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Surface analysis of telbal micro-watershed of south western himalayan region using RS and GIS techniques

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Abstract
Surface analysis was carried out in a micro-watershed of Telbal district Srinagar (J&K) using Digital Elevation Models. The study area is located between longitudes 74°50'36"E to 74°54'30"E and latitudes 34°8'7 "N to 34°9'58"N covering an area of 1090.75 hectares. Boundary of the study area was first delineated and geo-referenced in GIS environment. After geo-referencing, rectification was done with Linear Imaging Self Scanning Sensors image (LISS-IV data). Surface analysis in the form of the contour, slope, aspect and hill shade maps were generated in Arc map 10.2. Most of the study area lies in the slope range of 0-5% comprising 47.50% of the total area, 30.92% was observed to be nearly gentle slopping and 19.52% under very gentle to strong slopping. The 20 meter contour lines showed that the lowest elevation was 1580m above mean sea level and highest elevation was 2560m amsl. The maximum area faces towards northwest aspect which is about 23.43% of the total area and are steeper as compared to other areas and about 17.96% of the total area is facing towards north direction. Study area followed dendritic drainage pattern and 13 land uses were classified. The parameters generated can be considered as an important inputs for GIS-based decision support system for scientific land use planning of the watershed and can generate various outputs like land capability classification, soil suitability classification and other conservation plans for the area.

Keywords: surface analysis, watershed, GIS

1. Introduction
Watersheds are coupled human-natural systems resulting from interactions between anthropogenic activities and natural processes crossing over a broad range of spectral and temporal scales (Ximing *et al.*, 2013) [21]. The footprints of human activities continue to expand to critical point where it exerts a major effect on nearly all of the Earth's geophysical systems (Tim *et al*., 2003) [19]. Watershed development is one among the basic and important components of rural upliftment and natural resource management strategies in most of the countries across globe (Dwivedi, 2016) [5] and has emerged as a sustainable strategy to conserve the natural resources in terms of water, forest and soil in an integrated manner (Roy, 2005) [11]. For conservation of these precious resources, watersheds have been known as planning units to develop a judicious approach for optimum utilization of all natural resources which aim at optimizing productivity per unit area, per unit time and per unit of water (Das, 2012) [4].

A large number of tools and models have been used by different workers to study the watershed and use the data for planning/ development of the concerned watershed (Fadil *et al*, 2011; Tombus *et al.*, 2012) [6, 20]. Digital elevation models (DEMs), such as ASTER and other types of models have been used to extract diverse geo-morphological parameters with respect to drainage basins and other related parameters such as drainage networks, catchment divides, slope gradient and aspect, and upstream flow contributing areas (Shalu, 2013) [15].

Surface analysis involves various kinds of processing, including extracting new surfaces from existing surfaces, reclassifying surfaces, and combining surfaces (Mushtaq and Farjana, 2015) Arc GIS is typically used to represent maps as data layers that can be studied and used to perform analysis. Surface analysis will depict surface conditions plotted from reported data or generated by computer models. Surface analyst in GIS generated the contour, slope, aspect, and hill shade maps.

Among current strategies for managing natural resources and monitoring environmental changes, land use land cover has become a central component to enhance productivity (Solanke *et al.*, 2007). GIS and remote sensing techniques have efficiently been used for generation of information on land use land cover with the availability of high resolution LISS IV data. Sekhar and Rao (2002) has used land use land cover changes obtained from remote sensing images in a variety of hydrological modeling studies, most especially in surface runoff predictions and sediment yield estimation.

Methodology

The region is temperate wet with mild summer and severe winter with mean annual temperature of 13.5^{0}C. The soils of watershed are characteristically entisols with sandy loam to silty clay loam texture. Surface analysis was performed using ASTER DEM (30 meter spatial resolution) of the study area using spatial analyst tool to derive useful geospatial information from the study area. Using DEM as input in fill of hydrology tool of spatial analyst toolbox of Arcmap 10.2, fill DEM was created. This fill DEM was used as input in surface tool of spatial analyst tool for generation of slope, contour, hill shade, aspect and drainage map. Hydrology tool was used to derive several data sets that collectively describe the drainage pattern of the catchment. Raster analysis was performed to generate data on flow accumulation and flow direction then stream ordering was done by using Strahler stream order tool and finally drainage map of the study area was prepared.

The land cover map of the study area was prepared from Linear Imaging Self Scanning-IV (satellite imagery) using visual interpretation technique in ArcMap 10.2 software. This technique consists of a set of image elements, which help in the recognition or interpretation of various land use/land cover features systematically on the enhanced satellite imagery during the classification of features using visual interpretation which include tone (colour), texture, pattern, size, shadow etc. Different land uses were classified on the basis of these elements of classification and land use/land cover map was prepared. This map was then validated in the field to determine its accuracy. After ground truthing final land use and land cover map of the study area was generated.

