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# APPLICATION OF REMOTE SENSING AND GIS FOR IDENTIFYING SUITABLE SITES OF SURFACE RAINWATER HARVESTING STRUCTURES

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***Abstract***

*Today rainwater harvesting system is very important for semi-arid geographical area in world. But success of these systems mainly depends on identification of suitable sites and technology. However, the selection of appropriate sites for rainwater harvesting potential on a large scales present great challenge. It is necessary of all physiographic and climatic data in the study region. Remote sensing and Geographical Information Systems help to facilitate this task for large areas and permit rapid and cost effective sites survey. Integration of Remote Sensing (Floyd, 1986) GIS techniques provide reliable, accurate and update database on land and water resources, which is a prerequisite for an integrated approach in identifying suitable sites for rainwater harvesting structures (Meijerink et al. 1994). A study was conducted in Satara district in Maharashtra. The overall objective of the study was to firstly generating various base map layers then gets final map of the suitable surface rainwater harvesting potential sites using Survey of India to posheets, RS and GIS and limited field survey.*

***Key Words:*** *Remote Sensing, GIS, Rainwater Harvesting, Site Suitability etc.*

## 1. Introduction :

Assessing, managing and planning of the water resources for sustainable use is an important issue in human life, especially in water scarcity regions. Topography of an area along with geological structures and lithology play an important role for rainwater harvesting potential. In spite of several thousand years of experience in water harvesting, a number of open questions remain, e.g. how to increase the water yield of a given catchment area or how to identify areas suitable for certain techniques of water harvesting (Prinz and Vögtle, 1994); Thus development of methodology for identifying potential sites for RWH is an important step towards identifying areas suitable for certain techniques of rainwater harvesting. Integration of Remote Sensing (Floyd, 1986) GIS techniques provide reliable, accurate and update database on land and water resources, which is a prerequisite for an integrated approach in identifying suitable sites for water harvesting structures (Meijerink et al. 1994).

A study was conducted in the Satara district of Maharashtra. The overall objective of the study was to firstly generating various base map layers then gets final map of the suitable surface rainwater harvesting potential sites using RS and GIS and limited field survey.

## 2. Objectives

i) To generate physiography, slope and drainage maps layers using remote sensing and GIS
ii) To suggest the suitable surface rainwater harvesting sites in the area

## 3. Data Source And Methodology

The Survey of India to posheets were used for the preparation of the Base Map on 1: 50,000 scale in GIS technique. The Digital Elevation Model (DEM) and Slope themes were prepared using supervised classification technique.

In this study some basic maps like physiography (DEM), Slope and drainage have already prepared with the help of ArcGIS software, it is use for the site suitability map of the study area. It is important for the determination of new surface rainwater harvesting potential sites in the region.

Factor layers (maps) were incorporated in Arc View's finally suitability map was developed that show the potential sites for different RWH structures of study area.

Results showed that the methodology works efficiently in identifying potential areas for rainwater harvesting technologies. It can be concluded that integration of RS and GIS techniques and limited field survey can be useful for identification of potential sites for constructing RWH structures. Other information sources used extensive literature review and group discussion.

**4. The Study Area**

The Satara district is situated in the western part of the Maharashtra state (Fig.1) and lies between north latitudes17° 05" and 18° 11' and east longitude 73 ° 33' and 74° 54'. The geographical area of the district is 10480 km2.

