



Identification of potential sites for water harvesting structures in Gadela watershed using remote sensing and GIS

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Abstract

In this study the suitable sites for water harvesting structures in Gadela watershed has been identified using remote sensing and GIS. The satellite imagery of 30 m resolution data downloaded from bhuvan was used to prepare Elevation and slope map for the study area. The other thematic maps such as Land use land cover, Geomorphology, Soil, Transmissibility and Runoff maps were prepared to suggest suitable water harvesting structures. The weighted overlay approach has been applied for the prepared thematic maps based on their importance in water harvesting and converted to normalized maps. These maps were overlaid using Arc GIS tool to get the final suitability map. The suitability of the study area divided in to low, medium and high priority zones and found 31% of area is highly suitable and 45% as medium and 24% less suitable. 62 places Suitable for various harvesting structures. Twenty four Check dams, twenty five farm ponds, four nala bunds, contour trench in 187 ha for barren land and a Gully plug were proposed for the study area as per Integrated Mission For Sustainable Development (IMSD) guidelines.

Key Words: DEM, GIS, Curve number, thematic maps, weighted overlay

Introduction

Water plays a vital role not only in fulfilling basic needs but also in socio economic development. The rapid growth of industrialization, population explosion and agriculture activities resulted in creating pressure on fresh water resources leading to over exploitation of ground water and increasing scarcity of water. The precipitation in India is highly variable over time and space due to monsoon climate and land-mountain topography. Spatially it ranges from 100 mm in Rajasthan to 11000 mm in Mausingram, Meghalaya (Sharma and Paul, 1998). As per estimate about 92 Mha.m of the available surface water ultimately goes to the sea despite of construction of large dams, reservoirs, check dams, water harvesting structures etc (Bamne, 2014). Water harvesting is most important to conserve this precious natural resource which are depleting day by day at an alarming rate. The need and importance of water harvesting and conservation stressed in national water policy and national agriculture policy of Government of India.

The various rain-water harvesting structures such as

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check dams, farm ponds, nala bunds and percolation tanks etc. constructed at appropriate sites will check the flood and provide irrigation to downstream (Singh, 2009). The ground water table in most parts of Rajasthan is going down due to over exploitation and inadequate natural recharge resulting from frequent drought conditions in the region. The insufficient precipitation with erratic rainfall was giving alarming need for water harvesting to make the resource sustainable.

Study area

The Gadela watershed is located in the Udaipur district which falls under Agro-climatic zone IVA Sub humid region of Rajasthan. The study area is bounded by 73° 30' 0" to 74° 1' 20" E Longitude and 24° 40' 50" to 24° 56' 10" N Latitude covering survey of India (SOI) toposheets of 45H-13,14 and 45L-1,2,9 of 1:50,000 scale. The total catchment of Gadela watershed is 418.33 km² with highest elevation as 692 m and the lowest elevation is 420 m above mean sea level. The rainfall during south-west monsoon constitutes 80% of rainfall which is about 535 mm in the study area. On an average the numbers of rainy days in a year are 31.

Data used:

Survey of India toposheets
IRS P6 LISS III Satellite data



Aster DEM 30 m
Soil map (NBSSLUP)
Rainfall data from water resource dept. Rajasthan

Soil map, Geomorphology, Land use/ Land cover map and Transmissivity map were prepared in Arc GIS.

Materials and Methods

Preparation of Thematic maps

In order to study runoff and site suitability different thematic maps such as Elevation map, Slope map,

Elevation map

Elevation map of the study area delineated using the DEM obtained from Bhuvan and classified in to five classes.