Results and Discussion

Aspect

Surface analysis of the micro-watershed revealed large amount of variability in different aspect of the watershed. About 23.43 per cent of the total area falls under northwest category followed by 17.96 per cent which falls under north category (Fig.1, 1a) indicating that the area are protected from winds and receives more snow as it is shaded from direct sunlight during the winter. The lowest area of 7.21, 5.58 per cent falls under northeast and eastern aspecthave relatively higher soil moisture content (Gebre *et al.*, 2015) [7] while as only 0.18 per cent of area falls in the flat aspect.

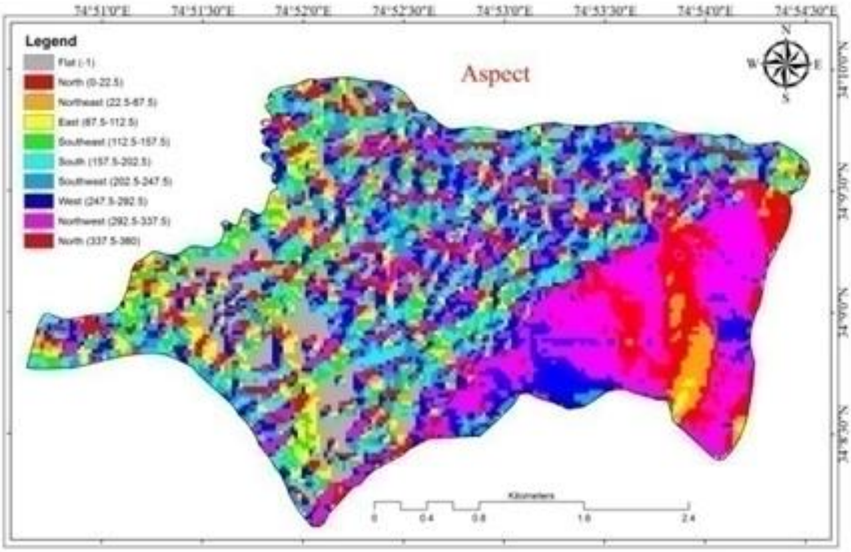

Fig 1: Aspect map of the study area

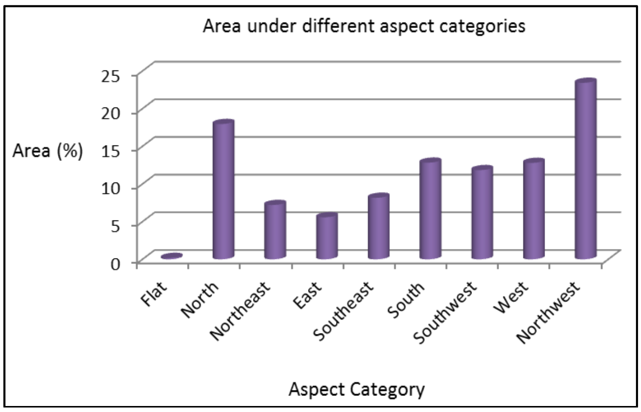

Fig 1a: Area under different aspect categories in the study area

Slope
It is a crucial parameter which controls the balance between runoff response and soil infiltration rates of a terrain. The slope was classified into eight slope classes and about 84.43 per cent of the study area lies in the slope range of 0-5 per cent (Table no. 1). The larger area being in the category of level to very gentle slope will have influence on soil erosion and therefore will face or encounter slight erosion. Gentle slopes are considered as tremendous for groundwater management as the nearly flat terrain is good for more infiltration (Gebre *et al.,* 2015) [7]. The spatial variability showed large variation in slope from north to south east (Fig. 2) which indicated more chances of runoff and erosion in these areas (Barungi *et al*., 2013; Shakeel and Kanth, 2009) [3, 14].

