The Pharma Innovation Journal 2022; SP-11(1): 270-275

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(1): 270-275

www.thepharmajournal.com
Received: 04-11-2021
Accepted: 06-12-2021

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Site selection for water harvesting structures in Tetavali watershed using remote sensing and GIS

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Abstract
Tetavali watershed of Dapoli taluk in Ratnagiri district is undertaken the study for selection of water harvesting structures using remote sensing and GIS technology. The SRTM DEM (30m) is used to prepare thematic layers viz slope map, drainage map, drainage density map. LANDSAT-8 image is used to prepare the Land use/ land cover map of study area. Lithology map and Geomorphology map is downloaded from Bhukosh –geological survey of India portal. Soil texture map of Tetavali watershed is prepared using soil texture data available with CAET, Dapoli. The weightages are assigned to the layers as per their contribution to suitability and ranking is allotted to each thematic layer. Integration of all thematic layers with assigned ranking gave suitability map of study area. Study found thirteen suitable structures for water harvesting. 6 farm ponds, 3 check dams, 2 percolation ponds, 1 cement nala bund and 1 earthen nala bund found suitable with 278.36 ha area suitable for water harvesting structure construction and 103.64ha of watershed not suitable for water harvesting structures.

Keywords: site selection, water harvesting structures, remote sensing, GIS

Introduction

Water is one of the important natural resource for survival of living being and for economic growth and development (Sinha and Narayan, 2015) [3]. Rainfall is the primary source of water, hence use of such valuable natural resource should be done very precisely.

Watershed is considered as ideal unit for land and water resource management and planning. Water harvesting is the collection of surface runoff which further can be used for agriculture and domestic purpose. Selection of site for construction of harvesting structures in a watershed need to check for different parameters of watershed as, location, slope of land, soil type, intensity of rainfall, land use land cover, drainage, stream flow, etc.

The Remote Sensing and GIS techniques have become valuable tools and could be used for watershed conservation, management and planning. This technique provides a reliable database on resources, while GIS technique is not only help to store, retrieval and analysis the spatial data but also facilitate spatial analysis through intersection and manipulation process. Integrated analysis of all thematic maps and their respective weightage in GIS platform can be utilized to prepare a map which represents the potential zones (Varade *et al*., 2012; Anbazhagan *et al*., 2005) [4, 1].

The present study Covers Tetavali watershed of Dapoli from Ratnagiri district, Maharashtra. The Konkan region of Maharashtra is bestowed with rich natural resources of soil, water and vegetation and receives about 3000 to 4000 mm of rainfall. Tetavali watershed have sandy loam texture of soil. To combat the water scarcity problem it became necessary to study for selection of water harvesting structures in Tetavali watershed.

Study area

Tetavali village is situated between 16^0 70' 33” N latitude and 73^{0}52’70”E longitude which covered area 381.64 ha. Soil texture of study area is sandy loam. 50.27% of total area of Tetavali watershed is covered with Forest. The field survey in this area becomes very time and manpower consuming task. So the RS and GIS is used to reduce the time and manpower requirement.

Materials and Method

1. SRTM DEM image data was collected from ISRO geoportal Bhuvan.
2. Control points for Geo-referencing were collected by using GPS locator and Village boundary map was taken from Tetavali village.

3. LANDSAT-8 image was downloaded from Earth explorer U.S. geological survey
4. Lithology and Geomorphology Data was procured from Bhukosh –geological survey of India portal
5. The different soil parameters such as sand, silt, clay were collected from Department of soil and water conservation engineering, college of agriculture engineering and technology, Dapoli.

Result and Discussion

Drainage Density Map

The drainage density of study area is created using DEM downloaded from Bhuvan, ISRO Geoportal, which gives idea about infiltration capacity of soil. Drainage density ranges from 1 to 13.37 km/sq.km. The drainage density of study area was divided into 5 classes of very poor (>9), poor (3-9), moderate (3-6), good (1-3), very good (0-1) and found 2.93%, 9.33%, 6.80%, 2.81%, and 78.13% area respectively for each class of drainage density.

