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Remote sensing and GIS technical approach in watershed shed delineation

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Abstract
Water is an essential natural resource for preserving and conserving the surrounding environment and ecosystem for all forms of life. The rudimentary element for watershed operations is the suitable management of precipitation by following the process of the way of collection, storage, and environment-friendly utilization of runoff water and recharge of the groundwater. This paper intends is to find the appropriate zones for water harvesting structures in the Uttarkashi District, Uttarakhand using Geospatial technology along with suitable decision-making models. For this study, models like Multi-Criteria Evaluation (MCE) and OPTRAM model combining remote sensing and GIS have been implemented in the establishment of appropriate zones for water harvesting structures. Criteria layers that have been considered for multi-criteria comparison were soil texture, slope, soil Moisture (2016-2022), land use/cover, soil map, and drainage network. A dummy soil conservation model was used to estimate the runoff depth for finding out the characteristics of the vicinity area. The results achieved using RS & GIS and the decision-making model were finally clubbed with Hierarchy Processes (AHP) for watershed delineation.

Keywords: Decision-making models, remote sensing, GIS, watershed, soil

Introduction
Water is a resource without which no life can exist on Earth and the variability and availability of this precious resources affects the quality-of-life in an insignificant manner. Therefore, the watershed development programme is multi-disciplinary in nature with integration of many inter-related activities to achieve restoration of ecological balance by harnessing, conserving, and developing degraded natural resources such as soil, vegetative cover, and water.

The watersheds development strategies in the area require accurate measurement of the past and present land cover/land use parameters as changes observed in these parameters determine the hydrological and ecological processes taking place in a watershed. Analysis of these changed parameters provides the measure of the distinct data framework and thematic changes information that might involve in upbringing of land cover and land use changes. Therefore, the high-resolution satellite data (Images) provide the broader overview of the ground situation and help in monitoring at periodic time intervals.

In view of above, present study focuses on identification of suitable sites for watershed delineation using remote sensing and GIS approach in the selected study area.

Study Area
Uttarkashi famous as Kashi of North is situated in Uttarakhand State, India. It is above 5000 ft. sea level in the Himalayas. The latitude and longitudinal extent of the district are 30.73°N 78.45°E. It is surrounded by mountains having high ridges, hills, plateaus, and a confined area as plains. Sparsely populated settlements and terrace fields can be seen towards slopes of hillsides.

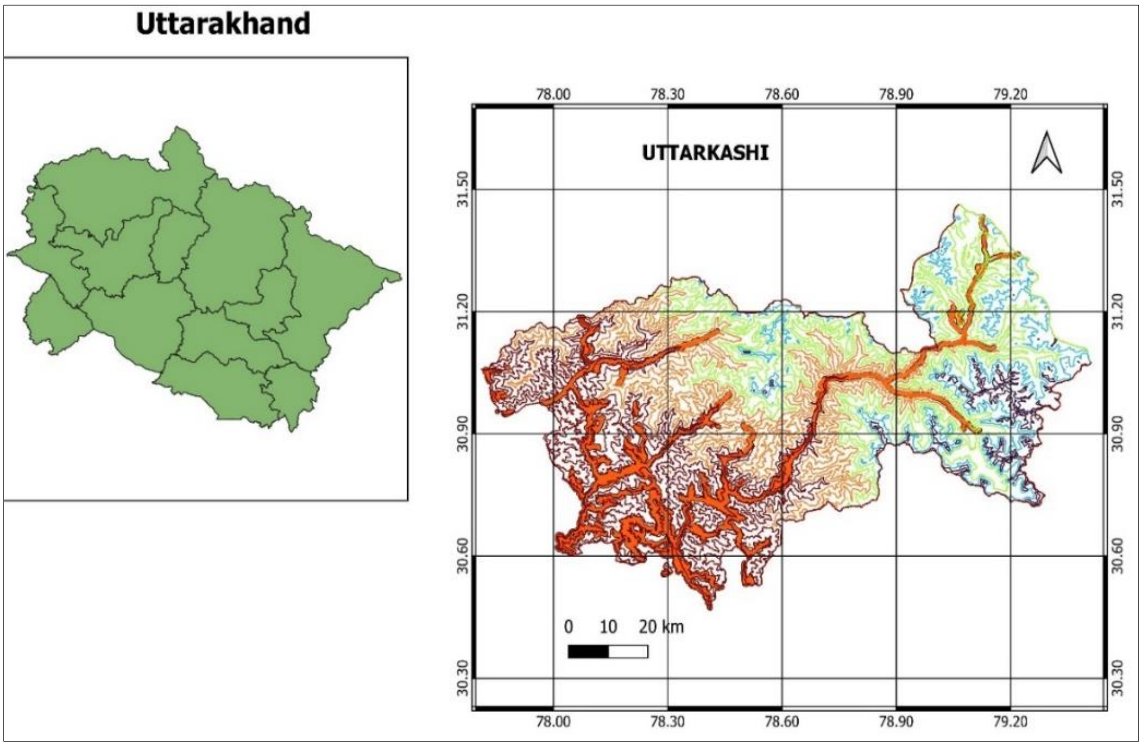

Fig 1: Study Area

Materials and Methods
Datasets
Remote Sensing

Sentinel 2 multispectral data and Digital Elevation Model (DEM) from SRTM has been utilized for the watershed delineation in the study area. The spatial resolution for the initial dataset is 10m while the latter one is available at 30 meters. Atmospheric correction of downloaded sentinel images was done for generating land use and land cover layers. Modelling of the datasets for watershed analysis was performed in Arc GIS 10.8 and ERDAS imagine, and final watershed delineated using an open -source software QGIS.

The datasets mentioned above namely sentinel 2a and SRTM was downloaded from Google earth engine platform. Further, the Land use and Land cover map was prepared using Support vector machine algorithm of Google earth engine and finally Slope analysis was done by QSWAT (Soil Water Analysis Tool) for generating watershed and basin boundary.

