Summer Fellowship Report

On

Quantum GIS (QGIS)

Submitted by

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Under the guidance of

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With Regards,

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1 About QGIS

1.1 INTRODUCTION:

QGIS (previously known as Quantum GIS) is a free and open-source cross-platform desktop geographic information system (GIS) application that supports viewing, editing, and analysis of geospatial data.

QGIS supports both raster and vector layers; vector data is stored as either point, line, or polygon features. Multiple formats of raster images are supported, and the software can geo-reference images. Reference 1

Figure 1 QGIS Logo

1.2 APPLICATIONS OF QGIS:

Since QGIS is free and open source software, it is very much useful in various applications some of the applications are as follows:

1. Forestry
2. Mining
3. Oil & Natural gas exploration.
4. Agriculture
5. Administration

1.3 FUTURE SCOPE FOR QGIS:

QGIS allows users to write, modify source code. It makes the applications of QGIS widespread. QGIS integrates with other open-source GIS packages, including PostGIS, GRASS GIS, and Map Server. Plugins written in Python or C++ extend QGIS's capabilities.

1.4 QGIS FEATURES USED FOR CURRENT PROJECT:

Some of the QGIS features used for study are listed as below:

i. Vector Analysis
ii. Raster Analysis
iii. Processing Toolbox - GRASS GIS tools
iv. Processing Toolbox - SAGA GIS tools

2 Site Suitability Analysis For Small Check Dams Using Q-GIS

2.1 ABSTRACT:

Water plays a vital role not only in fulfilling basic human needs for life and health but also in socio-economic development. As the primary source of water is rainfall, it becomes necessary for us to harvest it effectively, we can maximize the storage and minimize the wastage of rainwater. Using remote sensing and GIS will avoid huge investment in decision making and planning for required numbers and type of water storages structures to be constructed

Multicriteria Decision Analysis (MCDA) was carried out in Geographic Information System (GIS) for determining suitable zones for small check dam structures based on the physical characteristics of the watershed. Different layers which were taken into account for multi-criteria evaluation are: soil texture, land use, stream order, slope, elevation, lithology, NDVI, NDWI and drainage network. Analytical Hierarchy Processes (AHP) was used to find weights for the different criteria for finding suitable zones for construction of small check dams. These layers are overlayed in GIS to produce the site suitability map of the study area. This mapping helps in selecting potential sites for water storage structures such as small check dams and Reservoirs.

From the progress we can find the site suitable for small check dams in Kaveri basin. Finally, the output can be submitted as a proposal for the Tamil Nadu government for the larger project, because the Tamil Nadu government has given a statement on construction of check dams across Kaveri river basin.

Keyword: GIS, Multicriteria Decision Analysis, Analytical Hierarchy Processes.

2.2 INTRODUCTION - STUDY AREA:

Kaveri basin was used for selection of sites for construction of small check dams within the Tamil Nadu boundary. Kaveri basin is located between latitudes 10.05 N and 13.30 N and longitudes 75.30 E and 79.45 E.

Kaveri River Basin: Kaveri is an easterly flowing river of the Peninsular India that runs across three of the southern Indian states i.e. Karnataka, Tamil Nadu, Kerala and a Union Territory of Puducherry., Geologically, the basin forms a part of the South Indian Shield.

Criteria selected for Multicriteria Decision Analysis are Climate, Hydrology, Topography, Agronomy, Soils, Vegetation, water index, runoff depth.

Using Qgis watershed analysis is done for Kaveri basin. Catchment area of around 42,811 sq.km. approx. Within Tamil Nadu the basin covers more than 5 districts like Erode, Karur, Namakkal, Salem, Tirupur, etc.

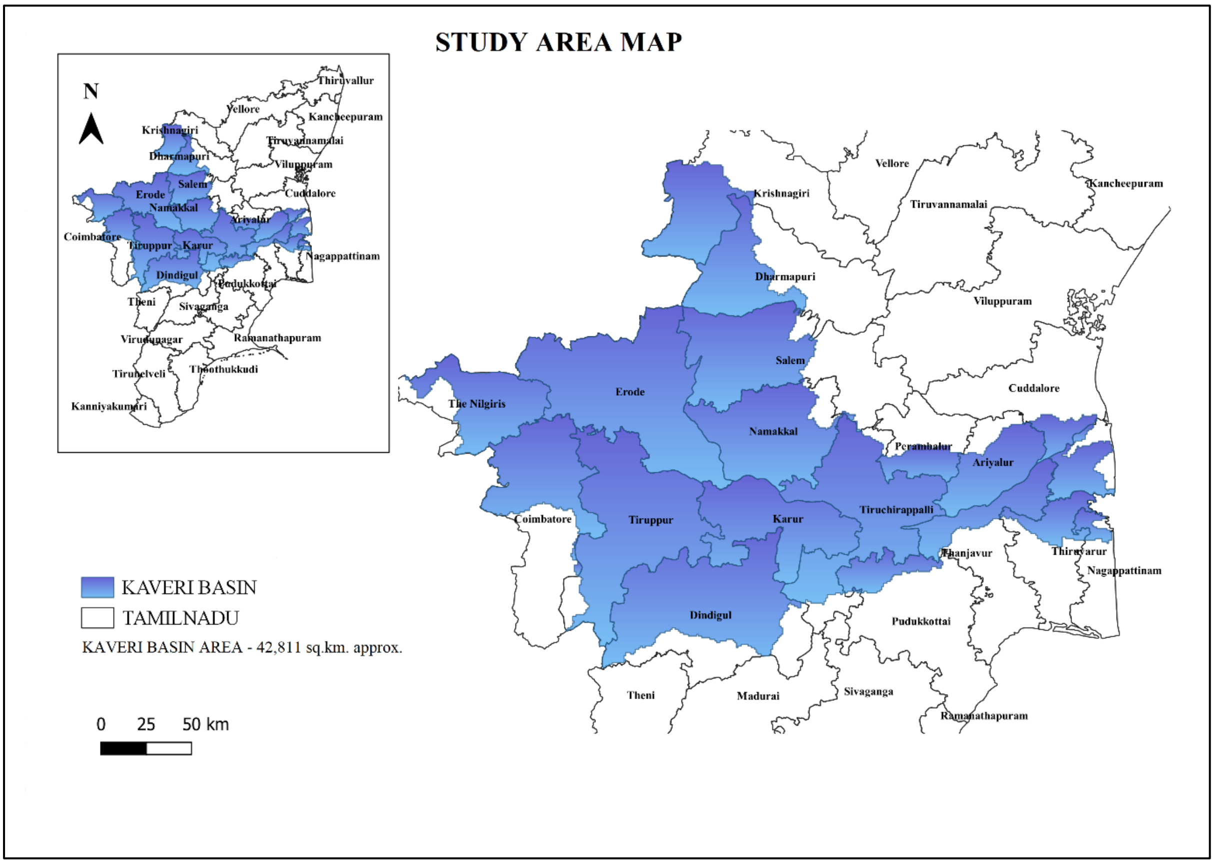


Figure 2 Study Area Map

2.3 PROBLEM STATEMENT:

Tamil Nadu is facing acute water shortage, with 81% less water in its reservoirs than its 10-year average as you can see below . The water level in its major reservoirs is at just 6% of their total capacity. And it is unlikely that the situation will improve soon. Reference 2

Tamil Nadu government had declared hydrological drought (shortage of water resources) in Karur, Salem, Vellore, Trichy, Perambalur, Tiruvallur, Namakkal, Virudhunagar, Kancheepuram, Madurai, Dindigul, Erode, Pudukkottai, Sivaganga and some other districts too.