Slope Map

Slope is important parameter for identification of sites of water harvesting structures. Slope map (%) of Tetavali watershed was prepared in Arc GIS 10.2 using Digital elevation model (DEM).slope of study area ranges from 0 to 32% in watershed. Study area was divided into 5 classes as gentle (0-5%), moderately gentle (5-10%), steep (10-15%), moderately steep (15-20%) and very steep slope (>20%) and found area of 36.55%, 36.53%, 15.67%, 7.67%, and 3.58% respectively under 5 classes of slope.

Land use Land cover Map

For sustainable utilization of land ecosystem, it is important to know natural characteristics of the land, extent and location, quality, productivity, suitability limitations in different land uses. This study used land use/land cover map created from LANDSAT 8 satellite image, downloaded from Earth explorer USGS portal (https://earthexplorer.usgs.gov/). The Tetavali watershed area was divided into 4 classes as forest, Agriculture, barren land and build up area and covers 50.27%, 26.4%, 9.67% and 13.66% of area respectively.

Geomorphology Map

The study area is divided into three geomorphological classes moderately dissected plateau, Pediment pediplain complex, water body and covers 32.19%, 67.19% and 0.62% of total area respectively. The Tetavali watershed is dominated by Pediment pediplain complex.

Lithology Map

The description of the chemistry, mineral composition and physical properties of rock is known as lithology. Tetavali watershed divided into two type of lithological class as basalt and Laterite. The Tetavali watershed is dominated by basalt 337.85 ha (88.44%), followed by Literate 44.15 ha (11.56%).

Soil Map

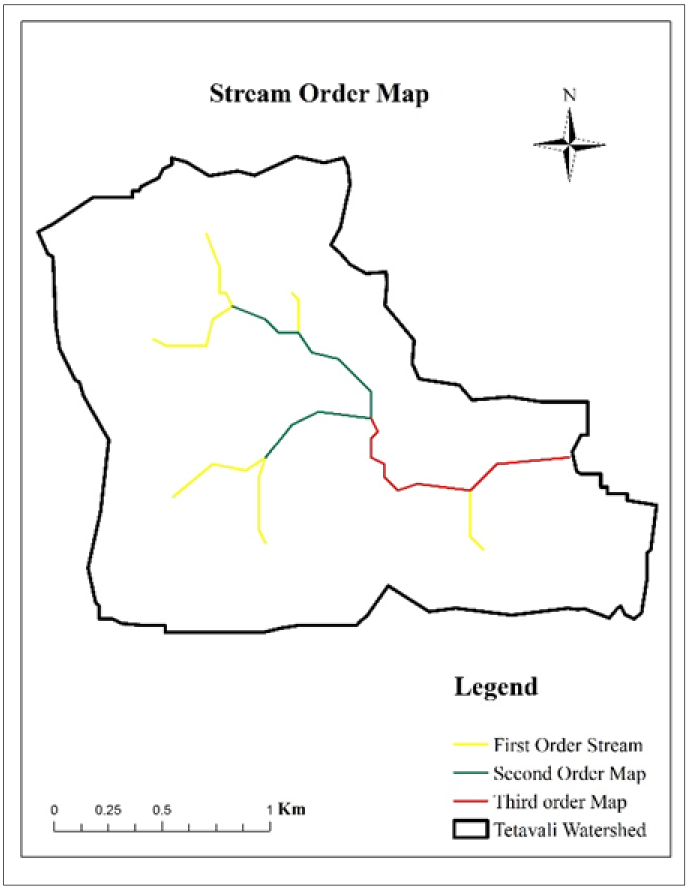
The soil texture of the study area was determined using data from department of Soil and Water Conservation Engineering, CAET, Dapoli. The study area found sandy Loam texture all over the watershed.