Table 1: Area under different slope categories

S. No.	Slope category	Slope (%)	Area (ha)	Area (%)
1	Level	0.0-0.05	518.11	47.50
2	Nearly gentle	0.5-2.0	337.27	30.92
3	Very gentle	2.0-5.0	65.56	6.01
4	Gentle	5.0-9.0	56.01	5.13
5	Moderate	9.0-15	50.95	4.67
6	Strong	15-50	40.27	3.71
7	Steep	50-100	19.71	1.80
8	Very steep	>100	2.87	0.26
Total			1090.75	100.00

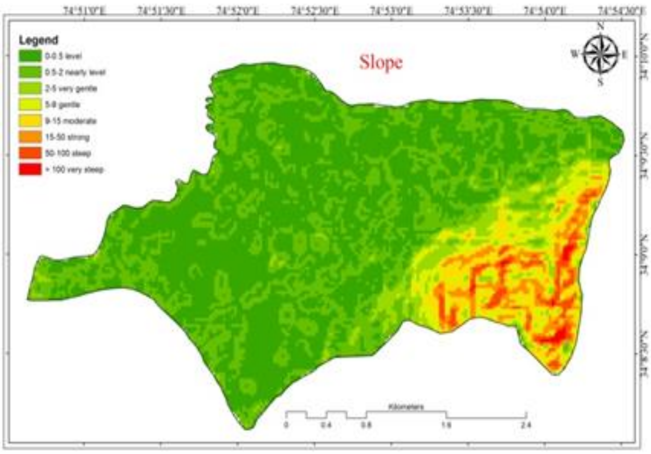

Fig 2: Slope map of the study area

Contour
The 20 m length of contour lines in the south east direction of the study are closer to each other representing steepest slope while in major part of the area contour lines are far from each other representing plain areas (Fig. 3). The lowest elevation was found to be 1580 m amsl and highest elevation was observed as 2560 m. Most of the area is being covered between 1600 m to1660 m amsl elevation in the central and western areas of the watershed. As we move towards northern part of the study area there is increase in the elevation from 1620 m to 1720 m amsl. Mountain steepness in the south eastern part can be easily visualized by closeness in the contour lines where variation in the elevation was from 1700 m to 2520 m amsl. The large differences in the contour lines indicated that the area are less steep and has lesser chances of surface runoff (Schorghofer and Rothman, 2002; Avanzi *et al.,* 2013) [12, 2].

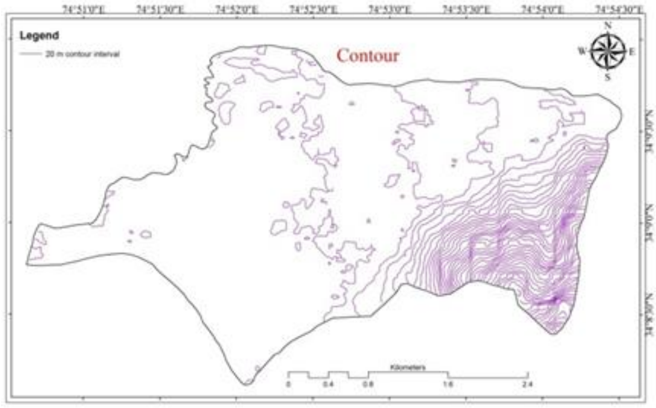

Fig 3: Contour map o the study area

Hill-shade
The southwestern areas are with high values indicated light shaded area which means that these areas receive less energy and radiation from the sun (Fig.4). It can be observed that even the plain areas having low slope vary in the hill shadewhich may be due to variation in aspect and slope which is different for different locations (Abdel-wahab and Al-Harthy, 2012) [1].

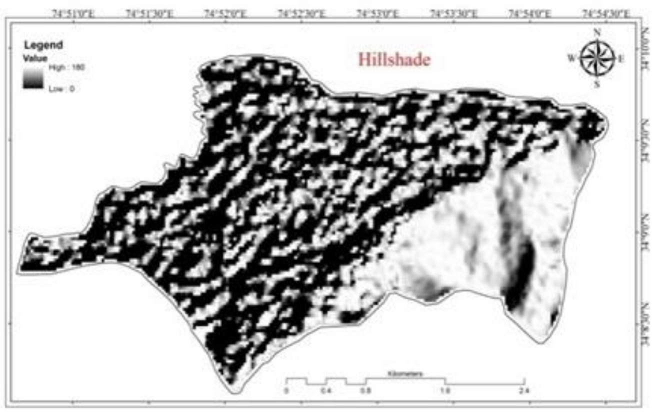

Fig 4: Hillshade map of the study area

Drainage
It revealed that study area followed dendritic drainage pattern and maximum area was perfectly well drained composed of homogenous rock without control by the underlying geologic structure (Pareta and Pareta, 2011) [9]. Most of the area of the watershed is plain with gentle slopes less than 3^0 are at lower risk to rapid runoff and erosion (Avanzi *et al.*, 2013) [2]. The areas of the watershed with both steep slopes and high sand content had a high risk of erosion. The network of 1st, 2nd and 3rd order stream can be visualized (Fig. 5).