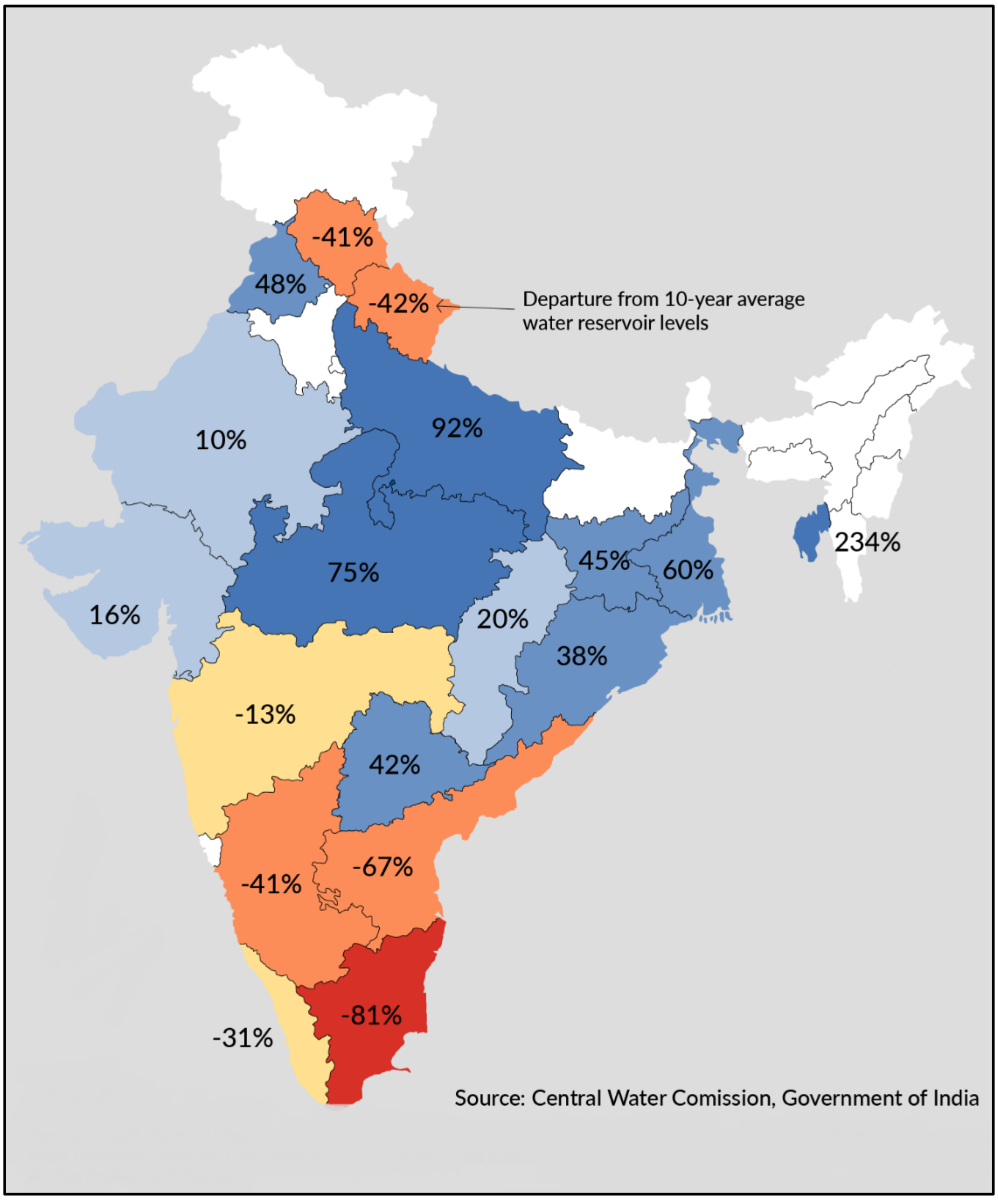


Figure 3 Map showing water shortage in reservoirs

2.4 AIM:

To find the suitable sites for construction of small check dams across Kaveri River Basin.

2.5 OBJECTIVES:

- To calculate the slope, TRI, flow accumulation, drainage direction and land use land cover of Kaveri basin.
- To detect NDVI, NDWI, & soil texture in Kaveri basin.
- To estimate runoff depth in Kaveri basin.

2.6 DATA AND SCRIPTS USED (Table 1):

DATA	SOURCE
SRTM DEM 30m	DIVA-GIS
Precipitation data 2010-2020	CHRS Data Portal
Soil Texture	Bhuvan - ISRO
Land use Land Cover	Decadal Land Use and Land Cover Classifications across India.
NDVI & NDWI (Landsat-8)	Google Earth Engine
Curve Number table	International Geosphere-Biosphere Programme (IGBP) classification table
Runoff Depth	Curve Raster x Annual Rainfall

2.7 GOOGLE EARTH ENGINE SCRIPT :

DATA	SCRIPT	RESOLUTION

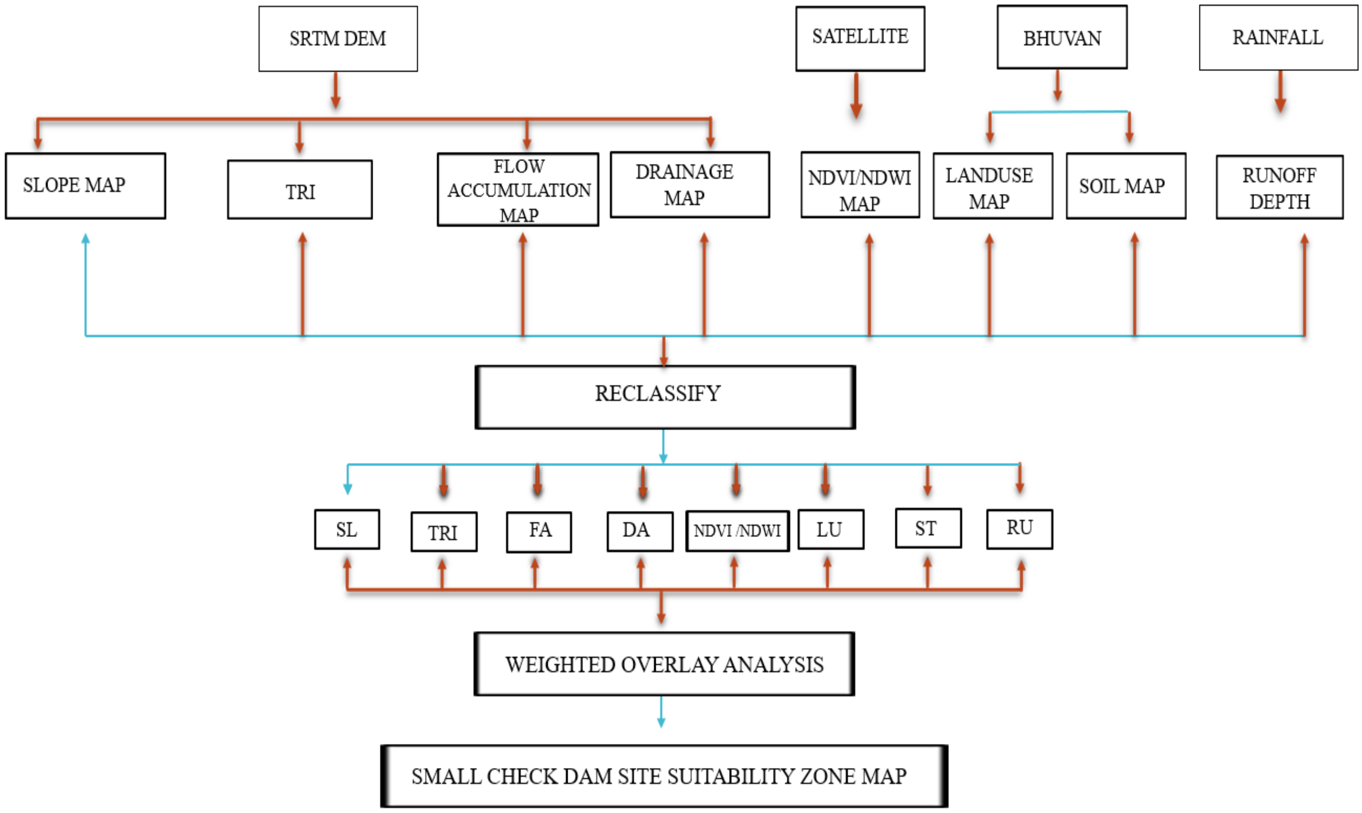
NDVI	var dataset =
	ee.ImageCollection('LANDSAT/LC08/C01/T1_8DAY_NDVI')
	.filterDate('2020-01-01', '2020-01-31');
	var colorized = dataset.select('NDVI');
	print(colorized)
	var ndvi=colorized.reduce(ee.Reducer.mean());
	var ndvi_crop=ndvi.clip(geometry);
	var colorizedVis = {
	min: 0.0,
	max: 1.0,
	palette: [
	'FFFFFF', 'CE7E45', 'DF923D', 'F1B555', 'FCD163', '99B718', '74A901',
	'66A000', '529400', '3E8601', '207401', '056201', '004C00', '023B01',
	'012E01', '011D01', '011301'
	],
	};
	Map.setCenter(78, 11, 7);
	Map.addLayer(ndvi_crop, colorizedVis, 'Colorized');
	Export.image.toDrive({
	image: ndvi_crop,
	description: "NDVI_2020",
	scale: 30,
	maxPixels:1e13,
	});
		30 meters

NDWI	var dataset = ee.ImageCollection('LANDSAT/LC08/C01/T1_8DAY_NDWI')
	.filterDate('2020-01-01', '2020-01-31');
	var colorized = dataset.select('NDWI');
	print(colorized)
	var ndwi=colorized.reduce(ee.Reducer.mean());
	var ndwi_crop=ndwi.clip(geometry);
	var colorizedVis = {
	min: 0.0,
	max: 1.0,
	palette: ['0000ff', '00ffff', 'ffff00', 'ff0000', 'ffffff'],
	};
	Map.setCenter(78.6569, 11.1271, 7);
	Map.addLayer(ndwi_crop, colorizedVis, 'Colorized');
	Export.image.toDrive({
	image: ndwi_crop,
	description: "NDWI_2020",
	scale: 30,
	maxPixels:1e13,
	});
		30 meters

2.8 Integrated Mission for Sustainable Development (IMSD) guidelines for construction of small check dams (Table 2):

Name of structure	% Slope type	Land use/ land cover	Soil type	Watershed area (ha)
Small Check dam	Nearly level to gentle slope (up to 5%)	Stream/River (Near agriculture land)	Clay soil	Up to 25

2.9 METHODOLOGY (Table 3) : Reference 6



2.10 DIGITAL ELEVATION MODEL (DEM):

A Digital Elevation Model (DEM) is a specialized database that represents the relief of a surface between points of known elevation. A digital elevation model is an ordered array of numbers that represent spatial distribution of elevations above some arbitrary data in the landscape (Moore et al 1993). DEM describes the elevation of any point in a given area in digital format.