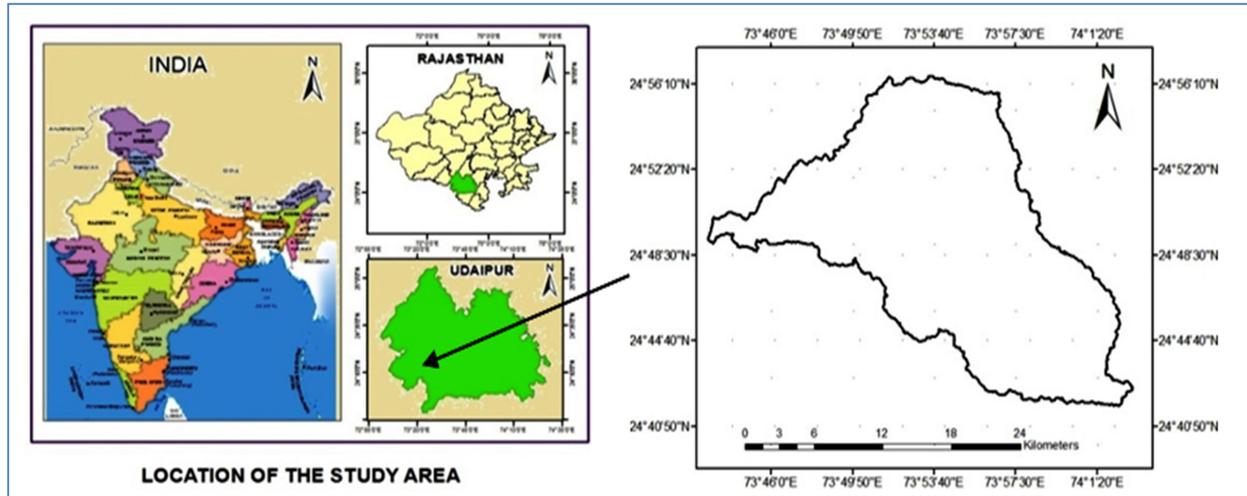


Fig 1.

Soil map

The soil map obtained from NBSSLUP (National Bureau of Soil survey and Land use planning) was digitized in Arc GIS and separated the boundary of watershed. The soils in the study area are classified in to coarse loamy and loamy skeletal which comes under hydrologic soil group B.

Slope map

Slope is one of the factors that control the infiltration of rainwater in to sub surface. In gentle sloping areas the surface runoff is slow allowing more time for rainwater to percolate, whereas, steep slope area facilitates high runoff allowing less residence time for rainwater to percolate. The slope map of Gadela watershed was derived from the digital elevation map in Arc GIS. The slope of the area was classified in to very low (0-3%), low (3-8%), medium (8-15%), Steep (15-30%) and very steep (>30%).

Land use/ Land cover

In Gadela watershed seven land use/ land cover classes were identified which are of Cultivable land, Scrub, Fallow land, mixed forest, Barren land and Built in land and water bodies. The area and

percentage under these classes was presented in table 1. The results revealed that about 54.2% of watershed was Cultivable and the lowest area under Built in land.

Geomorphology

The geomorphology map from bhuvan was used to extract the study area. The geomorphology units available in the area are Granite and gneiss, valley fills, water body, Phyllite and schist and structural hills. Granite and Gneiss are formed due to differential erosion and weathering is hard and compact, fine to medium grained categorized as good for runoff but poor in terms of groundwater recharge due to less porosity. Valley fills are mostly structural control and the materials are mostly sheet wash from plateau area and pediplains. This type of landform forms at the lower reach of the watershed filling the main stream and channels. Groundwater prospects are good in these areas. The valley fills occupied area about 7.05 Km² in study area.

Runoff map:

The rainfall for 20 years (1995-2014) from water resource department used to find the direct runoff (mm) with SCS- Curve number method.

Table 1. Land use classes in Gadela Watershed

SN	LULC	Area(km ²)	Percentage
1	Cultivable land	227.09	54.2%
2	Scrub	174.22	41.6%
3	Fallow	6.03	1.4%
4	Mixed forest	2.62	0.6%
5	Barren	2.02	0.5%
6	Built in	0.85	0.2%
7	Water body	5.98	1.4%

Table 2. Area contribution of Geomorphology classes.

