REMOTE SENSING AND GIS APPLICATION IN MORPHOMETRIC ANALYSIS OF MAHILPUR BLOCK, HOSHIARPUR, PUNJAB

Jasvinder Kaur[1*], Amandeep Singh[2], Rajesh Jolly[3]

Abstract:
The current study seeks to evaluate watershed resource management in Hoshiarpur District, Punjab. Water is an essential source for all living organisms on Earth. It is important that we use it wisely and sustainably to ensure that it is available for future generations. The geomorphology of watersheds, for example, may be mapped and monitored using remote sensing techniques. Geographical information systems and remote sensing are proven to be efficient tools for locating water harvesting structures by prioritization of mini-watersheds through morphometric analysis. For prioritization of watersheds, morphometric analysis is utilized by using the linear parameters such as bifurcation ratio, drainage density, stream frequency, texture ratio, and length of overland flow and shape parameters such as form factor, shape factor, elongation ratio, compactness constant, and circularity ratio. With the use of GIS, this process becomes easier, less stressful, and the degree of accuracy achieved is quite high. Although GIS is not a particularly ancient technology, we are constantly looking for new applications and opportunities. The first stage in any management operation is to determine the watershed area. Having a distinct region and a shared drainage point, a watershed is a natural hydrological unit. Since natural resources like soil, water, and plants are under extreme stress from biotic demand that is only growing, watershed management is an all-encompassing strategy for sustainable management and conservation of these resources GIS and remote sensing techniques are employed in action plans for the conservation of land and water resources. Topographical and cadastral maps from the Survey of India. Maps are used to create spatial databases that include information on the topography, vegetation, soil types, land use, geology, drainage, and network of stream channels. This primary resource data is used to build secondary vector layers and data structures for slope, erosion class, soil depth, land capability, etc. In order to find a viable solution for the watershed region, specific challenges are identified based on guidelines that have been developed. This Research will go over GIS and remote sensing methods for managing watersheds.

Keywords: Remote sensing, GIS, morphometric analysis, Remote sensing, GIS, morphometric analysis, Remote Sensing, GIS, Morphometric Analysis, Choes, Watershed

---

[1*]Research Scholar, Department of Geography, Lovely Professional University, Phagwara, Punjab
[2,3] Assistant Professor, Department of Geography, Lovely Professional University, Phagwara, Punjab

***Corresponding Author:** Jasvinder Kaur
*Research Scholar, Department of Geography, Lovely Professional University, Phagwara, Punjab

DOI: - 10.48047/ecb/2023.12.si5a.047

1. INTRODUCTION

Geography-based information systems (GIS) and remote sensing are effective tools for managing watershed landuse. These technologies can be utilised in the case study of Mahilpur block to compile data on the patterns of land use and produce maps that can be used for planning and decision-making.

Remote sensing uses sensors to collect data at a distance, whereas GIS is a computer-based application that allows users to modify and analyse spatial data. These technologies can be used to collect data on land use patterns such vegetation cover, water resources, and land use changes.

For instance, data on the vegetation cover in the Mahilpur block can be gathered via remote sensing. The kind and density of vegetation in various areas can be identified by examining satellite pictures. This data may then be used to produce maps that depict the prevalence of various vegetation types and pinpoint places that can benefit from conservation efforts.

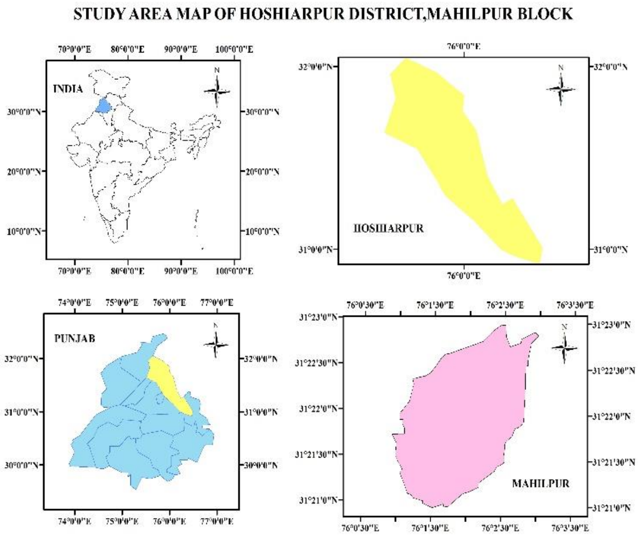
Land use patterns, soil types, and water resources are just a few examples of the various sorts of data that may be overlaid using GIS. This enables planners to spot potential conflicts between various land uses, such as agriculture and conservation. Planners can create plans to manage land use in a way that maximizes benefits while avoiding conflicts by examining this data.

