

Online Watershed Analysis Tool

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Abstract: The Watershed Analysis Tool is an interactive decision support system for developing effective management plans. This is an online tool developed using Google Maps API where decision makers can plan, monitor and manage watershed structures. In this study, an attempt is made to identify zones favorable for the application and adaptation of site-specific water conservation techniques for augmentation of groundwater through Geographical Information System techniques. The criteria adopted for the GIS analysis were based on the characteristics of watershed basins extracted from satellite imaginary data (DEM) obtained from ISRO Bhuvan supported by information on drainage pattern. This tool can be used to view watershed boundaries and to analyze the ground profile and to ascertain the site suitability to construct various water conservation structures.

Keywords: Runoff – Automated Watershed Delineation – Spatial Analysis – Site Suitability – Watershed Analysis Tool – Google Maps API

Introduction

Rain fall on the hills flows down in small rivulets. Many such rivulets, as they come down, join to form small streams. The small streams form bigger streams; and finally the bigger streams join the rivers. The entire area that supplies water to a stream or river, i.e. the drainage basin or catchment area, is called the watershed of that particular stream or river.

Significance of Watershed in Water Management

Since water follows a definite flow course watershed becomes an ideally hydrologic unit for carrying out developmental activity related with water management. Watershed approach for optimal planning, development and management aims at harnessing all natural resources for sustainable development and better living.

Watershed management is the integrated use of land, vegetation and water in a geographically discrete drainage area for the benefit of its residents, with the objective of protecting or conserving the hydrologic services that the watershed provides and of reducing or avoiding negative downstream or groundwater impacts. Watershed management approaches need to be adapted to the local situation and to changes in natural resource use and climate.

Category of Hydrologic Units in India

S. No.	Category of Hydrologic Units	Size Range (ha)	No. of Units
1.	Water Resource Region	270,00,000-1130,00,000	6
2.	Basins	30,00,000-300,00,000	35
3.	Catchments	10,00,000-50,00,000	112
4.	Sub-catchments	200,000-10,00,000	500
5.	Watersheds	20,000-300,000	3237
6.	Sub-watersheds	5,000-9,000	12000

S. No.	Category of Hydrologic Units	Size Range (ha)	No. of Units
7.	Micro-watersheds	500-1,500	400000

(Source: Watershed Atlas of India
<http://cgwb.gov.in/watershed>)

Objective of protecting or conserving the hydrologic services of watershed management:

- Erosion control and prevention of soil degradation
- Recharging of ground water to provide regular water supply for consumption and irrigation.

Factors affecting in planning and development of watersheds

The factors that play a greater role in planning and development process of a watershed are its size, shape, slope, climate, drainage, geomorphology, soils, soil erosion zones, land use/land cover and groundwater etc.

Investigations for Proper Planning

Various inputs are necessary for proper and scientific planning of water conservation structures in any terrain. Scientific investigations leading to a better understanding of the characteristics of sub-surface formations are to be taken up for realistic determination of these inputs. These can broadly be grouped into two categories namely viz. general studies and detailed studies.

General Studies

The synthesis of all available data relevant to ground water is the first step in this exercise. These data include

- rainfall distribution pattern,
- hydrogeological parameters with emphasis on lithological characteristics,
- nature of the terrain,
- intensity of ground water development and irrigation practices and
- chemical quality of surface and ground water etc.

The data is generally available in reports/records of various Central and State Government agencies. However, the data available often have considerable gaps. It is therefore necessary to have detailed studies to supplement the available data and for preparation of a scientific data base for proper implementation of suitable artificial recharge schemes.

Detailed Studies

Once the need for and suitability of the area for artificial recharge to ground water are identified on the basis of data collected from the general studies, areas identified as suitable for recharge augmentation are studied in detail as given below

S No	Type of Study	Inputs Anticipated
1	Remote Sensing Studies	Drainage characteristics and Lineament intensity. Distribution of various geomorphic units.
2	Hydrometeorological Studies	Rainfall amount, duration, daily and hourly rainfall intensity, variability of rainfall
3	Hydrological Studies	Source water availability, infiltration characteristics of major soil types and various land use categories
4	Geophysical Studies	Thickness of weathered zone in hard rocks Thickness and characteristics of granular zones in sedimentary terrain.
5	Hydrogeological Studies	Regional hydrogeology and aquifer characteristics Behaviour of ground water levels Ground water potential
6	Hydrochemical Studies	Quality aspects of source water for artificial recharge. Spatial and temporal variations in ground water quality.

