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Use of RS and GIS for MPKV Watershed Planning

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Abstract

The SoItoposheet 47 I, Cartosat-2 DEM and Landsat-8 satellite image of the area were used for planning of MPKV West watershed. Thematic maps such as Base map, Slope map, Soil map, Land use / Land cover map, Drainage map and Catchment map were prepared.In the drainage network, high priority for land treatments was found to 1st and 2nd order streams,due to steeper slopes the runoff generation would have been increased and for water storage structures high priority was found to 3rd and 4th order streams because of gentle and nearly flat slope. One farm pond in catchment-A twelve nalabunds are proposed under drainage line treatment in entire west part. Twenty Four loose boulder structures, especially in upper reaches of first order streams, are suggested. Under the area treatment continuous contour trenches with plantation (CCT/deep CCT + Plantation) in 102 ha area are proposed in catchment A to F. Plantation on 67 ha have been proposed in catchment-A and densification of plantation is proposed on 222 ha area in catchment-A.

Keywords: Remote sensing; Geographic information system; Watershed.

INTRODUCTION

The advent of remote sensing images from satellite based platforms has provided opportunities for extraction of up-to-date information on land use, soils of a watershed and then used to identify locations for soil and water conservation structures within the watershed. Deriving the spatial information on input parameters has become more handy and cost effective. The conventional methods proved to be too costly and time consuming for generating this input data. With the advent of remote sensing technology, besides with the powerful spatial processing capabilities of GIS and its compatibility with remote sensing data, the watershed planning approaches have become more comprehensive and robust. Remote sensing can facilitate studying the factors enhancing the process, such as soil type, slope gradient, drainage, and land cover.

Study area was located in Ahmednagar district, it is located in Ahmednagar district, situated on the Ahmednagar-Manmad highway, 35 km away from the district place. The study area of this research was Mahatma Phule Krushi Vidyapeeth (MPKV) Central Campus, Rahuri in Ahmednagar district, Maharashtra state. The area 1528 ha is located between 19° 19′ to 19° 22′ North Latitude and 74° 36′ to 74° 40′ East longitude.

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METHODOLOGY

Basic data products used for the study

Data collection	Source of data
Cadastral Map	University Engineer Office, MPKV Rahuri
Toposheets (47I)	Survey of India,
Digital Elevation Model (DEM)	Bhuvan website, (NRSC, Hyderabad) (http://bhuvan.nrsc.gov.in)
Remote sensing image	LANDSAT-8 satellite (http://www.espa.cr.usgs.org)
Soil map	Ground Coordinate data Obtained from dept. of Soil Science and Agricultural Chemistry, MPKV Rahuri

Softwares

ArcGIS 10.2

ArcGIS software developed by Environmental Systems Research Institute (ESRI) is graphic interphase software easy to handle and operate. It contains Arc Toolbox, collection of tools and function for operations in ArcCatalog. ArcGIS improves quality, adds important new capabilities and includes documentation improvements.

ERDAS Imagine v. 14

ERDAS Imagine image processing software is used for the analysis and interpretation of multi-spectral digital satellite images. It was used for accuracy assessment for supervised and unsupervised classification

Generation of thematic maps

Base map

A map representing the outline structure of the study area is known as a base map. It is skeleton structure of an area and represents the shape, size, position and relation of the physical features of an area. The base map is prepared using Survey of India toposheet of 1:50,000 scale. Toposheet was georeferenced and rectified using ArcGIS 10.2 software. Base map consists of various features like road network, settlements, water bodies, and railway line network *etc.*, delineated from the toposheet. The information content of base map is used as a baseline data to finalize the physical features of other thematic maps. Since the toposheets were very old all the features like roads, railways, settlements *etc.*, are updated with the help of rectified and scaled satellite imageries of the study area and ground truth data.

Digital Elevation Model (DEM)

DEM is an important parameter in resource management applications. It is a raster GIS layer representing the area as a regular arrangement of locations (rows and columns) with a value in each cell corresponding to its elevation (Kumar, 2006). The digital elevation model downloaded from website *bhuvan.nrsc.gov.in.* Using boundary of study area DEM was clipped using Extraction by mask function in Spatial Analyst tool in ArcGIS 10.2. Extracted DEM then subjected to Fills sinks in a surface raster function of Spatial Analyst tool to remove small imperfections in the data.