Planners can make wise judgments on how to manage the land in a sustainable and efficient manner with the use of the application of remote sensing and GIS for watershed land use management in the Mahilpur block.

2. DESCRIPTION OF STUDY AREA

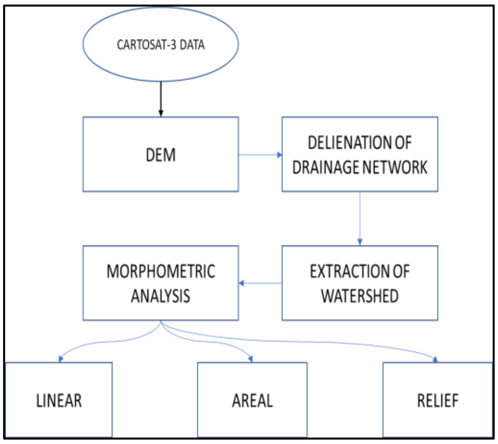
A watershed study area is a geographical region in which all the water that falls within it, whether as rainfall or snow, flows to a common location, such as a stream, river, lake, or ocean. The Mahilpur block is a particular administrative area within the Hoshiarpur district of the Indian state of Punjab.

Hence, the area within the Mahilpur block where water from precipitation or snowfall travels to a common point is referred to as the Mahilpur block watershed research area. A network of interconnecting streams, rivers, and other water bodies, as well as a variety of land uses, such as forests, agricultural land, urban areas, and natural regions, are likely to be the features that define this region. Several tasks could be included in a watershed study of the Mahilpur block, such as mapping the area's land uses and water bodies, keeping track of water quantity and quality, and looking for potential pollution sources or other risks to water resources. The findings of such research could guide management plans and policies meant to safeguard and enhance the quality of water resources within the Mahilpur block watershed study region



3. DATA AND METHOD USED

Remotely sensed satellite imaging data were processed in Arc GIS 10.0 software using the Spatial Analyst Tool to create multiple maps, and morphometric parameters were then examined to study the drainage features of the watershed and identify the probable recharge site. A combined use of multispectral satellite data, a digital elevation model (DEM), and survey of India's topographical sheets was made in the current paper to create extraction from a database of different drainage characteristics. Table 1 provides information about the data used. For the analysis of the watershed, the steps below were used.



a. Using ground control points (GCPs) and the UTM projection and WGS 84 datum, the SOI toposheets were geometrically rectified and georeferenced. Additionally, using Erdas Imagine 9.1 image processing software, all geocoded toposheets were mosaiced.

b. The research region's SRTM DEM and Survey of India topographical sheets were used to identify the Orr watershed's catchment area, which was then used to create the basin's AOI (region of Interest).