(Source: Manual on Artificial Recharge of Ground Water at <http://cgwb.gov.in>)

In this article, an attempt is made on Remote Sensing Studies to ascertain site suitability for various water conservation structures

Remote Sensing Studies

Remote sensing, with its advantages of spatial, spectral and temporal availability of data has now become a very useful tool in assessing, monitoring and conserving ground

water resources. Satellite data provides quick and useful baseline information on various parameters controlling the occurrence and movement of ground water such as geology, structural features, geomorphology, soils, land use, land cover, lineaments, slope, drainage density etc.

Observations from satellite data must be complemented by field checks, existing geologic maps and topographic sheets.

Selection of suitable sites for Water Conservation Structures

The selection of a suitable technique for artificial recharge of ground water depends on various factors. They include:

- Rainfall pattern and Runoff
- Topography and terrain profile
- Soil type and soil depth
- Thickness of weathered / granular zones

Water Conservation Structures

These are normally multi-purpose measures, mutually complementary and conducive to soil and water conservation, afforestation and increased agricultural productivity. They are suitable in areas receiving low to moderate rainfall mostly during a single monsoon season and having little or no scope for transfer of water from other areas. The structures commonly used are

- Bench Terracing
- Contour Bunds and Contour Trenches
- Gully Plugs, Nalah Bunds, Check Dams
- Percolation Ponds

Rules for site selection of water conservation structures

Based slope, aquifer types and amount of precipitation, the suitability of structures are given below:

Topographic slope	Type of Structure	Criteria
Steep Slope (20 - 10%) Runoff zone	Gully Plug	Limited Rainfall (annual precipitation is less than 1000mm)
Moderate Slope (10 to 5%) Piedmont zone	Nalah Bunds, Contour Bunds, Contour Trench, Percolation Tanks	
Moderate to Gentle Slope (2 to 5%) Transition zone	Nalah Bunds, Contour Bunds, Percolation Tanks, Check Dams	Confined Aquifer Hydrogeological Group: Consolidated
Gentle Slope (<2%) Storage Zone	Nalah Trench, Check Dams, Farm Pond	

Study Area

Adarsha watershed is located in Kothapally village (longitude 78°5' to 78°8' E and latitude 17°20' to 17°24' N) in Ranga Reddy district, Andhra Pradesh, India nearly

40 km from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru. It covers 465 ha of which 430 ha are cultivated and the remaining area is wasteland.

The watershed is characterized by an undulating topography with an average slope of about 2.5%. Soils are predominantly Vertisols and associated soils (90%). The soil depth ranges from 30 to 90 cm and has medium to low water-holding capacities.



Methodology

The map of Kothapally watershed was delineated from DEM derived from Cartosat-1 with vertical accuracy of 8m at 90% confidence which is available at ISRO's Bhuvan website. The base map was prepared through visual interpretation of Google satellite data, showing various permanent structures. ArcGIS hydrology tool is used to delineate watershed boundary, drainage network, etc.

Data Collection

- Source of data is ISRO's Geoportal (bhuvan.nrsc.gov.in)
- Type of data downloaded from Open Data Archive is CartoDEM version 1.1 R1

The Cartosat-1 Digital Elevation Model is a National DEM developed by the ISRO. It is derived from the Cartosat-1 stereo payload launched in 2005.

- Data vertical accuracy is of 8m at 90% confidence
- Data having horizontal resolution of one arc-second (approximately 30 meters)

Data Preparation

- The following thematic maps are prepared after delineation of watershed based on DEM data using ArcGIS 10 Hydrology tool
- Watershed Boundary Map
- Drainage Network Map