Soil Moisture

Soil Moisture data yielded from algorithm developed in Google earth engine, as the scale for readily available data was too big and their resolution was also very coarser as compared to the derived Soil Moisture datasets from Sentinel 2. The literature has also been refereed for validating the methodology for estimating SM by using optical data and one such very similar study was found for Italy in which scholar used OPTRAM Model. The results were satisfactory as the data range was in correlation with observed and estimated soil moisture was $r^2 = 0.79$ for Tuscany region [2].

Optram Model

Optical Trapezoids Model (OPTRAM) is based on the linear physical relationship that exist soil moisture and shortwave infrared transformed reflectance (*STR*). It is further parameterized based on the pixel distribution within the *STR-VI* space. The good correlations were found between soil Moisture measurements and OPTRAM estimates for a variety of land cover classes such as in case of dense or sparsely dense soil, vegetation, differential management (Rain irrigation and irrigation) [3].

Results and Discussion
Runoff Depth Map

Rainwater harvesting is a hydrological phenomenon and best explained by a hydrological model to display flow direction, run-off, and run-up areas and to identify the structure which can be flooded. The SCS curve discharge model is widely adopted method for calculating run-off because it depends on the land cover parameters. For the present study, SCS Run off curve number method explained in National Engineering Handbook (2004) and initially developed by the United States Department of Agriculture (USDA) has been adopted.

Equation for runoff curve number methods is as follows:

$$\boldsymbol{Q} = \boldsymbol{P-Ia}\ 2\ \boldsymbol{P-Ia} + \boldsymbol{S} \qquad (1)$$

Where, Q = runoff depth (mm) P = rainfall (mm) S = potential maximum retention after runoff starts (mm) Ia = initial abstraction (mm)

Initial abstraction is mainly either consists of interception or infiltration during the early parts of the storm, and surface depression storage. Its deduction is not easy because of involvement of various factors like the variability of infiltration during the first part of the storm as it depends on conditions of the watershed or at the beginning of a storm; therefore, it is assumed to be a function of the utmost potential retention. The runoff depth for selected study area was calculated using parameters based upon the OPTRAM model. The resultant map is given below.

