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Identification and Mapping of Soil, Water and Vegetation of Hattikuni Watershed

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Authors' contributions

This work was carried out in collaboration between all authors. Both authors read and approved the final manuscript.

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ABSTRACT

A study on identification and mapping of soil, water and vegetation of Hattikuni watershed in Yadagiri district was carried out using Google Earth and QGIS open-source software. The study area was located in North-Eastern dry Sone of Karnataka at 16˚ 51' 45" to 16˚ 59' 14" N latitude and 77˚ 9' 3" to 77˚ 20' 14" E longitude and elevation ranges from 436m to 622m above amsl. The study area falls under the Survey of India toposheet of E43X1 and E43X5 with an area of 138sq.km. Various Thematic maps were developed using Google Earth and QGIS such as DEM, slope, drainage, waterbodies, flow direction, aspect, hillshade, contour, vegetation and soil maps. From the study we found that there were in total of eleven waterbodies as per SOI toposheets (1960-61)

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and when compared with Google Earth, only eight waterbodies were found having that too with lesser water spread area as compared with toposheet. The soils in the area were classified into seven classes out of which the fine, mixed and lithic ustropepts occupies the maximum area followed by the rock/scrub land. By mapping of vegetation, we found that the total area coverage was 3456.95 ha which accounts to 24.99% of the total area. This study made a conclusion that Google Earth, QGIS and Toposheet can be used in combination for the mapping, identification and change detection of primary resources.

Keywords: Google earth; QGIS; toposheet; waterbodies; soil classes; vegetation percentage.

1. INTRODUCTION

Life on earth exists because of soil, water and vegetation which are also called as primary natural resources. Natural resources if kept in natural state that will have better quality and if used for human development which has to be, then comes a question of use and abuse of these resources. Human activity in various places for various reasons has overtaken the natural process of regrowth and regeneration. The human being has given prominent role for economic development leaving the all-other issues has less important [1,2,3]. This has led to very little importance was given to these primary natural resources.

Soil, one of the prominent natural resources is neglected in many of the places due to which majority of the soil/land either is eroded away or degraded in its quality. Due to modifications of the topographical features on the land surface, we could see water logging there by degrading the productive potential of the soil. Due to improper water management in canal irrigated area, we could see that salt accumulation has become a biggest problem and majority of cultivable land/soil area was lost has degraded lands. Cultivation of agricultural and allied crops helped human being to grow with dignity, but due to the desire for more, human being intensified cultivation of all types of classes and in today's agriculture class 1 to 8 lands were also cultivated, not given importance to its topographical aspects and other related aspects. Due to unscientific cultivation practices, over cultivation, discharge of industrial waste and municipality waste has poisoned the soil resource.

Water the second most important natural resources seems to be plenty if we take the global scenario and similarly of national scenario. The availability and distribution of this resource is so much skewed that many people on the land surface do not have water for drinking purpose and in some other region people have no value for water. It will be simply wasted as it seems plenty of water. Western Ghats which are having highest rainfall in the Karnataka face lot of drinking water problem in the winter and summer season. This tells us that those people who have plenty of water in rainy season are also not safe in other season in terms of quantity and quality. The non availability of surface water for drinking and agriculture mad people to drill tube Wells these tube Wells are drilled in a competitive 16 atmosphere. If one person drilled 50m deep the other will drill 60m and so on. This led to contamination of ground water with many minerals which are harmful to human being and this water is also not fit for portable purpose.

Vegetation, another most important natural resource is the least bothered one. Urbanization, industrialization and agricultural land expansion has taken a toll on the forest area. As we know that vegetation exists in many ways like trees, grass, shrubs and bushes. These protect the land/soil from the effect of the rain and wind against the erosion and its quality depletion. Reduction in the vegetation cover and type of vegetation has a very important role in safeguarding the other two natural resources soil and water.

The attempt was made to focus a role of Google Earth and GIS technologies in conservation of soil, water and vegetation [4,5,6]. Keeping above problems related to natural resources and freely available data and source of information along with Geospatial technology, this study was formulated with specific objectives as below.

1. To delineate and characterize selected watershed using Google Earth
2. To create digital elevation model on the selected watershed using Google Eart
3. To delineate, characterize and change detection of water bodies using Google Earth in selected watershed
4. To classify different soils on the basis of colour in the selected watershed using Google Earth

5. To estimate Vegetation percentage under selected watershed using Google Earth

2. MATERIALS AND METHODS

The study area was located at a distance of 15 kms from the district headquarters, Yadagiri district, Karnataka. The study area is situated in North-Eastern dry zone of Karnataka at 16˚ 51' 45" to 16˚ 59' 14" N latitude and 77˚ 9' 3" to 77˚ 20' 14" E longitude and elevation ranges from 436 m to 622 m. The study area falls under the Survey of India toposheet of E43X1 and E43X1 modified (1:50,000). The area is part of a Yadagiri reserved forest. We delineated the watershed boundary by geo-referenced E43X1 and E43X5 toposheets of 1:50000 scale and datum-WGS 84 [7].