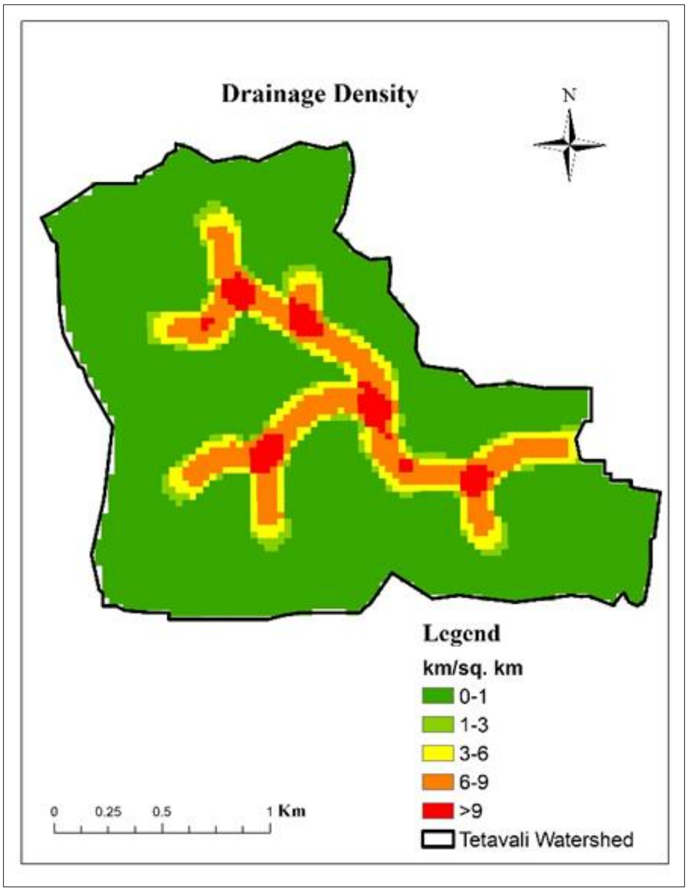
Weightages assigned

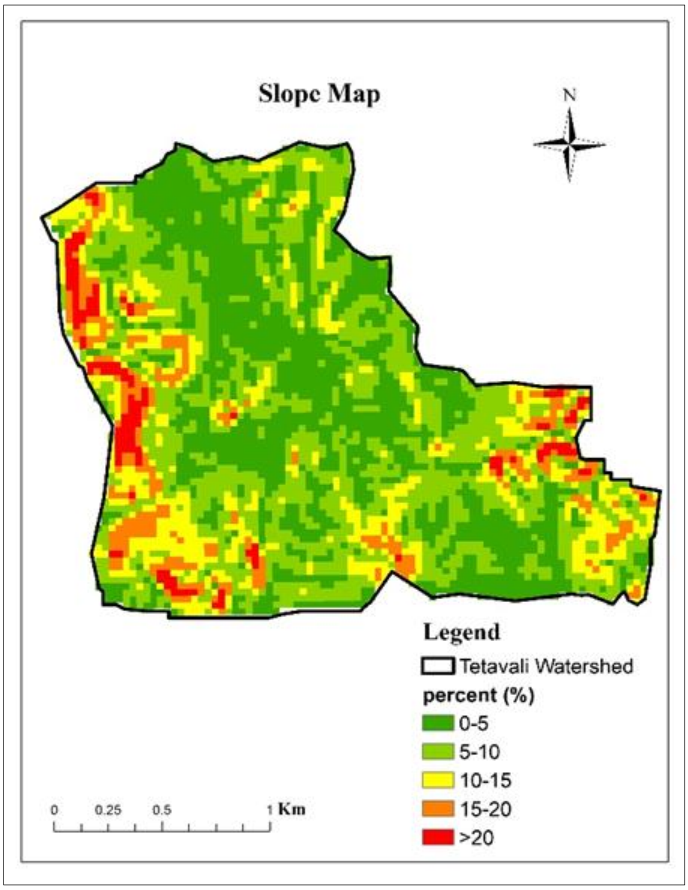
The weighted overlay is performed to find out potential zones from the watershed by assigning weightages to different layers formed in Arc GIS. The weightages are assigned as given in table (Waikar, 2014 and Bhange *et al.* 2016) [5, 2].

