International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 11, November-2014

Morphometric Analysis of Watershed using GIS and RS: A Review

Ashok S. Sangle
Department of Computer Science and IT
Dr. B .A. M. University
Aurangabad, India

Pravin L. Yannawar
Department of Computer Science and IT
Dr. B .A. M. University
Aurangabad, India

***Abstract*— The role of GIS and RS to prepare assessment, management and planning of the Geology are all over recognizing technology. We like this modern technology use as a concern because the availability of water is most critical thing, may be in particular situations, may be in particular season, if it is excess (flood) it may be issues, if it is less (drought)it may be issues. As concern us need deep sense towards the watershed plan for that we collect fourteen research papers. In all fourteen literatures the researchers analyses the morphometric study for watershed management plan and hydrologic implications. In that we focus on instead of locations, Paper name and author name we focus on matter of fact that is methodology, input raw data and process to enhance the study for sustainable watershed management water security.**

The content of this review paper divided in to seven sections namely Introduction, Literature Review, Conceptual Framework about generally how idea behind morphometric analysis, Methodology, Result, conclusions followed by references.

Keywords*— IRS- Indian remote Sensing; RS-Remote sensing; GIS- Geographical information system; SOI- Survey of India; LISS- Linear imaging self-scanning; SRTM-Shuttle radar Topography mission; ASTER- Advanced Spaceborne Thermal emission and reflection

I. INTRODUCTION

The drainage basin has been seen as the fundamental hydrologic and geomorphic areal unit. We dealing with the water with in watershed the main source of water are due to precipitation. The water as per as water concern with respect to precipitation even though we classify in terms of watershed or particular river basin or drainage basin. we Identify watershed problem for integrated modeling approach. It may be like as certain issues that are resources under pressure, population under water stress, impact of population and water governess crises some people get more water some get less and poor people not get efficient and some challenges are the securing water for people, food production, developing job created activities within watershed, dealing with variability of water in time and space, protecting the vital ecosystems, managing the risk issues like climatic changes, creating popular awareness & understanding, forgiving the political view to act, and naturally critical important for resources availability and quality so to avoid this emerging certain situations as like growing population, climate change, and whimsical rainfall so we need to advanced study and planning of water or implication for hydrologic processes. As an integrated approach we may have better or holistic watershed management plan to sustainable development of people life as when securing water and environment.

II. LITERATURE REVIEW

After collecting literature/research papers we go through these papers and depend upon our problem statement that is in short as straight forward for better watershed management & plan we want to predict drainage shape, shape area, shape perimeter, drainage streams, stream network, Stream hierarchy, stream length, etc it mean by using the morphometric analysis we want to study the drainage land area for analyses purposes so it may help for better land use/land cover, agriculture practices and in this stockholder or approach we want to reflect the better watershed management plan. Morphometry is the measurement and mathematical analysis of the configuration of earth's surfaces, shape and dimension of its landforms [1].

As per this we thing and go ahead and we found that for morphometric analysis all they (research papers) use techniques GIS approach and as well as Remote sensing integrated with GIS techniques. In all these papers total number of watershed we found near about 55 major to mini watersheds and sub-watersheds. All these watersheds may be geographically located in different locations (longitude and latitude) that not matter of fact and so absolutely all researchers do this analysis as per its own problem statement concern as like excess water it may cause flood, less water it may cause drought affected area, soil erosion etc may be agriculture practices, land use/land cover some other hydrologic implications but through morphometric parameters they analysis its particular watershed area. So through which precise descriptions of the geometry of landforms could be harnessed as data could be collected, organized, and analyzed and visualized using GIS and remote sensing techniques [1]-[14].

In RS integrated With GIS they use input data as remote sensing images, DEM may be the images are different resolutions that are 90m, 30m depend upon application complexity they choose data but that is not matter of fact what resolution is that and also they use data toposheets, topographical maps, local knowledge and GIS tool. GIS tool for example ArcGIS for better Image interpretation and analysis purposes and that is matter of fact analyzing information as per application using GIS tool. Another approach is that only GIS approach in that they use input data as a toposheets, topographical maps and some local knowledge to harness the morphometric parameters for watersheds evaluation and better plan.