The southern part of the district comprises the Peninsular Gneiss and granites. Central, northeastern and southwestern part comprises of sedimentary formations viz. sandstone, quartzite, shale, slate, limestone and dolomite. Deccan Trap basalts cover eastern parts. The depth of water level in the study area ranges from 1.15 to 8.75 mbgl. The water level data depicts that a major part of the district has moderate to moderately deep-water levels.

Quantum GIS and Google Earth softwares were used to identify the natural resources [8,9]. The delineation of watershed was done using QGIS by digitizing the toposheet. Then this digitized vector file was overlayed on Google Earth map to verify the watershed area. Terrain analysis for the delineated watershed was carried out. Terrain aspects include slope, Ascpet Hillshade, Relief and contour.

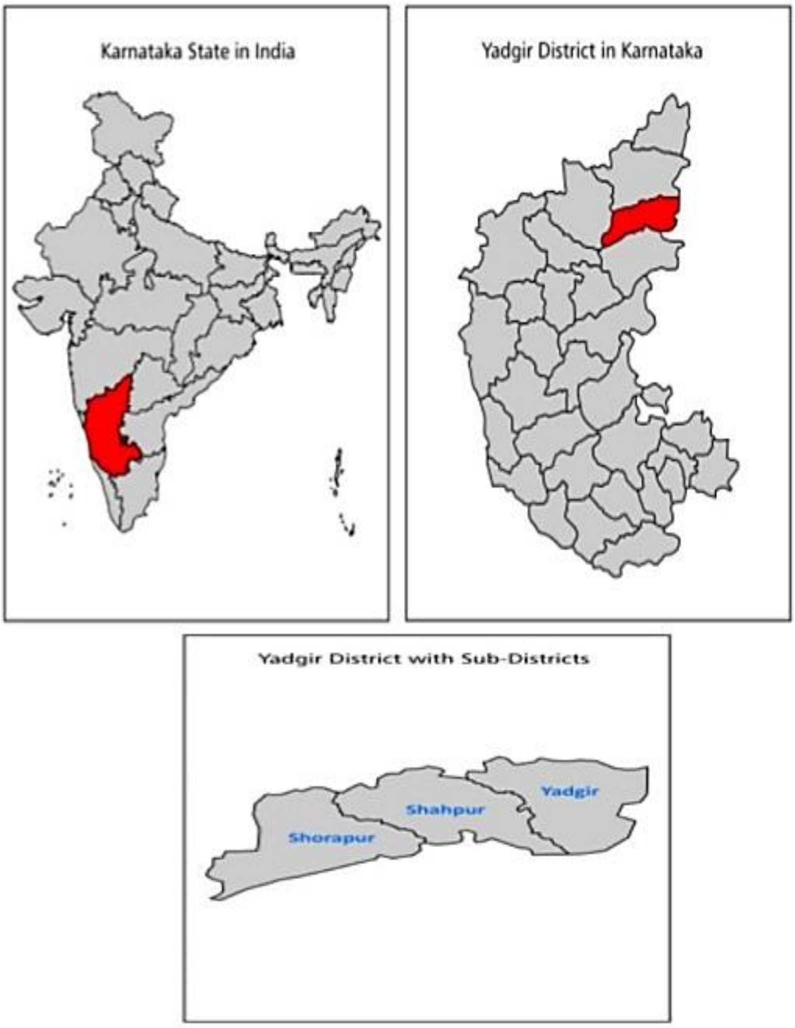


Fig. 1. Location map

The study of morphological characteristics of Hattikuni watershed was conducted. The term morphometry is derived from a Greek word where the “Morpho” means Earth and “Metry” means measurement so together it is measurement of Earth features. Morphometry is the measurement and mathematical analysis of configuration of the Earth’s surface and the shape and dimensions of its landforms. It includes the analysis on systematic description of the watershed geometry and its stream channel system to measure the linear, aerial and relief aspects of the drainage network. Morphometric analysis was carried out using topographical map of E43X1 and E43X5. The work involved assigning stream orders, counting stream numbers as per stream order, measuring stream lengths as per stream orders besides measuring the basin area, perimeter, maximum length of basin and maximum width of basin, form factor, drainage density, drainage texture, length of overland flow, circulatory ratio, elongation ratio, relief ratio, time of concentration, average slope etc were computed. Surface morphological properties govern the overall drainage behaviour of the watershed. The drainage or runoff from the watershed is the result of interaction of rainfall properties and various watershed features like area, shape, slope, length of different streams and contour details are to a great extent time invariant. Slope features may vary minutely due to developmental activities in the watershed such as land levelling grading, construction of soil and water conservation structures and similar other activities. These parameters can be used to compare runoff producing potential such comparisons of watersheds are useful in prioritizing watershed development work and selecting priority watersheds for applying various treatments to reduce runoff and soil loss through suitable conservation measures [10,11].