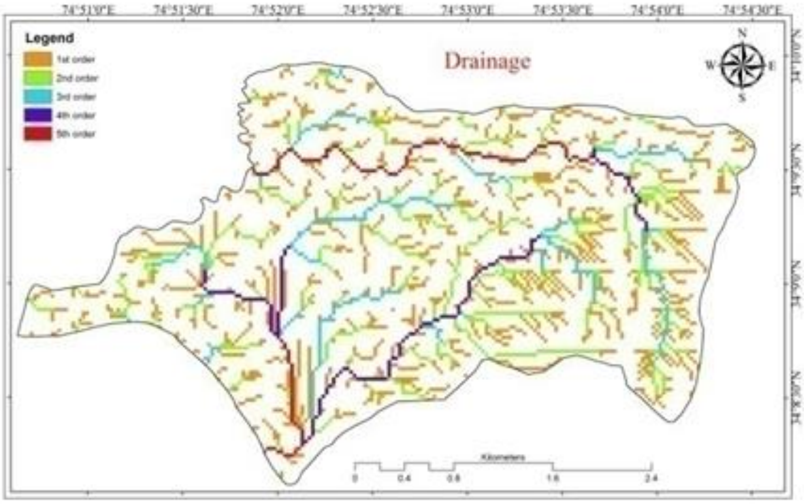

Fig 5: Drainage map of the study area

Land use land cover

Out of total area of 1090.75 ha about 22.79 per cent was found to be under built up, followed by 17.81 per cent under agricultural use with paddy as main crop (Table no. 2). However, 17.77 per cent (193.80 ha) of the total land was observed to be under mixed plantation consisting mainly of populus trees. The data also revealed that 14.63 per cent of the area was under evergreen forests, 8.97 per cent under orchards and 4.03 per cent under open forests while as 3.35 per cent of the land consisted of scrubs. The study also revealed that 2.18 per cent land was under recreational parks and grass lands consisted of 1.59 per cent of the total land. The land use also revealed that 1.28 per cent land was under vegetable cultivation followed by 0.46 per cent which was barren, 0.36 per cent was under wet land and 4.78 percent of the total area was under water bodies (Fig.6). Land use land cover pattern changes are important factors for assessing water resource conditions (Sheikh *et al*., 2011, Sudhishri *et al*., 2014). Land use / land cover helps in the generation of map output which can be directly used for agro action plan for the sustainable enhancement of the watershed (Ratnam *et al.*, 2013).

Table 2: Distribution of Land use/land cover classes of micro-watershed

LULC	Area	
	Hectare	**Per cent**
Agricultural field	194.348	17.81
Horticultural land	97.905	8.97
Mixed plantation	193.805	17.77
Vegetable field	14.061	1.28
Open forest	44.037	4.03
Evergreen forest	159.648	14.63
Grassland	17.394	1.59
Built up	248.563	22.79
Recreational park	23.823	2.18
Barren land	5.125	0.46
Scrub land	36.056	3.35
wet land	3.789	0.36
Water body	52.195	4.78
Total	1090.75	100.00

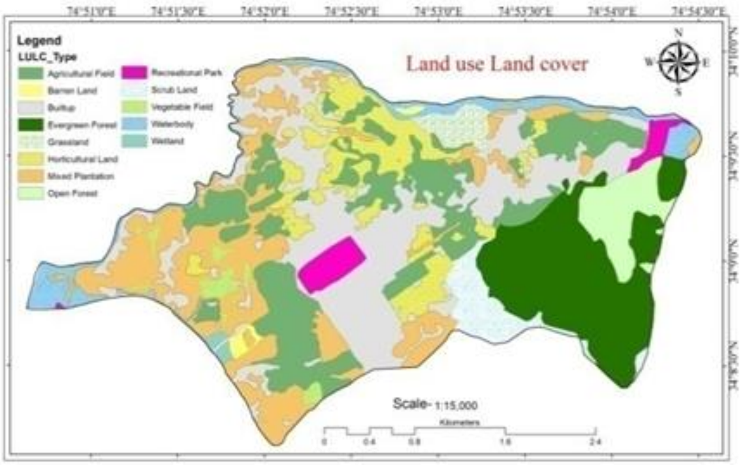

Fig 6: Land use land cover map

Conclusion

The surface analysis is useful for planning rainwater harvesting, watershed management and for various applications of watershed hydrology. A GIS based decision support system can be used for scientific land use planning of the area for improving both the crop production and productivity. The surface property maps along with land use land cover maps created by applying GIS analysis can be used as a guide for topographic structures of study area, without using GIS which under normal circumstance would require lot of time and labour. From the present study, it could be concluded that using GIS and ASTER DEM data is relatively simple to apply on large scale areas to gather all data and information for surface analysis and watershed characterization.

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