratio =Nu/Nu+1	Mean Stream Length =Lu/Nu	Drainage density = ∑Lu/A	Drainage Frequency =∑Nu/A	Form factor =A/L^2
1	First	344	1234862.8	2.09756	3589.71			
2	Second	164	550464.40	2.27777	3356.49	Second	164	550464.40
3	Third	72	266293.47	1.89473	3698.52	0.35	0.09	0.417
4	Four	38	267548.25	12.6666	7040.74		Four	38
5	Five	3	117353.94	3	39117.98		Five	3
6	Six	1	728.5517	0	728.5517		Six	1
Total		622	2437250.6	4.47		0.35	0.09	0.417

9. CONCLUSIONS

This study has demonstrated that water resource management plan for the sustainable development of the micro-watersheds can be effectively prepared using remote sensing and GIS techniques with an integrated approach through Arc GIS Desktop 9.3 and ERDAS Imagine 9.2 software for the sustainable watershed management. The remote sensing data combined with field survey details has provided a unique and hybrid database for the optimal planning and management of the watershed. The water and land resource development action plan is prepared using various thematic layers like slope, land use/ land cover, drainage, soil texture, soil depth, soil erosion and land capability and weight age and rank were assigned to the thematic according to their importance and these layers are overlaid using union operation and suggested suitable zonation for the water conservation structures like check dam, percolation tank, earthen nala bund, form pond, graded bunding, sunkan pond, roof rain water harvesting, and loose boulder structure and for soil conservation land resources development activities suggested are social forestry plantation with continuous contour trenches, check dam, afforestation with continuous contour trenches, canal command, conservation of forest, dry land agro-horticulture with farm pond, horticulture plantation, intensive agriculture with farm bund, irrigated agro-horticulture with farm bund, and pasture development etc. The conservation zonation structures were suggested to reduce soil erosion and conserve the water as natural resource for the sustainable watershed management. In the action plan for water conservation cement nala bund and canal command structures were suggested as >60% of the watershed is having slope of 1-3%. Roof rain water harvesting is suggested for the study area for the collecting and storing the rain water and also to improve groundwater level thereby assuring the sustainable water resource development of the region.

10. REFERENCES

[1] Morph metric analysis of Upper Tons basin from Northern Foreland of Peninsular India using CARTOSAT satellite and GIS.

[2] Quantitative morph metric Analysis of a Watershed of Yamuna Basin, India using (DEM) Data and GIS.

[3] Blair T C and McPherson J G 1994a Alluvial fans and their natural distinction from rivers based on morphology, hydraulic processes, sedimentary processes, and assemblages.

[4] Anderson, J.R., Hardy, E.E., Roach, J.T. & Witmer, R.E. 1976. A land use and land cover classification system for use with remote sensor data. U.S. Geological Survey, Professional Paper 964, Washington, DC.

[5] Bishop, Y.M.M., Fienberg, S.E. & Holland, P.W. 1975. Discrete Multivariate Analysis: Theory and Practice. MIT Press, Cambridge, MA.

[6] Campbell, J.B. 1981. Spatial correlation effects upon accuracy of supervised classification of land cover. Photogramm. Eng. Remote Sens. 47: 355-363.

[7] Chrisman, N.R. 1989. Modeling error in overlaid categorical maps. In: Goodchild, M.F. & Gopal, S. (eds.) Accuracy of Spatial Databases, pp. 21-34. Taylor and Francis, London.

[8] Chrisman, N.R. & Lester, M.K. 1991. A diagnostic test for categorical maps. Technical Papers, 1991 ACSM-ASPRS Annual Convention 6: 330-348. ASPRS/ACSM, Bethesda, MD.

[9] Colwell, R.N. 1983. Manual of Remote Sensing. American Society of Photogrammetry, Falls Church, VA. Congalton, R.G. 1988a. Using spatial autocorrelation analysis to explore the errors in maps generated from remotely sensed data. Photogramm. Eng. Remote Sens. 54: 587-592.

[10] Congalton, R.G. 1988b. A comparison of sampling schemes used in generating error matrices for assessing the accuracy of maps generated from remotely sensed data. Photogramm. Eng. Remote Sens. 54: 593-600.

[11] Congalton, R.G., Oderwald, R.G. & Mead, R.A. 1983. Assessing Landsat classification accuracy using discrete multivariate analysis statistical techniques Photogramm.