Linear aspects of the drainage network measured are,

Stream order (U), Stream number (N_u), Basin Length (L_b), Average basin width (B), Stream length (L_U), Bifurcation ratio (R_b), Stream length ratio (R_L) and Main stream length (L_c)

Areal aspects of drainage networks measured are,

Drainage area (A), Form factor (R_f), Drainage density (D_d), Drainage texture (D_t), Stream frequency (F), Circulatory ratio (R_c), Elongation ratio (R_e), Compactness coefficient (C_c), Texture ratio (R_t), Constant of channel maintenance (C) and Length of overland flow (L_g)

3. RESULTS AND DISCUSSION

The boundary of Hattikuni watershed was delineated in QGIS ver xx using SoI toposheet. The total area and perimeter of the watershed is 13884.95 ha and 70.72 km respectively.

Watershed delineated on Google Earth by overlaying of delineated watershed layer on Toposheet and corrected with changed topography. Length of watershed and minimum and maximum elevation points of watershed are 17.4 km, 436m and 622m respectively. Observed the changes in the features overlaid on the earth by comparing the toposheet and Google Earth satellite images (Fig. 2). There was little bit variation in watershed area and perimeter because the watershed boundary overlaid on the Google Earth and delineated watersheds both have a slight change in the digitization. The actual catchment area is 13789 ha. There is a change of 95.95 ha higher when we delineated the watershed boundary from Toposheet. This might be due to the fact that while digitizing there is a chance of getting outside the boundary as the contour interval in this Toposheet is 20 m.

The characteristics of the watershed are calculated by using mathematical equations and stream lines are digitized in QGIS. Fourth order stream is the trunk stream in the watershed. Length of each stream are calculated and ordered the streams. The details of the watershed characteristics especially the streams details are given in Table 1. The highest order stream was 4th. Among the four order streams first order stream is having more length (130.98 km) followed by 2nd order and successively 3rd and 4th order. The range of stream order was 174 to 34 of first and fourth order respectively.

Table 1. Stream order and its mean stream lengths of the watershed

Parameter	Stream order				Total
	1	2	3	4	
Number of streams	174	85	45	34	338.00
Stream length, km	130.98	56.3	25.07	20.89	233.24
Mean stream length, km	0.75	0.66	0.55	0.61	2.63

Table 2. Bifurcation ratio and Stream length ratio of the watershed

Stream order, U	Bifurcation ratio, R_b	Stream length ratio, R_L
1	2.05	-
2	1.88	0.88
3	1.32	0.84
4	-	1.10
Mean	1.31	0.71