Drainage map

Drainage map prepared from Digital Elevation Model. In ArcGIS environment. After preparing the drainage network map this map is updated using SoIToposheet to know the changes in the study area. Drainage map includes all the streams, tributaries and small stream channels and depicts flow pattern of drainage lines in the study area. Thelengths and numbers of all stream orders were obtained from drainage map prepared in ArcGIS 10.2 software using Spatial Analyst tool.

Slope map

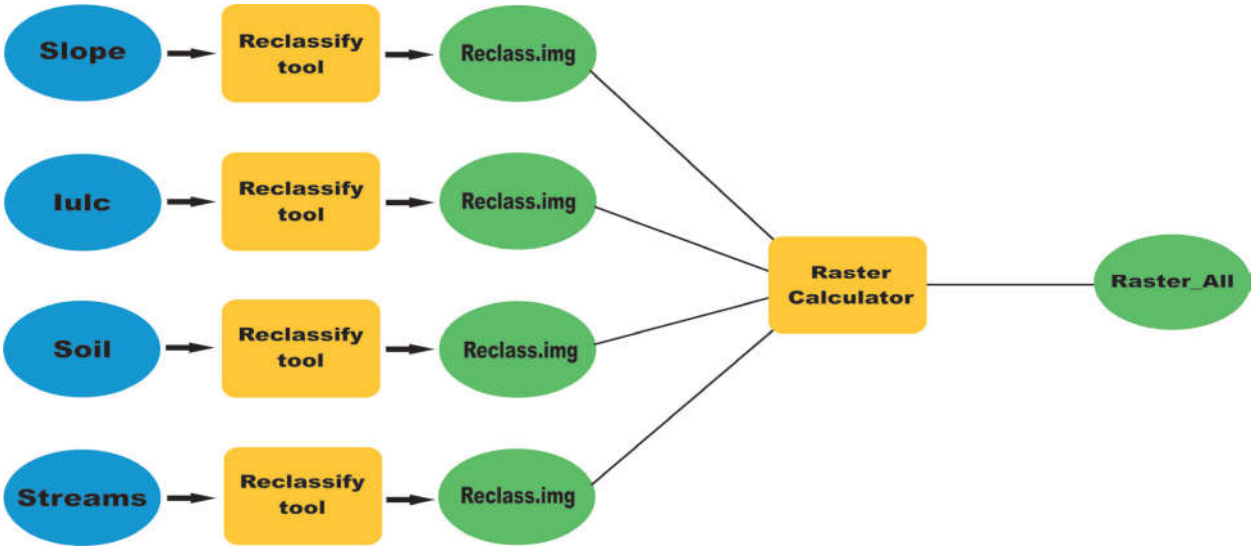
Slope is the most important terrain characteristics plays a vital role in morphology, runoff processes, soil erosion, infiltration and land use/ land cover (Gajbhiye and *et al* 2015). It is very important for understanding the spatial distribution, development and management of both land and water resources and major controlling factor in the development and formation of different landforms. The slope map was prepared for the study area from the DEM. The slope map was classified into seven classes according to IMSD guidelines as shown in table below. The slope assignment corresponds to the maximum change in elevation between a cell and its eight neighbours *i.e.* the steepest downhill gradient for a grid cell on a raster surface. The slope is expressed in percentage. If any neighbourhood cells are no data, they are assigned the value of the centre cell and slope is computed.

Slope (%)	Slope class
0-1	Nearly level
1-3	Very gently sloping
3-5	gently sloping
5-10	Moderately sloping
10-15	Steep
15 – 35	Very steep
> 35	Extremely steep

Soil map

Topographic data was taken and it is superimposed on the satellite data. Further image characteristics namely texture, tone, pattern, shape and association were prepared in order to compare with the soil distribution. The soil texture map was generated by carrying out soil analysis of collected samples from the watershed area by International pipette method using sodium hexametaphosphate as a dispersing agent as described by Piper (1966).

Soil sample data was obtained from department of Soil Science and Agricultural Chemistry, MPKV Rahuri. Data was interpolated using IDW function in Spatial Analyst tool using ArcGIS 10.2



Land use/ land cover map

Land Use (LU) and Land Cover (LC) these are the different things *i.e.*, Land use means how the land is used and land cover indicates what covers surface is on the earth. Land use and land cover change detection is important process for monitoring and managing natural resources in urban areas development. Land cover includes natural vegetation, water bodies, rock, soil, forest and waste land. Land use land cover map shows the distribution of watershed area under various land use categories. Provision of such maps helps watershed planners in effective and best possible utilization of its resources besides providing a comprehensive view of the total area planning and management of natural resources.

