"SITE SUITABILITY ANALYSIS FOR SURFACE RAINWATER HARVESTING OF MADHA TAHSIL, SOLAPUR, MAHARASHTRA: A GEOINFORMATIC APPROACH"

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Abstract:

Solapur district is facing the problem of scarcity of water throughout the year.Due to plain relief & temperate climate this district experiences less rainfall. Moreover, construction of major irrigation projects has limited scope due to topographical, social, financial and environmental constraints. To check this problem we can construct Check Dams, Percolation Tank, Bore Well, Dug Well, Dug cum Bore Well and Farm Pond in various parts of Solapur district. The study area comprises of a watershed area of Madha tahsil of Solapur district. The present study is carried out by GPS, Survey of India toposheets i.e. NE 43-7 and NE 43-11, on scale of 1:250,000, SRTM data for creation of DEM and satellite imagery of LANDSAT ETM+ (30mt. spatial resolution). The criteria like third order stream, 2 to 3 degree slope of land, sandy- clay soil, 500 mt. settlement buffer zone is consider and various techniques of GIS and remote sensing are used for getting more suitable sites for rainwater harvesting. By applying above process it was concluded that this area has limited scope of rainwater harvesting.

Key words: watershed management, Geographical information system and remote sensing, runoff estimation, stream order, site suitability for rainwater harvesting.

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Introduction

Water is one of the most vital requirements for economic and social development. Indian population and economy is increasing thereby increasing the demand for water for domestic, agricultural and industrial use. Reduction of surface runoff can be achieved by constructing suitable structures, which automatically helps to manage the other natural resources like soil and vegetation as the watershed condition affect these recourses. For the efficient management, one has to take suitable unit of management. Here, by taking watershed as a unit the water, soil, and vegetations can be managed efficiently, collectively, and simultaneously.

The word watershed refers to a "***contiguous area draining into a single water body or a water course" or "it is a topographical area having a common drainage"***. This means that the rainwater falling on an area coming within a ridgeline can be harvested and will flow out of this area thorough single point. Some refer it as a catchments area or river.

Rainwater harvesting (RWH) primarily consists of the collection, storage and subsequent use of captured rainwater as either the principal or as a supplementary source of water. Both potable and non-potable applications are possible (**Fewkes, 2006**). Examples exist of systems that provide water for domestic, commercial, institutional and industrial purposes as well as agriculture, livestock, groundwater recharge, flood control, process water and as an emergency supply for firefighting (**Gould & Nissen-Peterson, 1999; Konig, 2001; Datar, 2006**). The concept of RWH is both simple and ancient and systems can vary from small and basic, such as the attachment of a water butt to a rainwater downspout, to large and complex, such as those that collect water from many hectares and serve large numbers of people (**Leggett *et al*, 2001a**). Before the latter half of the twentieth century, RWH systems were used predominantly in areas lacking alternative forms of water supply, such as coral islands (**Krishna, 1989**) and remote, arid locations lacking suitable surface or groundwater resources **(Perrens, 1975).**

The problem of water and sensitive land is certainly acute and harsh, which demands special methods of control and management. Owing to increasing population and development of agriculture, water from various sources is consumed at such a fast rate that it is going to pose a grave water crises in near future. Besides, in the areas where irrigation water is made available unforeseen problems like water logging, alkalinity and salinity of the soil and various water born diseases and social problem have appeared in the absence of any scientific management of watershed. Hence, the present research has been planned to give thought to these problems and to suggest ways and means through rain water harvesting and proper watershed management.

Study Region

The region selected for the present study is Madha tahsil of Solapur district (Fig 1) It is located between 17° 40' to 18°30' North latitudes and 75°00' to 75°40' East longitudes occupying an area of 1544.9 sq km. The region has diversified physiography, south-west and north-east part is covered by plateau region and middle part is covered by small hills. Black soil is mainly found over south-west and north-east part, whereas the middle part is covered by mountainous soil. This region comes under semi-arid climate which is having low rainfall and high temperature.