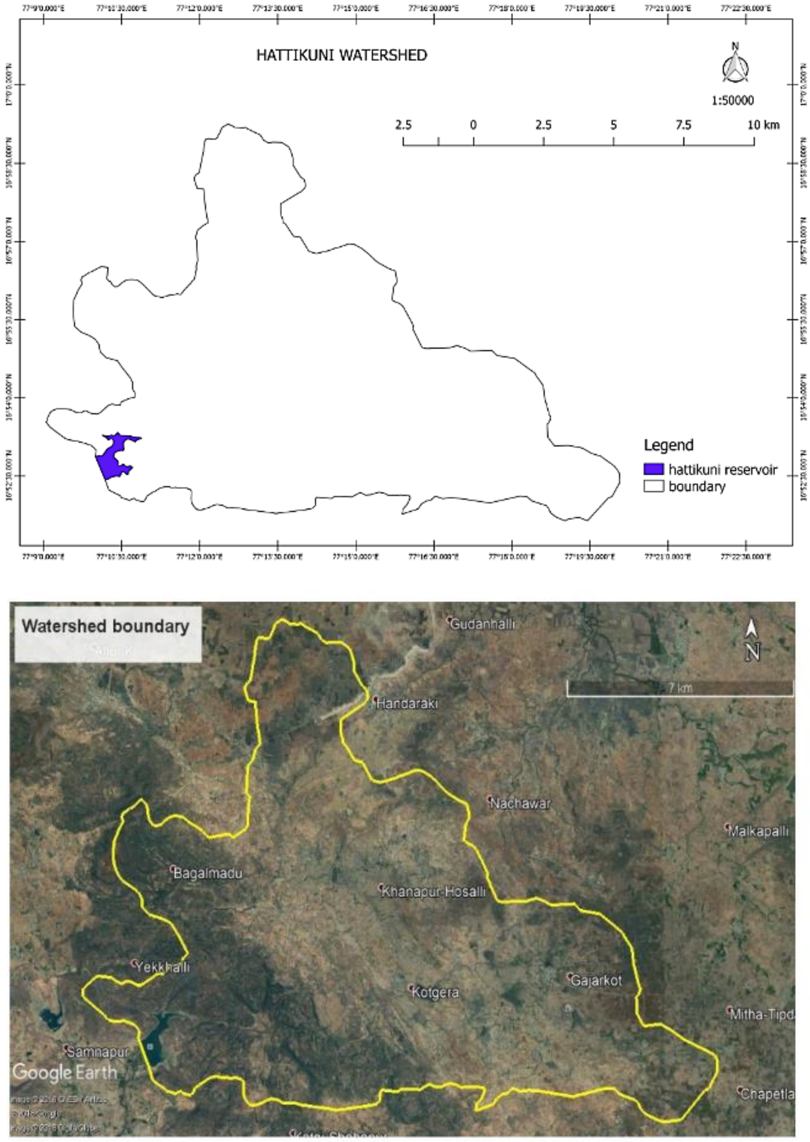


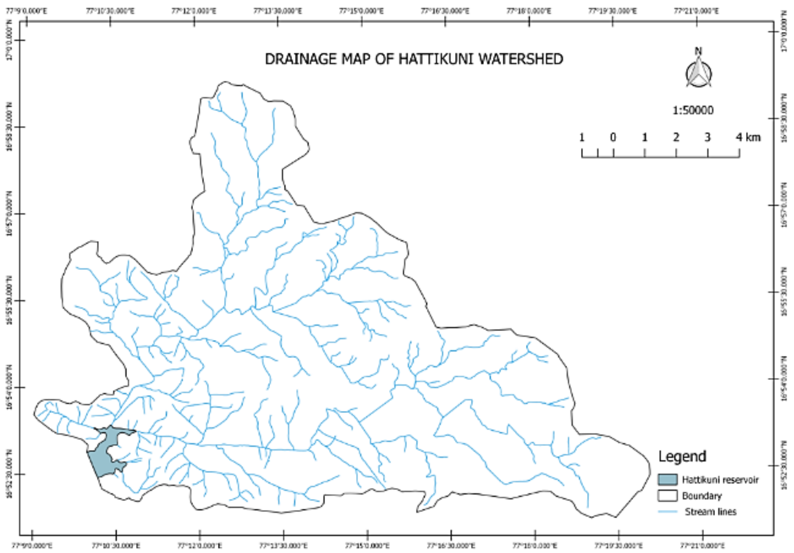
Fig. 2. Watershed delineated from QGIS and Google Earth

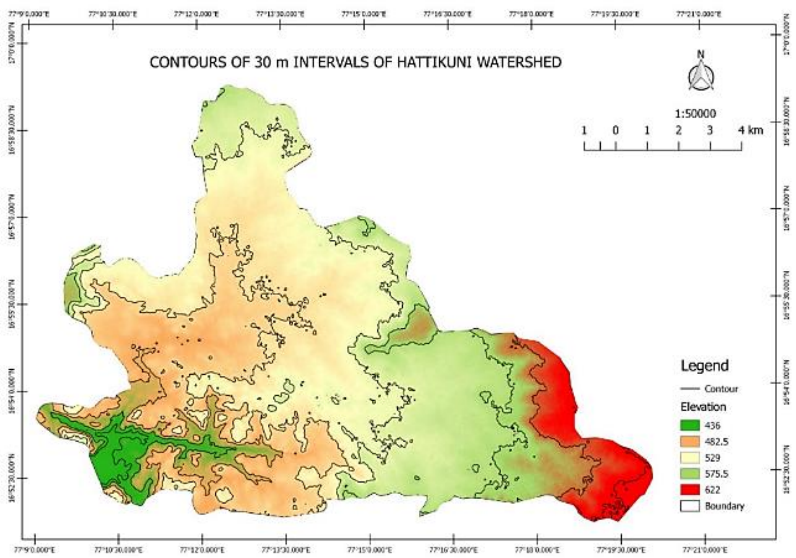
Bifurcation ratio and stream length ratio of the Hattikuni watershed is presented in Table 2. Bifurcation ratio ranges from a minimum of 1.32 to 2.05 and the stream length ratio varies from 0.84 to 1.1. In Hattikuni watershed there is no significant increasing trend in the stream length ratio from lower order to higher order [12,13,14]. Basically, there are two classes of R_b value; low and high. Low class means the drainage pattern is not affected by the geologic structures, whereas the high class means the drainage pattern is controlled by the geologic structures. Mean bifurcation ratio of Hattikuni watershed is 1.31, which indicates that drainage pattern is not affected by the geologic structures [15,16,17].

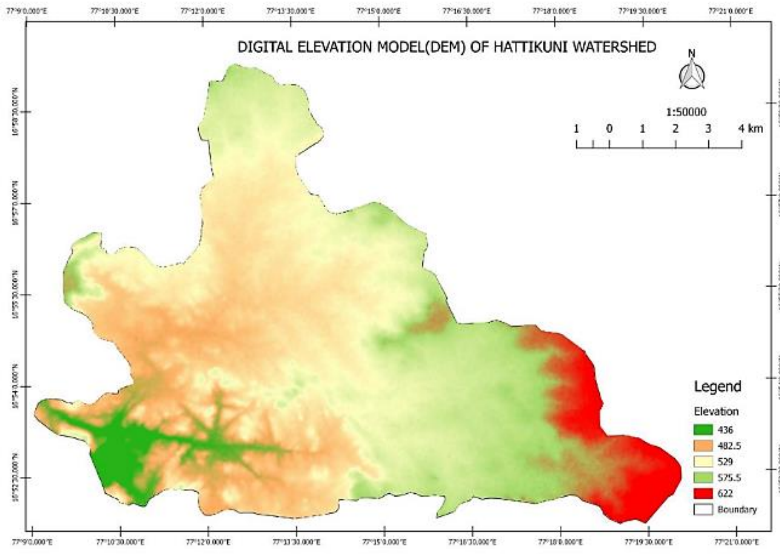
Using QGIS ver xx, various thematic maps were generated such as drainage map, contour map, digital elevation model, slope map, flow direction map, flow accumulation map, aspect map, geology map, soil map, forest boundary map, waterbodies map and others [18,19].