The Digital Elevation Model of Kaveri basin varies from 3 meter to 2466 meter. DEM is represented in meters. DEM of Kaveri basin is used to find the criteria's like slope, TRI (Terrain Ruggedness Index), flow accumulation, and drainage direction. Reference 3

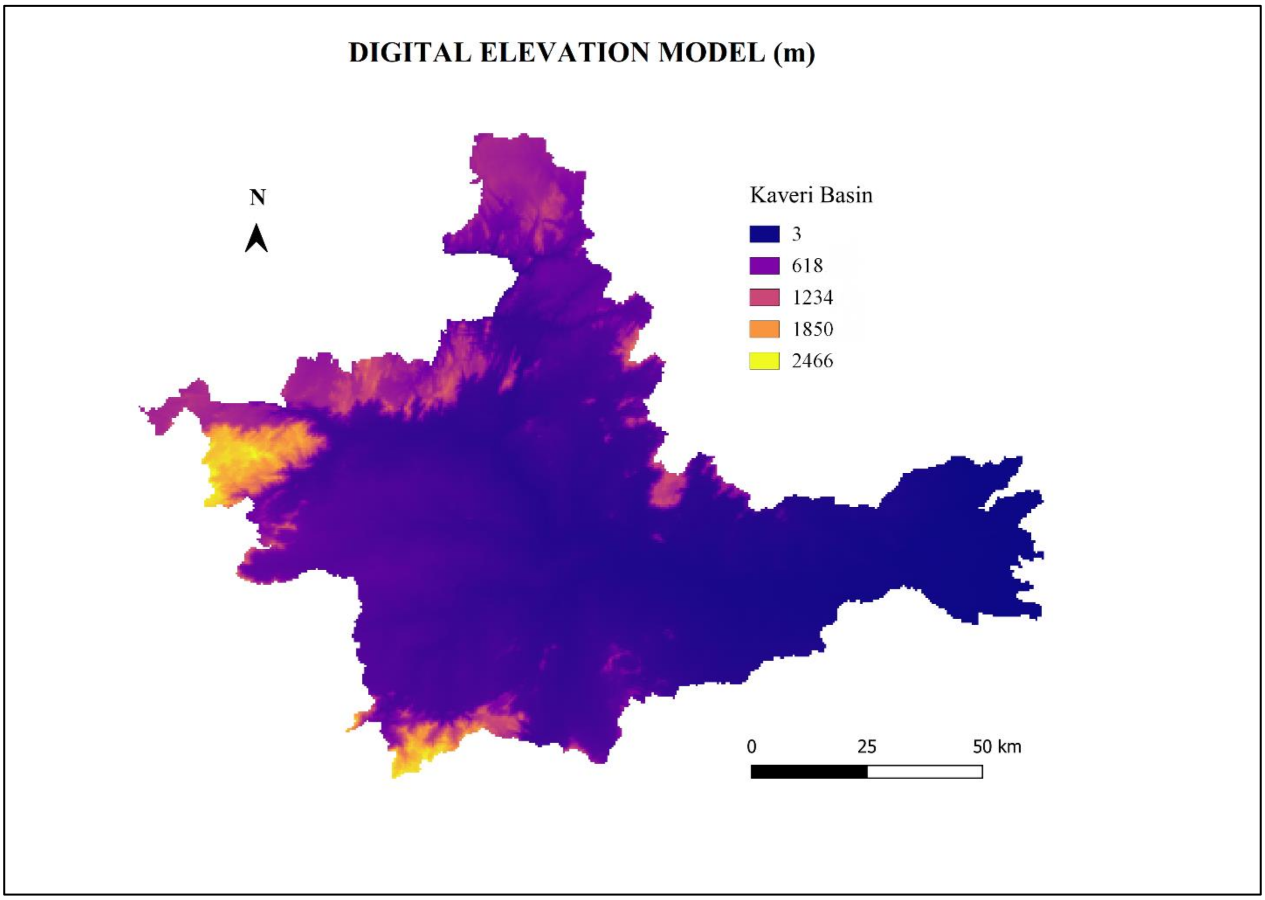


Figure 4 Digital Elevation Model of Kaveri River Basin (m)

2.11 SLOPE:

Slope is an important factor to be considered for the Check Dams Construction. The slope of land is an important geo spatial parameter for any geographic study. Slope refers to the elevation difference between two points of a unit distance. Slope is also referred to as gradient and is represented as percentage slopes or degree slopes. The slope area needs to be within the range of 50 % for check dam construction. The below slope map of the area which can be used for land development.

The figure below shows the slope from Kaveri DEM The slope map of Kaveri basin is prepared for slope analysis; we got a Slope range of 0 – 49.5184 percentage.

49.5184 percentage Represent areas with higher elevation.

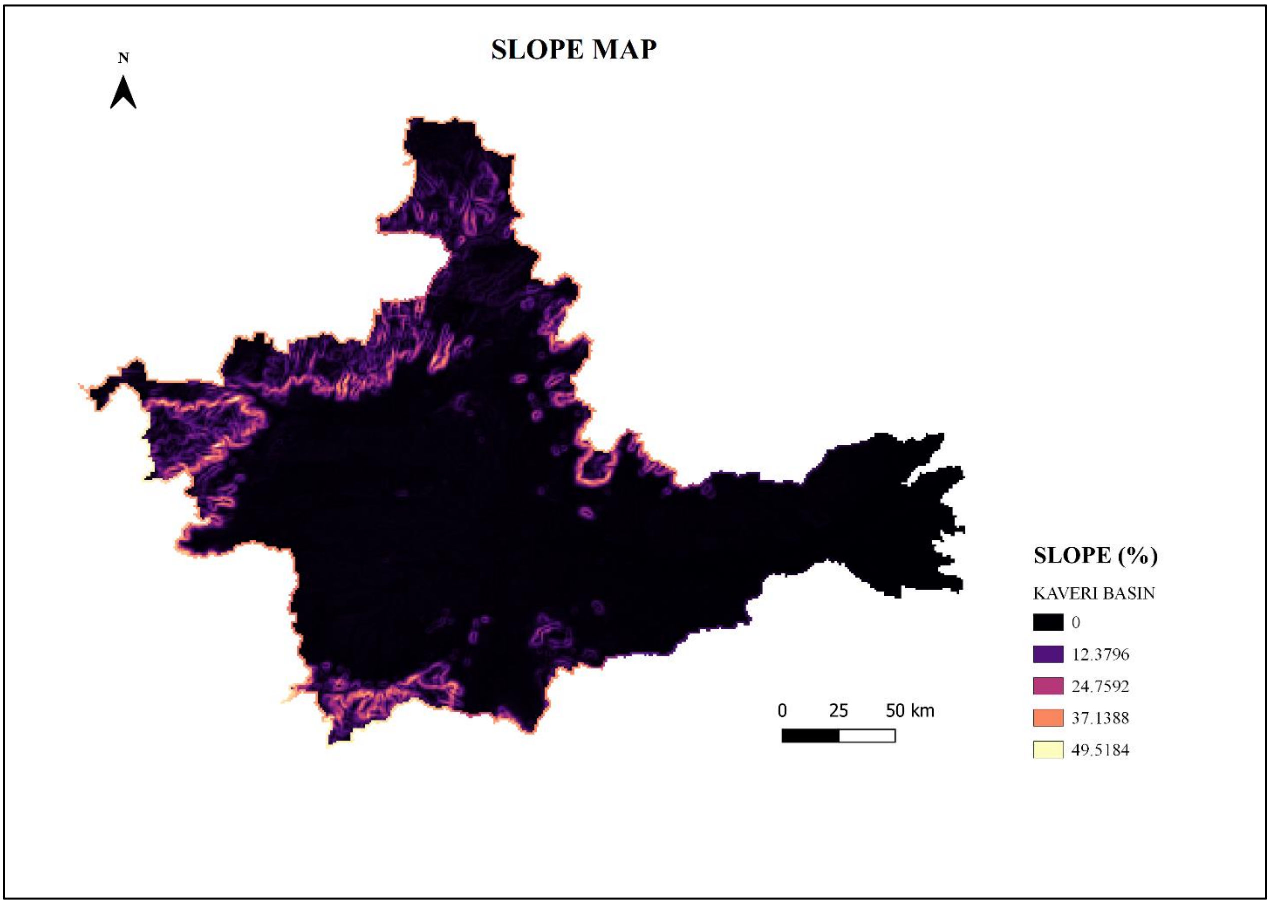


Figure 5 Slope Map in percentage

2.12 TRI - TERRAIN RUGGEDNESS INDEX:

The terrain ruggedness index (TRI) is a measurement to express the amount of elevation difference between adjacent cells of a digital elevation grid. While the slope gradient map provides data on the steepness of a hillslope (rise / run), terrain ruggedness index provides data on the relative change in height of the hillslope (rise), such as side of a canyon. Reference 5

TRI value consideration:

0-80 m	levelled terrain surface
81-116 m	nearly levelled surface
117-161 m	slightly rugged surface
162-239 m	intermediately rugged surface
240-497 m	moderately rugged
498-958 m	highly rugged
959-4367 m	extremely rugged surface

In below map , we got a TRI Range of 0 – 277.5 m.