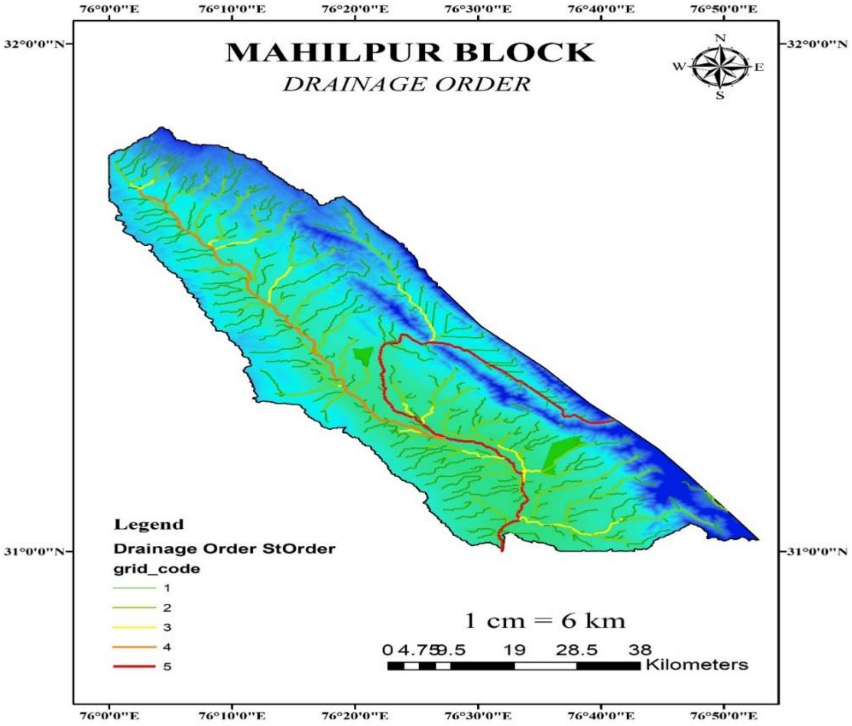
4. RESULT AND ANALYSIS

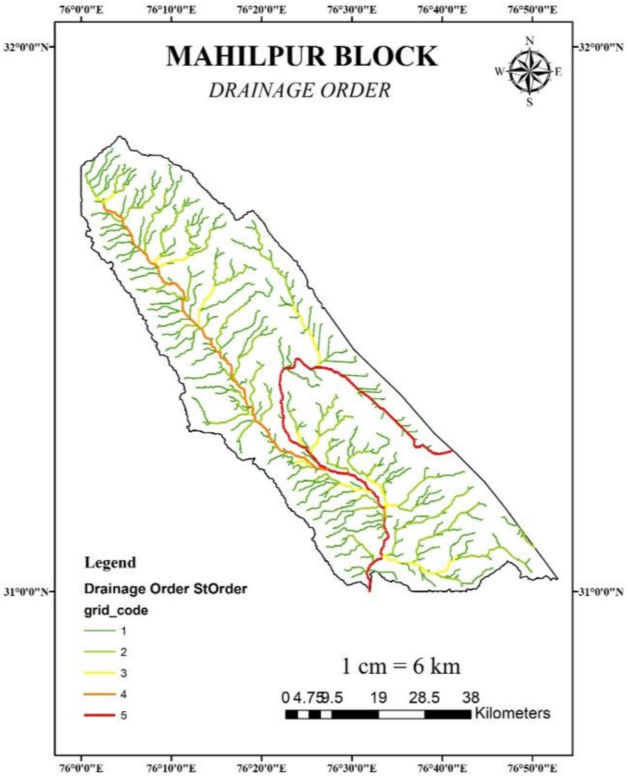
Survey of India topographical maps were employed extensively in the current work to meet the goals of morphometric analysis, remote sensing, and GIS approaches. Remotely sensed satellite imaging data were processed using the Spatial Analyst Tool in Arc GIS 10.0 software to create multiple maps, and morphometric parameters were then examined to study the drainage features of the watershed and identify the probable recharge site. GIS software is used to create a variety of maps using satellite imagery data and Survey of India topographical maps at 1:50000 sizes. The drainage features of all the sub-watersheds were then studied using morphometric parameters that were evaluated. The Hydrology tool in the Spatial Analyst tool is used to delineate watershed areas, resulting in 54 sub-watershed zones for producing stream order maps and morphometric analysis data of all sub-basins from the CartoSAT-1 DEM data. Under Raster Calculator the map algebra tool in the Arc GIS 10.0 toolbox is used to generate drainage maps for all sub-watersheds.