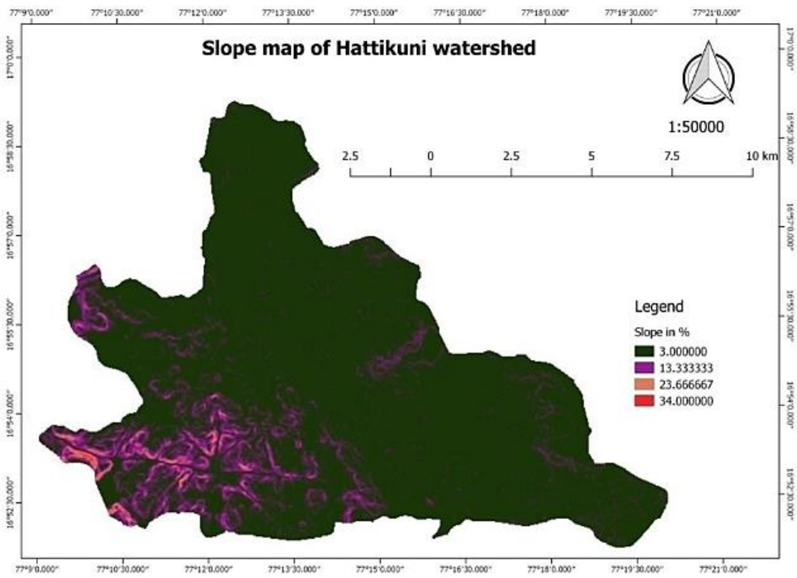
Table 3. Morphometric parameters of the watershed

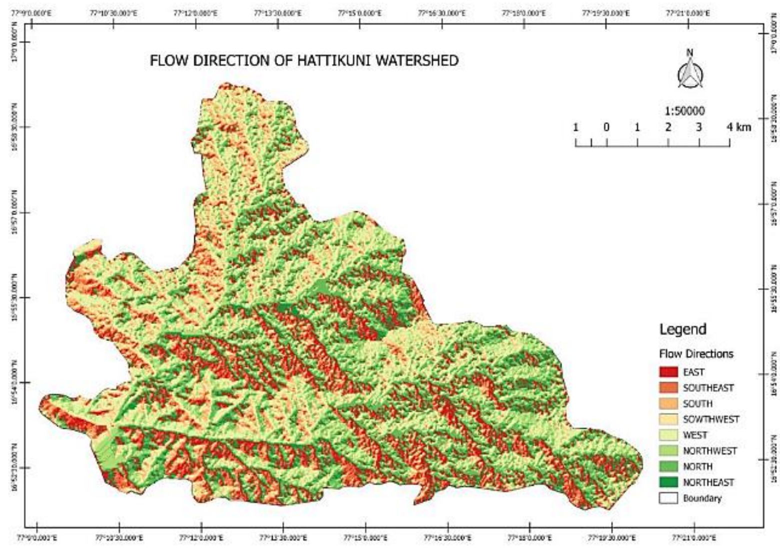
Sl.No	Areal aspects	Value/Area
1	Drainage area (A), ha	13884.95
2	Form factor (R_f)	0.46
3	Drainage density (D_d), km km^{-2}	1.66
4	Drainage texture (D_t), km^{-1}	4.77
5	Stream frequency (F), Nos.km^{-2}	2.43
6	Circularity ratio (R_c)	1.01
7	Elongation ratio (R_e)	0.02
8	Compactness coefficient (C_c)	1.69
9	Texture ratio (R_t)	2.41
10	Constant of channel maintenance (C), km^2 km^{-1}	0.60
11	Length of overland flow (L_g), km	0.30

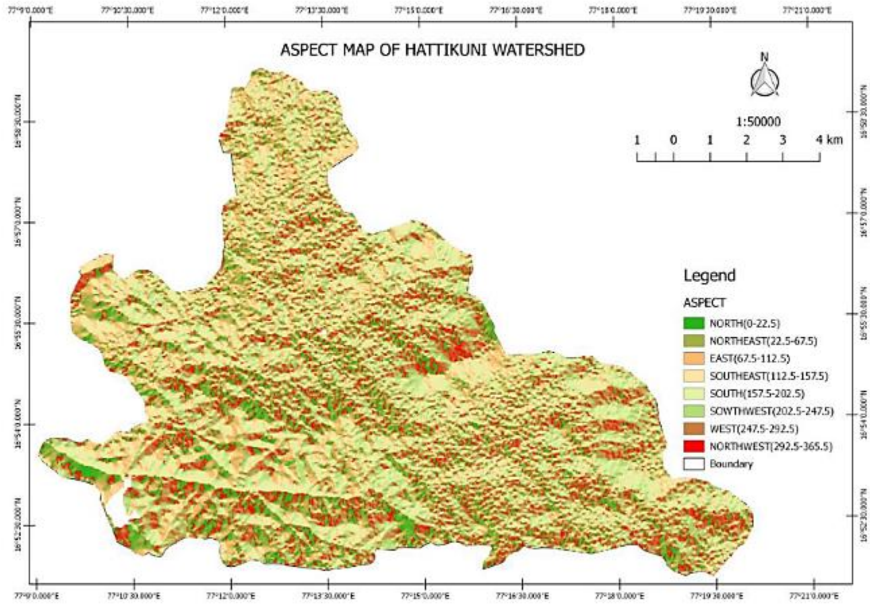





DIGITAL ELEVATION MODEL(DEM) OF HATTIKUNI WATERSHED
N
1:50000
1 0 1 2 3 4 km
Legend
Elevation
436
482.5
529
575.5
622
Boundary