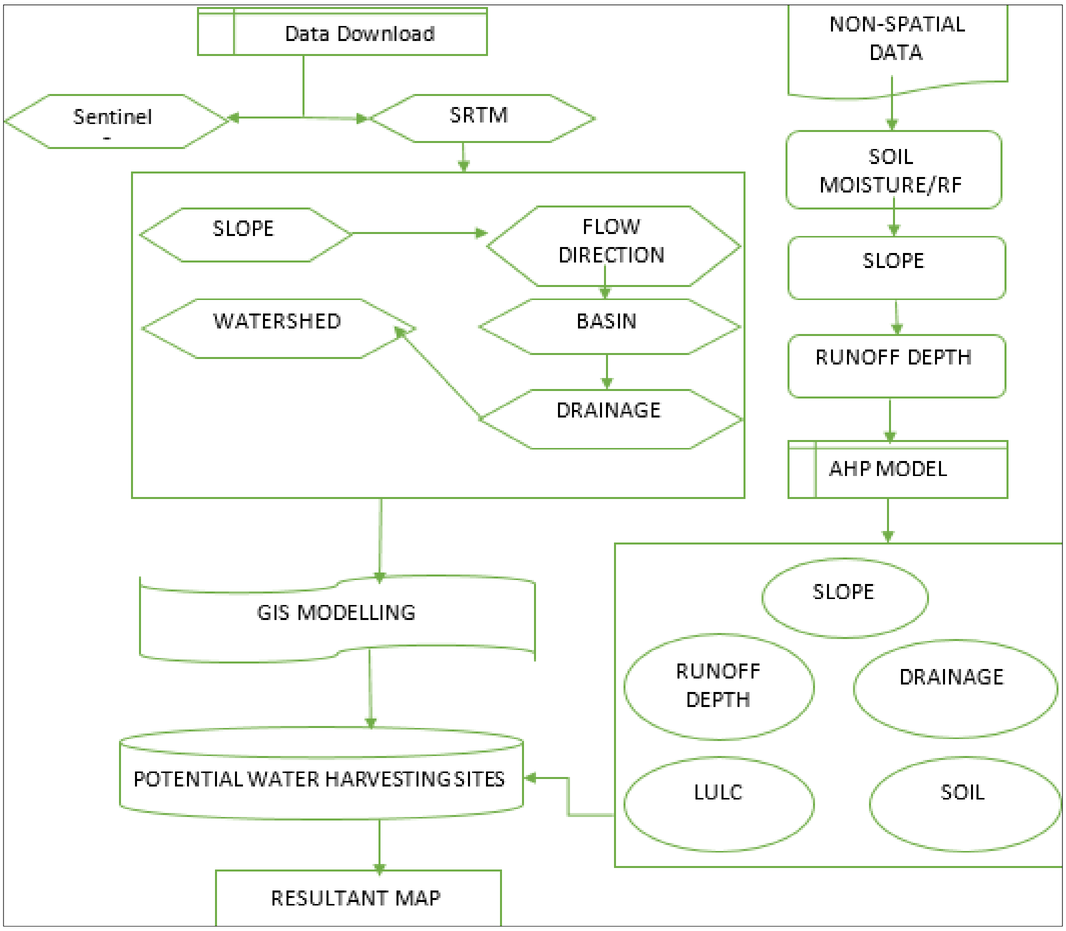

Fig 2: Methodology Flow Chart

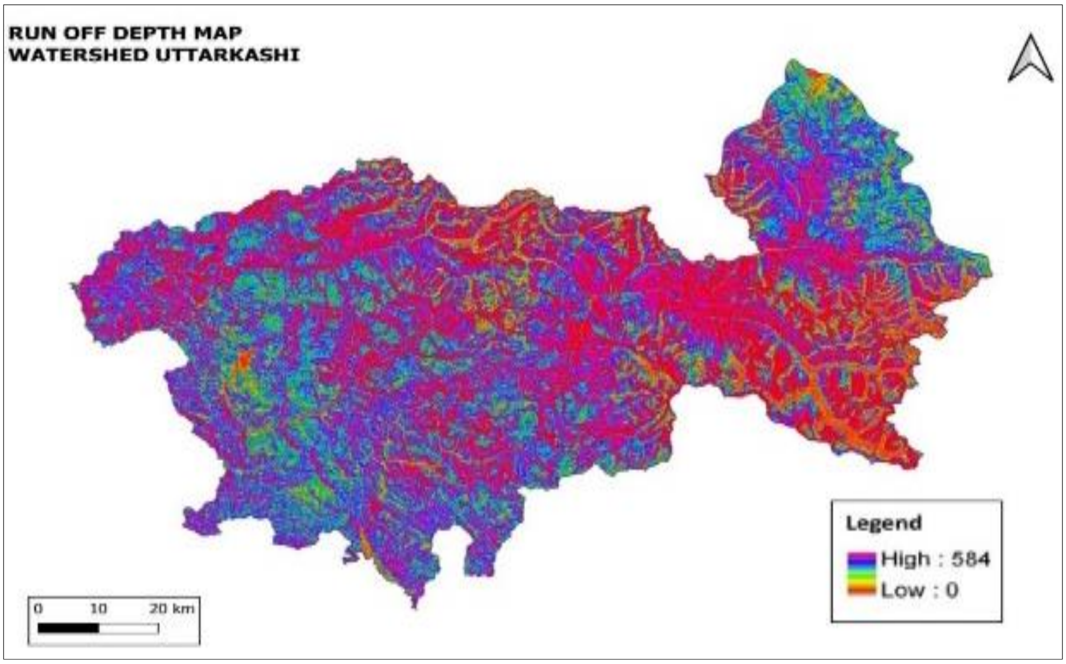

Fig 3: Runoff Depth Map for Uttarkashi

Soil Conserve Service - Curve Number Model

The soil conservation service (SCS) model depends on the runoff Curve Number (CN). Curved Number is estimated via the effect of soil and land cover on the rainfall runoff processes. The range of the Curve Number (CN) is between 1 (100% rainfall infiltration) and 100, lower values of the Curve Number indicate lower runoff, while higher values of Curve Number refer to higher values of runoff.

Evaluating Curve Number

Curve number is used to identify the runoff properties for a certain soil and land cover/ land use. It serves as input parameter for soil conservation service runoff equation.

Curve Number evaluates on pixel basis through the land cover/land use of an area and soil map that are again reclassified according to hydrologic conditions and hydrologic soil group as shown in Table 1.1. Infiltration depends on the soil property which impacts the relation between rainfall and runoff. The hydrologic Soil groups divides into four by the soil conservation service model according to the United States geology survey (USGS) land use and land cover classification system (A, B, C and D). As per results, A, B and D were found in the study area.

Table 1: Soil group and corresponding soil texture

Soil Group	Runoff Description	Soil Texture
A	Low runoff potential because of high infiltration rates	Sand, loamy sand and sandy loam
B	Moderately infiltration rates leading to moderately runoff potential	Silty loam and loam
C	High/moderate runoff potential because of slow infiltration rates	Sandy clay loam
D	High runoff potential with very low infiltration rates	Clay loam, silty clay loam, sandy clay, silty clay and clay

The high runoff potential has been identified in the western part of the study area and this area mostly belong to wasteland and open land. The soil texture varies from clay stone or silt clay to clay. A moderate runoff potential found in the south-eastern part of the study area and the landform in this region is undulating and plain terrain whereas the runoff seems high near the settlement.

The land cover classes present in the table 1.2 along with a map of the hydrologic soil group can be analysed in the ERDAS model maker to match the hydrologic soil group with the land cover.

Table 2: Runoff curve number for combinations of different land cover and hydrological soil groups

Hydrologic Soil Group				
Land cover/Land use	**A**	**B**	**C**	**D**
Built up	74	85	90	92
Cropland	72	81	88	91
Fallow land	77	86	91	94
Forest	43	65	76	82
Wasteland	77	86	91	94
Water body	98	98	98	98

Table 1.2 indicates curve number generated using the USGS land cover and Hydrologic soil group classification system (Maidment 1993) [61]. A high value of the curve number like 94 refers to an area that has a high runoff potential and low infiltration whereas low curve number of 43 indicates an area that has a low runoff potential and high infiltration.

Reclassification of land cover and soil map considering hydrologic conditions

Land cover or land use represents the surface conditions in a watershed and plays a key role in determination of the amount of initial abstraction. The land cover & land use map reclassified into different hydrologic conditions as per the USGS land use / land cover classification system and then runoff curve number further has been utilized to assign codes to the various land use/ land cover classes.

Reclassification of Soil map to Soil group

Application of the curve number method requires that the soils for the study area reclassified to fit in one of four categories (A, B, C and D). The condition to fit the soils classes to certain categories is subjective but depends highly on the infiltration rates and the textural soil composition.