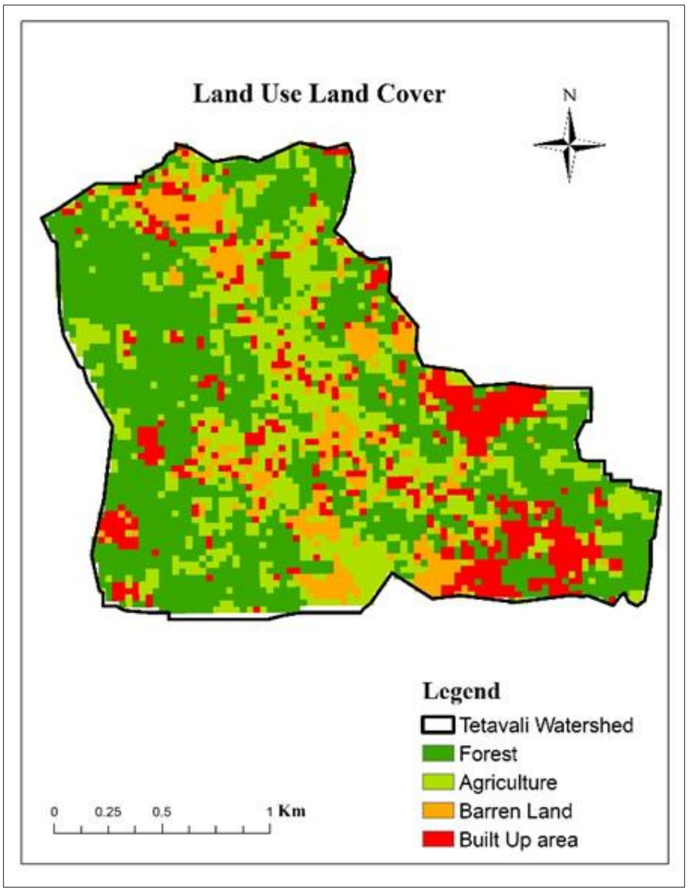
Table 1: Weightages assigned

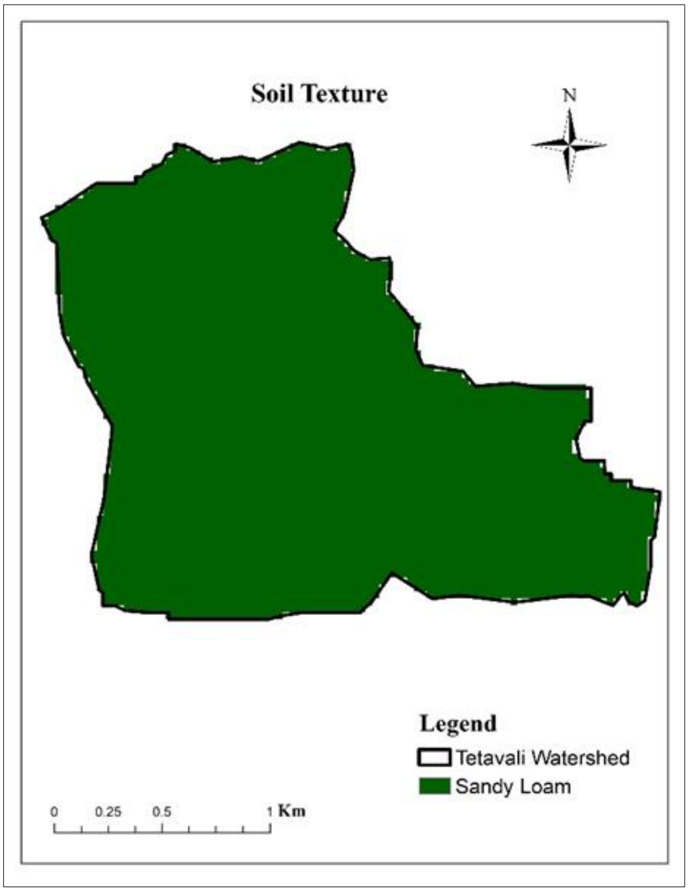
Layer	Weight Assigned (%)	Feature Classes	Rank
Geomorphology	30	Moderately Dissected Plateau	2
		Pediment Pedi plain Complex	5
		Water body/ River	4
Lithology	25	Basalt	5
		Laterite	3
Slope	10	Very Good (0-5%)	5
		Good (5- 10%)	4
		Moderate (10 – 15%)	3
		Poor (15 – 20%)	2
		Very poor (> 20%)	1
Drainage Density	20	0 – 1	5
		1 – 3	4
		3 – 6	3
		6 – 9	2
		>9	1
Land Use Land Cover	10	Forest land	3
		Agriculture Land	4
		Barren Land	2
		Build Up Area	1
Soil	5	Sandy Loam	5