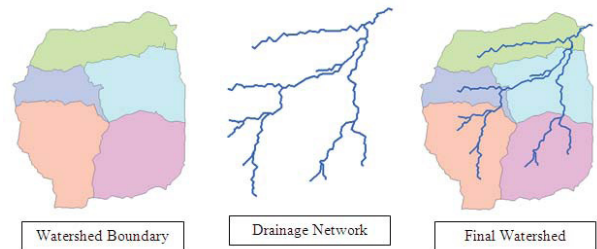
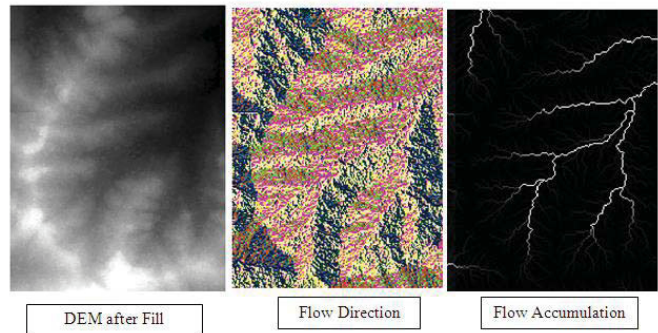
Delineation of watershed

Delineation is part of the process known as watershed segmentation, i.e., dividing the watershed into discrete land and channel segments to analyze watershed behavior.

Major steps involved in delineation of watershed

- Create ArcMap project (.mxd)
- Add DEM Layer

- Fill small sinks - Spatial Analysis Tool → Hydrology → Fill Tool
- Create Flow Direction - Spatial Analysis Tool → Hydrology → Flow Direction Tool
- Create Flow Accumulation - Spatial Analysis Tool → Hydrology → Flow Accumulation Tool
- Create Watershed Power Points
- Create Watershed - Spatial Analysis Tool → Hydrology → Watershed Tool
- Convert Raster to Polygon - Conversion Tools → From Raster → Raster to Polygon
- Create Stream Layer - Spatial Analysis Tool → Hydrology → Stream to Feature Tool
- Export shape layers KML file



Once layers are generated the same can be viewed on Online Watershed Analysis Tool which is developed based on Google Maps API at www.watersheds.in

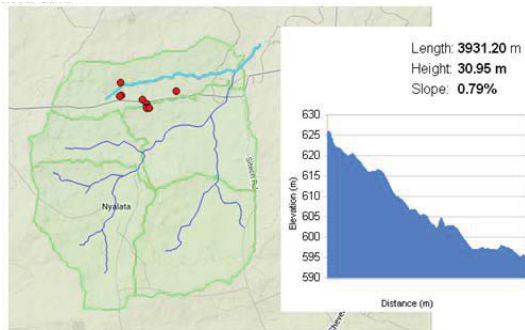
Online Watershed Analysis Tool

This tool is developed to view, analyze various factors affecting site suitability for water conservation structures such as watershed area, size, shape, stream length, surface profile, drainage density etc.

Features

- View watershed boundary map and drainage network map layer over Google Maps
- Find length of stream
- Find latitude, longitude, and altitude of a given point
- Find area of a selected watershed

- View ground profile along and across the stream path
- View existing water conservation structures along with attributes
- View proposed structures based on various factors
- Monitor the progress of structural construction work

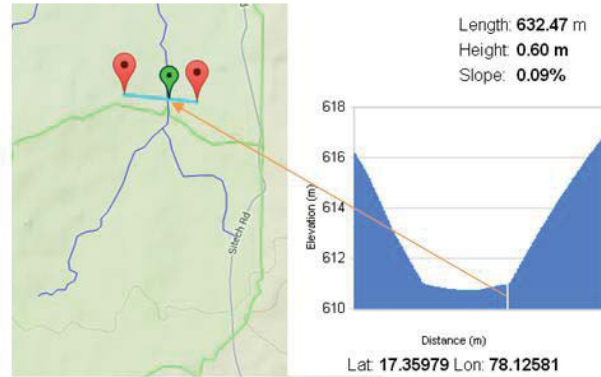


Ground profile of along the Stream

Technology

This tool is developed using JavaScript, Google Maps Javascript API v3, Google Elevation API, and ASP.NET technologies.

- Google's Map API is one of the most popular JavaScript libraries on the web. Google Maps comes with three base maps: street, satellite, and terrain
- Google Elevation API provides you a simple interface to query locations on the earth for elevation data



Ground profile across the Stream

Summary and Conclusions

In this study, topography and terrain profile is considered as one of the factor to select site suitability for water conservation structures like check dams, percolation tanks, farm ponds etc.

After considering the other factors such rainfall pattern and runoff, soil type and soil depth; this tool will be helpful in the finalization of physical plan including

- Preparation of lay-out plan of the project area on an appropriate scale showing the locations of proposed structures
- Determination of the number of structures required for recharge.
- Identification of tentative locations of proposed structures

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