The soil map of the region is given below

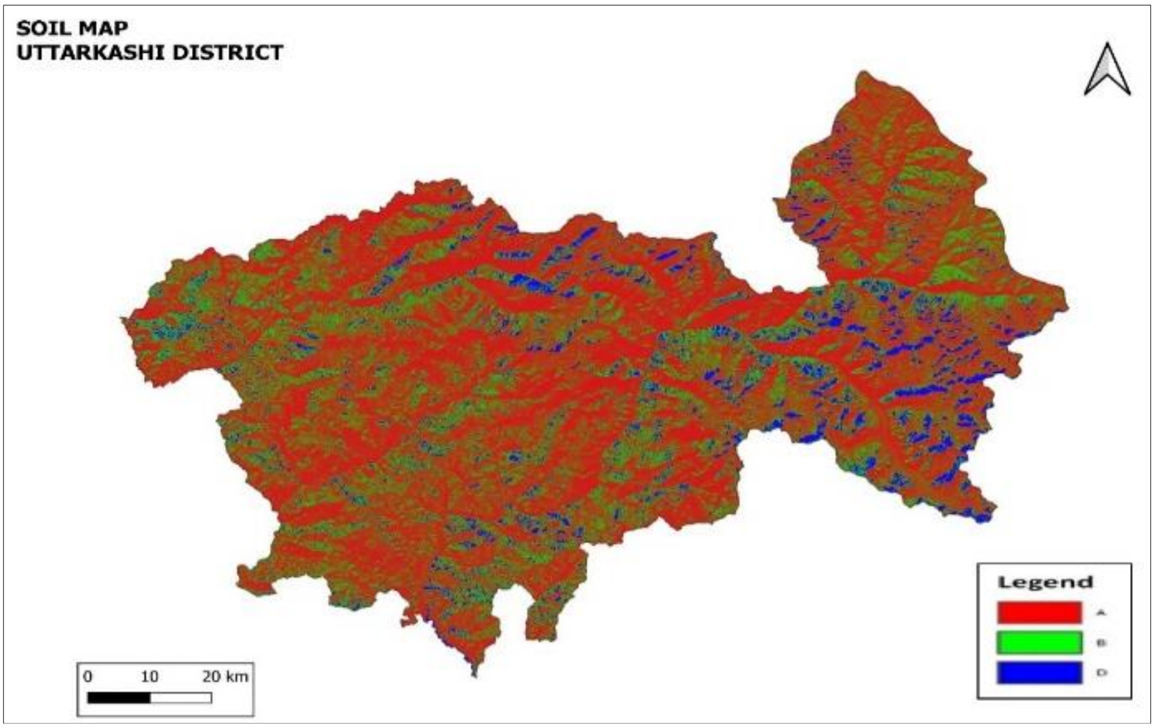

Fig 4: Soil Map

Generating Curve Number Map

The reclassified land cover as per hydrologic conditions and soil groups of the area considered to generate curve number map where high CN values indicate areas that have lowest infiltration, and more runoff is expected from these areas since the initial abstraction and storage area are minimal.

Determination of Runoff using Curve Numbers (CN)

The next step after generating the curve number map was to compute the values of maximum potential retention (S) that indicate the initial abstraction of rainfall from vegetation and soil. By using an SCS equation derivations, the value of S for each pixel was calculated.

Soil Texture

The soil presents the topmost layer of earth, and it is of tremendous importance to all life forms because it is the foundation upon which our whole ecosystem system depends for its sustainable sustenance. The soil consists of the weathered remains of rocks with variable amounts of organic material. The weathered material is produced by chemical and physical weathering processes, and it is modified by the activities of plants and animals and micro-organisms. Soil horizons develop within some parent material and slowly work their way down from the surface.

Texture indicates the relative content of particles of various sizes, such as sand, silt, and clay in the soil. Soil texture is an important parameter that will be taken into consideration of suggesting water harvesting structures.

Lineament in this study is defined as a map-able, the linear feature of a surface, whose parts are aligned in a rectilinear or slightly curvilinear relationship, and which differ from the pattern of adjacent features and presumably reflect some subsurface phenomenon. Lineament mapping is normally undertaken based on geomorphological features such as aligned ridges and valleys, displacement of ridge lines, scarp faces and river passages, straight drainage channel segments, pronounced breaks in crystalline rock masses, and aligned surface depression. (Koch and Mather, 1997; Hung *et al.*, 2016) [62, 63].

Structural trends such as discontinuity can be detected in many forms, such as faults, joints, bedding planes, or foliation, and may be useful in several environmental applications including landslide studies, hydrogeology, and mineral exploration. This discontinuity can be detected in the form of a lineament not only by ground mapping but also by using remotely sensed data.

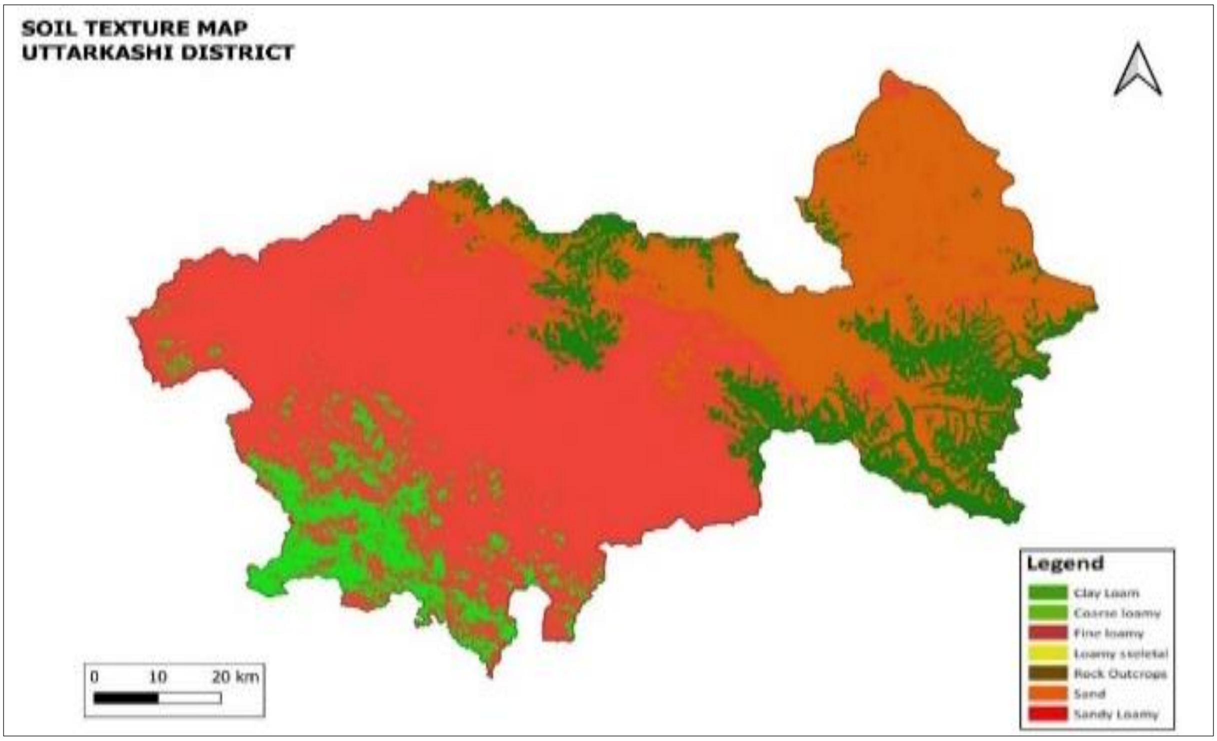

Fig 5: Soil Texture Map

Land Use/ Land Cover

The land is the most important natural resource, which embodies soil, water, and associated flora and fauna involving the total ecosystem (Rao *et al.*, 1996) [64].