Proposing water conservation structures based on priority

Proposing different water conservation structures plays a very crucial role, which requires a well-qualified and well-experienced work force with thorough knowledge in various water conservation programmes. For this purpose thematic layers like slope, flow direction and flow accumulation output raster maps along with drainage, soil, land use/ land cover and morphological characteristics were used. Weightages were given to significant units (on priority basis) in various thematic layers such as morphology, slope, drainage, soils and land use/ land cover in raster form in order to fix locations for suggesting appropriate recharge structures.

Existing land treatment map and existing soil and water conservation structures map were prepared by collecting GPS coordinates of sites and plotted in ArcGIS 10.2. These themes were calculated using raster calculator in spatial analyst of ArcGIS 10.2 based on the weightages decided. The formula for this raster calculation is as follows: [(land use/ land cover)*0.3] + [(soils)*0.1] + [(slope)*0.3] + [(drainage)*0.3]. A drainage raster

indicating high and low priority locations was generated by evaluating this equation. Based on this location priority raster, various water conservation structures were proposed in priority area.

RESULTS

Base map

The base map is represented by villages, roads, streets, canal, Places, etc. The base map was prepared using SoItoposheet and ground truth data in ArcGIS10.2 software.

Digital Elevation Model (DEM)

The digital elevation model downloaded from website *bhuvan.nrsc.gov.in.* The DEM was reclassified into two classes namely high (570 m) and low (510 m) and used to precisely delineate the physiographic features.

Slope map

Land use type	Area, Ha	Area, %
Waterbody	24.57	1.62
Agriculture	356.04	23.53
Barren	1065.33	70.42
Fallow	51.66	3.41
Habitation	15.03	0.99
Total	**1528**	**100**

The slope map was derived using the DEM for the study area. The slope map was classified into six classes according to IMSD guidelines. About 10.47% of the total study area fell into slope class 1 (< 1%) while 30.03% of the study area having a slope class-2 fell in the range of (1–3%). In similar way slope class-3 (3-5%), class-4 (5-10%), class-5 (10-15%) and class-6 (15-29.92%), were covered an area about 26.06%, 21.32%, 8.83% and 5.43%.

Classes % Slope	Area, Ha	Area, %
0-1	160.50	10.47
1-3	459.70	30.03
3-5	398.24	26.06
5-10	325.78	21.32
10-15	135.00	8.83
15-29.92	83.00	5.43
Total	1528	100

Drainage map

Drainage map was prepared by using Digital Elevation Model of study area. The drainage pattern observed in the study area is *dendritic.* The highest stream order is 3rd order. The total length of streams draining to respective outlet points of the catchments was found out using ArcGIS software. The Fig depicts drainage map of the MPKV central campus (west) and catchments of MPKV central campus (west).

Soil map

Textural classes	Area, Ha	Area, %
Clay	311	20.35
Silty clay	448	29.31
Clay loam	769	50.32
Total	1528	100

Soil map generated by IDW Interpolation technique in ArcGIS 10.2 Environment. Soil type data was Available at Department of Agricultural Chemistry, MPKV Rahuri (Nagawade, 2014) in the study area mainly three textural classes were found out and represented in Table below. Fig represents soil map of the study area. The other characteristic features of the soil are clay loam and clay were observed in the MPKV central campus (west).

Land use/ land cover map

Land use/land cover map for MPKV central campus (west) was used to represent the classification of land in various categories viz. Agriculture, water bodies, Barren, Fallow land and Habitation, which is given in table below Land use land cover map of MPKV Central campus (west) was prepared using Landsat-8 imagery and ArcGIS 10.2.

Accuracy assessment

The accuracy assessment was carried out for both unsupervised and supervised classification. Table given bellow shows result of Error matrix for unsupervised classification. Error matrix was formed in ERDAS Imagine v.14 software. Following tables shows error matrix for unsupervised and supervised classification respectively. Sample of 200 pixels were selected, ground truth data for selected sample was also collected. User's and producer's accuracy were determined. The overall accuracy is a measure of how well the classified pixels match the ground truth data while the Kappa coefficient measures how well the classification in question would compare to a chance arrangement of pixels to each land cover class.