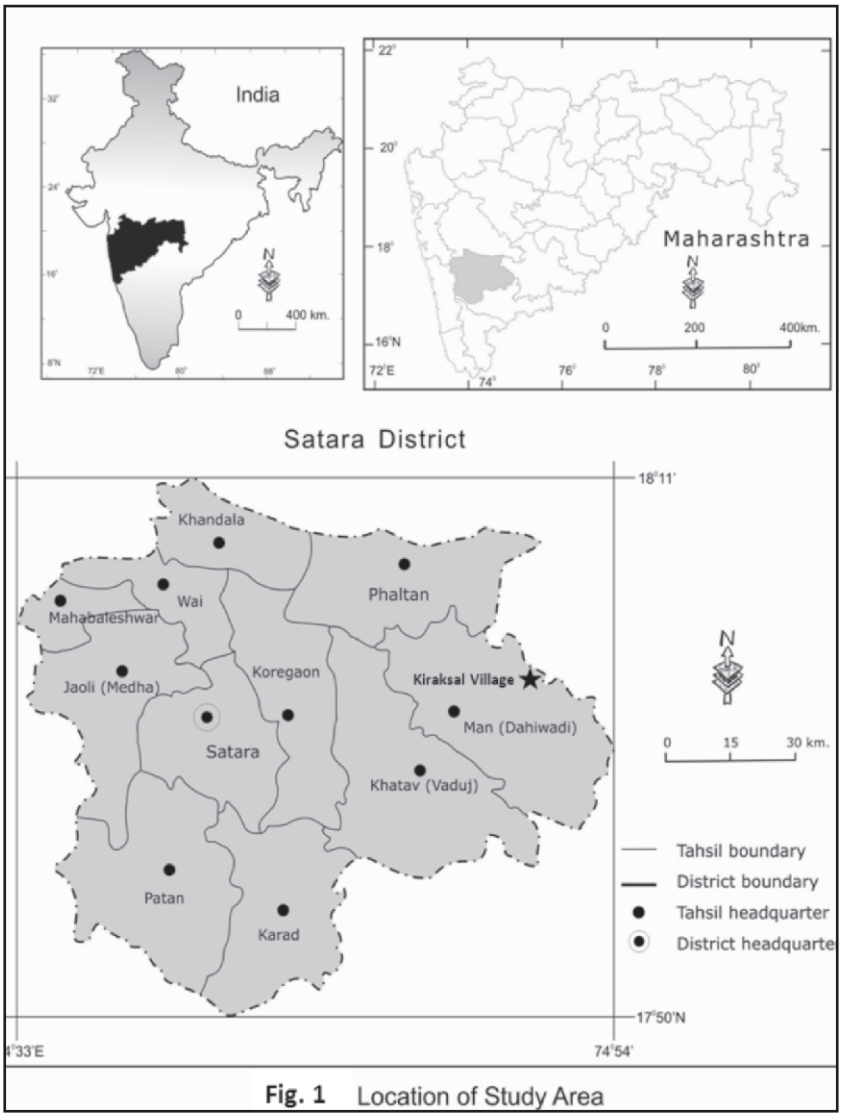


**Fig. 1** Location of Study Area

Satara district has typical landscapes due to variations in relief, climate and vegetation. The variation of relief ranges from the pinnacles and high plateau of the main Sahyadrians range having heights over 1200 metres above mean sea level to the subdued basin of Nira river with an average height of about 600 metres above mean sea level. The climate ranges from the rainiest in the Mahabaleshwar region which has an average annual of over 6000 mm to the driest in Man, Phaltan, Khandala and Khatav tahsils where the average annual rainfall is about 500 mm.

**5. Developing Criteria for Gis Mapping For Rainwater Harvesting:** The GIS database of RWH potential in Satara district was developed using ArcGIS and ArcView software, by utilizing both vector and raster (gridded) available databases.

**Table - 1**
**Criteria for GIS Mapping for Identifying Suitable Sites of RWH**

| Sr. No | Criteria | Height in Meters DEM | Slope in % | Drainage Density | Land Characteristics | Runoff Potential |
|---|---|---|---|---|---|---|
| 1 | Identification of Sutaible Sites of Rainwater Harvesting Structures | 840 to 1120 | >20 | High | Hilly, Rocky & Undulating, Steep Slope, 3. 1 st & 2 nd Order Streams | High Runoff Potential |
| | | 560 to 840 | 5 to 20 | Moderate | Uniform to Flat, Moderate Slope, 2 nd & 3rd order streams | Moderate Runoff Potential |
| | | 280 to 560 | < 5 | Low | Alluvial and Sedimentary, Gentle Slope, 3 rd & 4 th Order Streams | Low Runoff Potential |
| 2 | Data Source for Map Preparation | IRS P6, LISS -3, Post Monsoon (2010 -11) | Survey of India Toposheet 1:50000 | Survey of India Toposheet 1:50000 | NA | NA |

Source: Based on RELMA in ICRAF & UNEP, 2005

The major variables identified for potential sites of RWH in the GIS were runoff potential sites, ground water recharge sites and rainwater storage sites. For this purpose, we drew the Digital Elevation Model (DEM), runoff potential zones, nature of hydrogeology, soil and drainage maps with the help of GIS. In general the database comprises baseline thematic maps and composite processed maps, developed using mapping criteria as Table 1.