The drainage network map is overlaid with a Land Use/Land Cover map of the research area to identify the sites of the artificial groundwater recharge facilities. Projections and modifications in Arc GIS 10.0 were used to project all spatial datasets to UTM 43 North and WGS 1984 datums. Topographical sheets of the Mahilpur watershed, having 1:50,000 scales lie in The topographical maps were then scanned with 400 dpi resolution. The scanned map was georeferenced in Arc GIS 9.2 software and then converted into the GCS-WGS1984 projection system. The shape files for contours and drainages are digitized from the registered topographical sheets. During the digitizing process, human errors such as overshoot/undershoot, hanging, overlapping, and intersection were removed. The digital elevation model (DEM) and slope of the area were calculated using data from the Shuttle Radar Topography Mission (SRTM) C band radar. The spatial resolution of the SRTM-derived DEM is --m. The digitised contour and slope map of the area was used to assess the accuracy of the SRTM. Because of its free availability and ease of processing in a GIS setting, SRTM is an excellent candidate for this investigation.

Drainage Map

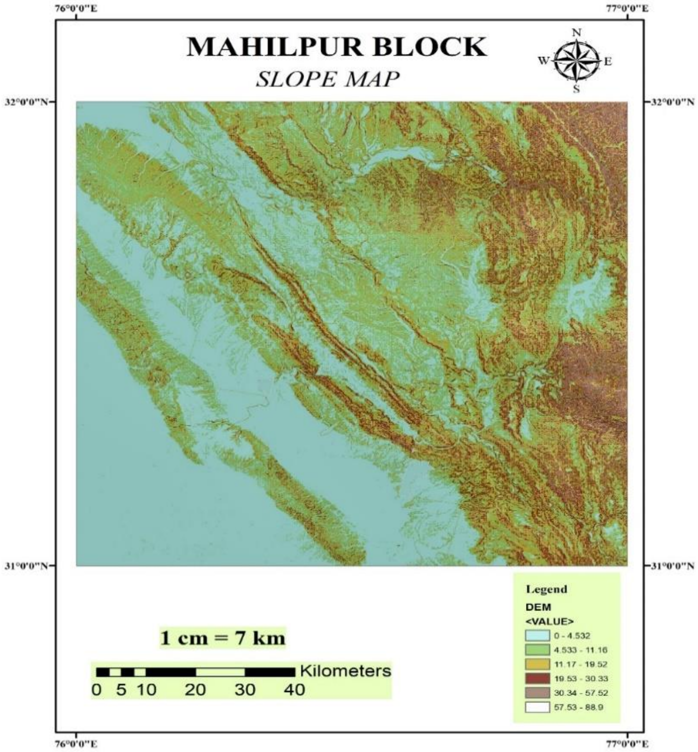
Drainage was digitised from satellite data (Cartosat DEM) 1 to create the drainage map. Drainages are drawn in the research region using a drainage delineation tool and SRTM, and they are corrected in GIS by comparing them to SOI topographical sheets. The stream ordering technique assigns an order number to each stream. The morphometric parameters for the specified watershed area were determined using the formula proposed by Horton (1945), Miller (1953), and Schumm (1956).





Slope Map

From SRTM and a contour map, the slope map was created. The triangulated irregular network (TIN) model and DEM are created from the digital contours using the 3D analyse tool. From this DEM, slope map was generated using the below mentioned process: Arc GIS 3D Analyst tool; Surface analysis; Slope; Percentage function. Slopes were classified in the guidelines mentioned in Integrated Mission for Sustainable Development (IMSD) document, Department of Space



RESULTS AND DISCUSSION

Morphometric Analysis: Watershed provided data on fundamental morphometric characteristics such area (A), perimeter (P), length (L), and number of streams (N). Stream length was used to compute the demarcated layer's basin length (Lb), and the number of streams was used to calculate the bifurcation ratio (Rb). Using equations, as described in Table. According to (Nooka Ratnam et al. 2005), linear parameters have a direct link with erodibility: the higher the value, the greater the erodibility. The highest value of the linear parameter was ranked first, followed by the second highest value, and so on. Shape parameters, on the other hand, have an inverse relationship with linear parameters, thus the lower their value, the greater the erodibility (Patel and Dholakia 2010; Patel et al. 2012). Thus, the lowest value of the shape parameter was evaluated as rank 1, the second lowest as rank 2, and so on. The compound factor was then calculated by adding all the rankings of linear parameters as well as shape parameters, and then dividing by the number of parameters. The mini-watershed with the lowest compound factor received the highest prioritised rank from the group of watersheds, and vice versa (Patel et al. 2012).