Used Materials

Survey of India toposheets (NE 43-11 and 43-7) on 1:250,000 scale, District resource maps by Geological survey of India are used for geological, geomorphological, geohydrological studies of Solapur district. SRTM degree tiles images of 2000 are used to get elevation of Madha region, LANDSAT ETM+ with 30 mt resolution satellite images of 22nd October 2005 pertaining to path-row 146-048 are used for Land use/Land cover mapping taken from GLCF site, soil texture map of Soil Survey Department, Solapur

was used to take soil texture characteristics of study region. **ArcGIS 9.3** and **ERDAS IMAGINE 9.1** was used for geoprocessing and image processing respectively.

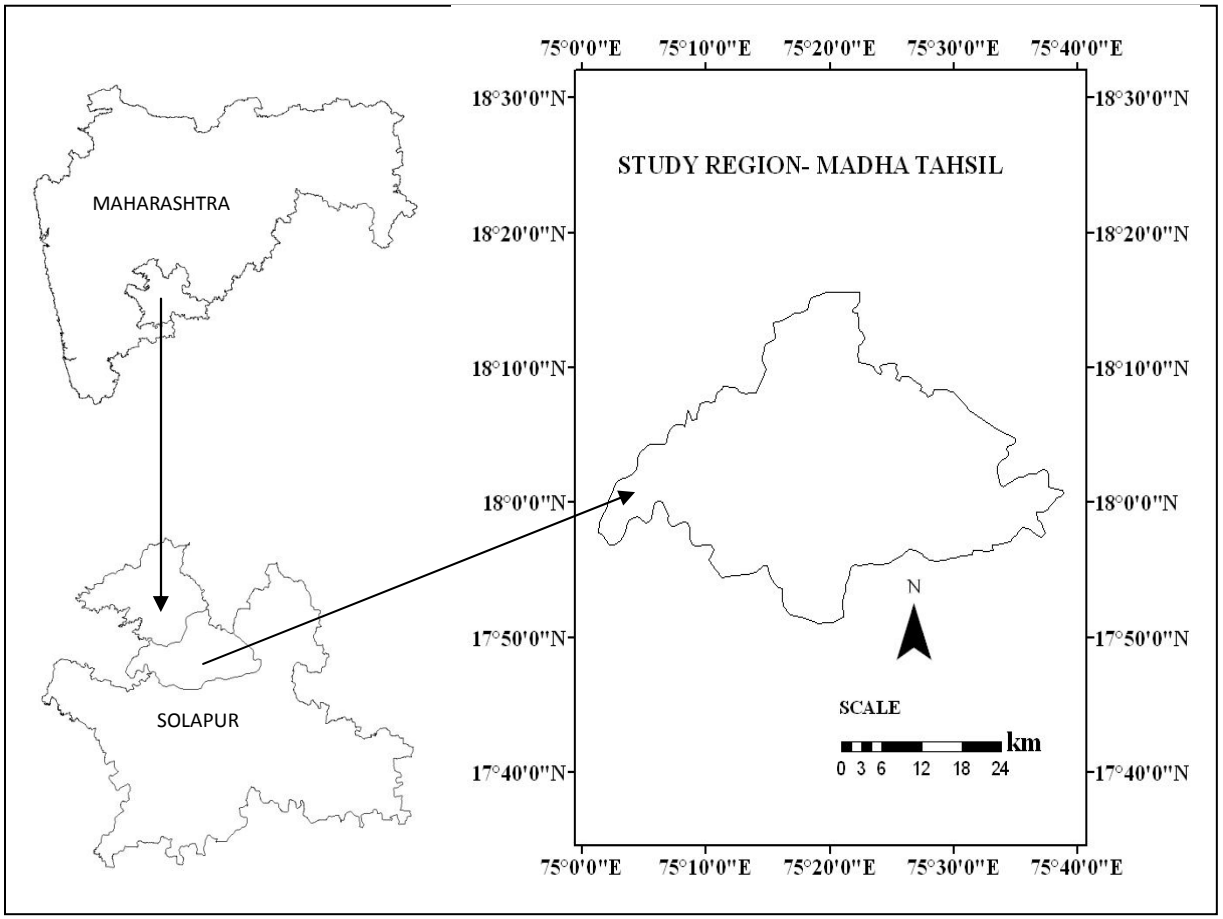


Fig: 1 – Location map of study area

Methodology

Satellite image, district resource maps and Elevation images were rectified using map to image geometric registration techniques with WGS 84 datum and Universe Transverse Mercator projection. Land use/ land cover map was created using rectified LANDSAT ETM+ images to know about area under various classes like barren land, Fallow Land, Forest area, Agriculture, Water bodies etc. After that Settlement map and Stream Order map were created with the help of toposheets, for digitizing stream order the Strahler Stream Order Scheme was used. Geological, Geohydrological, Geomorphological maps were also created using district recourse map. Slope and Aspect map was created using Digital Elevation Model (DEM). To calculate runoff estimation, Rational formula is used