Land use and Land cover refers to the features of land surface which may be natural, semi-natural, or manmade. Land Use & Land cover defines the usage of the land for example, industrial zone, residential zones, agricultural fields, etc. For the present study a land use/ land cover map was prepared with Remote Sensing data i.e., Sentinel 2. Figure 1.5 shows comprehensive information on the spatial distribution of land use/land cover categories and this also indicates towards pattern of their change that is a prerequisite for management and utilization of the land resources in the study area.

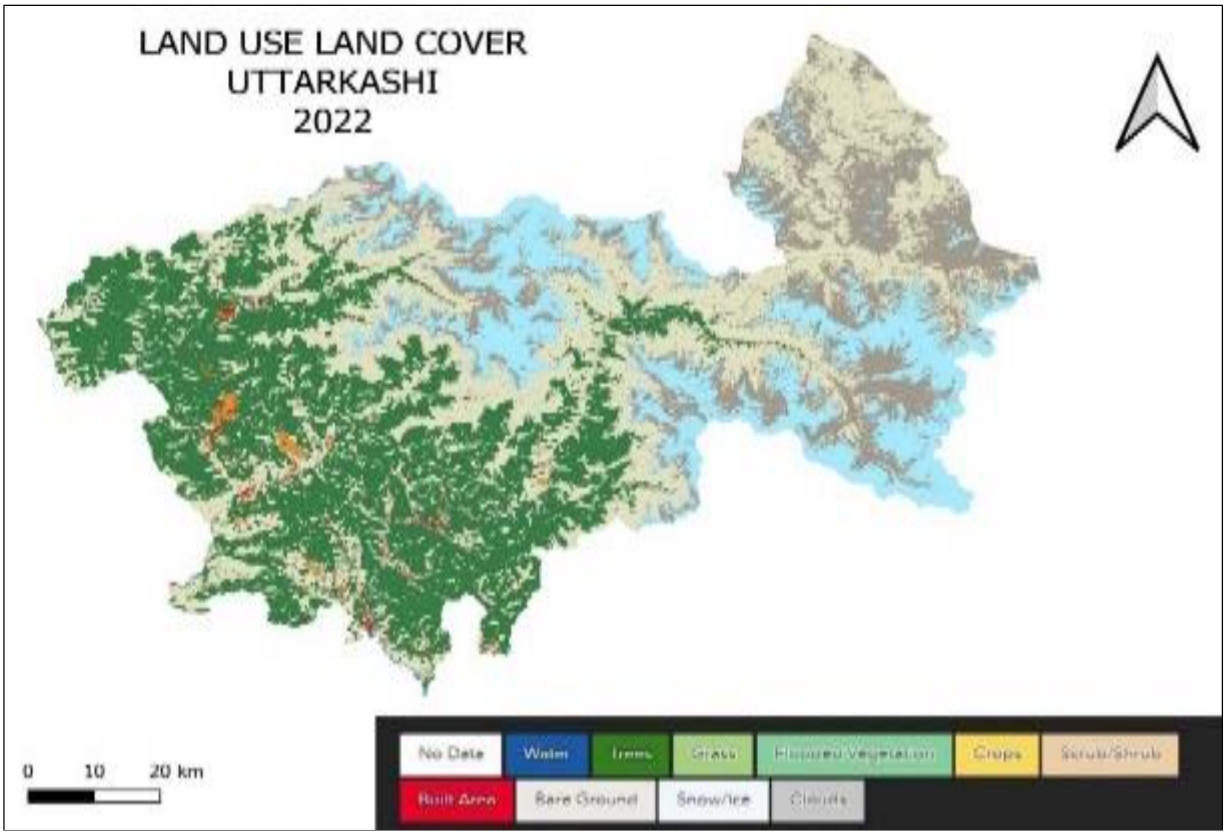

Fig 6: Land Use Land Cover Map

Result & Discussion

The stud results indicate very good use of optram-based soil moisture calculation that is estimated using LST and NDVI. LST data derived from Landsat 8 and NDVI from Sentinel2. After soil moisture estimation, next major step in watershed delineation is the identification of the potential sites for a watershed using parameters such as land use and land cover, Soil Texture, Soil Map, Drainage, and soil Moisture. A pairwise comparison known as Analytical Hierarchical Procedure (AHP) developed by Saaty (1977) [65] was used for pairwise comparison method which involves comparing each factor with all the other factors in pairs (Ronad 2017) [66]. Then, criterion weights mentioned in Saaty's technique were calculated by applying the principal difference of the squared reciprocal matrix of the pairwise comparisons between the two factors (Drobne *et al.* 2020) [67]. Pairwise comparisons compare two criteria to determine which is more important than the other for a desired objective. Table 1.3 presents the rating between the two criteria on a continuous 9-point scale.

Table 3: The scale of Pairwise comparison

Intensity of Importance	Definition
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to extremely strong importance
9	Extreme importance

Table 4: Different weight assign to Layers through AHP

	Runoff Depth	Slope	Soil texture	Drainage	Land use
Rainfall	1	2	3	4	5
Slope	1/2	1	2	3	4
Soil texture	1/3	1/2	1	2	3
Drainage	1/5	1/4	1/3	1	2
Land use	1/6	1/5	1/4	1/2	1

Table 5: Random index for different number of criteria

Number of Criteria	2	3	4	5	6	7	8
Random Index	0.00	0.58	0.98	1.12	1.24	1.32	1.41

The Random Index (RI) can be found from the specific table prepared by Saaty (1977) [65], depending on the order of the matrix. Five criteria were used in this study and therefore the value of random index is 1.12. Fig 1.6 shows the values of the Random index according to the number of criteria.