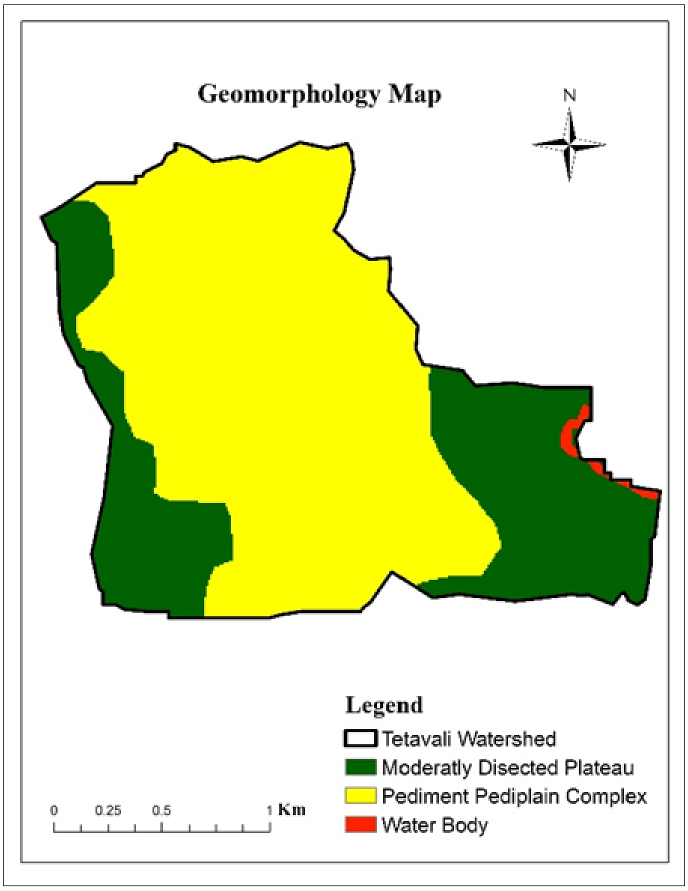

Stream Order Map
N
Legend
First Order Stream
Second Order Map
Third order Map
Tetavali Watershed
0 0.25 0.5 1 Km

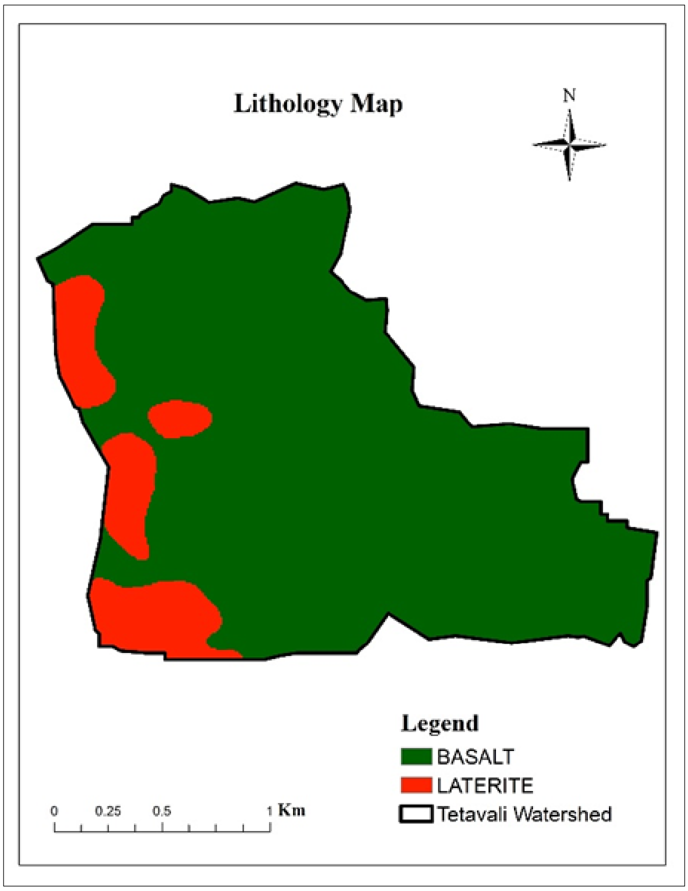

Drainage Density
N
Legend
km/sq. km
0-1
1-3
3-6
6-9
>9
Tetavali Watershed
0 0.25 0.5 1 Km