III. Conceptual Framework

Before According to Strahler (1964), systematic description of the geometry of a drainage basin and its stream channel requires measurement of linear aspects of the drainage network, areal aspects of the drainage basin, and relief (gradient) aspects of the channel network and contributing ground slopes.The American hydraulic engineer and hydrologist Robert E. Horton was the first to establish a quantitative methods for analysing drainage networks (Eze and Abua 2002, and Thorne 2006). Horton (1945) felt that the main stream should be of the highest order. He defined a first - order stream as one receiving no tributaries. That is, a headwater stream with no tributaries. A second - order is formed by the junction of two – first – order streams and can receive other first – order tributaries. A third – order stream is formed by the junction of two streams of like order forms a stream of next higher order, which can receive tributaries of any order lower than its own. Horton's system further demands that, after all streams have been classified, an investigator starts at the mouth of the basin study and reclassify part of the streams (Broscoe, 1959 and Haggett and Chorley, 1969). Strahler (1952) modified Horton's system by allowing his provisional scheme to determine the final ordering, such that; fingertip channel are designated order 1; where two first order channels join, a channel segment of order 2 is formed; where two channel segments of order 2 joint, a segment of order 3 is formed; and so on[1]. The usefulness of the stream order system depends on the premise that, on the average, if a sufficiently large sample in treated, order number is directly proportional to size of the contributing watershed, to channel dimensions and to stream discharge at that place in the system (Strahler, 1964). He further noted that the number of stream segments of any given order will be fewer than for the next lower order but more numerous than for the next higher order [1].The ratio of number of segments of a given order, Nu to the number segment of the higher order Nu +1 is termed the bifurcation ratio, Rb. The bifurcation ratio was introduced by Horton (1945) and modified by Strahler (1952). It characteristically ranges between 3 and 5 in homogeneous bedrock (Chorley 1969 and Waugh 1996). When natural log ln of number of stream is plotted against order, most drainage networks show a linear relationship with small deviation from a straight line [1].

The morphometric parameters were categorized in to three divisions: Basic Parameters, Derived Parameters and Shape Parameters. The basic parameters include area, perimeter, basin length, stream order, stream length, maximum and minimum heights and slope. The derived parameters are bifurcation ratio, stream length ratio, RHO coefficient, stream frequency, drainage density, drainage texture, basin relief and relief ratio. The shape parameters are elongation ratio, circularity index and form factor [7].

IV. Methodology

Morphometric analysis is best method for isolation of problem through which precise descriptions of the geometry of landforms could be harnessed as data could be collected, organized, and analyzed and visualized using remote sensing integrated with GIS techniques to resolve the applications.

A. *Input*

SOI Topographical maps, Toposheets (1:50000 scale). IRS - P6 (resourceSat-1) have three type of sensors namely; LISS IV high resolution sensors, LISS III medium resolution sensors i.e 23.5m resolution, AWIFA advanced wide field sensors, then IRS-1B LISS II, LISS 1D PAN, Landsat, SRTM data 90m resolution and ASTER data 30 m resolutions were data used as raw input in all research papers [1]-[14].

B. *Process*

Morphometric parameters are harnessed using GIS tool. There are variety of software & hardware tools (ArcGis, Acrhydro, Arcswat, SAGA GIS and ERDAS and dozens of more) the important factor is the level of integration of these tools to provide a smoothly operating, fully functional geographic data processing environment through the input→ storage &retrieval → manipulation and analysis → then output of productive results. Methods may be applied for creation of maps, the management of forests, Land use, land cover, natural resources management such as watersheds, and evaluation of drainage network and watershed management system. Parks and infrastructure, such as roads and water ways, evaluation of places for the location of new stores, as well as applications in risk analysis of natural hazards, emergency planning and responses.