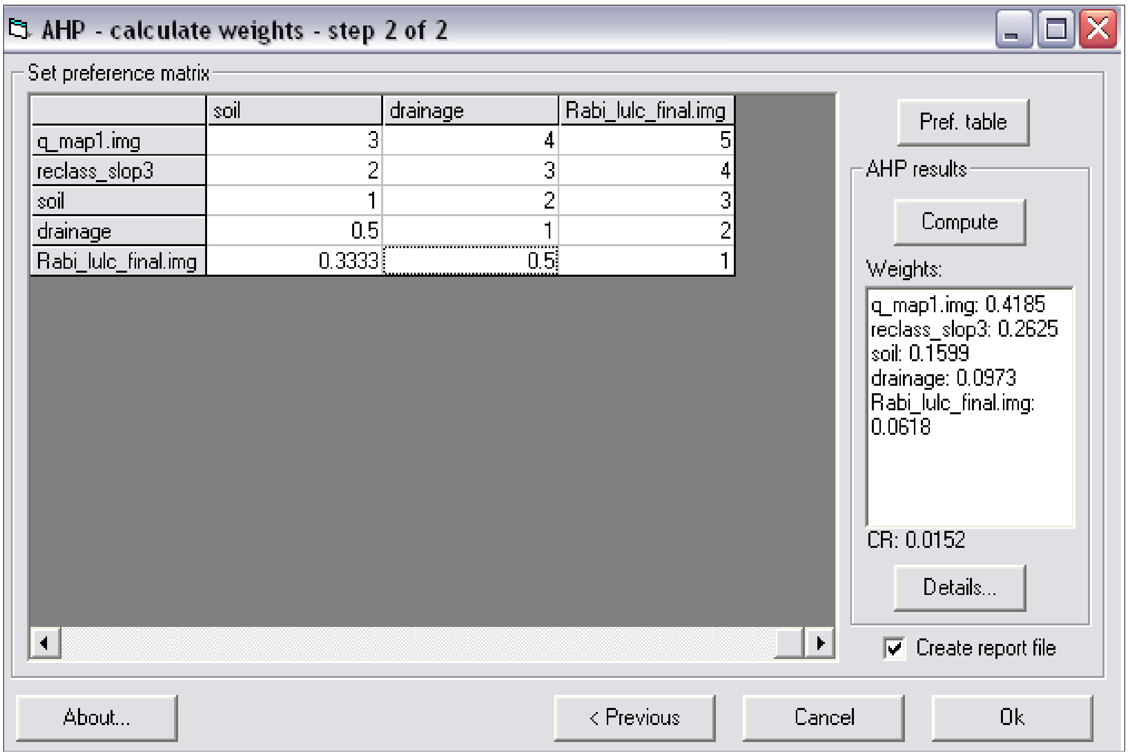

Fig 7: Showing Process of AHP in ArcGIS

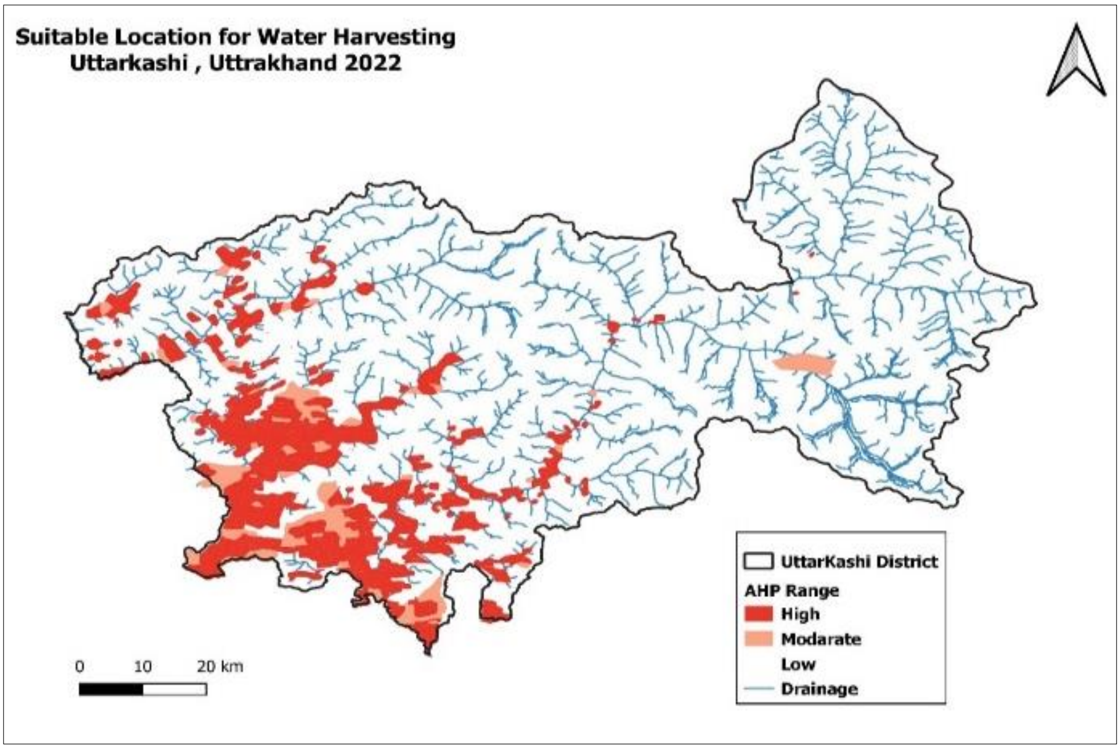

Fig 8: AHP Pairwise Resultant Map

Conclusion

The study findings indicate the usability of Spatial and Non-Spatial data with AHP process in delineating potential sites for watersheds in Uttarkashi region. The analysis of result shows in case if we do not have rainfall data to calculate runoff then in such scenarios Soil Moisture data at a higher level can be utilized for generating runoff depth map. To conclude, integration of remote sensing and decision-making models yields better results for watershed development.

References

1. Rao K, Singh KD. Sustainable development of land and water resources using Remote Sensing and GIS. J Indian Soc Remote Sens. 2006;34:223-229.
2. Singh PJ, Singh Darshdeep. Selection of suitable sites for water harvesting structures in Soankhand watershed, Punjab using Remote Sensing & GIS approach: A Case Study. J Indian Soc Remote Sens. 2009;37.
3. Sharma KV, Patil SG. Application of RS Technology for Impact Assessment of watershed development programme. J Indian Soc Remote Sens, 2008, 36.