Table 2 Empirical connections that are utilised to calculate the morphometric parameters

Morphometric Parameters	Formula	References
1. Stream order *(u)*	Hierarchical rank	Strahler
2. Stream length *(L)*	Length of Stream	Strahler
3. Bifurcation Ratio (R_b)	$R_b = N_u/N_{u+1}{}^b$	Strahler
4. Drainage Density (D_d)	$D_d = L_u/A^c$	Strahler

[b] R_b bifurcation ratio, N_u total number of stream segment of order 'u' N_{u+1} number of segment of next higher order

[c] D_d drainage density, L_u total stream length of all order, A area of the basin (Km^2)

Stream Analysis

Stream order is a measure of the degree of stream branching within a watershed. The length of a stream is denoted by its order (e.g., first-order, second-order, etc.).As per Strahler's method, all linkages that do not have any tributaries are given an order of one and are referred to as first order. The crossing of two links of different orders, on the other hand, will not result in an increase in order. For example, the intersection of a first-order and second-order connection will not result in a third-order link, but will keep the order of the highest ordered link. The Strahler method is the most commonly used stream ordering method. However, because this technique only grows in order at intersections of the same order, it does not account for all linkages and can be sensitive to the addition or removal of links. This was accomplished with the help of Arc GIS 9.1. As indicated in the technique chapter, this software is GIS-based and employs a geocoded database of layers. The use of these attributes database special fields—error and the ordering are stated. The drainage layer is constructed using a repeating process for error and order of steams, and it has suitable flow direction of the streams and connectivity, stream orders, and total number of streams. Streams per watershed and summation of all orders of streams. Stream ordering of drainage layer is carried out using this approach, which is tabulated below table

Calculation of morphometric parameters

To characterise the watershed, the following morphometric characteristics were used: basic parameters, linear parameters, and form parameters. Table 1 shows the results of different parameter calculations using the formulas provided in Table 1.

***Basic Parameters**:* The basic characteristics are watershed size, perimeter, stream length, stream order, and basin length

Area (A) and perimeter (P) The drainage area (A), which measures the amount of water that may be produced from rainfall, is most likely the most significant watershed parameter for hydrological design (Patel et al. 2012).

Linear Parameters Bifurcation ratio, drainage density, stream frequency, texture ratio, and length of overland flow are examples of linear Parameters

Drainage density (D_d) and bifurcation ratio (R_b)
The number of streams in a given order divided by the number of streams in the next higher order is known as the bifurcation ratio (R_b) (Schumm 1956). Watersheds with less structural disturbance and lower R_b include any deviation from the drainage pattern

Table.3 Linear aspect of the Mahilpur watershed

Stream order (w)	No of Streams (N_u)	Bifurcation Ratio (R_{bf})	Mean Bifurcation Ratio (R_{bm})	Total length of Streams (Km)	Mean Length of Streams (km)	Length Ratio (R_L)
1	**2062**		**4.62**	**1162.43**	**0.809**	**4.2**
2	**435**	**4.74**		**492.88**		
3	**91**	**4.78**		**231.96**		
4	**19**	**4.79**		**142.31**		
5	**5**	**3.8**		**30.96**		
				54.23		
Total	**2613**		**Total**	**2114.77**		