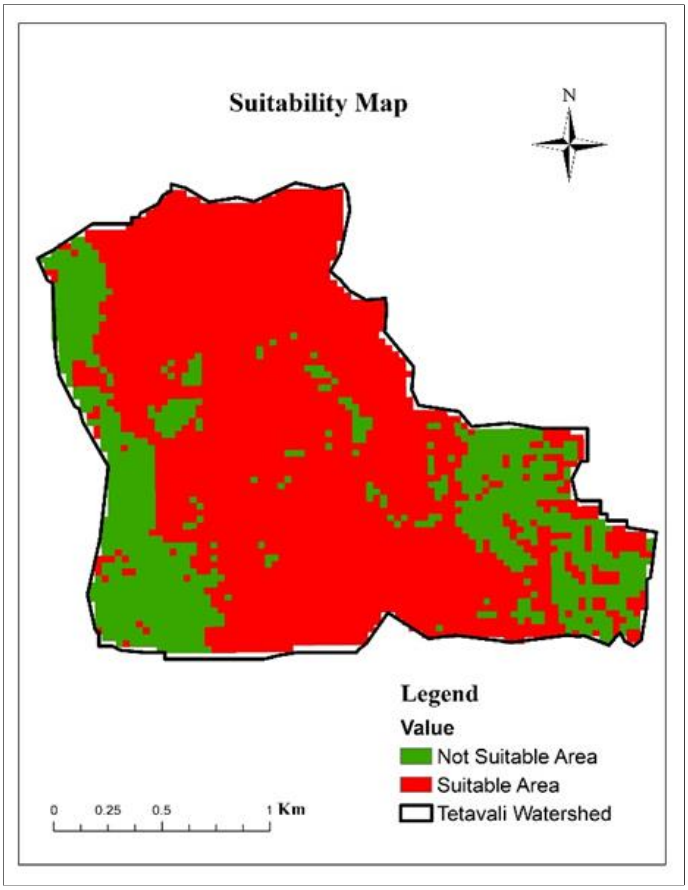

Slope Map
N
Legend
Tetavali Watershed
percent (%)
0-5
5-10
10-15
15-20
>20
0 0.25 0.5 1 Km

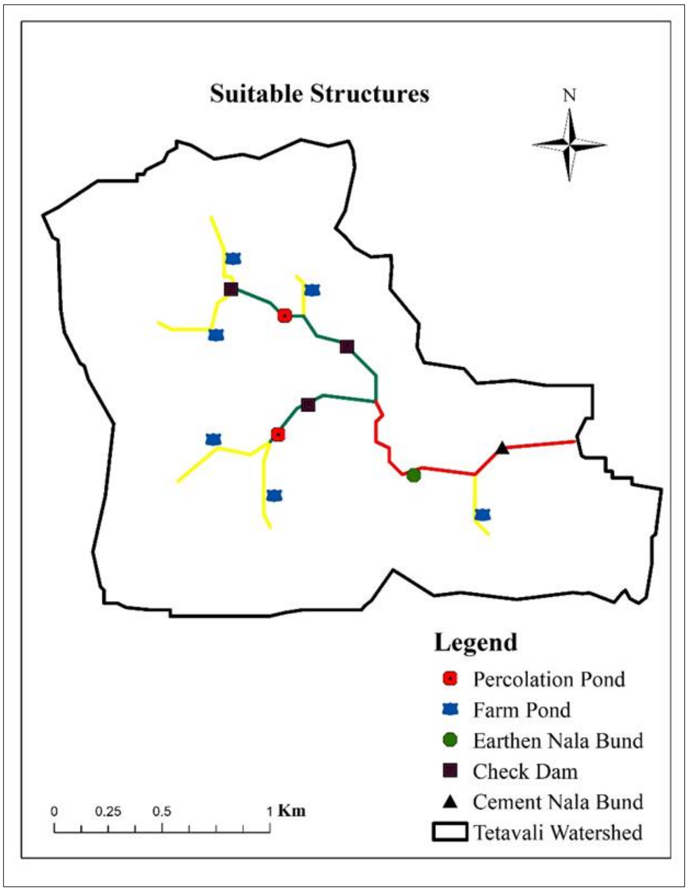

Land Use Land Cover
N
Legend
Tetavali Watershed
Forest
Agriculture
Barren Land
Built Up area
0 0.25 0.5 1 Km