Error matrix for supervised classification of study area

Land use/ Land cover	Water body	Habitation	Agricultural	Fallow land	Barren land	Total
Water body	3	1	0	0	0	4
Habitation	0	1	0	0	1	2
Agricultural	0	1	41	2	2	46
Fallow land	0	0	1	7	0	8
Barren land	0	1	1	5	133	140
Total	3	4	43	14	134	200
Producers	100	25	95.34	50	99.25	

Overall accuracy = 0.92 Kappa coefficient = 0.84

Result shows that more accuracy was found supervised classification with Overall accuracy = 0.77 and Kappa coefficient = 0.57 as compare to unsupervised classification with Overall accuracy = 0.92 and Kappa coefficient = 0.84. Therefore supervised classification used for land use land cover. Percent area in LU/LC gives idea about barren area which largest portion of MPKV central campus (west) hence soil conservation measures can be applied on large scale.

Error matrix for unsupervised classification of study area

Land use / Land cover	Water body	Habitation	Agricultural	Fallow land	Barren land	Total
Water body	3	1	0	0	0	4
Habitation	0	1	0	0	1	2
Agricultural	0	1	36	6	3	46
Fallow land	0	0	1	6	1	8
Barren land	3	2	15	12	108	140
Total	6	5	52	24	113	200
Producers	50.00	20.00	69.23	25.00	95.57	

Overall accuracy = 0.77, Kappa coefficient = 0.57

Priority based on slope and land use/land cover analysis (Panhalkar 2010)

Slope categories nearly level, very gently sloping, gently sloping, moderately sloping, steep and very steep were assigned weightage from 1 to 5 respectively. Common land use categories *i.e.*, water body, habitation, agricultural land, barren land and fallow land in all the six catchments were considered for prioritization. Weightage assigned to classes as shown in Table bellow

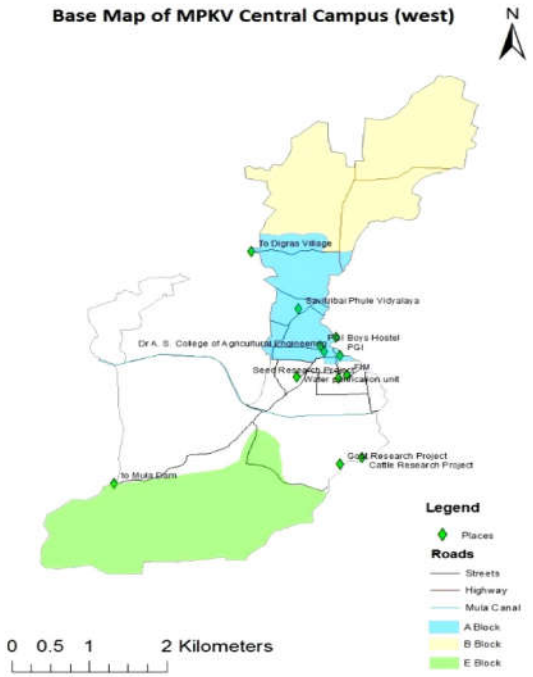
Weightage assigned for land use classes and slope classes

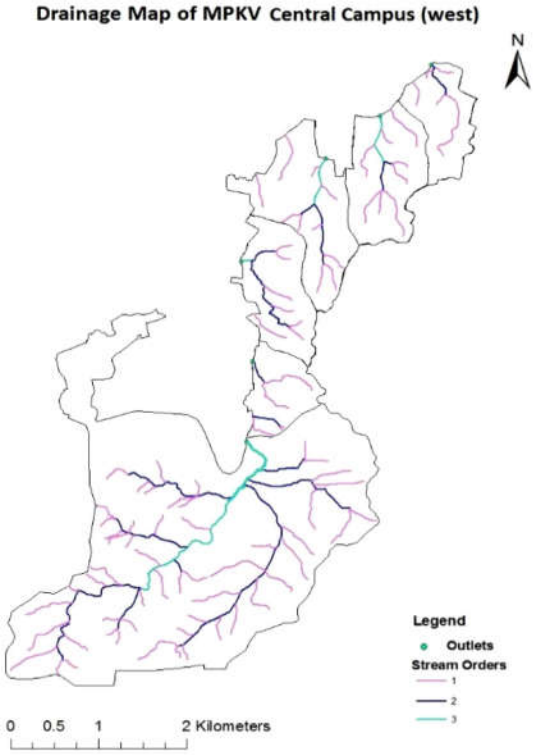
Slope Class	LU/LC Class	Weightage	Priority	Area, ha
0-1	Waterbody	1	5th	20.25
1-3	Habitation	2	4th	642.33
3-5	Agriculture	3	3rd	614.61
5-10	Fallow	4	2nd	202.68
10 % <	Barren	5	1st	24.57