Rational Method Formula: - $Q = \frac{CIA}{360}$

Where,

Q = Peak rate of runoff in cum/sec for the given frequency of rainfall

C = Rational runoff coefficient having values ranging from zero to one depending upon Watershed conditions

I = Intensity in mm per hour for design frequency and for duration equal to time of Concentration

A = Area of watershed in hectors

Values of C for different slopes, land use and soil types are given in **Table No.1** as per Rational Method.

Table No. 1. Values of 'C' used in Rational Method

Vegetative Cover and Slope in %	Soil Texture		
	Sandy Loam	Clay and Silt Loam	Stiff Clay
Cultivated Land			
0 to 5	0.3	0.5	0.6
5 to 10	0.4	0.6	0.7
10 to 30	0.52	0.72	0.82
Pasture Land			
0 to 5	0.1	0.3	0.4
5 to 10	0.16	0.36	0.55
10 to 30	0.22	0.42	0.6
Forest Land			
0 to 5	0.1	0.3	0.4
5 to 10	0.25	0.35	0.5
10 to 30	0.3	0.5	0.6

Source: Watershed Management Guidelines for Indian conditions, by E. M. Tideman

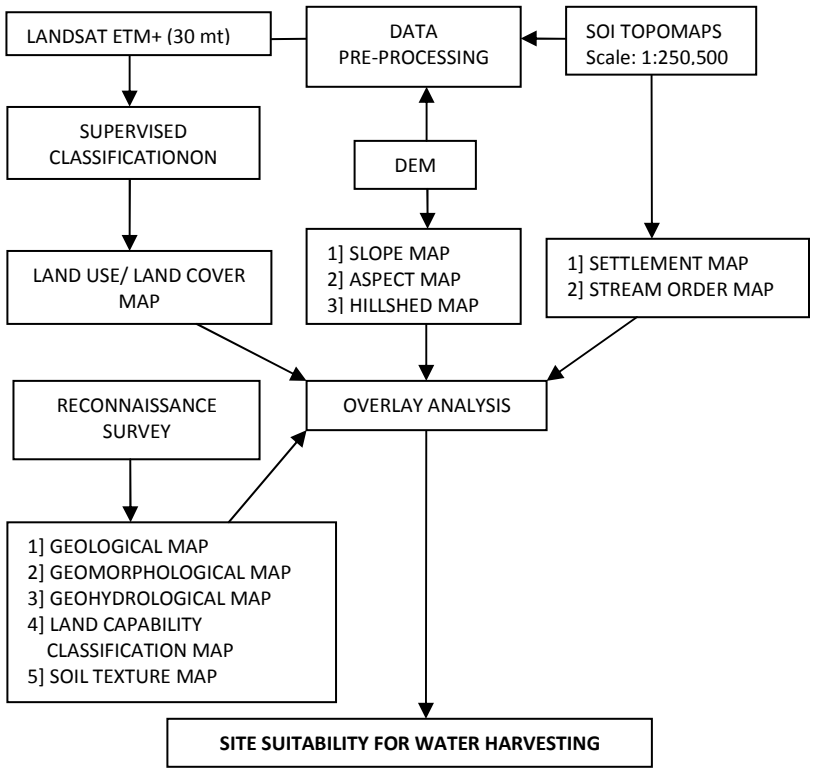


Fig. 2 Paradigm of this study

By using this method we classify whole Madha tahsil in 11 basins and calculate runoff estimation for each basin and get fallowing value which is showing in **Table No.2**

runoff, and yield of drainage basin.