Soil Texture
N
Legend
Tetavali Watershed
Sandy Loam
0 0.25 0.5 1 Km


Geomorphology Map
N
Legend
Tetavali Watershed
Moderatly Disected Plateau
Pediment Pediplain Complex
Water Body
0 0.25 0.5 1 Km


Lithology Map
N
Legend
BASALT
LATERITE
Tetavali Watershed
0 0.25 0.5 1 Km


Suitability Map
N
Legend
Value
Not Suitable Area
Suitable Area
Tetavali Watershed
0 0.25 0.5 1 Km



Site Suitability Analysis

Site Suitability Analysis

Water harvesting sites in study area was selected on the basis of integration of thematic maps. The suitability of area suitable for water harvesting structures was done on the basis of ranking assigned. The Rank 1 was assigned for not suitable area and 2 for suitable area. And study after integration of all the thematic layers found 278.36 ha (72.86%) area suitable for water harvesting structure construction and 103.64ha (27.14%) of watershed not suitable for water harvesting structures.

Water harvesting structures

Water harvesting is collection of runoff for its productive use. Effective water harvesting can done with suitable water harvesting structures. Proper land management practices and Suitable structures can help to reduce surface runoff and help to improve infiltration. IMSD guidelines were considered for selecting water harvesting sites in Tetavali watershed. The multilayer integration of thematic layers in ArcGIS helps to select suitable water harvesting structures. Total 13 suitable sites fond suitable for water harvesting in Tetavali watershed.

Farm Pond

Farm ponds are made by either constructing embankment across a water source or by excavating pits or the combination of both methods. Site having slope less than 5 percent and stream with first stream order was suggested for farm pond construction. Six suitable sites were identified in Tetavali watershed for construction of farm pond.

Check dam

Check dams are very popular water harvesting structure as it shows complementary benefit of controlling soil erosion. In Tetavali watershed slope below 15 percent and streams of first to fourth order were considered suitable for construction of water harvesting structure. There are 3 suitable sites suggested for construction of check dam.

Percolation pond

Percolation ponds are structures constructed across streams and bigger gullies for impounding and recharging the ground water. Area with slope less than 10% and streams of first to fourth order found suitable for construction of percolation pond. In Tetavali watershed there are two sites found suitable for construction of percolation ponds.

Earthen nala bund

Earthen nala bund is found suitable in areas with slope less than 5 percent, by fulfilling all the suitability criteria for construction of earthen nala bund study area found one suitable site for construction of earthen nala bund.

Cement nala bund

Cement nala bund impound water and in turn can control the speed of flow through nala during monsoon season. For selection of suitable sites for cement nala bund the site should have slope less than 5 percent and can be constructed on third and fourth order stream. So after fulfilling all the suitability criteria for cement nala bund construction study area found one site suitable.

Conclusions

1. Drainage density was classified in five classes of range 0-1, 1-3, 3-6, 6-9 and >9 km/ sq. km which covers 298.44 ha, 10.73 ha, 25.9 ha, 35.65 ha, 11.19 ha of area, respectively.

2. Slope in study area was classified in five classes starting from 0-5, 5-10, 10-15, 15-20 to more than 20% on area of 139.61ha, 139.05ha, 59.87ha, 29.2ha and 13.67ha, respectively.
3. Land use land cover of the watershed was divided in 4 classes as forest, agriculture, barren land and built up area with area of 192.03 ha, 99.70 ha, 37.73 ha and 52.54ha of total area, respectively. Total watershed represents the sandy loam texture of the soil.
4. Study found three geomorphological classes in watershed as moderately dissected plateau on 122.98 ha, Pediment pediplain complex on 256.65 ha and water body on 2.37ha of area of watershed.
5. Two classes of lithology were found in Tetavali watershed, laterite rock over 44.15ha and basalt rock on 337.85 ha. The suitability of area in watershed for water harvesting structures found as 278.36 ha (72.86%) area suitable for water harvesting structure construction and 103.64ha (27.14%) of watershed not suitable for water harvesting structures.
6. Thirteen water harvesting structure were suggested suitable in Tetavali watershed, six farm ponds, three check dams, two percolation pond and one each of earthen nala bund and cement bund were suggested suitable for water harvesting in watershed.

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