**5.1 Nature of Terrain (DEM):** Any digital elevation is representation of the continuous variation of relief over space is known as a digital elevation model (DEM). 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). Fig.2 shows nature of terrain in study area. Due to the hilly and undulating topography proportion of area under cultivation is small. This is varying poor area for rainwater harvesting structures as compared to the foot hills and plain area. It is suitable for constructing bench terracing, contour terracing, loose boulders and gully plug etc. runoff rainwater harvesting structures.

The foot hills and plateau region having height between 600 to 900 metres comes under uniform area includes the central and eastern part of the study region. This division covers 29.12 per

cent area of the district. The average gradient in this relief division varies from 10 to 30 metres per kilometres. There are several small hill ranges running to the east and south-east direction from the main ranges of Sahyadri and Mahadeo. The surface is dotted with the scattered hills. Except Mahableshwar tahsil, this relief division covers relatively uniform area in all parts of the district. Most of the area in this category is covered by the shrub, grasses and deciduous forests. In this division agricultural is poor due to the infertile soils but it is suitable area for recharge and storage structures for rainwater harvesting which is Nala bands, Gabion Structures, Check Dams, Percolation tank and Sub-surface dams. The region is also favorable for artificial recharge structures like recharge pits and trenches, recharge dug and bore wells (CGWB).

The plain or flat area covers major portion of the river valleys draining the land towards north east and south east. This physical division includes an altitude below 600 metres which shares 26.77 per cent of the total area of the district, the average gradient of this relief division varies from 1 to 10 metres per kilometres. The soils are medium deep black soil. Besides these it is agriculturally developed area having suitable for storage rainwater structures constructing in the region which is Farm ponds, Village ponds and K.T. Waires.

**5.2 Drainage :** Fig.3 shows slope and drainage density in study area. Runoff zone has high drainage density and is dominated by 1st order streams. Similarly recharge zone has a moderate drainage density and is dominated by 2nd and 3rd order streams, while the drainage density is poor in storage zone drainage is dominated by higher order stream (GoI, CGWB, 1994).

A decision support model for selection of sustainability structures based on the drainage orders. It is to be noted here that gabion structures and Percolation Tanks may be selected both for 2nd order as well as 3rd order streams. Drainage order is a very important consideration for selection of the type of the recharge / harvesting structure as the order determines the total quantum of run-off available for recharge/ harvesting (GoI, Ministry of Drinking Water and Sanitation Govt. of India)

**6. Suitability of Rainwater Harvesting Structures in the Study Area :**Table 2 and Fig 4 shows the GIS mapping results and suggests the suitability of rainwater harvesting structures in the study area on the basis of slope, runoff potential and drainage order. To overcome this problem, construction of rainwater harvesting structures are proposed to augment both surface and sub-surface storage and recharge. Firstly, these activities reduce runoff velocity, thereby minimize erosion and secondly, allow the retained water to percolate and result in increased recharge.

**Table 2**

**Suitability of Rainwater Harvesting Structures in the Study Area**

| RWH Main Type | RWH Type | Slope | Runoff Potential | Drainage Order | Suitability |
|---|---|---|---|---|---|
| Runoff Structures | CCT, Loose Boulders, Gully Plug etc. | >20 | High | 1st | High |
| | | 5 - 20 | Moderate | 2nd & 3rd | Moderate |
| | | < 5 | Low | Up to 4th | Not Suitable |
| Recharge Structure | Gabion, Check Dam and P.T., | >20 | High | 1st | Not Suitable |
| | | 5 - 20 | Moderate | 2nd & 3rd | High |
| | | < 5 | Low | Up to 4th | Moderate |
| Storage Structure | Farm Pond, Subsurface Dam and K.T.Waires | >20 | High | 1st | Not Suitable |
| | | 5 - 20 | Moderate | 2nd & 3rd | Moderate |
| | | < 5 | Low | Up to 4th | High |

Source: Methodology based on D. Ramakrishnan &et al., 2008

**7. Conclusion:** Today rainwater harvesting system is very important for semi-arid geographical area in world. But success of these systems mainly depends on identification of suitable sites and technology. However, the selection of appropriate sites for rainwater harvesting potential on a large scales present great challenge. Integration of Remote Sensing (Floyd; Lillisand and Kiefer, 2000) GIS techniques provide reliable, accurate and update database on land and water resources, which is a prerequisite for an integrated approach in identifying suitable sites for water harvesting structures.