4. Vijith H, John T. Identification of groundwater potential zones of a tropical river basin, Kerala using Remote Sensing and GIS techniques. J Indian Soc Remote Sens. 2011;39.
5. Joshi KA, Kundal P. Water resources development action plan for Sati watershed Chandrapur district, Maharashtra using Remote sensing and GIS. J Indian Soc Remote Sens. 2004;32.
6. Raojagdesswara P, Rao Suryaprakasa B. An integrated study on groundwater resources of Peddagedda watershed. J Indian Soc Remote Sens, 2004, 34.
7. Chakaravarty AK. Strategies for watershed management planning using Remote sensing techniques. J Indian Soc Remote Sens. 1993;21:87-98.
8. Trivedi RK, Singh RM. A micro level approach for integrated watershed investigation development planning & artificial recharge site selection for groundwater in Malani river watershed. Gondwana Geol Mag. 2005;20:137-146.
9. Saraf AK, Choudary PR. Integrated Remote Sensing & GIS for ground exploration & identification of artificial recharge sites. Int J Remote Sens; c1998.
10. Durbude DG, Venkatesh B. Site suitability analysis for soil & water conservation structures. J Indian Soc Remote Sens. 2004;32:399-405.
11. Thinh NX, Vogel RT. Application of Analytic Hierarchy Process in the multiple criteria decision analysis of retention areas for flood risk management. Environ Informatics Syst Res. 2007:675-682.
12. Dr. Kuldeeppareta, Pareta U. Hydro Geomorphology Study of Karawan Watershed Using GIS and Remote Sensing Techniques. E-International Scientific Res J. 2011;3(4). ISSN: 2094-1749.
13. Bera K, Bandyopadhyay J. Ground Water Potential Mapping in Dulung Watershed using Remote Sensing & GIS techniques, West Bengal, India. Int J Sci Res Pub. 2012;2(12):2250-3153.
14. Moore ID, *et al.* Digital Terrain Modelling: A Review of Hydrological, Geomorphological and Biological applications. Hydrological Processes. 1991;5(1):3-30.
15. ESRI. Creating model processes. Available from: http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Creating_model_processes
16. ESRI. An overview of Model Builder. Available from: http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=An_overview_of_ModelBuilder
17. Physical Geography. Chapter 10: Applied Geography. Available from: http://www.physicalgeography.net/fundamentals/10ah.html
18. ESRI Knowledge Base. GIS Dictionary - Reclassification. Available from: http://support.esri.com/en/knowledgebase/GISDictionary/term/reclassification
19. Brady NC. The Nature and Properties of Soils. New York: MacMillan, 1974, 639.
20. AHP Tutorial. Multi-criteria Decision Analysis using Analytic Hierarchy Process (AHP). Available from: https://mi.boku.ac.at/ahp/ahptutorial.pdf
21. Martin D, Sha SK. Integrated approach of using remote sensing and GIS to study watershed prioritization and productivity. Indian Institute of Remote Sensing, Dehradun; c2007.
22. Central Ground Water Report. State Government Rajasthan; c2008.
23. Padmavathy AS, Raj KG, Yoearajan N. Check dam site selection using GIS approach. Adv. Space Res. 1993;13(11):123-12.
24. Gupta KK, Sharma JR. Estimation of water harvesting potential for a semi-arid area using GIS and remote sensing. Remote sensing and geographic information systems for design and operation of water resources; c1997.
25. IWMP Report of Ajmer District. Soil and Water Conservation Department; c2009.
26. Agarwal CS. Study of drainage pattern through aerial data in Naugarh area of Varanasi district, U.P. J Indian Soc Remote Sens. 1998;26:169-175.
27. Akram J, Mohd YK, Subah R. Watershed prioritization using morphometric and land use land cover parameters: A remote sensing and GIS-based approach. J Geological Soc India. 2011;78:63-75.
28. Angilliri YE. Morphometric analysis of Colanguil river basin and flash flood hazard, San Juan, Argentina. Environ Geol. 2008;55:107-111.
29. Aparna P, Nigee K, Shimna P, Drissia TK. Quantitative analysis of geomorphology and flow pattern analysis of Muvattupuzha River Basin using Geographic Information System. J Aquatic Procedia. 2015;4:609-616.
30. Arulbalaji P, Padmalal D. Sub-watershed prioritization based on drainage morphometric analysis: A case study of Cauvery River Basin in South India. J Geological Soc India. 2020;95:25-35.
31. Asfaw D, Workineh G. Quantitative analysis of morphometry on Ribb and Gumara watersheds: Implications for soil and water conservation. Int Soil Water Conserv Res. 2019;7:150-157.
32. Ayele A, Yasuda H, Shimizu K, Nigussie H, Kifle W. Quantitative analysis and implications of drainage morphometry of the Agula watershed in the semiarid northern Ethiopia. Appl Water Sci. 2017;7:3825-3840.
33. Babar Md. A textbook of hydrogeomorphology: Fundamentals, application, and techniques. New India Publishing Agency, Pitam Pura, New Delhi; 2005:137.
34. Biswajit M. Analysis of hydrological inferences through morphometric analysis: A remote sensing-GIS based study of Gandheswari River Basin in Bankura District, West Bengal. Int J Hum Soc Sci Stud. 2016;2(4):68-80.
35. Brocklehurst S, Whipple KX. Hypsometry of glaciated landscapes. Earth Surf Processes Landforms. 2004;29(7):907-926.
36. Central Ground Water Board Report of Buldhana District, Central Region Nagpur; c2013.
37. Central Ground Water Board Report of Buldhana District, Central Region Nagpur; c2019.
38. Clarke JI. Morphometry from maps. In: Essays in geomorphology. Elsevier publication, Co., New York, 1996, 235-274.
39. Deshpande GG. Geology of Maharashtra. Geological Society of India, Bangalore; 2012:156-157.
40. Dubey SK, Sharma D, Mundetia N. Morphometric analysis of the Banas river basin using the geographical information system, Rajasthan, India. J Hydrology. 2015;3(5):47-54.