Table No. 2 Area,

Sub_basin name	Area in hectors	Runoff in cumecs	Yield of drainage basin (in cm depth over the basin)
BASIN 1	17.52	5.627	98.58504
BASIN 2	15.03	1.237	18.59211
BASIN 3	13.02	0.393	5.11686
BASIN 4	9.467	1.088	10.300096
BASIN 5	22.765	0.572	13.02158
BASIN 6	8.651	0.316	2.733716
BASIN 7	12.617	1.03	12.99551
BASIN 8	11.66	0.709	8.26694
BASIN 9	28.545	0.530	15.12885
BASIN 10	16.08	0.7487	12.039096
BASIN 11	10.023	0.66	6.61518

To find out suitable sites for Check dams, Nala bunding, Dug well, Bore cum Dug well, Percolation tank, farm pond etc. for that following criteria is used,

1. **Site selection criteria for Percolation Tank**
   - A tank can be located either across small streams by creating low elevation.
   - Terrain with highly fractured and weathered rock for speedy recharge.
   - Submergence area should be uncultivated as far as possible.
   - Rainfall pattern based on long-term evaluation is to be studied so that the percolation tank gets filled up fully during monsoon (preferably more than once).
   - Soils in the catchment area should preferably be of light sandy type to avoid silting up of the tank bed.
   - The location of the tank should preferably be downstream of runoff zone or in the upper part of the transition zone, with a land slope gradient of 3 to 5%.

2. Site selection criteria for Nala Bunds

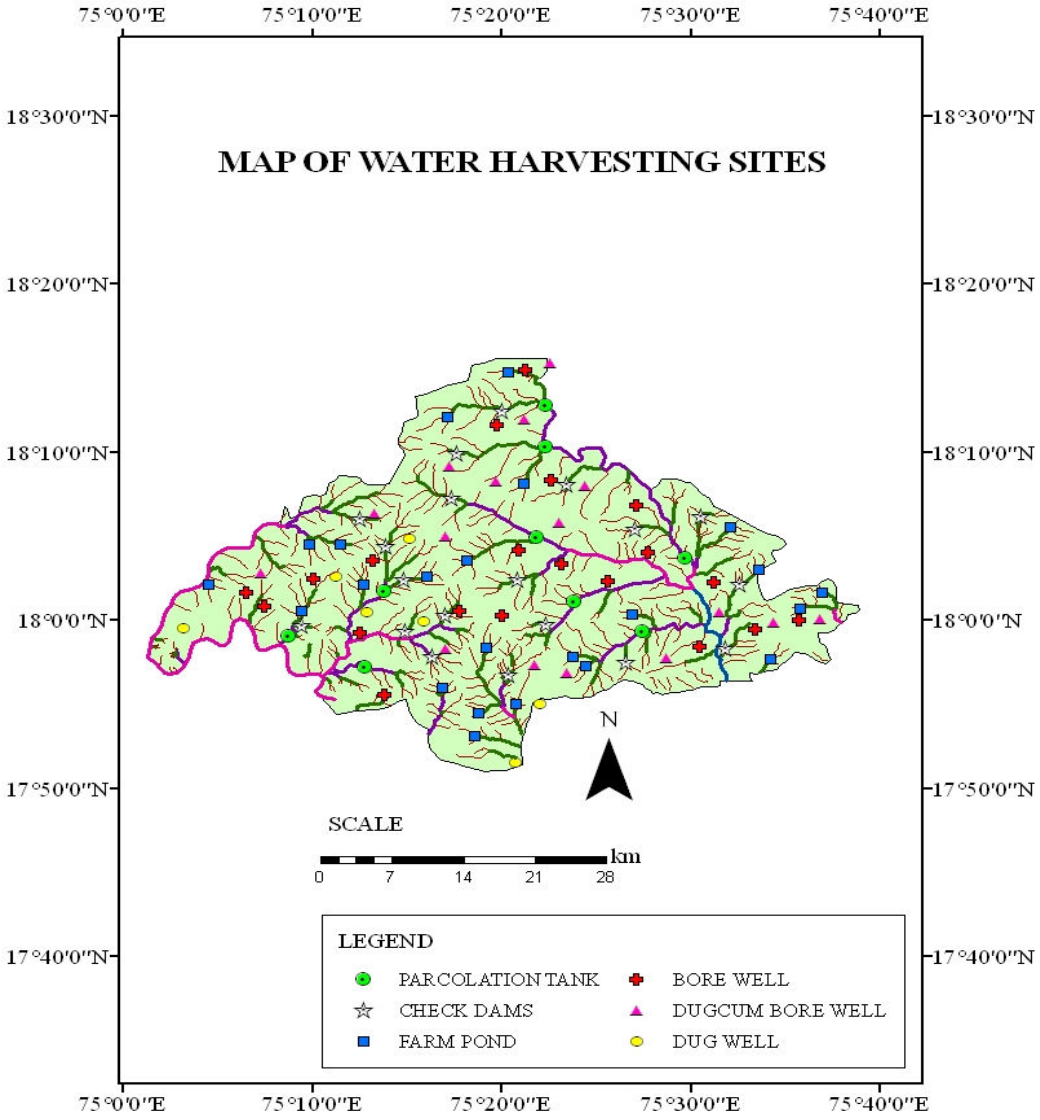
- Nala bunds can be constructed across bigger streams of second order in areas having gentle slopes.
- The rainfall in the catchments should be less than 1000 mm/annum.
- The soil downstream of the bund should not be prone to water logging.
- The Nala bunds should be preferably located in area where contour or graded bunding of lands have been carried out.
- The rock strata exposed in the ponded area should be adequately permeable to cause ground water recharge through ponded water.