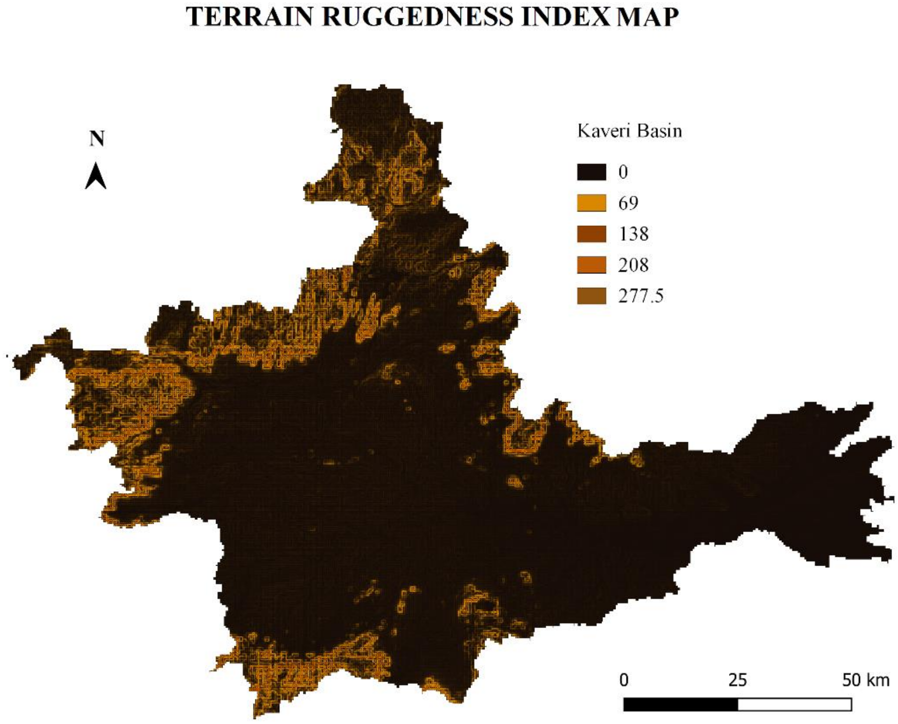


Figure 6 Terrain Ruggedness Index Map

2.13 FLOW ACCUMULATION:

The Flow accumulation operation performs a cumulative count of the number of pixels that naturally drain into outlets. This operation can be used to find the drainage pattern of a terrain. As input the operation uses the output map of the Flow direction operation.

The Flow Accumulation tool calculates accumulated flow as the accumulated weight of all cells flowing into each down slope cell in the output raster. If no weight raster is provided, a weight of

1 is applied to each cell, and the value of cells in the output raster is the number of cells that flow into each cell.

The result of flow Accumulation can be used to create a stream network by applying a threshold value to select cells with a high accumulated flow. Thus, calculation Shows the Flow Accumulation from Kaveri river basin. The Flow Accumulation map of Kaveri basin is prepared for flow accumulation analysis, we got a flow accumulation of 1 – 352905 Cubic. Meters.

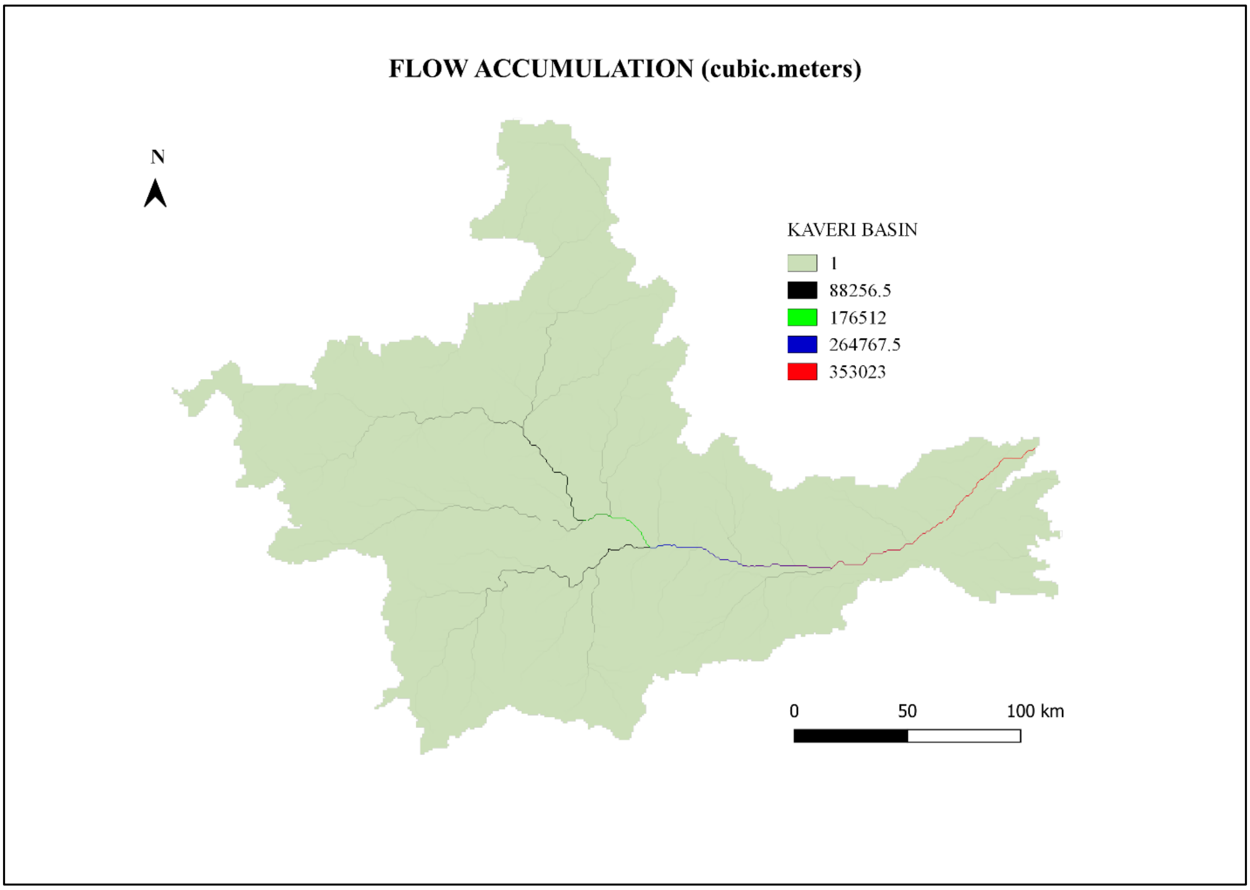


Figure 7 Flow Accumulation Map

2.14 DRAINAGE DIRECTION:

The drainage basin includes both the streams and rivers that convey the water as well as the land surfaces from which water drains into those channels. The drainage basin acts like a funnel - collecting all the water within the area covered by the basin and channelling it into a waterway. Drainage direction is the main direction of water run-off over the geographic area of interest.

Size of the drainage basin, complexity of its geological structure, and number of available observation places for the analysis of hydrogeological conditions. A combination of hydrogeological mapping and drainage analysis can form an important tool for planning of watershed development programmes.

The map shows the Drainage map of Kaveri River basin computed using DEM. The drainage map of Kaveri is prepared by watershed analysis, we have Obtained Drainage Range of -8 to 8. Positive values show the water run-off in the main streams of Kaveri basin and negative values represents the run-off from other sub-streams in Kaveri basin.