SN	Geomorphology class	Area(km ²)
1	Granite and gneiss	362
2	Valley fills	7.05
3	Water body	7.19
4	Phyllite and Schist	42.15
5	Structural hills	0.006

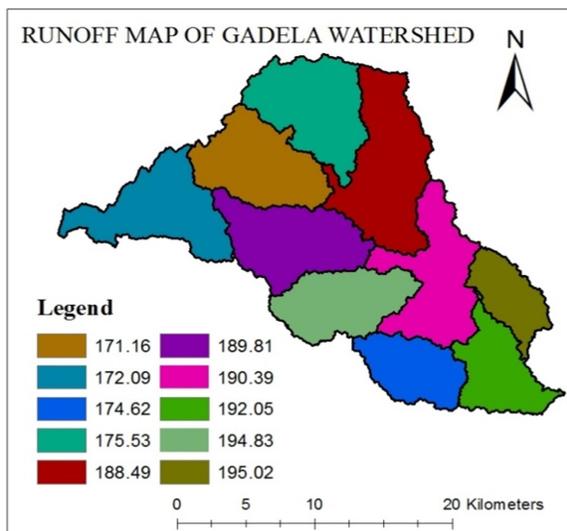


Fig 2: Basin wise Runoff map of Gadela Watershed.

Transmissivity map:

The transmissivity values obtained from pumping test was used to know the soil layers behavior in water transmissibility. Pumping test had been conducted at four different places in the study area and was divided in to 4 classes' very poor, poor, moderate and good.

Weighted overlay approach

Different thematic maps such as soil map, slope map, land use/ land cover map, geology map, geomorphology map, runoff map and transmissivity map was used to give the priority ranks by understanding their importance in setting priority. Knowledge based weight assignment was carried out for each layer and they were integrated and analysed by using the weighted overlay technique. Weighted overlay accepts only integer rasters so continuous raster have to be reclassified as integer before they can be used. The weightage for individual thematic layers were fixed depending on their suitability for water harvesting structures. The maximum value was given to the feature with highest suitability in terms of storage and recharge and minimum for the feature having low potentiality sites.

Table 3: Weights of eight themes for Suitability of Water harvesting structures

SN	Themes	Weight
1	Geomorphology	5
2	Land use/Land cover	2
3	Soil	3
4	Slope	4
5	Topographic Elevation	3
6	Transmissivity	4.5
7	Runoff	4.5

Table 4. Pair wise comparison matrix and normalized weights of the themes

Themes	Themes							Normalized Weight
	GM	LU	Soil	Slope	TE	TR	RF	
GM	1	2.5	1.67	1.25	1.67	1.11	1.11	0.1923
LU	0.4	1	0.67	0.50	0.67	0.44	0.44	0.0769
Soil	0.6	1.5	1	0.75	1	0.67	0.67	0.1154
Slope	0.8	2	1.33	1	1.33	0.89	0.89	0.1538
TE	0.6	1.50	1	0.75	1	0.67	0.67	0.1154
TR	0.9	2.25	1.50	1.13	1.50	1	1	0.1731
RF	0.9	2.25	1.50	1.13	1.50	1	1	0.1731
								1.000

Note: GM = Geomorphology, LU = Land use/Land cover, TE = Topographic Elevation, TR = Transmissivity



Results and Discussion

By applying the overlay technique three priority areas have been suggested by considering Slope, Soil, Topographic elevation, Land use/ Land cover, Geomorphology, Transmissivity and runoff of the watershed. The percentages of area under different classes were shown in Table 5.