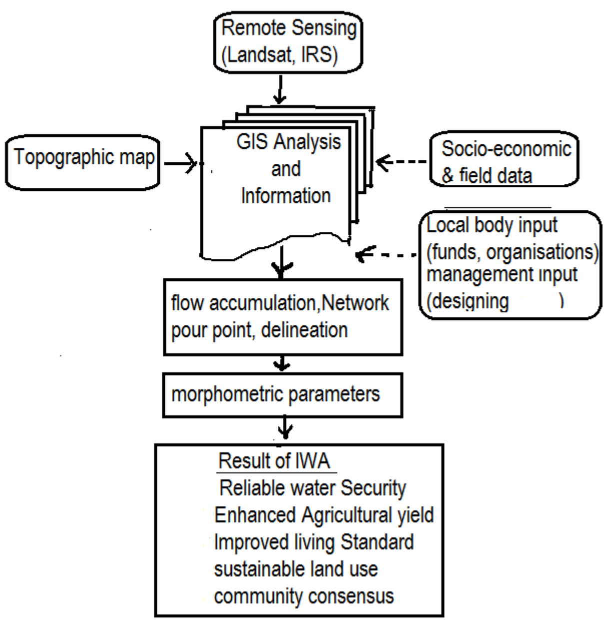

Fig. 1. Process Flow

C. Result

In all papers they use morphometric parameters to conclude result in below table 1 we summarise the morphometric parameters and its formula's [1]-[14]. The evaluation of the morphometric parameters necessitates for preparation of drainage map, ordering of the various streams, measurement of the catchment area and perimeter, length of drainage channels, drainage density and frequency, bifurcation ratio, texture ratio, circulatory ratio and constant channel maintenance, which helps to understand the nature of drainage basins [11] for efficient better sustainable watershed plan to reliable water security, enhance agriculture yield.

TABLE I. TABLE SHOWS THE COMPUTATION OF RESULTS USING MORPHOMETRIC PARAMETERS.ES

Sr. no.	Morphometric Parameters	Methodology	Reference
1	Stream order (u)	Hierarchical order	Strahler (1964)
2	Stream Length (Lu)	Length of the stream	Horton(1945)
3	Mean Stream Length (Lsm)	Lsm = Lu / Nu km Where, Lu=Mean stream length of a given order Nu= Number of stream segments	Strahler (1964)
4	Bifurcation Ratio (Rb)	Rb = Nu / Nu+1 Where, Nu=Number of stream segments present in the given order Nu+1= Number of segments of the next higher order	Schumn(1956)
5	Mean Bifurcation Ratio	Rbm = Average of bifurcation ratios of all orders	Strahler (1964)
6	Drainage Density (D)	$D= \Sigma Lu / Au$) km/km^2 Where, Lu=Total Stream length of all orders (km) Au=Area of the Basin (km2)	Horton (1945)
7	Drainage Texture(Rt)	Rt = Σ Nu/P Where, Nu= Stream Number, P = Perimeter (km)	Smith (1950)
8	Stream Frequency (Fs)	Fs = Σ Nu /Au Where, Nu=Total number of streams in the basin Au= Basin Area (km2)	Horton (1945)
9	Length of Over Land Flow (Lg)	Lg = 1/ D×2 Km Where, D = Drainage density (km/km2)	Horton (1945)
10	Form Factor (Rf)	$Rf = Au / Lb^2$ Where, Au=Area of the Basin (km2) Lb=Maximum Basin length (km)	Horton (1945)
11	Circularity Ratio (Rc)	$Rc = 4\pi Au/ P^2$ Where, Au= Basin Area (km2) P= Perimeter of the basin (km), Π = 3.14	Miller(1953)
12	Elongation Ratio (Re)	Re= √Au/π / Lb Where, Au= Area of the Basin (km2) Lb=Maximum Basin length (km), Π = 3.14	Schumn (1956)
13	Relief Ratio (Rh)	Rh = H / Lbmax Where, H = Maximum basin relief (km) Lbmax= Maximum basin length (km)	Schumm (1954)
14	Ruggedness Number (HD)	HD= H×Dd Where, H= Maximum basin relief, Dd= Drainage density	Strahler (1964)
15	Relative Relief (Rhp)	Rhp = H× (100) / P Where, H = Maximum basin relief P = Perimeter of the basin (km)	Melton (1957)
16	Form factor (Ff)	$Ff=A/Lb^2$ Where, A= basin area, Lb^2 = square of the basin length	Horton (1945)

V. CONCLUSIONS

It is concluded that in all these papers near about 55 major-mini sub-watersheds used for morphometric analysis study so depend upon places the different researcher have different watershed problems some have soil erosion, some have drought affected area, flooding, some, for better land use/ land cover, drainage basin, drainage network evaluation, other hydrologic implications and watershed development and plan purposes they do study and for that they use modern technology to evaluate morphometric parameters.

In one paper they derived morphometric parameters from three different data sources viz., SOI Toposheet (1:50000), SRTM data(90 resolution) and ASTER data (30m resolution) are evaluated to examine any difference within the results itself for proper planning and management; minor differences there in result it matter of application complexity.

So depends upon slope and aspect, Curvature, profile curvature, plan form curvature i.e. the nature of surface as like small-small depressions and rising ground and hill etc. so because of that nature of surface or drainage geometry could have the different-different drainage surface pattern and on the basis of that we reflect the morphometric watershed analysis study for the purpose development, sustainable growth, improved living standard and through morphometric parameters are how influence the features of each parameter to evaluate the watershed and this is a deep sense towards the watershed management through morphometric analysis watershed area.