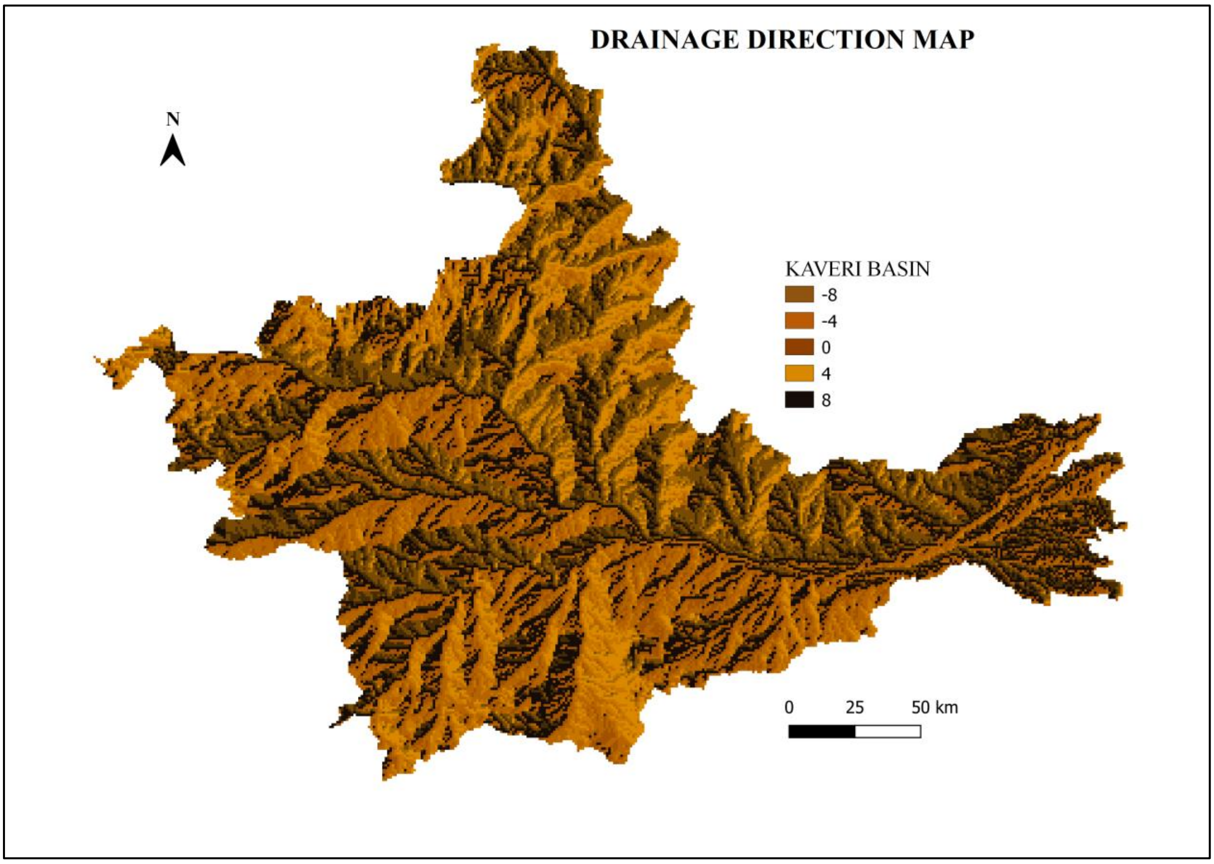


Figure 8 Drainage Direction Map

2.15 NDVI (NORMALIZED DIFFERENCE VEGETATION INDEX):

Normalized Difference Vegetation Index (NDVI) has also been taken as a criterion as this indicates presence of vegetation area and as it greatly helps to identify the zones, where the soil is having the capability of storing or carrying water in it.

Formula: In Landsat 8, **NDVI** = (Band 5 – Band 4) / (Band 5 + Band 4).

Values description: The value range of an NDVI is -1 to 1. Negative values of NDVI (values approaching -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Landsat-8 data source is used for NDVI.

Thus, calculation Shows the Normalized Difference Vegetation Index for Kaveri Basin from Google Earth Engine. The Normalized Difference Vegetation Index of Kaveri basin is prepared to find Normalized Difference Vegetation Index, We have Obtained Normalized Difference Vegetation Index Range of -0.6 to 0.8.

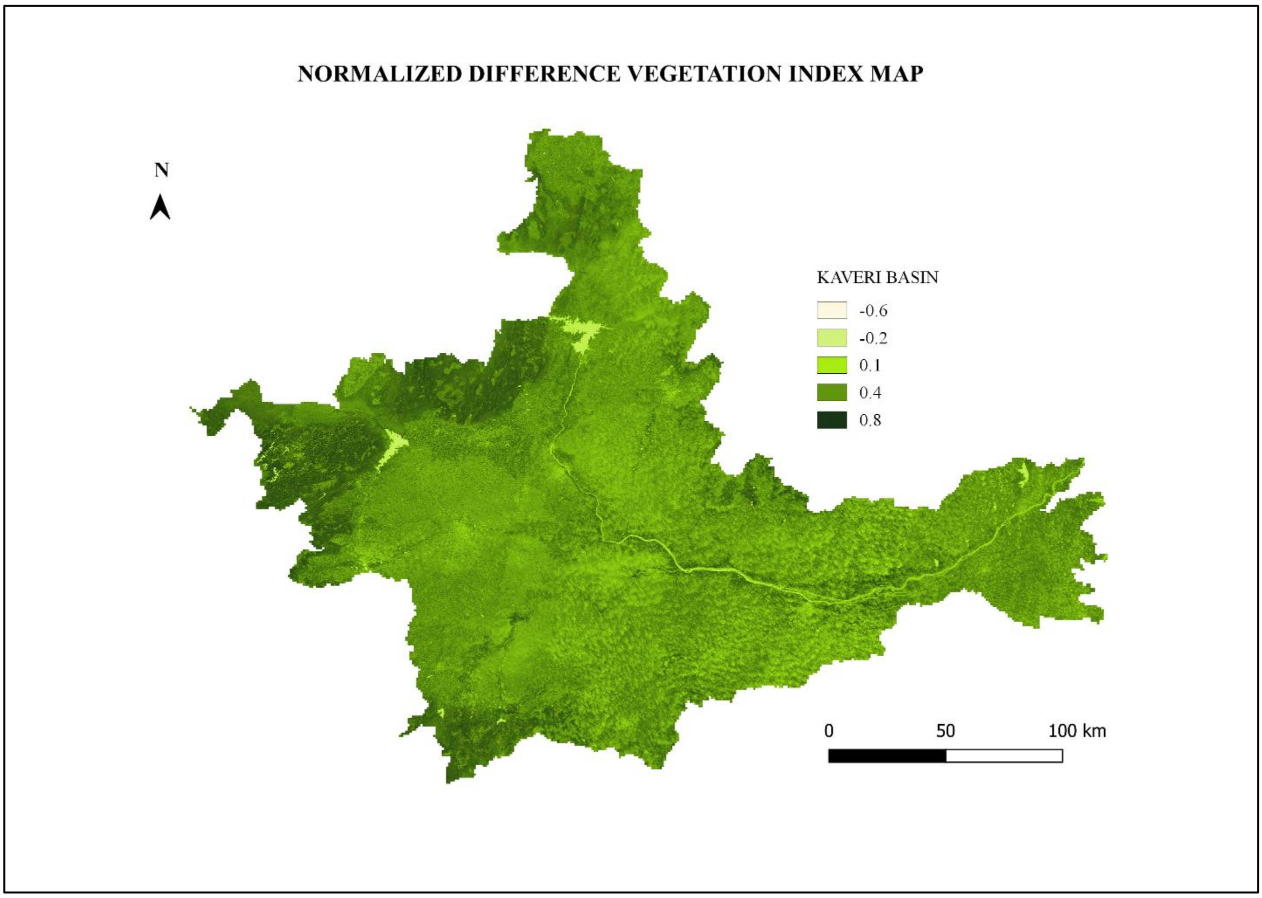


Figure 9 NDVI MAP

2.16 NDWI (NORMALIZED DIFFERENCE WATER INDEX):

The NDWI product is dimensionless and varies between -1 to +1, depending on the leaf water content but also on the vegetation type and cover. High values of NDWI (in blue) correspond to high vegetation water content and to high vegetation fraction cover.

Formula: In Landsat 8, **NDWI** = (Band 3 – Band 5) / (Band 3 + Band 5).

Values description: Index values greater than 0.5 usually correspond to water bodies. Vegetation usually corresponds to much smaller values and built-up areas to values between zero and 0.2. Landsat-8 data source is used for NDWI.

Thus, calculation Shows the Normalized Difference Water Index for Kaveri Basin from Google Earth Engine. The Normalized Difference Water Index of Kaveri Basin is prepared to find Normalized Difference Water Index, We have Obtained Normalized Difference Water Index Range of -0.2 to 0.7.