4. CONCLUSION

Watershed areas should be prioritised because they are a consideration for placing water harvesting structures and for practises that protect the land. In the following article, a summary a potential GIS-integrated method for creating a rough ranking of sub-watershed priorities. In this study, the entire region was divided into - watersheds, and priority-setting was done while taking into account several morphometric factors. The criteria for determining a watershed's ranking in this study are based mostly on the necessity to protect watersheds. According to this model, it is reasonable to predict that watersheds that are given a low priority for restoration will likely have a high level of environmental quality and stability and, as a result, should be given a high priority for protection. In order to prioritise conservation efforts, it is necessary and appropriate for developing nations like India to divide the watershed region into smaller watersheds. The research showed that the SRTM with GIS is a very effective technique for defining watersheds. The prioritisation of watersheds can be done extremely well using morphometric analysis. Positioning a water harvesting structure and choosing appropriate soil conservation measures for the Mahilpur watershed are both made easier with the use of morphometric analysis and GIS. These structures could effectively stop too much water entering from the watersheds. For hydrological communities and water resource modellers, it will lessen the likelihood of heavy runoff and flooding. As a result, prioritisation is an essential component of planning for the implementation of a watershed management programme. Given the large investment in the watershed development programme, it is now critical to prioritise activities in order to achieve economic results. As a result, this effort will assist planners in addressing problematic locations at a low cost.

5. REFERENCES

1. Bagyaraj M, Gurugnanam B, Nagar A (2011) Significance of morphometry studies, soil characteristics, erosion phenomena and land form processes using remote sensing and GIS for Kodaikanal hills, a global biodiversity hotspot in Western Ghats, Dindigul District, Tamil Nadu, South India. Res J Environ Earth Sci 3(3):221–233
2. Bali R, Agarwal K, Nawaz Ali S, Rastogi S, Krishna K (2012) Drainage morphometry of Himalayan Glacio-fluvial basin, India: hydrologic and neotectonic implications. Environ Earth Sci 66(4):1163–1174. doi:10.1007/s12665-011-1324-1
3. Brooks RP, Wardrop DH, Cole CA (2006) Inventorying and monitoring wetland condition and restoration potential on a watershed basis with examples from Spring Creek Watershed, Pennsylvania, USA. Environ manage 38(4): 673–687
4. Chopra R, Dhiman RD, Sharma P (2005) Morphometric analysis of sub-watersheds in Gurdaspur district, Punjab using remote sensing and GIS techniques. J Indian Soc Remote Sens 33(4): 531-539
5. Miller VC (1953) A quantitative geomorphic study of drainage basin characteristics in the Clinch Mountain area Virginia and Tennessee. DTIC Document
6. Miller JR, Craig Kochel R (2010) Assessment of channel dynamics, in-stream structures and post-project channel adjustments in North Carolina and its implications to effective stream restoration. Environ Earth Sci 59(8):1681–1692
7. Mukherjee S, Shashtri S, Singh C, Srivastava PK, Gupta M (2009) Effect of canal on land use/land cover using remote sensing and GIS. J Indian Soc Remote Sens 37(3):527–537
8. Patel DP, Dholakia M (2010) Feasible structural and non-structural measures to minimize effect of flood in lower Tapi basin. Int J WSEAS Trans Fluid Mech 3(5):104–121
9. Hlaing KT, Haruyama S, Aye MM (2008) Using GIS-based distributed soil loss modeling and morphometric analysis to prioritize watershed for soil conservation in Bago river basin of Lower Myanmar. Front Earth Sci China 2(4):465–478
10. Horton RE (1945) Erosional development of streams and their drainage basins; hydro-

physical approach to quantitative morrphology. Geol Soc Am Bull 56(3):275

11. Huggel C, Schneider D, Miranda PJ, Delgado Granados H, Ka¨a¨b A (2008) Evaluation of ASTER and SRTM DEM data for lahar modeling: a case study on lahars from Popocate´petl Volcano, Mexico. J Volcanol Geoth Res 170(1):99–110
12. Youssef AM, Pradhan B, Hassan AM (2011) Flash flood risk estimation along the St. Katherine road, southern Sinai, Egypt using GIS based morphometry and satellite imagery. Environ Earth Sci 62(3):611–623