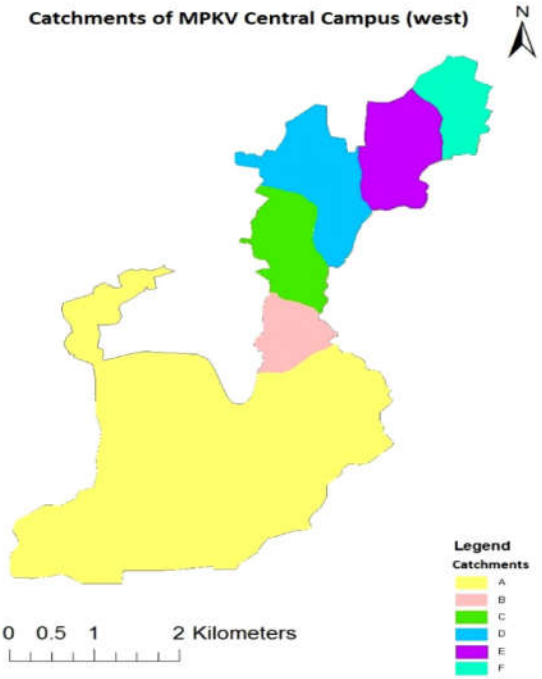
Existing land treatments

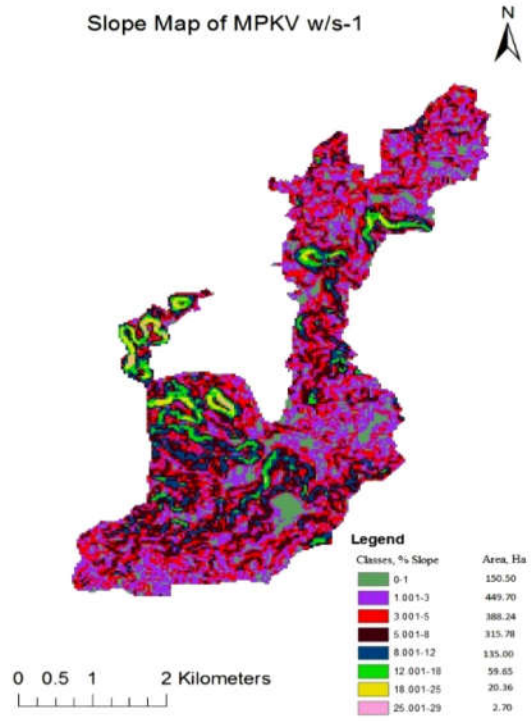
During research on study area it was found that some land treatments were already exist. Continuous Contour Trenches (CCT) and CCT with plantation were found in good working condition. Ground truth data was collected of study area covered by these treatments was collected and using ArcGIS 10.2 existing land