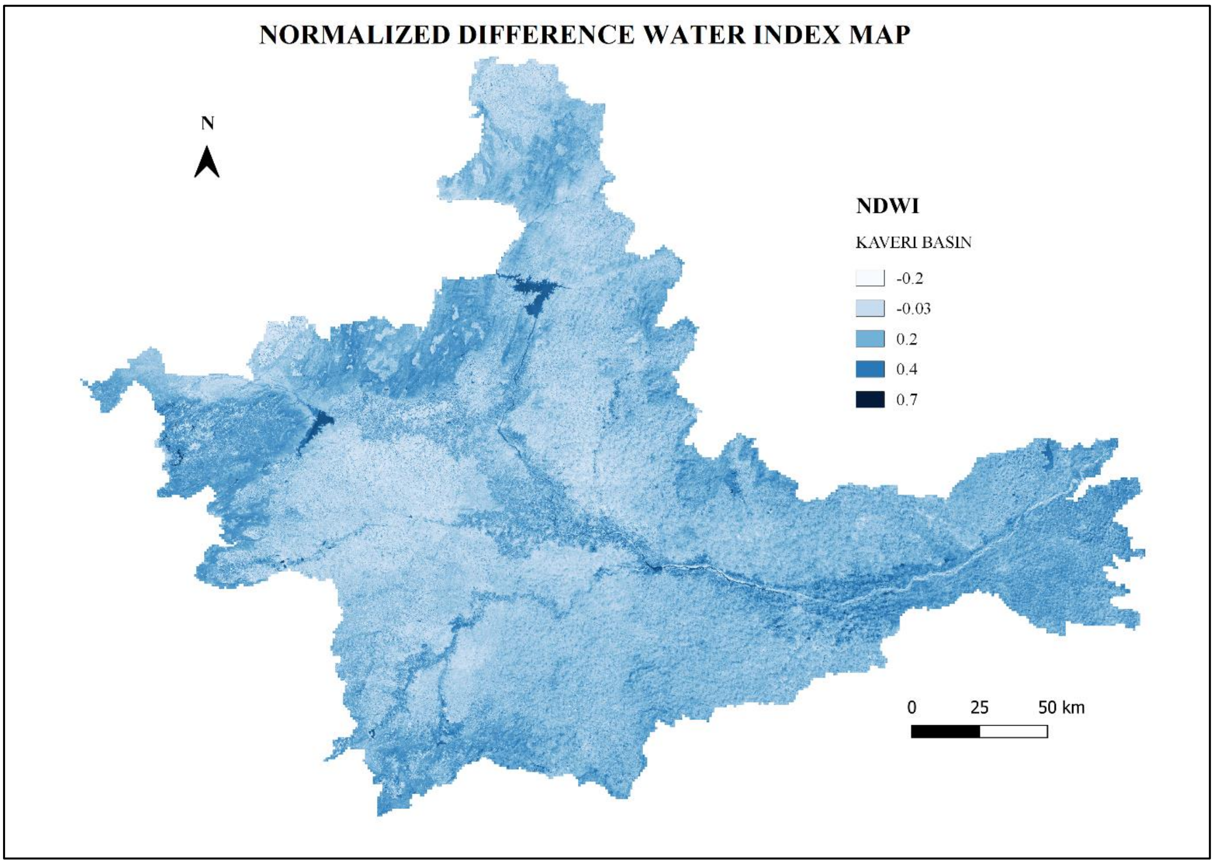


Figure 10 NDWI MAP

2.17 LAND USE LAND COVER (LULC):

In this study LULC is corelated with the runoff produced by annual precipitation in the Kaveri river basin. For example, denser vegetation is correlated with higher rates of interception and infiltration and thus lower runoff Land cover was obtained from satellite imagery (IGBP - Decadal Land Use and Land Cover Classifications across India, 2005) with a spatial resolution of 30 m. A maximum-likelihood algorithm was used to classify land cover using the means, variances, and covariances from the signature. Reference 4

Thus, we have 13 land classification for the Kaveri basin.

(Deciduous Broadleaf Forest, Cropland, Built-up Land, Mixed Forest, Shrubland, Barren Land, Fallow Land, Wasteland, Water Bodies, Plantations, Grassland, Evergreen Broadleaf Forest, Permanent Wetlands)

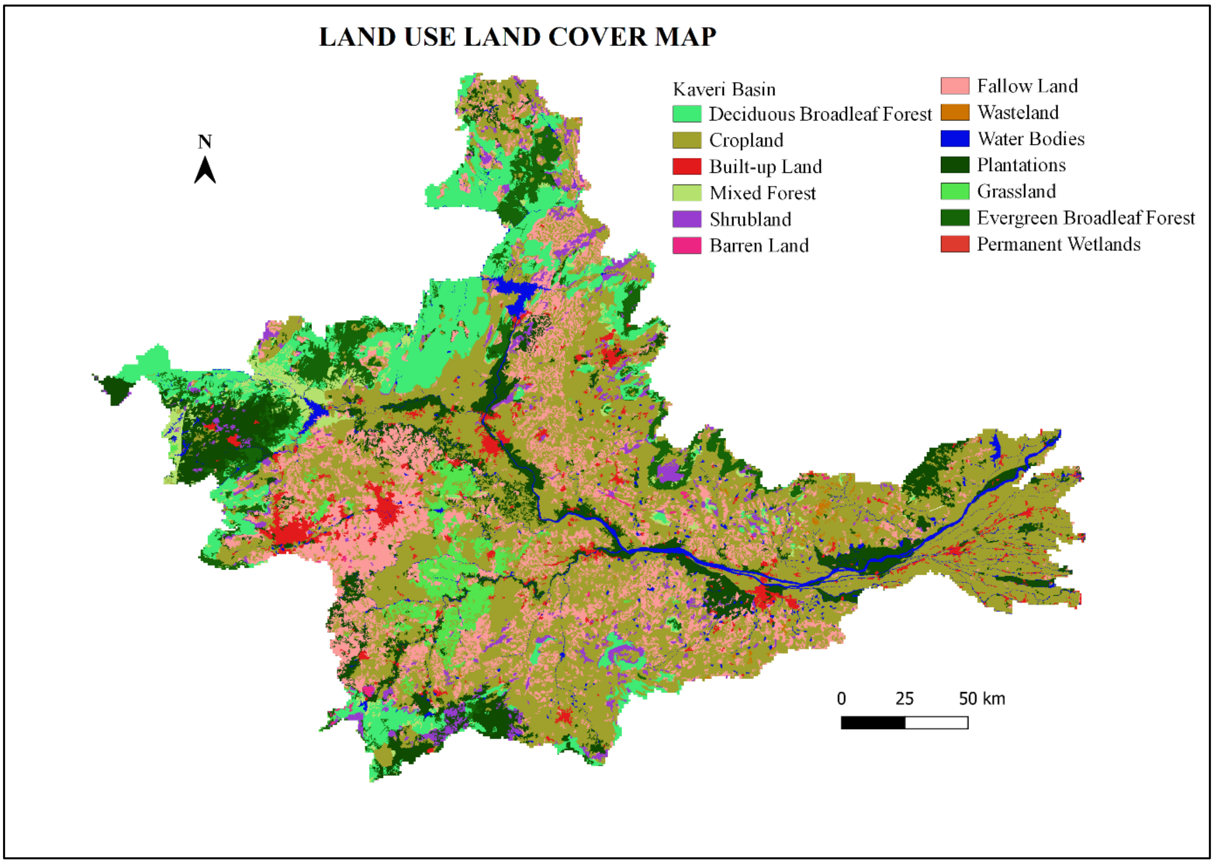


Figure 11 Land use Land Cover Map

2.18 SOIL TEXTURE:

Soil texture affects the rate of infiltration and the surface runoff. The textural class of a soil is determined by the layers of Clay Skeletal, Loamy, sandy and clay soil. Soils with high water-holding capacities are more suitable for Rainwater Harvesting (RWH). Sites with clay soil are the best for water storage due to the low permeability of clay and its ability to hold the harvested water.

Soil texture is likely a critical criterion for selecting sites for Small Check Dams, especially if the purpose is to preserve the water for human, livestock, and agricultural purposes.