The identification of rainwater harvesting sites is interdependent on various parameters like nature of terrain, runoff potential, hydrogeology, soil and drainage by using remote sensing and GIS technique. Again, the study area was classified into suitability for rainwater harvesting sites based on the number of parameters loaded using GIS integration. Present study clearly shows the suitability of rainwater harvesting structures in the study area. This study best exemplifies the integrated approach of remote sensing and GIS and in water resource development.

Scope exists for construction of suitable artificial recharge structure in central and eastern parts of the district. The percolation tanks, cement nala bunds. KT weirs, earthen nala bunds etc., are suggested in basaltic area at suitable sites. Apart from this the dug well recharge technique must be promoted in the district to enhance the sustainability.

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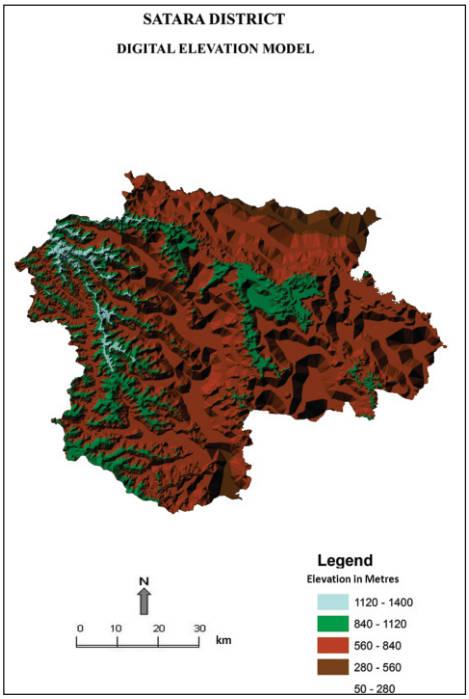


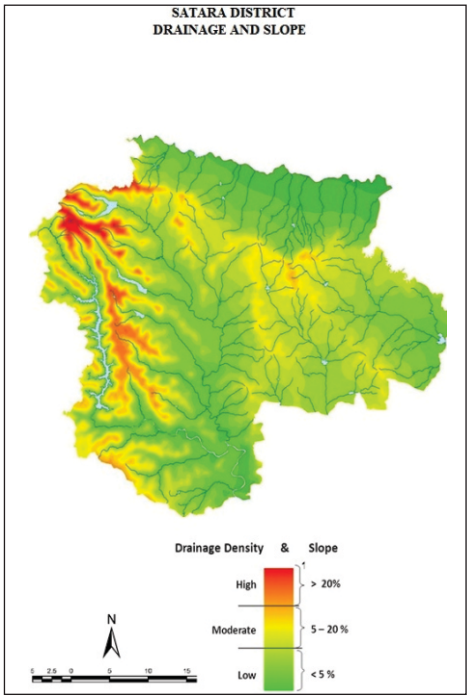


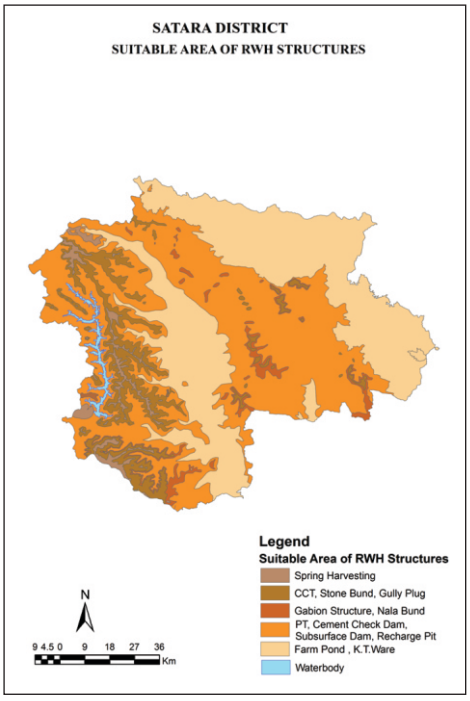


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