ACKNOWLEDGMENT

We all author thanks to Department of Computer Science and Information technology of Dr. Babashaeb Ambedkar Marathwada University Aurangabad for providing the experimental lab and other facility.

REFERENCES

[1] J. I. Clark, "Morphometry from Maps Essay in geomorphology", Elsevier publishing company, New York, 1966, pp.235-274

[2] EzeBasseyEze & Joel Efiong, "Morphometric Parameters of the Calabar River Basin: Implication for Hydrologic Processes", Journal of Geography and Geology, vol.2, no. 1, September 2010..

[3] Panhalkar S.S., Mali S.P., Pawar C.T." Morphometric Analysis and Watershed Development Prioritization of Hiranyakeshi Basin in Maharashtra, India"International Journal of Environmental Science, volume 3 no. 12012.

[4] Sujata Biswas, S.Sudhakarand V. R. Desai, "Prioritization of Subwatersheds Based on Morphometric Analysis of Drainage Basin: A Remote Sensing and GIS Approach",PhotonirvachakJournal of the Indian Society of Remote Sensing, vol. 27, no. 3, 1999.

[5] G.Tamma Rao,V.V.S. GurunadhaRao, Ratnakardakate, S.T.MallikharjunaRao and B. M. Raja Rao, "Remote Sensing and GIS Based Comparative Morphometric Study of Two Sub-watershed of Different Physiographic Conditions, West Godavari District, A.P.",Journal Geological Society of Indiavol.79, april 2012, pp.383-390.

[6] Syed Ahmad Ali, Nazia Khan," Evaluation of Morphometric Parameters—A Remote Sensing and GIS Based Approach", Open Journal of Modern Hydrology, 2013, 3, 20-27

[7] Ziaur Rehman Ansari, A.K. Rao and Alia Yusuf,"GIS Based Morphometric Analysis of Yamuna Drainage Network in Parts of Fatehabad Area of Agra District, Uttar Pradesh",Journal Geological Society of India vol.79, May 2012, pp.505-514.

[8] S. A. Ahmed, K.N. Chandrashekarappa, S. K. Raj, V. Nischitha, G. Kavitha, "Evaluation of Morphometric Parameters Derived from ASTER and SRTM DEM – A study on Bandihole Sub-watershed Basin in Karnataka", journal of Indian Society Remote Sensing, June 2010 38 : 227–238.

[9] Sharad Chandra Dwivedi, "Morphometric Analysis of Four Sub-watersheds in Bah Area of Agra District using Remote Sensing and GIS Techniques", 12th ESRI India user conference 2011.

[10] Arpita Pankaj, Pankaj Kumar, "GIS-Based Morphometric Analysis of Five Major Sub-watersheds of Song River, Dehradun District, Uttarakhand with Special Reference to Landslide Incidences", Journal Indian Society Remote Sensing March 2009, 37:157–166.

[11] Amee K. Thakkarand S. D. Dhiman, "Morphometric Analysis and Prioritization of Mini watersheds in Mohr watershed, Gujarat using Remote Sensing and GIS techniques", Journal of the Indian Society of Remote Sensing, vol. 35, no. 4, 2007.

[12] H. Vijith and R. Satheesh, "On GIS based Morphometric Analysis of two Major Upland Sub-watersheds of Meenachill River in Kerala", Journal of the Indian Society of Remote Sensing, vol. 34, no. 2, 2006.

[13] RrajivChopra, Raman Deep Dhiman and P.K. Sharma, "Morphometric Analysis of Sub-watersheds in Gurdaspure District, Punjab using Remote Sensing and GIS Techniques", Journal of the Indian Society of Remote Sensing, vol. 33, no. 4, 2005.

[14] S. K. Nag, "Morphometric Analysis using Remote Sensing Techniques in the Chaka Sub-basin, Purulia District, West Bengal", Journal of the Indian Society of Remote Sensing, vol. 26, no. l&2, 1998.

[15] V. Mallikarjuna, K. R. K Prasad, P. Udaya Bhaskar and M. Sailakshmi, "Watershed Modeling of Krishna Delta, Andhra Pradesh using GIS and Remote Sensing Techniques", International Journal of Engineering Science and Technology, ISSN: 0975-5462, vol. 4 no.11 November 2012.