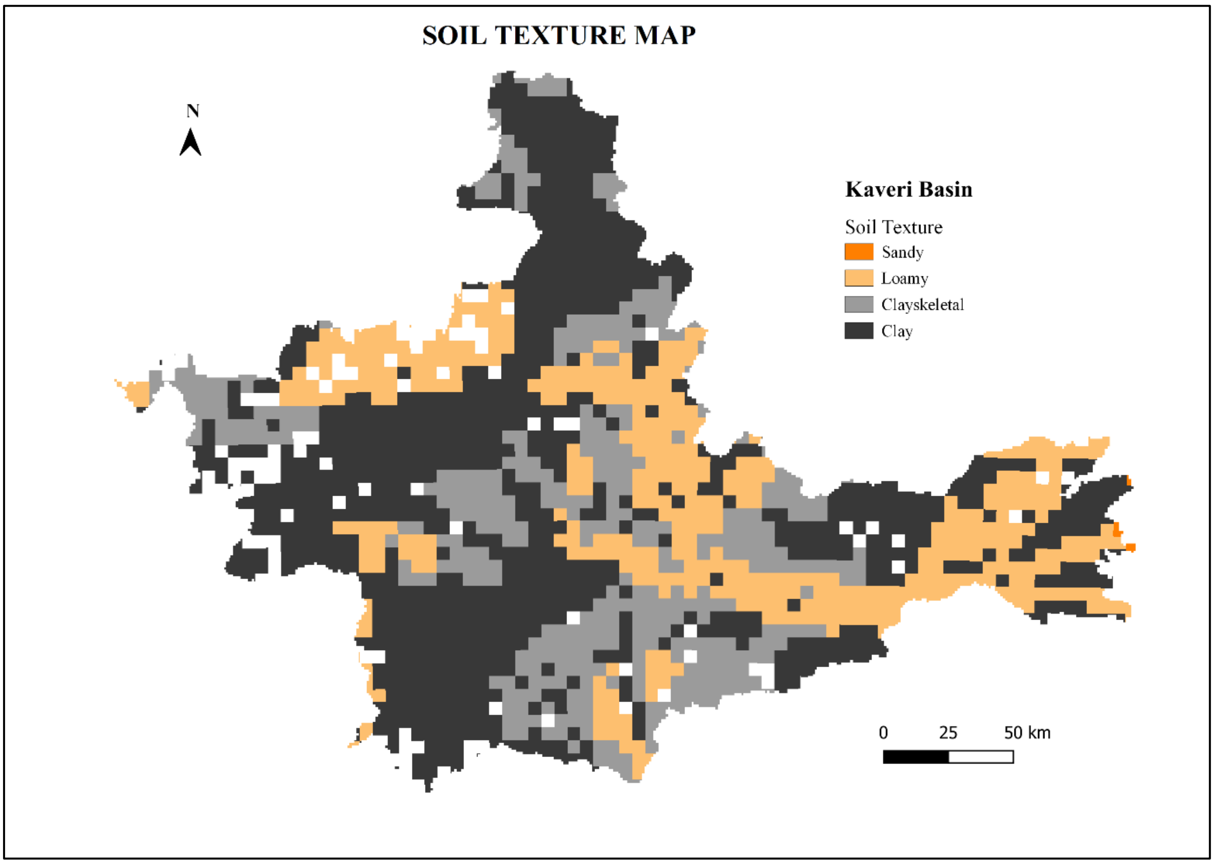


Figure 12 Soil Texture Map

2.19 RUNOFF DEPTH:

Runoff depth is an important criterion for selecting suitable sites of small check dams. Runoff depth is used to assess the potential water supply during runoff. The curve number (CN) provided by the Soil Conservation Service was used to estimate the runoff depth. CN is predictable from the effects of soil and land cover on rainfall/runoff. CN was estimated for each pixel for the study area using the land-cover and soil-texture maps. Reference 7

Runoff depth can be expressed as: Runoff = CN raster * Rainfall raster

i.e., in Curve number CN Approach where in a curve number gives you a %. If you multiply the % to the rainfall you get runoff E.g. for a city land the CN is 90% which means 90 mm out of 100 mm will go as runoff.

CN raster is derived by adding the CN attribute table to the land use land cover attribute table. CN varies from 0 to 100 and represents the runoff response to a given amount of precipitation. High CNs indicate that a large proportion of the rainfall will become surface runoff. The downstream area of the watershed had more runoff than the upstream area. Runoff depth of Kaveri basin varies from 551mm to 1249mm.

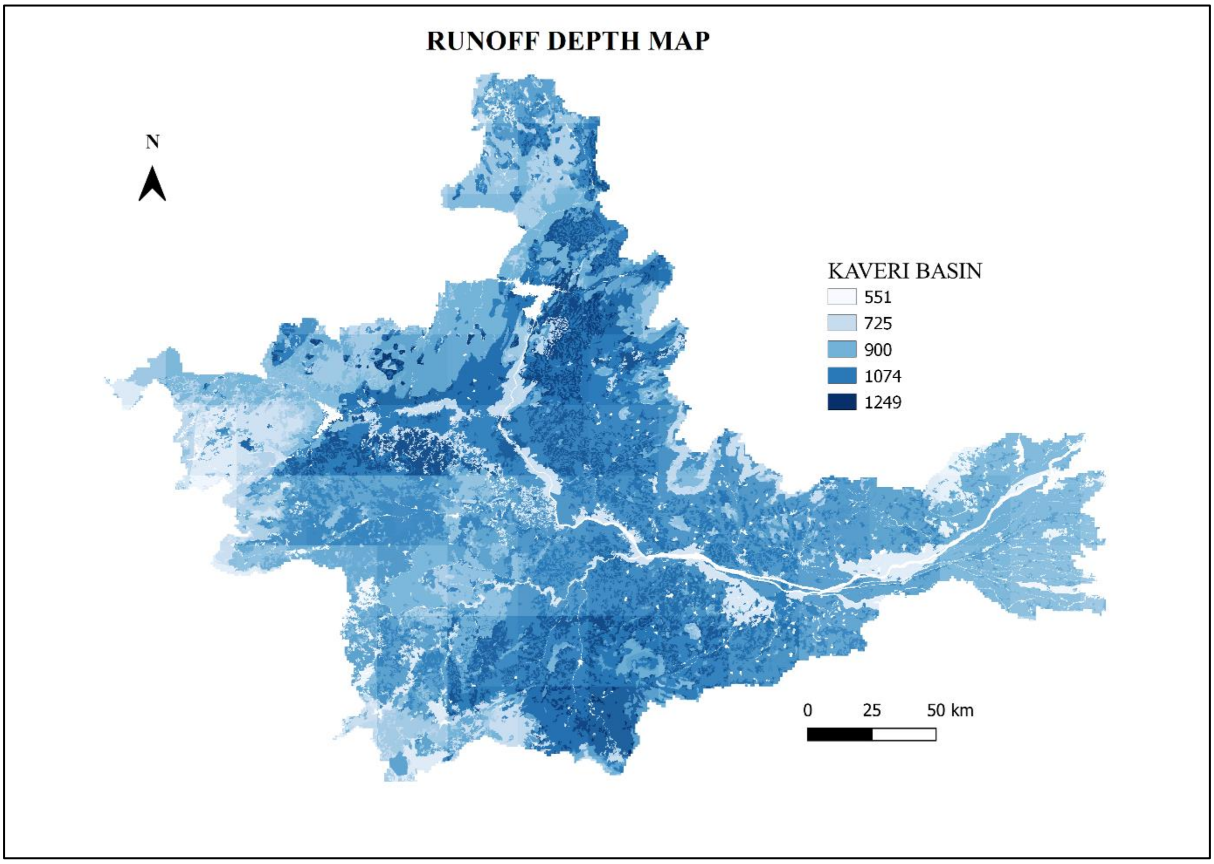


Figure 13 Runoff Depth Map

THE IGBP VEGETATION CLASSIFICATION AND CORRESPONDING CN VALUES TABLE WITH SOIL GROUPS (Table 4)

ID	IGBP classification definition	CNs assigned			
		A	B	C	D
1	Evergreen Needleleaf Forest	34	60	73	79
2	Evergreen Broadleaf Forest	30	58	71	77
3	Deciduous Needleleaf Forest	40	64	77	83
4	Deciduous Broadleaf Forest	42	66	79	85
5	Mixed Forest	38	62	75	81
6	Closed Shrublands	45	65	75	80
7	Open Shrublands	49	69	79	84
8	Woody Savannah	61	71	81	89
9	Savannah	72	80	87	93
10	Grasslands	49	69	79	84
11	Permanent Wetlands	30	58	71	78
12	Croplands	67	78	85	89
13	Urban and Built-up	80	85	90	95
14	Cropland/Natural Vegetation Mosaic	52	69	79	84
15	Snow and Ice	N/A	N/A	N/A	N/A
16	Barren or Sparsely Vegetated	72	82	83	87
17	Water bodies	N/A	N/A	N/A	N/A

2.20 RASTER RECLASSIFICATION (Table 5):

Reclassification is the process of reassigning a value, a range of values, or a list of values in a raster to new output values. Reclassification is an important process when you need to combine dissimilar data using a common value scale. For example, In the deer habitat model, additional raster's of soil type, slope, aspect, and vegetation might also be reclassified on a suitability scale of 1 to 4. These raster's, which originally held values belonging to different measurement scales, could then be added to find the most suitable site. Hence, a unified standard for preference value is assigned by reclassification.