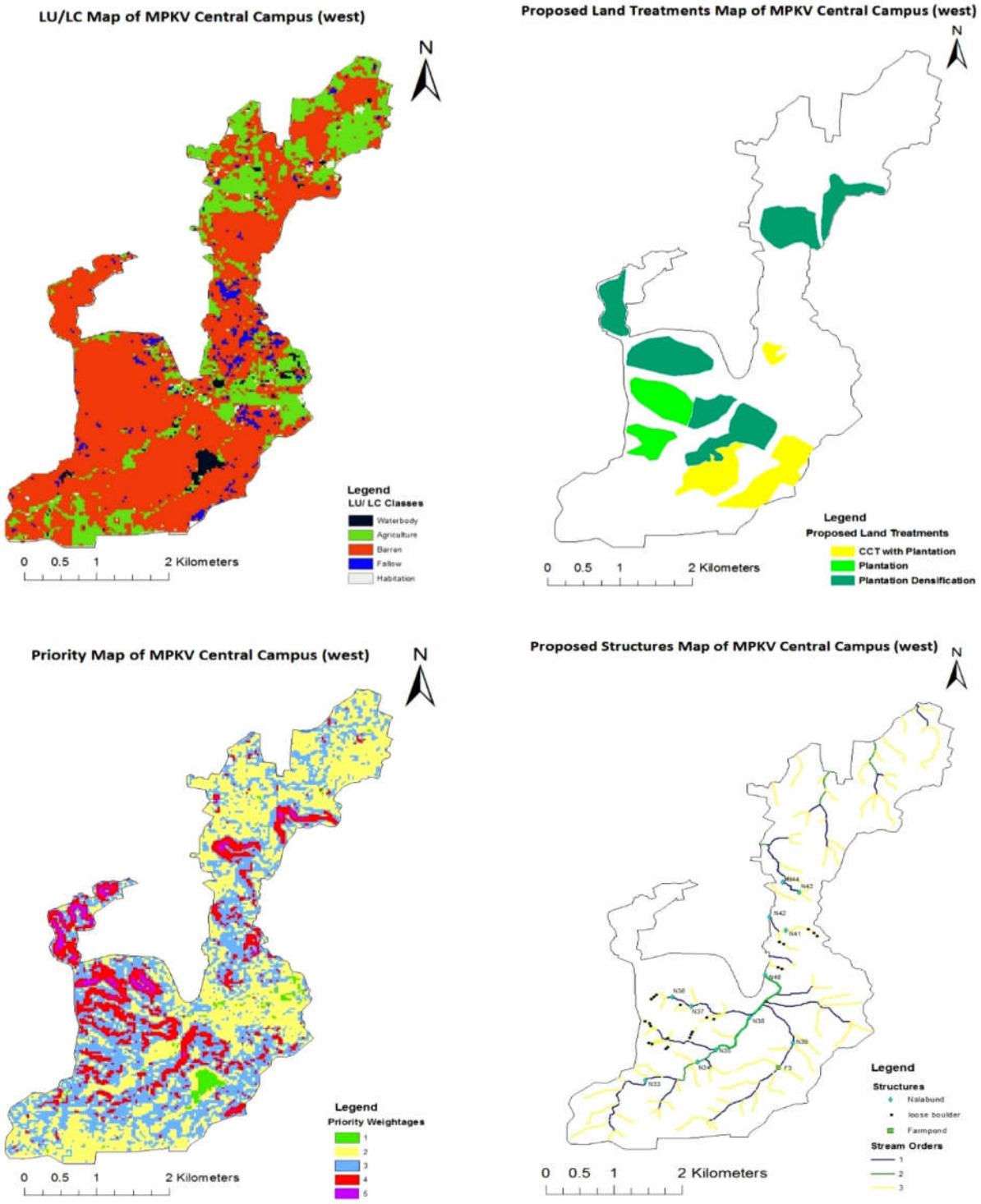
treatments map was prepared. map depicts existing and treatments map for MPKV central campus east region. Area under only CCT, and CCT with plantation land treatment was found 67 ha and 222 ha respectively.











Existing soil and water conservation structures map

In study area some soil and water conservation structures were found. Existing soil and water conservation structures in priority area were identified and GPS locations of all structures were collected These locations were imported in ArcGIS 10.2 software to generate existing soil and water conservation structure map of MPKV central campus west part. Map depicts existing structures map showing nala bunds thirty two in numbers, ten storage tanks and two farm ponds in the study area.

Proposed soil and water conservation plan

The raster thematic maps like drainage, slope and land use/ land cover were considered for the prioritization. in the drainage network High priority for land treatments was found to 1st and 2nd order streams because of steeper slopes, the runoff generation will be more and for water storage structures high priority was found to 3rd and 4th order streams because of gentle slope and nearly flat slope. In case of slope of the watershed, high priority was found more than 8 % slope. Whereas, low priority were considered for the slope range 1 to 8 %. Lastly for land use/ land cover, high priority was found to Scrub Fallow land because of no vegetation and most of the soils are silty clay content so runoff in these areas are more and low priority was found to water body, habitation, agriculture and plantation. It obstructs the runoff water to flow as runoff and make it to infiltrate in to the soil.

Keeping in view all above points, considering essential factors of high priority area different soil and water conservation structures and land treatments suggested. Using raster calculator mentioned in methodology different soil and water conservation structures were suggested for study area. map depicts proposed land use treatments in study area CCT/deep CCT with plantation, plantation on already existing CCT/ deep CCT and densification or improvement of existing plantation are proposed. map depicts proposed land treatments which gives treatment regions showing proposed plantation on 67 ha area, proposed CCT/deep CCT with plantation on 102 ha area and proposed forest densification on 222ha area. Depicts soil conservation and water storage structures like loose boulder structures, nala bunds and farm ponds. 24 (Twenty Four) loose boulders, 12 (Twelve) nala bunds, and 1 (one) farm pond site are suggested in the high priority region.

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