Table 5: Gadela Watershed-Area Statistics of Prioritization

SN	Prioritization	Area(km ²)	Area in %
1	Low	100	24
2	Medium	188	45
3	High	130	31

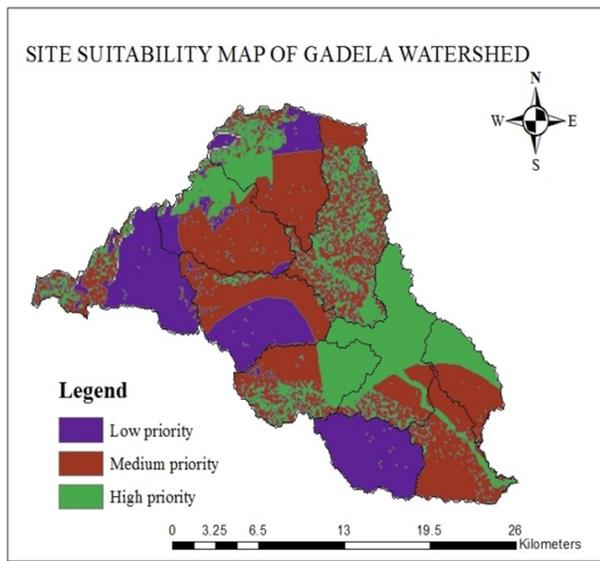


Fig 3: Site Suitability for Water harvesting structures

Low priority areas

The low priority areas were found in the region of Steep to moderate slope having low transmissivity and high runoff mostly confined to western part of the watershed. The total area coming under the low priority class was 9 km² (2.1%).

Medium priority

The medium priority area was found at moderate to gentle slope and was confined to middle of the catchment. The area covering under medium priority was 211km² (50 %).

High priority

The analysis reveals that high priority area is on Southern part of the watershed and in hilly area on the upper part of basin. This category accounts for 198 km² (47.3%).

Planning of Sites for Water harvesting

Based on the IMSD (Integrated Mission for Sustainable Development) guidelines the location of sites for water harvesting structures suggested by considering slope, Drainage and Suitability map of the watershed. The structures suitable for the area are check dams, percolation tanks, Nala bunds, Contour trenches, Gully plugs and farm ponds.

The farm ponds are generally constructed at the first order stream in the cultivable area where the slope is not more than 5% and 25 places are found as suitable for farm ponds. 24 Check dams are proposed up to 3rd order stream in the cultivable area and percolation tanks are suitable where the soil has good infiltration to utilize for both ground water recharge and water harvesting. The site is suitable for 2 percolation tanks found in the first basin of scrub land, 4 Nala bunds, contour trench for 187 ha on barren land and a gully plug in forest area were suggested.

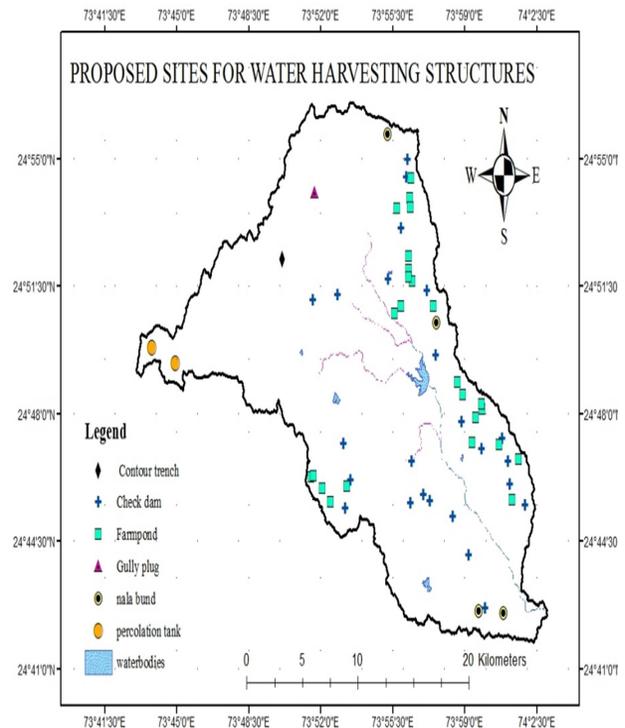


Fig 4: Proposed sites for Water harvesting structures.

Conclusion

From the study it was found that remote sensing coupled with GIS is an efficient tool in timely water resource planning.