A linear function is used to assign preference value to different classes of all criteria. The maximum preference value used for every criteria is 100 as a total weightage for all the raster's in this study. Individual preference values are adjusted accordingly. Reference 8

RECLASSED VALUE
4 – HIGH
3 – MODERATE
2 - LOW
1 – VERY LOW

RECLASSED SLOPE
0 through 5 = 4

5 through 10 = 3
10 through 30 = 2
30 through 49.5184 = 1

RECLASSED TRI
0 through 100 = 4
101 through 140 = 3
141 through 200 = 2
200 through 227.5 =1

RECLASSED DRAINAGE
-8 through -4 = 1
-4 through 0 = 2
0 through 4 = 3
4 through 8 = 4

RECLASSED SOIL TEXTURE
Clay = 4
Clay Skeletal = 3
Loamy = 2
Sandy = 1

RECLASSED RUNOFF DEPTH
551 through 725 = 1

725 through 900 = 2
900 through 951 = 3
951 through 1249 = 4

RECLASSED RUNOFF DEPTH
Deciduous Broadleaf Forest = 4
Cropland = 3
Built-Up Land = 2
Mixed Forest = 4
Shrubland = 4
Barren Land = 3
Fallow Land = 2
Wasteland = 1
Water Bodies = 1
Plantations = 3
Grassland = 3
Evergreen Broadleaf Forest = 3
Permanent Wetlands = 2

RECLASSIFIED NDVI in Raster calculator
(("NDVI KAVERI@1" <= 0) * 1) + ((("NDVI KAVERI@1" > 0) AND ("NDVI KAVERI@1" <= 0.25)) * 2) + ((("NDVI KAVERI@1" >0.25) AND ("NDVI KAVERI@1" <= 0.5)) * 3) + (("NDVI KAVERI@1" > 0.5) * 4)

RECLASSIFIED NDWI in Raster calculator

(("NDWI KAVERI@1" <= 0) * 1) + ((("NDWI KAVERI@1" > 0) AND ("NDWI KAVERI@1" <= 0.25)) * 2) + ((("NDWI KAVERI@1" >0.25) AND ("NDWI KAVERI@1" <= 0.5)) * 3) + (("NDWI KAVERI@1" > 0.5) * 4)

2.21 WEIGHTED OVERLAY ANALYSIS (Table 6):

Weighted overlay is usually done for the suitability analysis. It uses several weighted raster layers for the calculation. GIS uses Boolean logic to perform overlay analysis. For each input layer we have to assign the weight value. This weight value is multiplied to the input layer. Then you have to sum all these weighted layers to generate the final output map. Reference 8

Suitability of dam sites is calculated as weighted summation of different criteria layers using QGIS Raster calculator tool. Weightage assigned to different criteria's are shown below. Excluding the water body and built up area, which has the classes value 1,is multiplied with the summation result. Then, weight is assigned to each criteria to find the level of suitability.

CRITERIA NO	CRITERIA	WEIGHT
C1	TRI	12
C2	SLOPE	14
C3	RUNOFF DEPTH	15
C4	NDWI	10
C5	NDVI	06
C6	LULC	10
C7	FLOW ACCUMULATION	11
C8	SOIL TEXTURE	12
C9	DRAINAGE DIRECTION	10
TOTAL WEIGHT CRITERIA		100

2.22 SITE SUITABILITY MAP:

After assigning weightage to all the layers , the weighted overlay analysis is done using the SAGA tool in the processing toolbox and also to cross-check the result, the same weighted overlay analysis was done using a Raster calculator.

The site suitability map shows the areas which are suitable for future construction of small check dams. Here the Kaveri basin is divided into four zones (i.e. High suitability zone, Moderate suitability zone, Low suitability zone and Extremely low suitability zone). These zones are considered according to the reclassified criteria and weighted overlay analysis.

The high suitability area like Dindigul, Karur, Erode, Salem, etc. are considered as the most suitable sites for future construction of small check dams and the moderate suitability zones like Tirupur, Coimbatore, Tiruchirappalli, etc. are also considered for construction of small check dams with some limitations.

Low suitability and Extremely low suitability zones like Thanjavur, Nagapattinam, Kumbakonam are not suitable for small check dams. So those zones are not considered for construction of small check dams' construction.

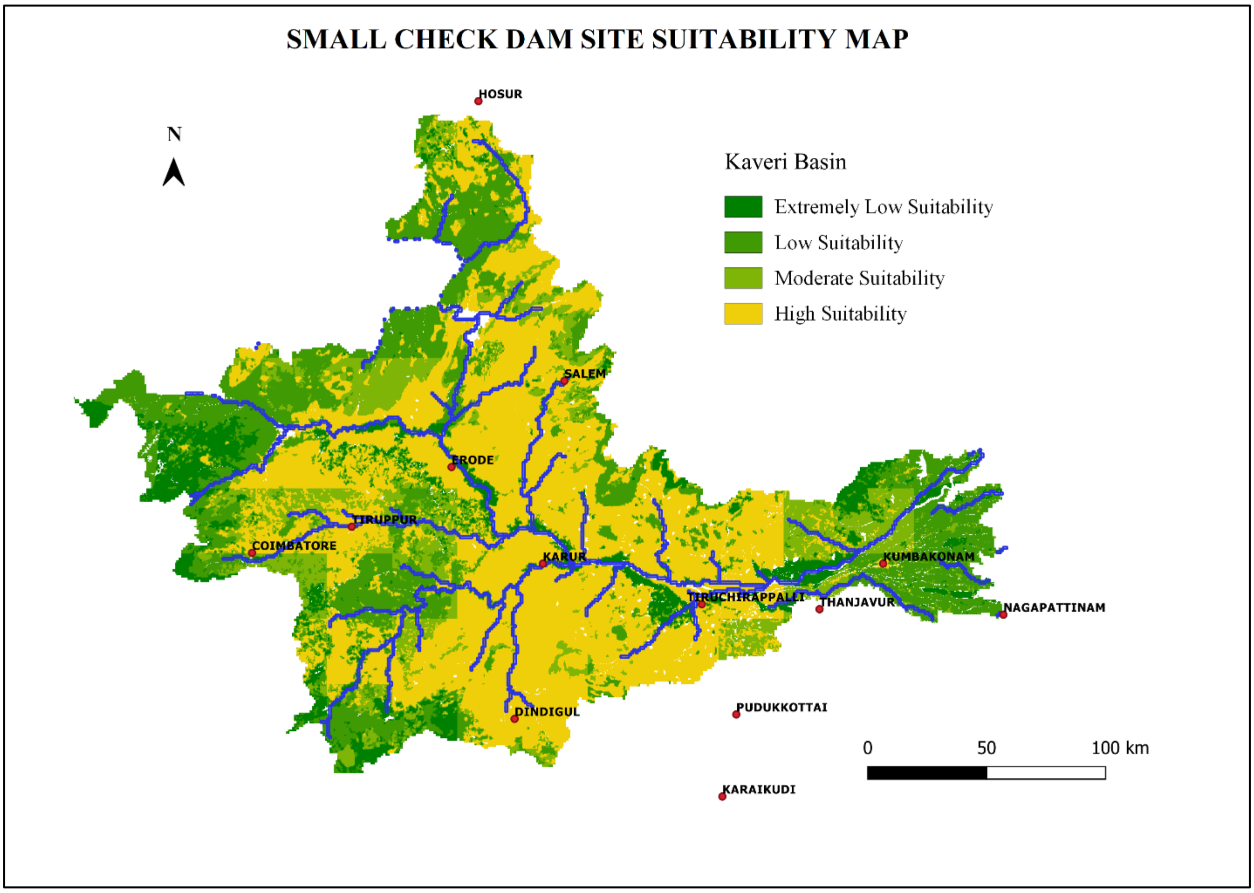


Figure 14 Small Check Dam Site Suitability Map

2.23 CONCLUSION:

The high suitability zone is the most comfortable area to construct small check dams and moderate suitability zone can also be considered for construction of small check dams but when compared to high suitability zone, the construction of small check dams will be little more costly in moderate suitability zone.

Other two zones i.e. low suitability and extremely low suitability are not suitable for construction of small check dams because those zones don't favour the construction of small check dams.

Cost for construction of small check dams will be from 5 lakhs to 8 lakhs based on the site of construction. Small check dams which cost below one lakh rupees are built across streams to prevent the seasonal water from flowing away into the sea. Their capacity to conserve water is from 0.01 - 0.1 mcft (million cubic feet).

The selected zones for small check dam sites could be effectively used for storage of water for use in the winter season when the precipitation decreases. The high suitability zone was very effective for the construction of the low-cost small check dam, to arrest mud flows. Similarly, the second zone would also play a role in checking dams for initially storing the water during monsoon season. The incorporation of high-resolution DEM to enhance the accuracy of results should be done. Moreover, data about highly precise geological faults, as well as formations, are also required. For effective planning of small check dam’s construction, the rainfall, soil map and discharge data can be used. In addition, for future studies, the incorporation of population maps is also suggested in order to ensure maintenance for construction. The present study has been done for small check dams, but the technology may be applied for selection of sites for bigger dams also.

4 Spoken Tutorial Project

4.1 Introduction:

The Spoken Tutorial project is funded by MHRD government of India. The main of this project is creation of spoken tutorials on Free and Open Source Software (FOSS) in various Indian languages. This will for benefit the learners to learn in their vernacular language.

The Spoken Tutorial team creates the video tutorial series videos in majority of Indian languages. The Spoken Tutorials are made by various experts/professionals of that field.
The tutorials are classified into various levels of expertise
i.e. beginners' level, Intermediate level, Advanced level. Reference 9

Figure 15
Spoken Tutorial project Logo

4.2 Contribution for the Spoken Tutorial Project:

The tutorial creation procedure itself is very innovative and informative. Working for the spoken tutorial project taught me more on how to create content for learning using video tutorials. I have contributed the scripts for the following topics for the creation of Spoken Tutorials :

1. Image Stacking
2. Image Clipping
3. False Colour Composition
4. Unsupervised Classification
5. Supervised Classification

5 Reference:

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