Slope map of Hattikuni watershed
1:50000
2.5 0 2.5 5 7.5 10 km
Legend
Slope in %
3.000000
13.333333
23.666667
34.000000


FLOW DIRECTION OF HATTIKUNI WATERSHED
N
1:50000
1 0 1 2 3 4 km
Legend
Flow Directions
EAST
SOUTHEAST
SOUTH
SOWTHWEST
WEST
NORTHWEST
NORTH
NORTHEAST
Boundary



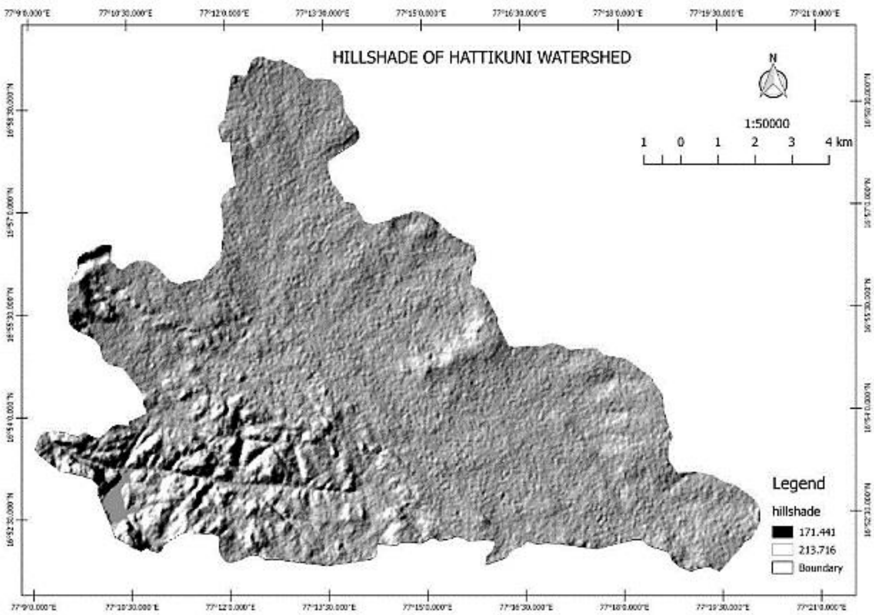


Fig. 3. Thematic maps

Table 4. Relief aspects of the watershed

Sl.No	Relief parameters	Value
1	Maximum watershed relief (H), m	186.000
2	Relative relief (RR)	0.002
3	Relief ratio (Rr)	0.011
4	Ruggedness number (Rn)	0.310
5	Time of concentration (Tc), min	206.500
6	Basin relief (S), %	1.608

Drainage map was prepared by using Survey of India toposheet on 1:50,000 scale. The drainage pattern observed in the study area is dendritic. The highest stream order is 4th order. The total length of streams draining to Hattikuni River was found out using QGIS software.

Contour map was prepared from Digital Elevation Model (DEM) with 30 m contour interval [12]. The corresponding contour intervals were recorded in the attribute table. The highest contour line was 540m and the lowest contour line was 330m. There were number of high peaked mountains having spot heights 622m and there were depressions having 436m.

Digital Elevation Model (DEM) was prepared using TCX converter software by taking a random elevation points in the watershed. This DEM was used to create contour map of that area. Red color indicates higher elevation portion of the watershed which is located in south-east portion. Highest elevation was also found nearer to the outlet. Green colour indicates either flat or rolling topography [20,21].

The slope map was derived using the DEM for the study area and presented in Six slope classes were generated at an interval of 10 per cent. The slope map was merged with the basin map to create slope attributes of drainage basin. Most of the area of watershed comes under slope less than 3 per cent and it is indicated by green color in the map. The higher slope land is indicated by red color. Higher slope is located towards the outlet as there are number of peaked mountains [22,23,24].

The flow direction map shows the direction of the generated flow in the watershed. Flow is generated from ridge portion and is towards the southwest corner which is the outlet of the watershed, total runoff created in the watershed is drained through that outlet. It was observed in the watershed that water was flowing from all the eight directions [25,26,27].

The aspect represents slope direction. The values of the output raster were representing the compass direction. In this study it was found that the slope was oriented more towards east, south-east, south and south-west [28,29].