Identification of potential sites for water harvesting

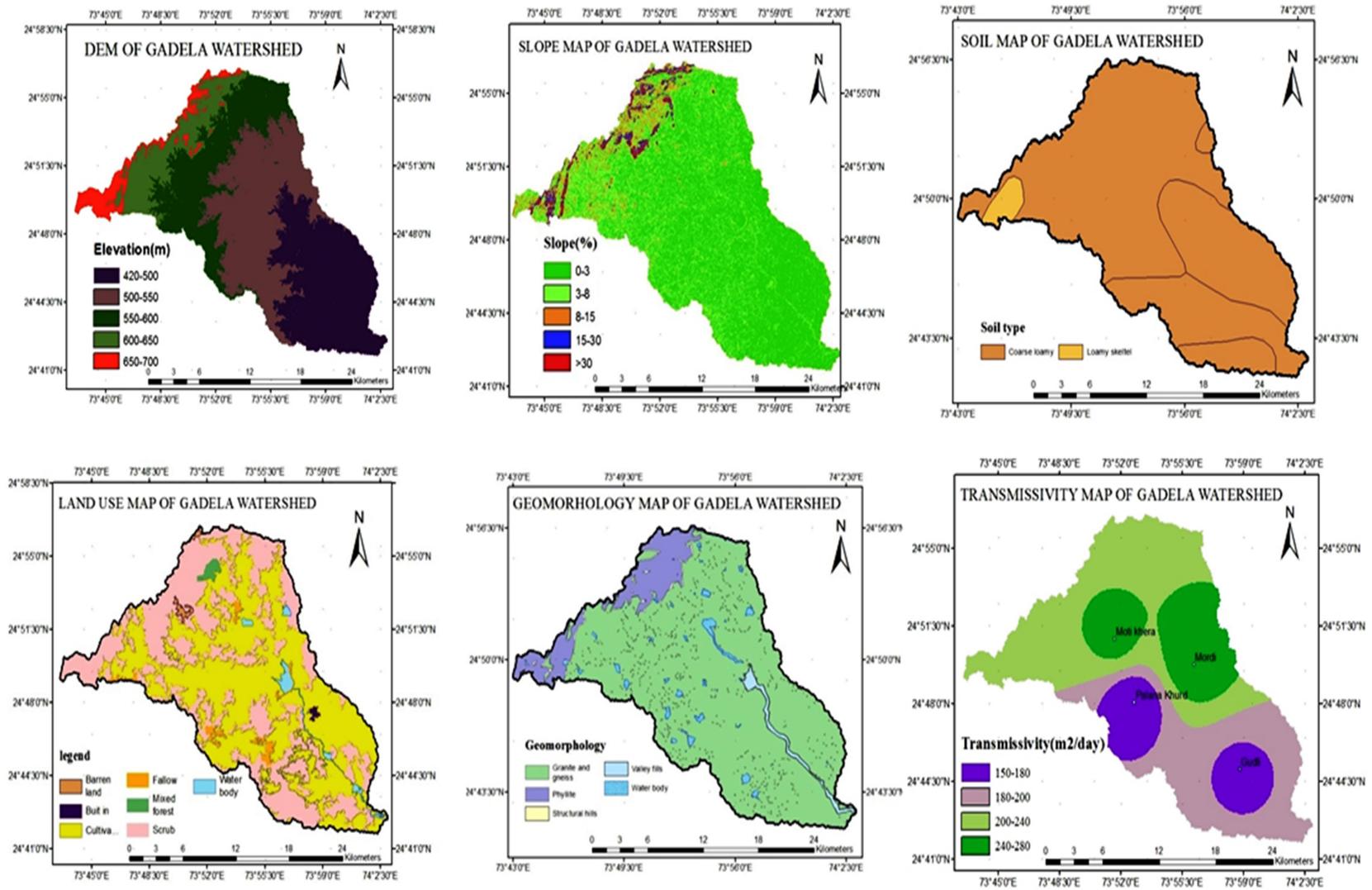


Fig 5. Different thematic maps of Gadela watershed

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