3. **Site Selection criteria for Farm ponds**
   - In relatively flatter terrain with good soil cover, a farm pond has an earth section with usually 3:1 side slopes on waterside and 2:1 side slopes on the downstream face.
   - The drainage area above the pond should be large enough to fill the pond in 2 or 3 spells of good rainfall.
   - The pond should be located where it could serve a major purpose: e.g. for irrigation, it should be above the irrigated fields and for sediment control it should intercept the flow from the most erodible parts of the catchment.
   - Junction of two drainage channels or large natural depressions should be preferred.
   - The land surface should not have excessive seepage losses unless it is meant to serve as a percolation tank for ground water recharge.

4. **Site Selection criteria for Bore wells**
   - Where present land use is crop land or fallow land
   - Where slope is 0–10%,
   - Where major lineament intersects

5. **Site Selection criteria for Dug-cum-bore wells**
   - Where land use is crop land or fallow or waste land
   - Where slope category 0–5%,
   - Where minor lineaments and major lineaments intersect

6. **Site Selection criteria for Dug well**
   - Where land use is crop land or fallow or waste land
   - Where slope category 0–3%,
   - Where minor lineaments intersect



Conclusion

The geomorphological characteristics has different geohydrological pattern of the drainage. The main river Sina flows through the middle level plateau. The drainage in the watershed is having dendritic drainage pattern of streams. The Deccan trap, unit of denudational origin, has the number of suitable sites for dam construction, also the geological structure viz AO & 1 paeochoe basaltic lava flow > 190 mt are present in Deccan trap, which is much suitable for water harvesting. The middle part of the study region is more suitable for ground water development.

The study region is having the contrast ratio of the irrigated land to the unirrigated land. Irrigated land area is too less to develop the agriculture. The region is having 11 major sub-basins. Rational method is used for runoff estimation and sub basin wise runoff has been calculated. Sub-basin one which is of Sina River is having highest yield as compare to other sub basins. By this it is clear that all the sub-basins have enough yields but the rain water is not properly harvested.

Site selection for water harvesting is carried out by overlying the slope, Soil texture, Geohydrology, Geology, Geomorphology, land use/ land cover, stream order and settlement buffer maps. The region is having the full scope for the percolation tank, checks dams, farm ponds, dug well, bore well and dug cum bore well. This study will help in the proper management of the study region according to rainfall.

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