41. Tahan EI, Elhanafy AHMH, Elhanafy HEM. Statistical analysis of morphometric and hydrologic parameters in arid regions, a case study of Wadi Hadramaut. Arabian J Geosci. 2016;9(2):1-10.
42. Farhan Y, Anbar A, Al-Shaikh NR. Prioritization of semi-arid agricultural watershed using morphometric and principal component analysis, remote sensing, and GIS techniques, the Zerqa River Watershed, Northern Jordan. Agric Sci. 2017;8:113-148.
43. Fryirs KA, Brierley GJ. Geomorphic analysis of river systems: An approach to reading the landscape. West Sussex: Wiley Blackwell Publication; 2013:29-62.
44. Gangalakunta P, Reddy O, Maji AK, Gajbhiye KS. Drainage morphometry and its influence on landform characteristics in a basaltic terrain, Central India: A remote sensing and GIS approach. Int J Appl Earth Geoinformation. 2004;6:1-16.
45. Gebre T, Kibru T, Tesfaye S, Taye G. Analysis of watershed attributes for water resources management using GIS: The case of Chelekot Micro Watershed, Tigray, Ethiopia. J Geographic Info System. 2015;7:177-190
46. Gizachew K, Berhan G. Hydro geomorphological characterization of Dhidhessa River Basin, Ethiopia. Int Soil Water Conserv Res. 2018;6:175-183.
47. Golekar RB, Baride MV, Patil SN, Adil SH. Altimetric and hypsometric analysis for soil and water conservation: A case study of Anjani and Jhiri river basin, Northern Maharashtra, India. Earth Sci Res J. 2015;19(1):51-58.
48. Gutema D, Kassa T, Sifan AK. Morphometric analysis to identify erosion-prone areas on the upper Blue Nile using GIS: Case study of Didessa and Jema sub-basin, Ethiopia. Int Soil Water Conserv Res. 2017.
49. Sarkar D, Gangopadhyay SK, Sahoo AK. Soil resource appraisal towards land use planning using satellite remote sensing and GIS: A case study in patloinala micro-watershed, district puruliya, West Bengal. J Indian Soc Remote Sens. 2006;34(3):245.
50. Sweitzer J, Langaas S, Folke C. Land use and population density in the Baltic Sea drainage basin: A GIS database. Ambio. 1996;25:191-198.
51. Mahamid I, Thawaba S. Multi-criteria and landfill site selection using GIS: A case study from Palestine.
52. Islam MM, Kumamoto T, Nishigaki M. Evaluating flood hazard for land-use planning in Greater Dhaka of Bangladesh using remote sensing and GIS techniques. Water Resour Manage. 2007;21(9):1601-1612.
53. Sumathi VR, Natesan U, Sarkar C. GIS-based approach for optimized siting of municipal solid waste landfill. Waste Manage. 2008;28(11):2146-2160.
54. Muralikrishna K, Mishra PK, Chalam RVRK. Deciding alternative land use options in a watershed using GIS. J Irrig Drain Eng. 2007;133(2):162-174.
55. Nagne AD, Dhumal RK, Vibhute AD, Rajendra YD, Kale KV, Mehrotra SC. Suitable sites identification for solid waste dumping using RS and GIS approach: A case study of Aurangabad, (MS) India. In: 2014 Annual IEEE India Conference (INDICON). IEEE; 2014. p. 1-6.
56. Kundal M, Joshi AK. Water resources development action plan for Sasti watershed, Chandrapur District, Maharashtra using remote sensing and geographic information system. J Indian Soc Remote Sens. 2004;32(4):363-372.
57. Mahato R, Bushi D, Nimasow G, *et al.* AHP and GIS-based delineation of groundwater potential of Papum Pare District of Arunachal Pradesh, India. J Geol Soc India. 2022;98:102-112. https://doi.org/10.1007/s12594-022-1936-y
58. Ambrosone M, Matese A, Di Gennaro SF, *et al.* Retrieving soil moisture in rainfed and irrigated fields using Sentinel-2 observations and a modified OPTRAM approach. Int J Appl Earth Obs Geoinformation. 2020;89:102113. https://doi.org/10.1016/j.jag.2020.102113.
59. Sadeghi M, Babaeian E, Tuller M, Jones SB. The optical trapezoid model: A novel approach to remote sensing of soil moisture applied to Sentinel-2 and Landsat-8 observations. Remote Sens Environ. 2017;198:52-68. https://doi.org/10.1016/j.rse.2017.05.041.
60. Kumar Girish M, Aggrawal KA. Delineation of potential sites for water harvesting structures using Remote Sensing and GIS. J Indian Soc Remote Sens. 2008;36:323-334.
61. Sulzer D, Maidment NT, Rayport S. Amphetamine and other weak bases act to promote reverse transport of dopamine in ventral midbrain neurons. Journal of neurochemistry. 1993 Feb;60(2):527-35.
62. Koch M, Mather PM. Lineament mapping for groundwater resource assessment: a comparison of digital Synthetic Aperture Radar (SAR) imagery and stereoscopic Large Format Camera (LFC) photographs in the Red Sea Hills, Sudan. International Journal of Remote Sensing. 1997 May 1;18(7):1465-82.
63. Hung Y, De Kok TM, Verbeke W. Consumer attitude and purchase intention towards processed meat products with natural compounds and a reduced level of nitrite. Meat science. 2016 Nov 1;121:119-26.
64. Rao MV, Paliyath G, Ormrod DP. Ultraviolet-B-and ozone-induced biochemical changes in antioxidant enzymes of Arabidopsis thaliana. Plant physiology. 1996 Jan 1;110(1):125-36.
65. Saaty TL. A scaling method for priorities in hierarchical structures. Journal of mathematical psychology. 1977 Jun 1;15(3):234-81.
66. Charis EK, Ronald W. New directions in social disorganization theory. In Recent developments in criminological theory; c2017 Jul 5. p. 265-294. Routledge.
67. Kopylov U, Hanzel J, Liefferinckx DC, Marco DD, Imperators N, Plevris ND. Effectiveness of ustekinumab dose escalation in Crohn’s disease patients with insufficient response to standard-dose subcutaneous maintenance therapy. Alimentary Pharmacology & Therapeutics. 2020;52(1):135-142.