Hillshade map is presented showed the mountain region of the watershed. All the hillocks of the watershed located in southwest corner inside the forest area. Dark region of the watershed shows the shade of the hills in that region. We can also see in the map that majority of the area looks like depressed places

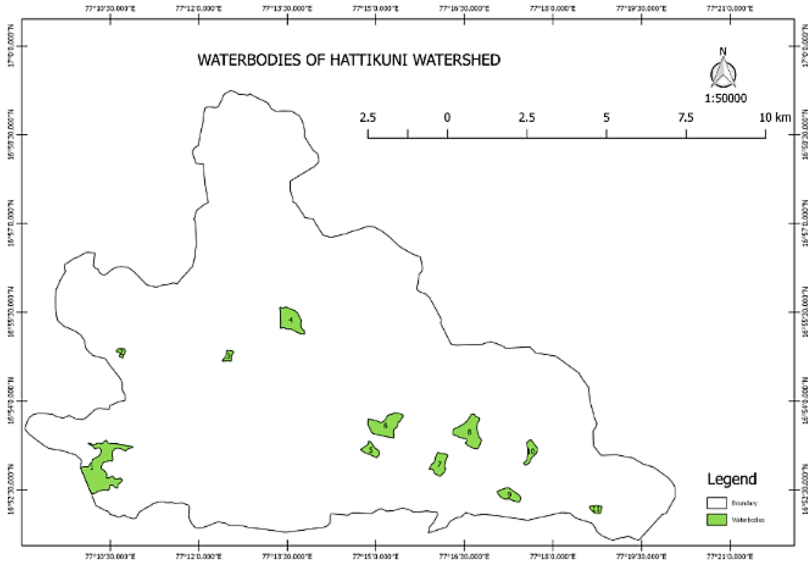
3.1 Comparing Water Bodies of Both Topodsheet and GoogleEarth

The separate delineation was carried out on Toposheet and google earth. The Toposheet delineated waterbody represents the year 1960-61 and google earth represents the recent past (2016).

From Table 5 and the Fig. 4. Outoff eleven waterbodies delineated on the Topasheet only three have remained in the recent past. We found that seven waterbodies were existing on the Google Earth in the recent past and these waterbodies are existing all together in a different location as compared to Toposheet [30,31]. Eight waterbodies were lost from Toposheet as we could see majority of them were converted as agricultural land and some of them were infected with Prosopis juliflora. It was also foundthat whatever the waterbodies were remaining they have shrunked in their waterspead area [32,33,34]. This might be due to encroachment or growth of shrubs or bushes. This also tells us the flow to the waterbodies might have decreased.

Table 5. Area of the water bodies on toposheet and Google Earth

Number of Waterbodies		Area(ha)	
Toposheet	**Google earth**	**Toposheet**	**Google earth**
1	1	106.84	93.243
2	2	4.99	0.043
3	3	7.05	0.011
4	4	42.54	0.013
5	5	14.93	0.036
6	6	49.72	0.018
7	7	25.40	0.586
8	8	52.14	26.068
9	9	19.86	3.570
10	10	15.88	6.207
11	-	7.62	-



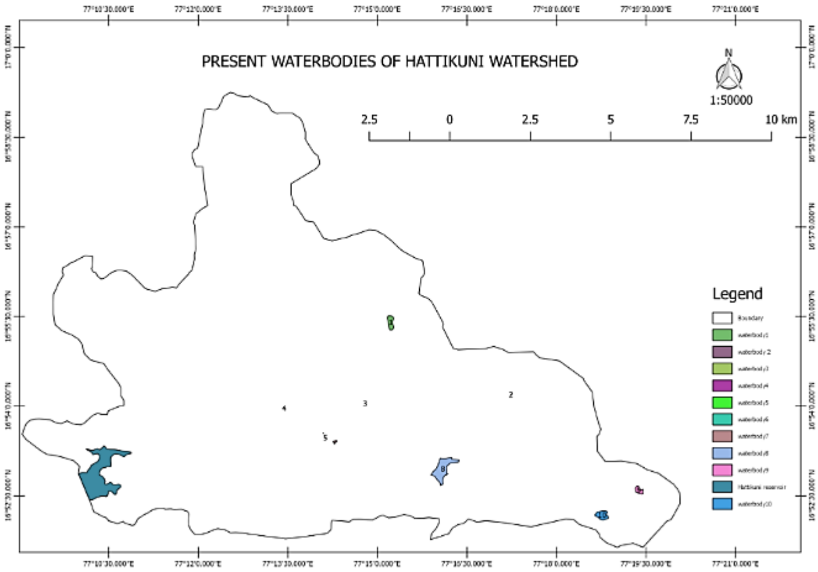


Fig. 4. Water bodies delineated from toposheet and Google Earth

Table 6. Details of soil classes

Sl.No	Soil type	Area (km^2)	Percentage area
1	Clayey skeletal, mixed, typic, Rhodustalfs	0.018	0.01
2	Fine mixed, Lithic Ustropepts	58.53	42.15
3	Fine, mixed, Typic haplustalds, Clayey skeletal, mixed, Typic	0.3407	0.25
4	Fine, mixed, Typic Ustropepts, Clayey over loamy, mixed, Typic Ustifluvents	3.48	2.51
5	Loamy, mixed, Lithic Ustorrthents	9.27	6.68
6	Rockland	53.28	38.37
7	Very-fine, montmorillonitic, Typic, Chromusterts	13.31	9.59

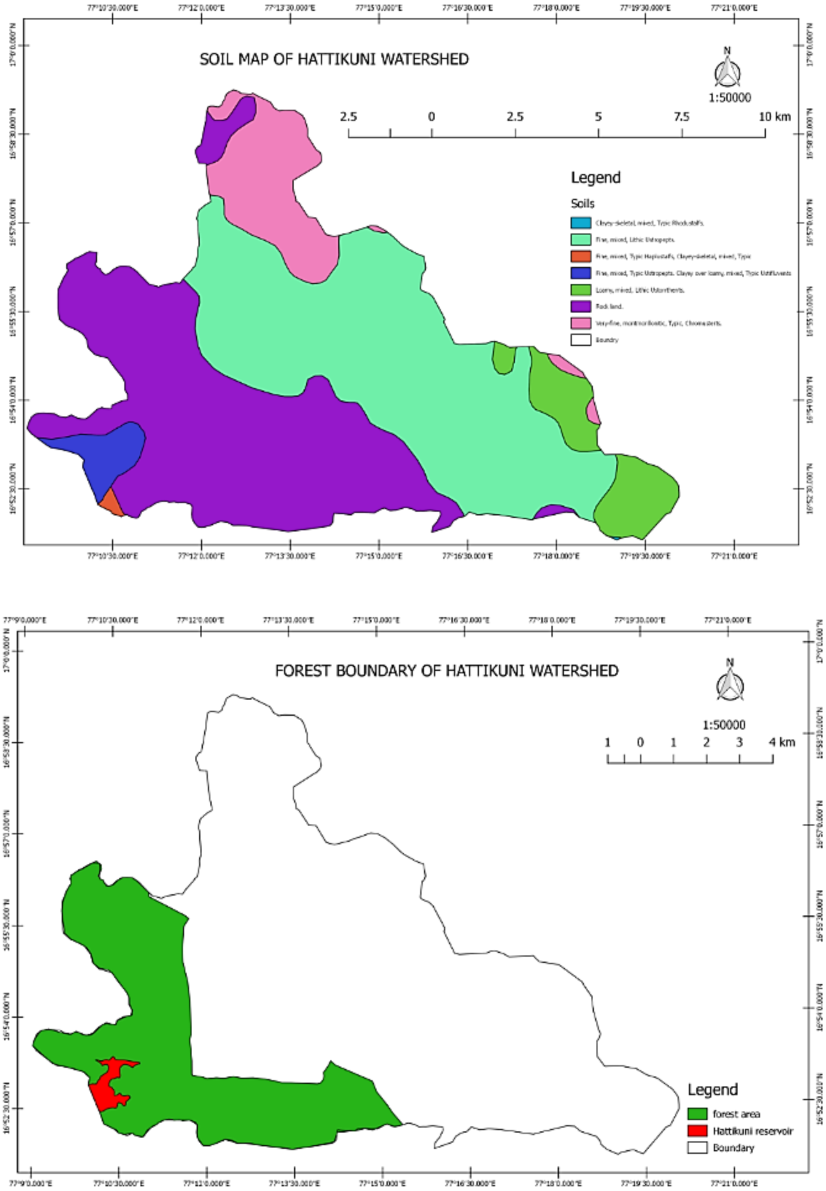


Fig. 5. Soil map and Forest boundary map

3.2 To classify Different Soils in the Selected Watershed Using Google Earth

Soil map of the study area was prepared by obtaining details from the Department of Mines and Geology and is presented in Fig. 5. The highest area is occupied by fine, mixed, Lithic ustropepts with 58.53 sqkm covering 42.15 per cent of the total area and the minimum area is occupied by Clayey skeletal, mixed, Typic, Rhodustalfs having 0.018 sqkm covering 0.01 per cent of total area [35-37].

3.3 To Estimate Vegetation Percentage Using Google Earth

The total area of the watershed was 13884.95ha and the forest found was 3456.95ha. vegetation percentage were calculated and it was found that 24.99 per cent. It was also found that majority of the vegetation has concentrated near the outlet. There is a need to establish vegetation on the ridges of the watershed.

Vegetation/forest area = 3456.95 ha.

Total area of the watershed = 13884.95 ha.

Vegetation/forest percentage = 24.99 percent of the total watershed area

4. CONCLUSIONS

From the change detection analysis, it was found that waterbodies have decreased in their number as well as in the volume. Some of the waterbodies were converted into agricultural lands. The total vegetation percentage in the watershed is 24.99% is very less. From the study it can be concluded that Google earth and the open GIS software can be comfortably be used for natural resources identification and mapping. Use of Google earth and open-source GIS tools can be used for other areas and there is a need to check in detail, by mapping the soil. There is a need to use these available sources for the conservation and management of all the natural resources. There should be an attempt to quantify precisely, the change in water spread area of the different water bodies. Can take up the work to select suitable conservation practices to soil, water and vegetation conservation based on Google earth.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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